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

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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 in this area tackles this issue through the development and implementation of novel strategies for the assessment and health monitoring of highway bridges, rail structures, pavements and foundations. The resulting picture of health of these vital elements of our transportation infrastructure will provide the information required to prioritize repair and replacement, while advanced assessment will allow structures to remain in service longer.
Thrust Area 2: New Materials for Longevity and Constructability	This thrust area investigates new materials and technologies to improve durability and extend the life of transportation infrastructure. The materials and technologies investigated will improve multi-modal transportation connections.
Thrust Area 3: New Systems for Longevity and Constructability	This thrust area focuses on evaluation, development, and application of engineering systems to improve the durability and longevity of new and existing transportation infrastructure. In these times of economic austerity, New England's transit networks face challenges related to cold weather, aging, deterioration, evolving load demands, and construction efficiencies. Addressing these issues, applicable to both roadway and railway modes of transit, will 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 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 will increase system performance, lower the costs of maintenance and provide more timely notification of assets that need immediate repair or replacement. Managing infrastructure for performance, capacity and maintenance with connected technologies will become the standard expectation of the future. This thrust area applies to all forms of infrastructure including highway and railroad bridges and other fixed assets including roadways and ramps.

TIDC will provide base funding to each member university contingent upon performance. Additional funding of $250,000 will be made available through an annual competitive RFP process.

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 bi-monthly progress reports for each research project to ensure performance is adequately tracked.

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 transportation-related educational activities.

Formal metrics to measure program effectiveness include numbers of undergraduate and graduate students participating in intra-consortium exchange initiatives or industrial internships; seminars, workshops, and conferences hosted; number of K-12 students who participate in transportation-focused tours or activities at member institution; total number of classrooms reached by STEM Ambassadors, including specifics on classrooms populated by under-represented groups of students.

Technology Transfer

The TIDC goals and performance metrics reflect the full spectrum of research activities through technology concept inception and assessment to technology adoption. The projects funded by TIDC will support the following technology transfer activities: (1) development of new technologies, techniques, or methodologies; (2) publishing journal, conference and policy papers that become references for practitioners for the modification of codes and standards for technology adoption; (3) deployment of new technologies, techniques, or practices; (4) improvements in the processes, technologies, and techniques in addressing transportation issues; (5) workforce development; (6) adoption of technologies, techniques, or practices; and, (7) development or modification of codes and standards to facilitate wider technology adoption.

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 four research thrust areas; 1) monitoring and assessment, 2) new materials for longevity and constructability, 3) new systems for longevity and constructability, and 4) connectivity for enhance asset and performance management.

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.

Formal metrics to measure technology transfer goals include successfully demonstrated proof-of-concept; number of technical reports published; number of relevant papers published through peer-reviewed journals; number of relevant papers published in conferences, symposia, workshops, and meetings; number of technologies deployed in transportation applications through pilot or demonstration studies; number of research deliverables disseminated; number of webinars given; number of instances of technology adoption by Industry or transportation agencies and of commercialization; and, number of instances of research changing Industry or transportation agency practices, decision making, or policies.

As part of TIDC's Technology Transfer Plan (dated November 30, 2018) the following technology transfer goals and performance measures were established:

Table 2: Technology Transfer Goals & Performance Measures	
Goal	**Performance Metrics**
Output: Development of new technologies, techniques, or methodologies	Successfully demonstrate proof-of-concept
Output: Publishing journal, conference and policy papers that become references for practitioners for the modification of codes and standards for technology adoption	Number of technical reports published
	Number of relevant papers published through peer-reviewed journals
	Number of relevant papers published in conferences, symposia, workshops, and meetings
Outcome: Deployment of new technologies, techniques, or practices	Number of technologies deployed in transportation application through pilot or demonstration studies
Outcome: Improvements in the processes, technologies, and techniques in addressing transportation issues	Number of research deliverables disseminated
Impact: Workforce development	Number of webinars given
Impact: Adoption of technologies, techniques, or practices	Number of instances of technology adoption by industry or transportation agencies and of commercialization
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

Collaboration

Institutional leads will serve on the TIDC Management Team which will help to ensure each institution has ownership 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 has a Technical Champion. The Technical Champion has subject matter expertise and serves as a resource for the principal investigators. The Technical Champion will help integrate the research results into DOT or Industry practice and will help with the implementation or project results during and after the research. 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. As more projects are added and advanced, the number of Technical Champions and their contributions will change. See table 6 on page 11 for a complete list of Technical Champions.

Formal metrics to measure collaboration goals include presentations given at non-member universities, documented conversations regarding collaboration between TIDC and other UTCs, 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 23 projects continuing from the last reporting period and 4 more research projects have been approved and started. See Table 3 for a list of all active TIDC funded research projects.

Table 3: Active TIDC Projects

Project Number & Title Institution	Institution(s)	Start Date
Thrust Area 1: Transportation Infrastructure Monitoring and Assessment of Enhanced Life		
1.1 – Field Live Load Testing and Advanced Analysis of Concrete T-Beam Bridges to Extend Service Life	University of Maine	7/1/2018
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
1.11 – Energy Harvesting and Advanced Technologies for Enhanced Life	University of Rhode Island	7/1/2018
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
Thrust Area 2: New Materials for Longevity and Constructability		
2.1 – Asphalt Mixtures with Crumb Rubber Modifier for Longevity and Environment	University of Rhode Island	7/1/2018
2.3 – Measuring Adhesion Between Binders and Aggregates Using Particle Probe Scanning Force Microscopy at Low Temperatures	University of Vermont	1/1/2019
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
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
3.6 – Recycling Infrastructure Assets and Reduction of Transportation System Greenhouse Gas Emissions	University of Rhode Island	7/1/2018
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
3.11 – Assessment of Micropile-Supported Integral Abutment Bridges	University of Maine	9/1/2019
3.12 – Lateral Loading of Unreinforced Rigid Elements and Basal Stability of Column-Supported Systems	University of Maine	6/1/2019
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
4.7 – Integrated Green Infrastructure and Sustainable Transportation Planning	University of Rhode Island	7/1/2018

The following accomplishments have been achieved during the reporting period:

Individual TIDC research project have achieved successes during the reporting period. The following are some examples of accomplishments achieved under individual research projects. 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 page.

Project 1.1 (UMaine): Comparative analysis of strain data recorded during live-load testing of skewed and un-skewed bridges has led to the identification of specific behaviors where these

bridges differ. Linear, 3D finite element analysis has provided further evidence that these differences are indeed due to the presence of skew. As a result, a novel, nonlinear FE strategy has been developed to handle the capacity rating of skewed T-beam bridges and extended to prestressed concrete girders. The accuracy of the technique has also been demonstrated be simulating real tests of two bridges up to failure.
Project 1.6 (UConn): A case study was conducted that validated the proposed method for fault identification that is specifically tailored to railway track systems. To conduct the case study, a testbed structure was constructed with a piezoelectric transducer. Researchers formulated and executed fault identification built upon Bayesian inference. The simulation data was used to practice the identification of fault location and severity. The outcome provides a preliminary demonstration of the feasibility of Bayesian inference for fault identification.
Project C3.2018: The UMass Lowell team has conducted field measurements of a local prestressed concrete bridge (Lincoln St Bridge, Lowell, MA) using 3D ground penetrating radar (GPR). This application was used for detecting subsurface steel rebar and surface cracking of concrete. A technical report summarizing the findings is in progress and will be submitted to the City of Lowell in the next reporting period.

Additionally, in July 2019, TIDC released the 2019 Request for Proposals on the TIDC website (https://www.tidc-utc.org/opportunities/research-opportunities/2019-request-for-proposals/) to compete for $250,000 in competitive funding as mentioned in Section I a. Through the 2019 Request for Proposals, TIDC sought proposals from its member universities for research relevant to one of the four research thrusts that will address enhanced durability and life extension of infrastructure and have long-term and real-world value to state departments of transportation in New England and beyond. Proposals were due to TIDC on September 30, 2019. Three competitive proposals were received and sent to the TIDC Advisory Board for review. The review is scheduled to be completed on October 31, 2019 with award notifications being sent on November 29, 2019.

Education & Workforce Development

In an effort to ensure all education and workforce development goals are met, TIDC personnel finalized the Communications, Education, and Outreach Plan. The purpose of this plan is to provide clear guidelines and strategies to effectively achieve TIDC's goals and objectives for communicating research findings, providing opportunities for workforce development and K-12 outreach, and the expected and required acknowledgments for all reports. In addition, the creation of toolkits to be used in K-12 classrooms and for the University of Maine 4-H Ambassador Program Cooperative Extension is continuing. While existing 4-H STEM Toolkits provide an experiential science learning opportunity for youth by providing materials needed to successfully complete science-based activities, the TIDC will create transportation related toolkits to encourage youth to learn more about the transportation industry.

Toward this end, UMaine TIDC personnel met with the UVM 4-H Cooperative Extension to view a bridge building kit that has been approved for possible implementation within the Region 1 UTC consortium. This kit is deemed appropriate for the interim use, while more research-focused kits are being built. Toolkits will be available to the K-12 school districts in Maine. The completion of the initial toolkits are expected to be completed in the spring of 2020, with the

testing of the activities for the 4-H Ambassador program beginning in the spring of 2021. Copies of the toolkits and activities will be made available on the TIDC website and are planned to be distributed to member universities with 4-H Cooperative Extensions.

A student poster contest was held in conjunction with the 2019 TIDC Annual Conference. The purpose of the Student Poster Contest was to allow students to present their research findings to DOT members, researchers, and other attendees of the conference. There were eight contest entries and seven of the students attended the conference to present their findings. During the poster presentation, the conference attendees visited each student's poster and talked with the students about their finding and asked questions. At the end of the presentations, certificates were awarded to posters that placed 1st, 2nd, and 3rd in the contest. The 1st place certificate was presented to Andrew Schanck from UMaine for his poster titled "Capacity Assessment of Older T-Beam Bridges Using Field Load Testing and Nonlinear Proxy Finite-Element Analysis." 2nd place was awarded to Bijaya Rai from UConn for her poster titled "Development and Testing of High / Ultra-High Early Strength Concrete Durable Bridge Components and Connections." 3rd place resulted in a tie, being awarded to Mark Castaldi of UConn and Cy Ryding of Western New England University.

Technology Transfer

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

TIDC researchers have participated in eleven 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
TIDC Annual Conference	Conference – Presentations & collaborations	University of Maine, Orono, ME	6/6/19-6/7/19
12th ASNEngr Annual Conference	Conference – Keynote Lecture	Chicago, IL	7/27/19-7/29/19
ASCE Engineering Mechanics Institute (EMI) Conference	Conference – Collaboration & Information exchange	Caltech, Pasadena, CA	6/18/19-6/21/19
International Bridge Conference	Conference – Presentation	National Harbor, MD	6/10/19-6/12/19
2019 Northeast Connected and Automated Vehicle (NECAV) Summit	Conference – Collaboration & Information exchange	Hartford, CT	7/12/19-7/13/19
ASME IDETC-CIE 2019	Conference – Information exchange	Anaheim, CA	8/18/19-8/21/19

	(Dr. Jiong Tang is the conference general chair)		
US-Korea Conference 2019 (UKC2019)	Conference – Presentation	Rosemont, IL	8/14/19
VTrans Innovation Showcase	Conference – Poster Presentation	Berlin, VT	9/11/19
11th International Committee on Pavement Technology (ICPT)	Conference – Presentation of Technical Paper	Kuala Lumpur, Malaysia	7/11/19
2nd International Interactive Symposium on Ultra-High Performance Concrete	Poster Display	Albany, NY	6/2/19-6/5/19
2019 New England Transportation Symposium	Conference – Invited Lecture	Concord, NH	6/19/2019

Additionally, TIDC has published and submitted 15 publications, conference papers, and presentations and two Journal publications. 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.

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 within its designated Fast Act topic. The Advisory Board evaluate and recommends the disbursement of competitive funding through an open RFP process to support additional activities at member universities. The Advisory Board also reviews TIDC's annual performance metrics from each member university to determine the status of performance based base funded projects. The Advisory Board is currently comprised of members from state DOTs in Region 1.

During this reporting period, the TIDC Management Team met each month, with the exception of July, for a total of five meetings. On June 6th & 7th, TIDC held its first Annual Conference at the University of Maine in Orono, ME. The TIDC Annual Conference provided the opportunity for researchers to share their research findings to date. State DOTs in the New England Region, local industry, students from member universities, non-affiliated faculty and staff, and the general public were invited to attend the Annual Conference. Upon completion of the Annual Conference, the TIDC Advisory Board and the TIDC Management Team held individual meetings followed by a large collaborative meeting to hear feedback and suggestions from the members.

The following table identifies the 25 active collaborations and stakeholders and their contributions during the reporting period. (* indicates new project collaborators during this period)

Table 5: Research Project Collaborators		
Organization	**Location**	**Contribution**
ADAPT Corporation	Redwood City, CA	In-kind
Advanced Infrastructure Technologies	Orono, ME	In-kind, collaborative research, personnel, facilities
Amtrak	Philadelphia, PA	Collaborative research, personnel
Argonne National Laboratory	Lemont, IL	Collaborative research, personnel
ATANE Consulting *	New York City, NY	Collaborative research, personnel
City of Lowell	Lowell, MA	Collaborative research, personnel
Connecticut Department of Transportation	Newington, CT	Collaborative research, personnel
Connecticut Transportation Institute *	Storrs-Mansfield, CT	Collaborative research
Federal Highway Administration – Rhode Island Division	Providence, RI	Collaboration with outreach efforts
Intergraph Corporation	Madison, AL	In-kind
Maine Bureau of Motor Vehicles	Augusta, ME	Collaborative research
Maine Department of Transportation	Augusta, ME	In-kind, collaborative research, financial, personnel, equipment
Massachusetts Department of Transportation	Boston, MA	Collaborative research, personnel
McInnis Cement	Montreal, Quebec, Canada	Collaborative research
Metro-North Railroad Company	New York City, NY	Collaborative research, personnel
New Hampshire Department of Transportation	Concord, NH	Collaborative research, personnel
Oak Ridge National Laboratory	Oak Ridge, TN	In-kind, collaborative research, personnel, facilities
Omnisens *	Morges, Switzerland	Collaborative research, personnel, equipment
Pike Industries, Inc *	VT, NH	Equipment
Precast/Prestressed Concrete Institute Northeast (PCINE)	CT, MA, ME, NH, NY, RI, VT	Collaborative research, personnel
Providence and Worcester Railroad Company	Stamford, CT	Collaborative research, personnel
Rhode Island Department of Transportation	Providence, RI	Collaborative research, personnel
Sperry Rail Service	Shelton, CT	Collaborative research, personnel
Steelike Concrete *	Springfield, VA	In-kind
The Nature Conservancy of Vermont *	Montpelier, VT	Collaborative research, personnel
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 Natural Resources	Montpelier, VT	Collaborative research, personnel
Vermont Agency of Transportation	Montpelier, VT	In-kind, collaborative research, personnel, financial
Voestalpine Nortrak Inc. *	Pueblo, CO	In-kind
Western New England University	Springfield, MA	In-kind, collaborative research, personnel, facilities, financial
XSEDE: University of Texas at Austin	Austin, TX	In-kind, collaborative research, equipment

All TIDC funded projects have met the goal of having a Technical Champion (as described in Section I a, Collaboration) assigned to each. Additionally, some research project have additional Technical Advisors involved in their projects. The following table identifies the 25 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 6: Active Technical Champions & Advisors

Name and Title of Technical Champion or Advisor	Organization
Andrew Bardow, Director, Bridges and Structures	Massachusetts Department of Transportation
Steven Cascione, Programming Services Officer	Rhode Island Department of Transportation
Henry Chango, Contract Administrator	D'Ambra Construction Company, Inc.
Brian Clang, Bridge Inspection Engineer	Massachusetts Department of Transportation
Cassidy Cote, Hydraulics and Structures Engineer	Vermont Agency of Transportation
Callie Ewald, P.E., Geotechnical Engineering Manager *	Vermont Agency of Transportation
Karen Gross, Geotechnical Engineer	Maine Department of Transportation
Joshua Hasbrouck, Civil Engineer, Bridge Program	Maine Department of Transportation
Dr. Wilfred Hernandez, P.E., Safety Specialist/EDC Coordinator *	Federal Highway Administration – Rhode Island Division
Garrett Kilfoyle, Assistant Engineer, Bridge Maintenance	Maine Department of Transportation
Brandon Kipp, Project Manager, Pavement Management Section	Vermont Agency of Transportation
John Kocur, Director of Engineering	Sperry Rail Service
James Lacroix, P.E., State Bridge Design Engineer	Vermont Agency of Transportation
Sam Maxim, Bridge Maintenance Engineer *	Maine Department of Transportation
Andrew Mrockowski, Transportation Engineer	Connecticut Department of Transportation
Edmund (Ned) Newton, Civil Engineer	Massachusetts Department of Transportation
Dale Peabody, Director, Transportation Research	Maine Department of Transportation
Paul C. Petsching, P.E., Senior Civil Engineer	Rhode Island Department of Transportation

Aaron Schwartz, Hot Mix Asphalt Engineer	Vermont Agency of Transportation
Rite L. Seraderian, P.E., FPCI, LEED AP, Executive Director	Precast/Prestressed Concrete Institute Northeast
Nick Ward, P.E., Hydraulics Engineer, Project Delivery Bureau, Structures	Vermont Agency of Transportation
James Wild, Concrete Materials Manager	Vermont Agency of Transportation
Dr. Kathleen Wilson, P.E., Chief Civil Engineer	Rhode Island Department of Transportation
Hailing Yu, Civil Engineer	U.S. DOT Volpe Center

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 individual Semi-Annual Progress Reports are available at https://www.tidc-utc.org/research/tidc-funded-projects-and-reports/. Information was shared at conference presentations, including the 1st TIDC Annual Conference (see table 4 on page 8 for a complete list of Conferences and Workshops). Further results were disseminated through journal articles, professional magazines, and meetings with New England State DOTs.

During the reporting period, TIDC held its first annual conference at the University of Maine in June 2019. DOT personnel, industry members, and the general public were invited to attend the conference to hear presentations of each research project's results up to the date of the presentation. Additionally, graduate students supported by TIDC had the opportunity to present findings through the Annual Student Poster Contest held during the TIDC Annual Conference.

Findings from project 1.1 were also presented at the Annual UMaine Student Symposium in April 2019. According to UMaine Student Symposium website "The annual UMaine Student Symposium provides an opportunity for the public to interact one-on-one with UMaine students as they present their research and creative work. Projects are showcased thorough posters, exhibits, oral presentation, and more." For more information about this event, please visit https://umaine.edu/umss/.

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

Research

TIDC will continue to start new, relevant, and innovative research projects. During the next reporting period, the review of the 2019 Request for Proposals will be completed and the awards will be announced on November 29, 2019. Selection of new base-funded projects will begin and the performance current research projects will continue to be evaluated against the mission, goals, and objectives of TIDC. Additionally, TIDC plans to expand the Competitive Solicitation in 2020 to Universities outside of the TIDC consortium that conduct transportation related research in Region 1 in an effort to create the greatest impact in New England.

Education & Workforce Development

TIDC personnel at UMaine have created a partnership with a local elementary school to begin the process of implementing transportation related activities into their curriculum. The pilot of the activities is expected to begin in December 2019 or January 2020 with activities in two classrooms. After this pilot, the program is expected to be delivered to the entire school in by April of 2020.

TIDC personnel at UMaine are also working to create better partnerships with MaineDOT, industry leaders in Maine, and Maine Community Colleges to create more opportunities for workforce development in the state and beyond. A forum for collaboration is planned for March of 2020. The goal of this forum is to allow TIDC personnel and researchers to better understand the needs of DOTs and industry in regards to workforce development. Focus will be placed on infrastructure durability needs to match with the goals and objectives of TIDC.

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.

Technology Transfer

To accomplish TIDC's technology transfer objectives identified in Section I. a., Technology Transfer (pg. 3), the following venues and mechanisms will be employed: (1) a TIDC website and social media accounts that promote findings and opportunities for collaboration directly to the public; (2) widely disseminated, online TIDC bi-annual newsletters to begin in 2020; (3) the expansion of the TIDC Annual Conference through early advertising and outreach activities in New England; (4) continued participation in regional transportation conferences (i.e. the Maine Transportation Conference hosted by the Maine DOT, the Rhode Island Transportation Conference hosted by URI, and others as appropriate); and (5) promotion of all market-ready technology transfer opportunities through industry/trade publications, the TIDC website and social media accounts.

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 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. Additionally, the TIDC Management Team and the TIDC Advisory Board will be meeting in November 2019 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 2020 conference have been selected (June 3-4, 2020 at UMass Lowell).

II. PARTICIPANTS & COLLABORATING ORGANIZATIONS

a. What individuals have worked on the project?

In total, 41 principal investigators, faculty, administrators, and management team members and 59 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 R. Bryce, Dr. Bill Davids, Dr. Roberto Lopez-Anido, James Anderson, Dr. Douglas Gardner, Dr. Yousoo Han, Dr. Aaron Gallant, Dr. Warda Ashraf, Dr. Jonathan Rubin, Dr. Andrew Goupee, Dr. Keith Berube, Kathryn Ballingall, Vu Phan, and Amanda Collamore	Andrew Schanck*, Joshua Clarke, Sunil Bhandari, SK Belal Hossen, Anthony Salafia, Braedon Kohler, Rakibul I. Khan, and Nicholas Alvarez*.
University of Connecticut	Dr. Ramesh Malla, Dr. Jiong Tang, Dr. Kay Wille, Dr. Jin Zhu, and Dr. Song Han	Sudipta Chowdhury, Gang Wang, Areej Althubaity, Jiachen Wang, Mark Castaldi, David Jacobs, Suvash Dhakal, Francis Almonte, Stephanie Kreitler, Sean Doolittle, Liam Gerety, Yixin Yao, Sachin Tripathi, Jeet Rosa, Alex Distelman, Xinyan Huang, Giovanna Fusco, Zheng Ren, and Bijaya Rai.
University of Massachusetts Lowell	Dr. Tzuyang Yu, Dr. Xingwei Wang, Dr. Susan Faraji, and Dr. Zhu Mao	Ahmed Alzeyadi, Harsh Gandhi, Sanjana Vinayaka, Ruben Diaz, Jade Man, Hao Peng, Aral Sarrafi*, Mark Todisco, Brett Daniels, Andres Miguel Biondi Vaccariello, Jingcheng Zhou, Hamed Abshairi, Sina Razzaghi, Celso doCabo, Nick Valente, Matt Southwick, and Xiaoyu Zhang

University of Rhode Island	Dr. K. Wayne Lee, Dr. Michael Greenfield, Dr. Sze Yang, Dr. George Veyera, Dr. Natacha Thomas, Dr. Christopher Hunter, and Dr. Farhad Atash	Neha Shrestha, Stephan Zaets, Ali Sharai, David Schumacher, and Mason Hyde
University of Vermont	Dr. Mandar Dewoolkar, Dr. Ehsan Ghazanfari, Dr. Ting Tan, Dr. Dryver Huston, Dr. Donna Rizzo, Dr. Arne Bomblies, Dr. Hamid Ossareh, and Dr. Kristen Underwood	Sienna Roberge, Maziar Foroutan, Zhuang Liu, Rachel Seigel, Austin Kopec*, Bridger Banci, Lindsay Worley, and Matthew Trueheart*.
Western New England University	Dr. Moochul Shin and Dr. ChangHoon Lee	Caleb Tourtelotte, Cy Riding*, Isaiah Colombani*, Cameron Cox, Andrew Masullo, and Nicholas Pantorno

b. What organizations have been involved as partners?

During the process of selecting research projects, TIDC has received commitments of support and matching funds from 33 collaborators during this reporting period. The type of support provided by the collaborators varies from in-kind, financial, equipment, to supplies. In addition, many collaborators provide direct personnel links in research through Technical Champions (see below for further information). 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?

The University of Vermont's Physics department has provided equipment for testing.

III. OUTPUTS

a. Publications, conference papers, and presentations:

The following table includes a list of the nine accepted and submitted papers and reports:

Table 8: Publications, Conference Papers, and Presentations

Type	Title	Citation	Date	Status
Conference Abstract	Proxy Finite Element Analysis for Load Rating RC T-Beam Bridges	Davids WG and Schanck A (2020). Proxy Finite Element Analysis for Load Rating RC T-Beam Bridges. ASCE Structures Congress, St. Louis MO, 2020.		Accepted
Conference Paper	Evaluation of Correlations between Intelligent Compaction Measurement Values and In-Situ Spot Measurements	Foroutan M., Bijay K C, Ghazanfari E. (2020). Evaluation of Correlations between Intelligent Compaction Measurement	2/14/19 & 9/20/19	Submitted & Accepted

		Values and In-Situ Spot Measurements. ASCE Geo-Congress 2020: Vision, Insight, Outlook, Minneapolis, MN, 2020.		
Journal Article	Simulating Hydraulic Interdependence between Bridges Along a River Corridor Under Transient Flood Conditions	Trueheart, M.E., Dewollkar, M.M., Rizzo, D.M., Huston, D., Bomblies, A. (2020). Simulating Hydraulic Interdependence between Bridges Along a River Corridor Under Transient Flood Conditions. *Science of the Total Environment*, Vol 699, January 10, 2020, 134046, ISSN 0048-9697.	4/16/19, 8/1/2019, 8/21/19, & 8/29/19	Submitted, Revised, Accepted, & Available online
Journal Paper	Electromagnetic Evaluation of Brick Specimens Using Synthetic Aperture Radar Imaging	Tang Q., Hu J., Yu T. (2019). Electromagnetic Evaluation of Brick Specimens Using Synthetic Aperture Radar Imaging. *NDT & E International*, Vol. 104, June 2019, pp 98-107.	6/2019	Published
Poster	Development and Testing of High / Ultra-High Early Strength Concrete for Durable Bridge Components and Connections	Rai B., Wille K., (2019). Development and Testing of High / Ultra-High Early Strength Concrete for Durable Bridge Components and Connections. 2nd International Interactive Symposium on UHPC, Albany, NY. 2019.	6/2/19-6/5/19	Presented
Conference Proceeding	Behavior of Eyebars on a 110-year-old Truss Railroad Bridge	Jacobs, D.W., Dhakal, S., and Malla, R. B., "Behavior of Eyebars on a 110-year-old Truss Railroad Bridge," Proceedings, International Bridge Conference, Engineers' Society of Western Pennsylvania (ESWP), Pittsburgh, PA; Aug. 2019; 592-599	6/10/19-6/12/19	Reviewed & Presented
Technical Paper	Determining the Effect of Climate and Loading on Fatigue Cracking and Roughness of Asphalt Pavement Using InfoPave	Farahmarzi, M., Shrestha, N. and Schumacher, D. "Determining the Effect of Climate and Loading on Fatigue Cracking and Roughness of Asphalt Pavement Using InfoPave."	7/1/2019	Submitted

		Submitted to 2018-2019 T&DI/ASCE-LTPP International Data Analysis Contest		
Conference Paper	Elemental Testing of Carbonated Silty Sand Treated with Lime	Hossen, S.B., Gallant, A.P., and Ashraf, W. (2020). "Elemental Testing of Carbonated Silty Sand Treated with Lime." *Proc. Geo-Congress 2020*, GSP, ASCE, Minneapolis, MN, pp. 1-10	7/6/2019	Submitted
Conference Abstract	Geo-Statistical Evaluation of the Intelligent Compaction Performance in a Reclaimed Base Project	Foroutan M., Ghazanfari E. (2020). Geo-Statistical Evaluation of the Intelligent Compaction Performance in a Reclaimed Base Project. 4th International Conference on Transportation Geotechnics, Chicago, IL, 2020.	7/12/19 & 8/20/19	Submitted & Accepted
Conference Abstract	Effectiveness of Biochemicals to Control CaCO3 Crystallization in carbonation Activated Binder Systems	Khan, R & Ashraf, W. 2019. "Effectiveness of Biochemicals to Control CaCO3 Crystallization in carbonation Activated Binder Systems", *ACI Fall Convention*, Cincinnati, OH, October 19-23, 2019.	7/15/19	Accepted
Conference Keynote Lecture	Response Monitoring of Very Old Truss Railroad Bridge for High Speed Trains	Malla RB (2019). Response Monitoring of Very Old Truss Railroad Bridge for High Speed Trains. 12th ASNEngr Annual Conference, Chicago, IL, 2019.	7/27/19-7/29/19	Accepted & Presented
Conference Paper	Transportation Infrastructure Assessment through Solar Energy Harvesting	Austin DeCotis, David Schumacher, Michael L. Greenfield, and K. Wayne Lee, "Transportation Infrastructure Assessment through Solar Energy Harvesting", submitted to Transportation Research Record for January 2020 TRB meeting.	8/1/2019	Submitted
Technical Paper	Implementation of Warm Mix Asphalt contained Reclaimed Asphalt Pavement in Rhode Island	Shrestha, N., Lee, K., and Veyera, G.E. "Implementation of Warm Mix Asphalt contained Reclaimed Asphalt Pavement in Rhode Island."	8/1/2019	Submitted

		Submitted to 2020 TRB Conference.		
Conference Paper	Infrastructure Management through Solar Energy Harvesting	DeCotis A, Schumacher D (2019). Infrastructure Management through Solar Energy Harvesting. US-Korea Conference 2019. Rosemont, IL. August 16, 2019.	8/16/2019	Accepted & Presented
Conference Poster	Detection of pipeline defects using Brillouin Optical Time Domain Reflectometer (BOTDR)	Wang X, "Detection of pipeline defects using Brillouin Optical Time Domain Reflectometer (BOTDR)," Poster Presentation, Asia-Pacific Optical Sensor Conference, Auckland, New Zealand, November 19-22, 2019.	9/5/2019	Accepted

b. Journal publications:

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

Table 9: Journal Articles and Publications

Title	Citation	Date	Status
Capacity Assessment of Older T-Beam Bridges by Nonlinear Proxy Finite-Element Analysis	Schanck A and Davids WG (2020). Capacity assessment of older T-beam bridges by nonlinear proxy finite-element analysis. *Structures.*	9/26/2019	Accepted
On Live Load Impact Factors for Railroad Bridges	Jacobs, W. and Malla, R. B "On live load impact factors for railroad bridges," International Journal of Rail Transportation, Vol. 7, Issue 4; April 2019; pp 262-278; (https://doi.org/10.1080/23248378.2019.1604182)	4/2019	Accepted: 4/3/2019 Published: 4/29/2019

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 and Presentations				
Type	**Title**	**Citation/Description**	**Date**	**Status**
Non-Member University Presentation	Next Generation railroad Infrastructure: Splitting/Bursting Damage of Prestressed Concrete Crossties	Graduate Seminar at the Department of Civil, Construction, and Environmental Engineering, University of New Mexico, Albuquerque, NM	3/25/2019	Presented
Non-Member University Presentation	Bioresources for Enhancing the Sustainability of Cement-based Materials	Presentation at the University of Texas, Arlington to technical personnel, faculty members, and graduate students	6/13/19	Presented
Professional Magazine	Eye Strain	Jacobs, D. W. and Malla, R. B., "Eye Strain," RT&S- Railway Track and Structures, Vol. 115. No. 9, New York, NY, Sept. 03, 2019, pp 12-19	9/3/2019	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: 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 finite-element analysis method was developed under project 1.1. This new technique is used to determine the load rating of concrete girder bridges.

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

Nothing to report.

IV. OUTCOMES

A field test of a pedestrian bridge on the University of Massachusetts Lowell campus was conducted under project 1.5. 28 meters of sensing fiber cable (OZ optics SMF-1300/1550-9/125-1TBYL-L) was placed on the pedestrian bridge connecting Ball Hall and Olney Hall. A load of 707 kg (1559 lbs) was applied at the 19 meter mark. BOTDA (Brillouin Optical Time Domain Analysis) Measurements were taken before and after the load. The test validated the sensing system's ability to perform in real-world applications as tested in the laboratory.

V. IMPACTS

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

Nothing to report.

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?

Nothing to report.

d. What is the impact on transportation workforce development?

Nothing to report.

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.