Quarterly Progress and Performance Indicators Report:
Project Number and Title: 2.10 Durability Evaluation of Carbon Fiber Composite Strands in Highway Bridges
Research Area 2: New materials for longevity and constructability
PI: *Roberto Lopez-Anido, University of Maine*
Co-PI(s): *Keith Berube and Andrew Goupee, University of Maine*
Reporting Period: *4/1/2022-6/30/2022*
Submission Date: *6/27/2022*

****IMPORTANT: Please fill out each section fully and reply with N/A for questions/sections with nothing to report. For ease of reporting to the USDOT, please do not remove, or change the order of, any sections/text. You may remove/add each rows in tables as needed. Thank you! ****
The report is due on the last day of the reporting period in .doc format to tidc@maine.edu.

Overview:

*Provide **BRIEF** highlights of activities performed during the reporting period.*

- A new data acquisition computer (with SSD drive) was purchased and is being installed at the pylon base station to provide the link to the existing MaineDOT network.
- The existing data acquisition (DAQ) code was updated to improve the system restart after a power outage, and to incorporate the temperature at the wireless nodes to be included in the data that is recorded.
- A wind speed/direction sensor has been purchased.

Meeting the Overarching Goals of the Project:

How did the previous items help you achieve the project goals and objects? Please give one bullet point for each bullet point listed above.

- The new computer provides improved response and increased storage capacity within a smaller housing. This will alleviate issues with overheating and network communication, which will enable continuous operation and eliminate system downtime.
- The improvements to the software code will minimize software downtime and the need for physical site visits for maintenance, while the additional node temperature data will improve the accuracy of the recorded results.
- The wind speed/direction sensor will provide data that will be implemented into the thermoelastic model that predicts CFCC strand force response.

Accomplishments:

List any accomplishments achieved under the project goals in bullet point form…

- The structural health monitoring system allows for the real-time capture of major CFCS force changes.
- Currently, the continuous structural health monitoring system is operational for one stay (10B). When the continuous system becomes operational to collect data on the six stays, further assessment of CFCS long-term durability will be possible.

Task Progress and Budget:

Complete the following tables to document the work toward each task and budget (add rows/remove rows as needed, make sure you complete the Overall Project progress row and include all tasks even if they have ended or have not been started)…

Table 1: Task Progress			
Task Number	**Start Date**	**End Date**	**% Complete**
Task 1.1: Upgrade Data Acquisition System	6/1/2019	8/30/2022	85%
Task 1.2: External Environmental Sensing	1/1/2020	10/30/2022	80%
Task 1.3: Implement Analytical Model	11/1/2019	12/31/2021	100%
Task 1.4: Durability Assessment	11/1/2019	12/31/2022	75%
Phase 1 Overall	6/1/2019	12/31/2022	Phase 85 % Complete

Table 2: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date (include the date)**
Enter Phase 1 Full Budget $135,783 DOT $65,482 UMaine $70,301	Enter Phase 1 Full Spend Amount (Federal + Cost Share)	Enter Phase 1 % Spent
Enter Phase 2 Full Budget	Enter Phase 2 Full Spend Amount (Federal + Cost Share)	Enter Phase 2 % Spent
Enter Phase 3 Full Budget	Enter Phase 3 Full Spend Amount (Federal + Cost Share)	Enter Phase 3 % Spent

Is your Research Project Applied or Advanced?

☒ **Applied** (*The systematic study to gain knowledge or understanding necessary for determining the means by which a recognized and specific need may be met.)*

☐ **Advanced** *(An intermediate research effort between basic research and applied research. This study bridges basic (study to understand fundamental aspects of phenomena without specific applications in mind) and applied research and includes transformative change rather than incremental advances. The investigation into the use of basic research results to an area of application without a specific problem to resolve.)*

Professional Development/Training Opportunities:

Describe any opportunities for training/professional development that have been provided. Did you provide a training to a State DOT/AOT or industry organization? What was the training? When was it offered? How many people attended? Did you meet with a State DOT/AOT or industry organization to inform them of your findings and how these findings could help their organization? When? How many attended the meeting?

- *N/A*

Technology Transfer:

Complete all of the tables below and provide additional information where requested. Please provide ALL requested information as this is one of the most important sections for reporting to the USDOT. ***ONLY provide information relevant to this reporting period.***

Use the table below to complete information about conference sessions, workshops, webinars, seminars, or other events you led/attended where you shared findings as a result of the work you conducted on this project:

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events

Type	Title	Citation	Event	Location	Date(s)
i.e. Conference, Symposium, DOT/AOT presentation, Seminar, etc.	Presentation Title	Full Citation	Name of event (i.e. TIDC 1st Annual Conference) or who was the presentation given to?		

Use the table below to report any publications, technical reports, peer-reviewed articles, newspaper articles referencing your work, graduate papers, dissertations, etc. written as a result of the work you conducted on this project. Please list only completed items and exclude work in progress.

Table 4: Publications and Submitted Papers and Reports

Type	Title	Citation	Date	Status
Journal paper	Hybrid wireless-fiber optic monitoring system of carbon fiber composite strands in highway bridges	Structural Health Monitoring, Sage	To be submitted in third quarter	In preparation

Answer the following questions (N/A if there is nothing to report):

1. Did you deploy any technology during the reporting period through pilot or demonstration studies as a result of this work? If so, what was the technology? When was it deployed?
   Structural health monitoring at the Penobscot-Narrows Bridge.
2. Was any technology adopted by industry or transportation agencies as a result of this work? If so, what was the technology? When was is adopted? Who adopted the technology?
   MaineDOT adopted the monitoring technology.
3. Did findings from this research project result in changing industry or transportation agency practices, decision making, or policies? If so, what was the change? When was the change implemented? Who adopted the change?
   N/A
4. Were any licenses granted to industry as a result of findings from this work? If so, when? To whom was the license granted?
   N/A

5. Were any patent applications submitted as a result of findings from this research? If so, please provide a copy of the patent application with your report.
   N/A
6. Were any industrial contracts awarded base on furthering planned research and development activities as a result of findings from this work? If so, when? How much was awarded? Who awarded the contract?
   N/A

Please add figures/images that can be included on the website and/or in marketing/social media materials to further clarify your research to the general public.

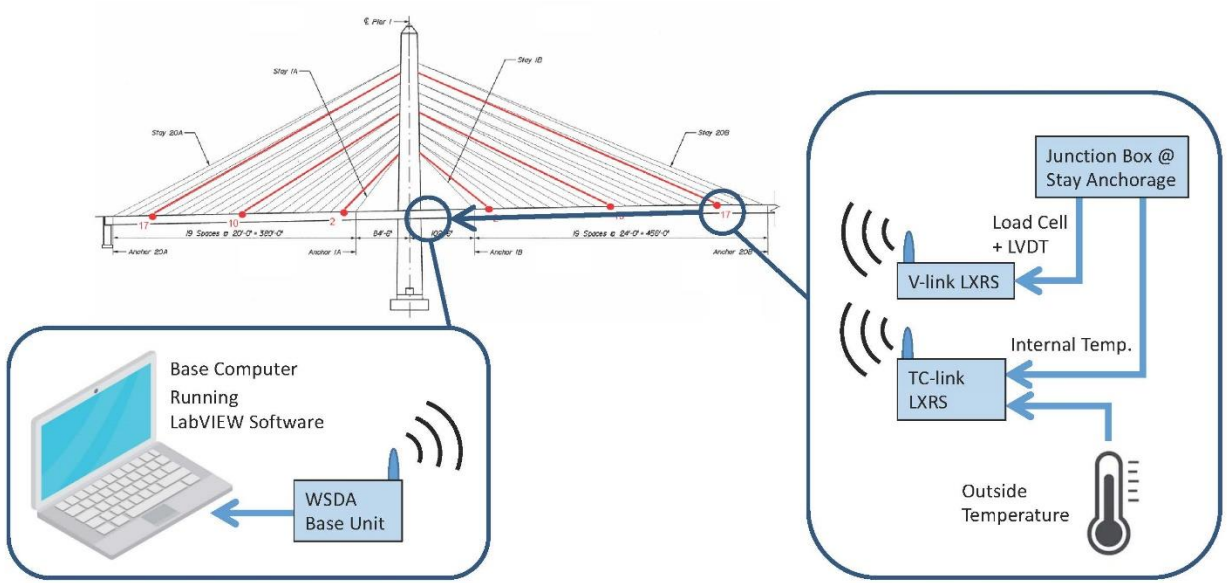

Figure 1. Wireless data acquisition schematic

Describe any additional activities involving the dissemination of research results not listed above under the following headings:

Outputs:

Definition: Any new or improved process, practice, technology, software, training aid, or other tangible product resulting from research and development activities. They are used to improve the efficiency, effectiveness, and safety of transportation systems. List any outputs accomplished during this reporting period:

- Example: New sensing technology was developed. This technology will…

The continuous structural health monitoring technology implemented at the bridge site will allow for identifying events that affect the response of the carbon fiber composite strands (CFCS) and the anchor systems, as follows:

- Real-time capture of major CFCS force changes.
- Correlation of external environmental factors and mean CFCS response.
- Improved data accuracy using wireless node temperature sensitivities.
- Eventual quantitative assessment of CFCS durability.

Outcomes:

Definition: The application of outputs; any changes made to the transportation system, or its regulatory, legislative, or policy framework resulting from research and development activities. List any outcomes accomplished during this reporting period:

- Example: The developed sensing technology was installed in Bridge A in town, state on 1/1/2021. This installation will…

N/A

Impacts:

Definition: The effects of the outcomes on the transportation system such as reduced fatalities, decreased capital or operating costs, community impacts, or environmental benefits. The reported impacts from UTCs are used for the assessment of each UTC and to make a case for Federal funding of research and education by demonstrating the impacts that UTC funding has had on technology and education. NOTE: The U.S. DOT uses this information to assess how the research and education programs (a) improve the operation and safety of the transportation system; (b) increase the body of knowledge and technologies; (c) enlarge the pool of people trained to develop knowledge and utilize technologies; and (d) improves the physical, institutional, and information resources that enable people to have access to training and new technologies. List any outcomes accomplished during this reporting period:

- Example: The developed sensing technology's successful deployment resulted in the adoption of the technology by the StateDOT. The technology will be installed in all new bridge installments of this type. This adoption will…

The continuous structural health monitoring technology implemented 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 (CFCS) and the anchor systems.

Participants and Collaborators:

*Use the table below to list **all** individuals (compensated or not) who have worked on the project.*

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members

Individual Name	Email Address	Department	Role in Research
Roberto Lopez-Anido	RLA@maine.edu	UMaine Civil and Environmental Engineering	Project PI, Graduate student co-advisor, and Structural lead.
Keith Berube	keith.berube@maine.edu	UMaine Mechanical Engineering Technology	Project Co-PI and Data acquisition instrumentation lead.
Andrew Goupee	Andrew.goupee@maine.edu	UMaine Mechanical Engineering	Project Co-PI, Graduate student co-advisor, and Modeling lead.

*Use the table below to list **all** students who have participated in the project during the reporting period. (This includes all paid, unpaid, intern, independent study, or any other student that participated in this project.) **ALL FIELDS ARE REQUIRED.***

Table 6: Student Participants during the reporting period								
Student Name	**Start Date**	**End Date**	**Advisor**	**Email Address**	**Level**	**Major**	**Funding Source**	**Role in research**
Jake Bear	5/16/22		Keith Berube	Jake.Bear@maine.edu	Undergraduate Senior	Mechanical Engineering Technology		Jake is updating the data acquisition code to record additional variables that will result in more accurate data. He also provides hardware installation support.

Use the table below to list any students who worked on this project and graduated or received a certificate during this reporting period. Include information about the student's accepted employment (i.e. the student is now working at MaineDOT) or if they are continuing their students through an advanced degree (list the degree and where they are attending).

Table 7: Students who Graduated During the Reporting Period			
Student Name	**Degree/Certificate Earned**	**Graduation/Certification Date**	**Did the student enter the transportation field or continue another degree at your university?**
N/A			

Use the table below to list any students that participated in Industrial Internships:

Table 8: Industrial Internships			
Student Name	**Degree/Certificate Earned**	**Graduation/Certification Date**	**Did the student enter the transportation field or continue another degree at your university?**
N/A			

*Use the table below to list **organizations** that have been involved as partners on this project and their contribution to the project.*

Table 9: Research Project Collaborators during the reporting period						
Organization	**Location**	**Contribution to the Project**				
		Financial Support	**In-Kind Support**	**Facilities**	**Collaborative Research**	**Personnel Exchanges**
		List the amount	List the amount	Mark with an "x" where appropriate		
N/A						

*Use the table below to list **individuals** that have been involved as partners on this project and their contribution to the project.*
*(**List your technical champion(s) in this table.** This also includes collaborations within the lead or partner universities who are not already listed as PIs; especially interdepartmental or interdisciplinary collaborations.)*

Table 10: Other Collaborators

Collaborator Name and Title	Contact Information	Organization and Department	Date(s) Involved	Contribution to Research
Dale Peabody Director, Transportation Research		Transportation Research, MaineDOT	Since the start of the project	Technical champion

Use the following table to list any transportation related course that were taught or led by researchers associated with this research project:

Table 11: Course List

Course Code	Course Title	Level	University	Professor	Semester	# of Students
i.e. CE 123		Grad or undergrad?	Where was the course taught?	Who taught the course?	Enter Spring, Fall, Summer, Winter and the year	How many students were enrolled in the class?
N/A						

Changes:

List any actual or anticipated problems or delays and actions or plans to resolve them (list no-cost extension requests here)…
The schedule has been affected by disruptions of day-to-day campus and field work due to the University restrictions imposed in response to COVID-19 health safety precautions.
List any changes in approach and the reasons for the change…
N/A

Planned Activities:

List the activities planned during the next quarter.

- We have hired an undergraduate student to work on the project during the Summer. He currently works in Dr. Keith Berube's Lab where he is updating the data acquisition software.
- We have refurbished the existing equipment box for our fiber-optic sensor unit. It will be installed onsite during the Summer.
- The remaining items required for the full system implementation (computer, wind sensor, and electrical hardware) have been purchased..
- Final installation of sensors and instrumentation at the Bridge site is scheduled for July. The installation will include accessing the structural health monitoring system remotely and adding a wind speed/direction sensor.
- We plan to draft a journal paper to communicate the findings of the research project.