Quarterly Progress and Performance Indicators Report:

Project Number and Title: Wireless Joint Monitoring System (w-JMS) for Safety of Highway Bridges

Research Area: Thrust 1 Transportation infrastructure monitoring and assessment for enhanced life

PI: *Shinae Jang, Ph.D., P.E, Associate Professor in-Residence, Department of Civil & Environmental Engineering, University of Connecticut, Storrs, CT*
Co-PI(s): *Song Han, Ph.D., Department of Computer Science & Engineering, University of Connecticut; and*
Ramesh B. Malla, Ph.D.,F. ASCE, F. EMI; Professor, Department of Civil & Environmental Engineering University of Connecticut

Reporting Period: ***7/1/2022 – 9/30/2022***

Submission Date: 9/30/2022

****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. This summary should be written in lay terms for a general audience to understand. This should not be an extensive write up of findings (those are to be included in the final report), but a high-level overview of the activities conducted during the last three months **no more than 3 bullet points at no more than 1 sentence each** ….*

- The research team (RT) collected field data using the developed sensor system with renewable power sources and WiFi connection from the testbed bridge.
- The Research Team presented the research outcome to the 16th International Symposium of Functionally Graded Materials, and a webinar to tran-SET.
- The Research Team drafted 2 journal manuscripts out of the results of the project.

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.

- Data collection from the testbed bridge using the developed sensor systems with renewable power and WiFi connection.
- Dissemination of the research outcome to international society and the general public.
- Draft journal papers on the development of the sensor system, selection of bridges, and bridge expansion joint monitoring.

Accomplishments:

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

- Products: 1 conference paper, 2 journal paper manuscripts (in preparation), and a webinar presentation accessible from YouTube
- Sensor development is completed.
- The collected data from the developed system indicated reasonable agreement with traditional sensors.
- Consideration of other bridges for medium and larger movement joints

Task, Milestone, and Budget Progress:

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: Title	**Start Date**	**End Date**	**% Complete**
Task 1 Inputs from NE DOTs	10/1/2021	12/31/2021	100%
Task 2 Preliminary Sensor Development	1/1/2022	4/30/2022	100%
Task 3 Field Tests, Data Collection and Analysis: Adjustment on Sensor System	5/1/2022	5/31/2023	50 %
Task 4 Numerical Final Element Modeling of the Bridge	9/1/2023	3/31/2023	0 %
Task 5 Data Analysis, Assessment, and Validation of Sensor System and Bridge FE Models	4/1/2023	7/15/2023	10 %
Final report preparation and submission	7/16/2023	9/30/2023	0 %
Overall project			50%

Table 2: Milestone Progress			
Milestone #: Description	**Corresponding Deliverable**	**Start Date**	**End Date**
Milestone 1: Finalizing the sensing system for field implementation and data collection	A report on the updated system and data collection	7/1/2022	9/30/2022
Milestone 2: QPR4 submission	Quarterly Progress Report 3		9/30/2022

Table 3: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date (include the date)**
To be provided separately by UConn PI/Lead	To be provided separately	To be provided separately

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.)*

Education and Workforce Development:

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

1. Did you provide any workforce development or training opportunities to transportation professionals (already in the field)? If so, what was the training? When was it offered? How many people attended? (i.e. The research team provided an in the field training for the SAR technology for 3 maintenance crew members of the MassDOT on 3/31/2021. The members learned how to use the technology and interrupt the data.)

The RT was invited to participate the joint tran-SET webinar series by Transportation Consortium of South-Central States (Tran-SET), UTC Region 6 – partnership of 11 institutions from 5 states (Arkansas, Louisiana, New Mexico, Oklahoma, and Texas), led by Louisiana State Uniersity. The PI gave a talk on "Wireless joint monitoring system for highway bridge resilience" as part of their webinar on the "Use of wireless technologies for transportation infrastructure management" on 9/23/2022 using Zoom (Please see announcement flyer in Appendix). There were about 15 – 20 participants (on and off) and the presentation was recorded and will be available in their YouTube channel.

2. Did you hold meetings with any transportation industry organizations or DOTs? If so, what was the meeting's purpose? When was it offered? How many people attended? (i.e. The research team held a meeting with MaineDOT to update them on the progress of the research findings and how the findings can be implemented on 3/31/2021. 15 DOT maintenance members were present at the meeting.)

Yes, the Research Team met with Bao Chuong, technical champion of the project from Connecticut DOT, to discuss the completion of the sensor system and data collection on 8/2/2022 at 11AM, using Microsoft Teams. 7 people attended.

3. Did you host/participant in any K-12 education outreach activities? If so, what was the activity? What was the target age/grade level of the participants? How many students/teachers attended? When was the activity held? (i.e. 25 8th graders and 2 teachers visited the concrete lab and created small concrete trinkets like Legos on 3/31/2021. They learned about the different types of fibers that can be used in the concrete.)

   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 4: Presentations at Conferences, Workshops, Seminars, and Other Events					
Type	**Title**	**Citation**	**Event & Intended Audience**	**Location**	**Date(s)**
Conference	Wireless joint monitoring system for New England's highway bridges	Jang, S., Fils, P., Ren, D., Wnag, J., Han, S., Malla, R.B. (2022). "Wireless joint monitoring system for New England's highway bridges." 16th International Symposium of Functionally Graded Materials.	16th International Symposium of Functionally Graded Materials & Researchers and Professionals	Hartford, CT	8/8/2022 – 8/10/2022
Webinar	Wireless joint monitoring system for highway bridge resilience	Jang, S. (2022). "Wireless joint monitoring system for highway bridge resilience," part of Joint Tran-SET Webinar Series, 9/23/2022	Joint Tran-SET Webinar Series & Transportation Professionals and Researchers	Online	9/23/2022

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 5: Submitted/Accepted Publications, Technical Reports, Theses, Dissertations, Papers, and Reports				
Type	**Title**	**Citation**	**Date**	**Status**
Conference Paper	Wireless joint monitoring system for New England's highway bridges	Jang, S., Fils, P., Ren, D., Wang, J., Han, S., Malla, R.B. (2022). "Wireless joint monitoring system for New England's highway bridges." 16th International Symposium of Functionally Graded Materials; Hartford, CT, August 8-10, 2022.	8/10/2022	In press

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?

   The developed joint monitoring system was deployed on 7/26/2022 on the selected bridge in Tolland, CT. A wireless displacement/temperature/humidity system with an LVDT were deployed as shown in Figures 1 – 3. The entire system was solar-powered and data was transferred to the cloud with Wifi connection successfully. The measured data are shown in Figures 4 – 6 below.

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?

   N/A

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. Did industry organizations or DOTs provide cost-share (cash or in-kind) to your research during the reporting period? Who was the organization? Please provide an in-kind support invoice from the organization with your report (this is kept confidential and used for record keeping purposes only).

   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. This is very important to our Technology Transfer initiatives.

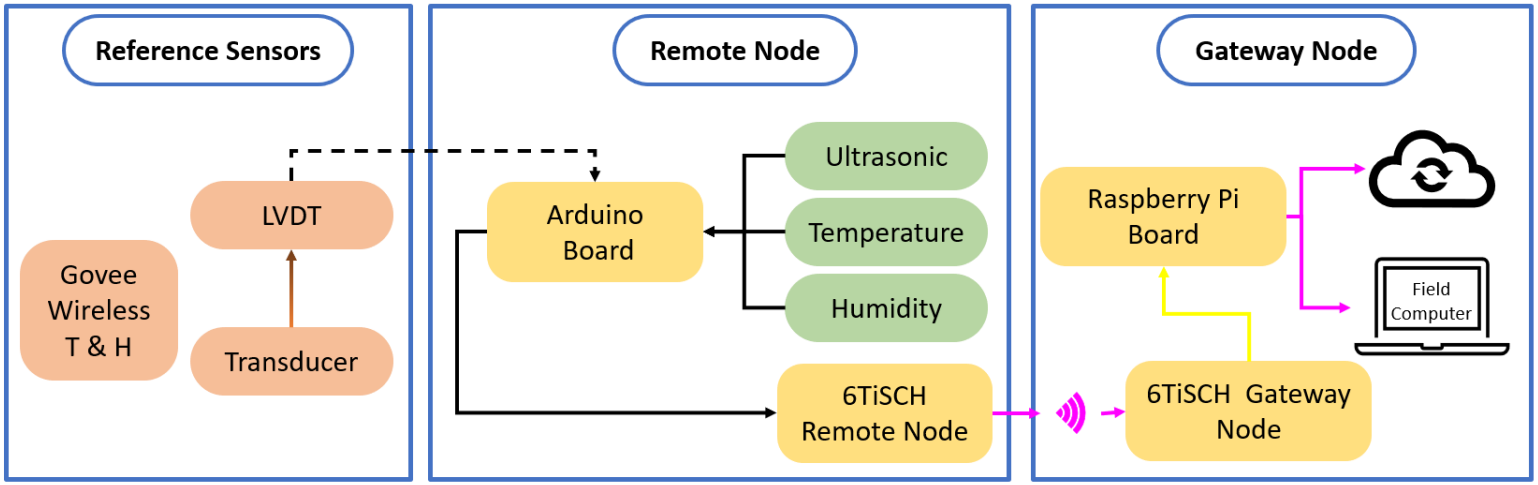

Figure 1. Sensor Deployment Schematics (7/26/2022 deployment)

Figure 2. Sensor locations on the testbed bridge (7/26/2022)

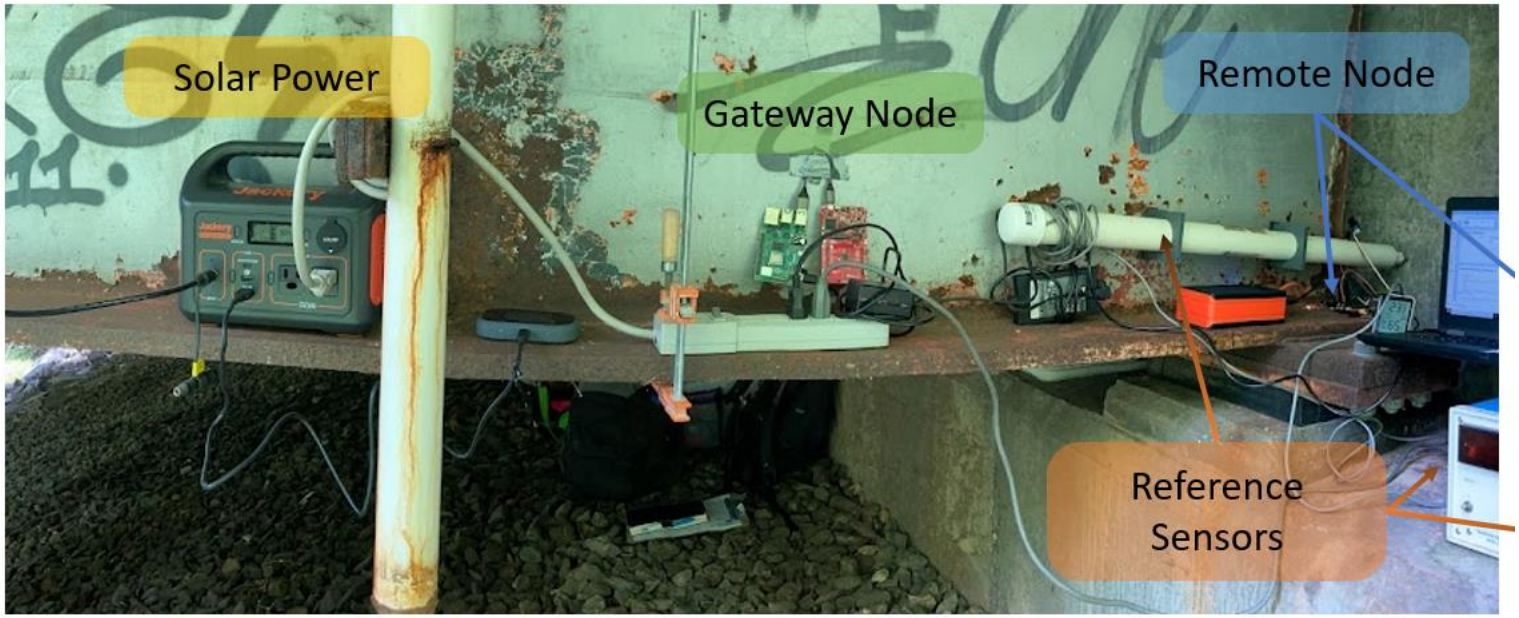

Figure 3. Deployment Photo including Call-out Explanation (7/26/2022)

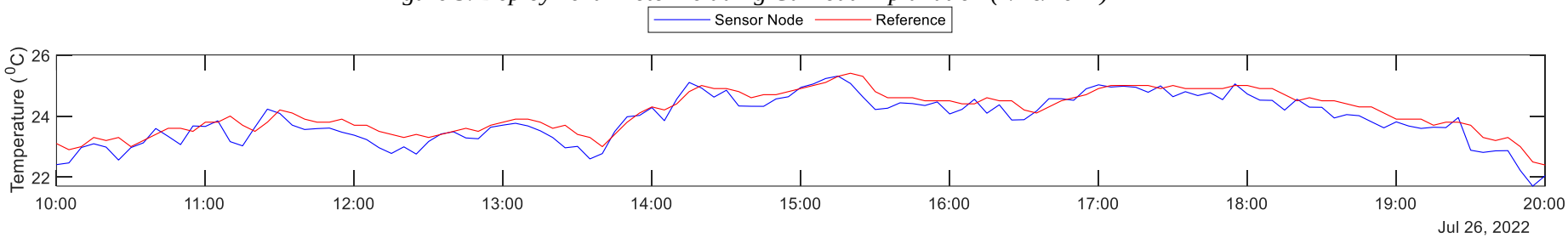

Figure 4. Temperature measurement from wireless sensor (blue) and commercial reference sensor (red)

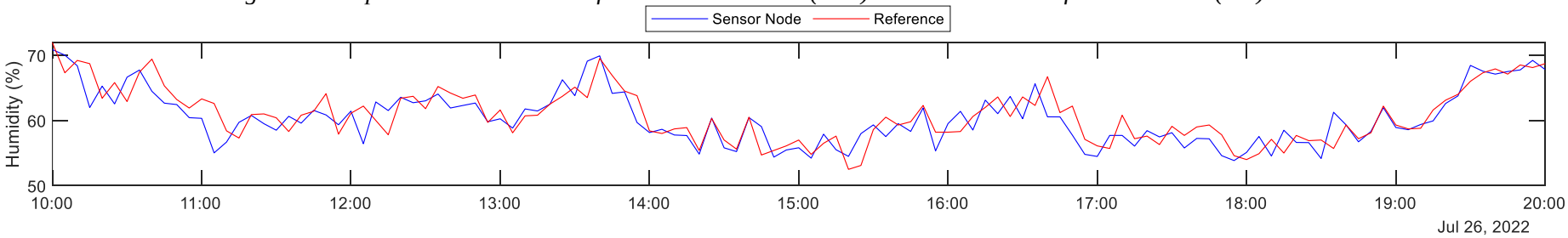

Figure 5. Humidity measurement from wireless sensor (blue) and commercial reference sensor (red)

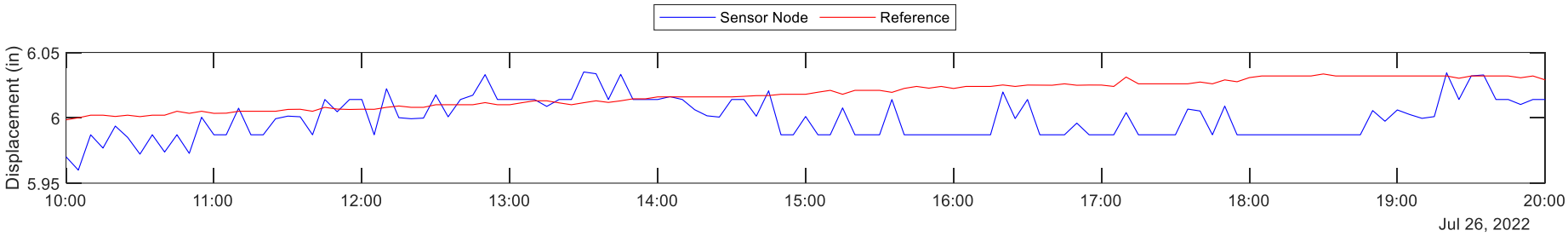

Figure 6. Displacement measurement from wireless ultrasonic sensor (blue) and LVDT (red)

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

N/A

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:

- Examples: New sensing technology was developed. This technology will… A UAV was created to hold new monitoring technology. This will allow maintenance crews to… A new college course was created based on the research findings. This will train future transportation professionals to…

A prototype of wireless displacement/temperature/humidity sensor system was developed with a renewable solar-based power station. This technology will enable long-term monitoring of the expansion joints of our bridges at affordable costs.

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… The UAV was successfully used by ___ Organization to inspect ___ Bridge in in town, state on 1/1/2021… The newly created college course was taken/completed by __ students in the 2021 fall semester.

The developed joint monitoring system was deployed on 7/26/2022 on the selected bridge in Tolland, CT. A wireless displacement/temperature/humidity system with an LVDT was deployed. The entire system was solar-powered and data was transferred to the cloud with WiFi connection successfully.

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 new UAV monitoring technology was adopted by __ organization to be used for __ bridges inspections. This will allow inspectors to… The college course has been adopted by another member university…

N/A

Participants and Collaborators:

Use the table below to list individuals (compensated or not) who have worked on the project other than students.

Table 6: Active Principal Investigators, faculty, administrators, and Management Team Members				
Individual Name & Title	**Dates involved**	**Email Address**	**Department**	**Role in Research**
Shinae Jang, Ph.D., P.E.; Associate professor in residence; Department of Civil & Environmental Engineering, University of Connecticut	7/1/2022 – 9/30/2022	Shinae.jang@conn.edu	Civil & Environmental Engineering	PI
Song Han, Ph.D.; Associate Professor; Department of Computer Science & Engineering, University of Connecticut	7/1/2022 – 9/30/2022	Song.han@uconn.edu	Computer Science and Engineering	Co-PI
Ramesh Malla, Ph.D., F. ASCE; F. EMI; Professor; Department of Civil & Environmental Engineering, University of Connecticut	7/1/2022 – 9/30/2022	Ramesh.malla@uconn.edu	Civil & Environmental Engineering	Co-PI

*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 7: Student Participants during the reporting period								
Student Name	**Start Date**	**End Date**	**Advisor**	**Email Address**	**Level**	**Major**	**Funding Source**	**Role in research**
Pierredens Fils	7/1/2022	9/30/2022	Shinae Jang		Ph.D.	Civil & Environmental Engineering	GAANN	Develop sensor prototype working with CS students, field deployment organization and performance tests
Daisy Ren	7/1/2022	9/30/2022	Shinae Jang		B.S.	Civil & Environmental Engineering	TIDC	Conducting the calibration tests for the ultrasonic displacement sensor, attending the field deployment, paper presentation
Jiachen Wang	7/1/2022	9/30/2022	Song Han		Ph.D.	Computer Science & Engineering	Unpaid student participant	Prototype sensor development, wireless communication Graphical User Interface (GUI) design, attending the field deployment,

								software debugging
Rinchen Sherpa	7/26/2022	7/26/2022	Shinae Jang		M.S.	Civil & Environmental Engineering	Unpaid student participant	Attending field deployment

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 during the reporting period (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 8: 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?**
			Please list the organization or degree

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

Table 9: Industrial Internships			
Student Name	**Internship Name/Organization**	**Dates of Internship**	**Did the student enter the transportation field or continue another degree at your university?**
Pierredens Fils	Michael Baker International	5/23/2022 – 8/19/2022 (Tentative end date)	He will continue his PhD degree study at the CEE Department, UConn after his summer internship.

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

Table 10: 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 during the reporting period. (**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 11: Other Collaborators

Collaborator Name and Title	Contact Information	Organization and Department	Date(s) Involved	Contribution to Research
	For internal use only			*(i.e. technical champion, technical advisory board, test samples, on-site equipment, data, etc.)*
Bao Chuong, P.E.; Transportation Supervising Engineer; Connecticut DOT – Bridge Design		Connecticut Department of Transportation, Newington, CT	7/1/2022 - 9/30/2022	Technical champion

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

Table 12: 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?
CE 3610	Basic Structural Analysis	undergraduate	University of Connecticut, Storrs, CT	Shinae Jang (PI)	Summer Session I, 2022	12
CE 2110-001	Applied Mechanics I: Statics	Undergraduate	University of Connecticut, Storrs, CT	Ramesh Malla (co-PI)	Fall 2022	98

CE 2110-020	Applied Mechanics I: Statics	Undergraduate	University of Connecticut, Storrs, CT	Shinae Jang (PI)	Fall 2022	235
CE 4900W-003D	Civil Engineering Project I	Undergraduate	University of Connecticut, Storrs, CT	Shinae Jang (PI)	Fall 2022	17

Changes:

List any actual or anticipated problems or delays and actions or plans to resolve them (list no-cost extension requests here)…

- Technical champion indicated that the expansion joint was not included in the current testbed. The RT re-investigated the fact and other bridges for testbed selection, and long-term deployment was delayed. The RT found that the current monitoring location shows elongation/shrinkage of highway bridge well and the correct location to monitor, and will continue monitoring this bridge.
- In addition, long-term deployment requires environmental hardening of the developed sensing system.

List any changes in approach and the reasons for the change…

- The project milestones are achieved, however, continuous data collection from the permanent deployment will be delayed until the next quarter.

Planned Activities:

List the activities planned during the next quarter.

- Environmental hardening of the developed sensing system
- Longer-term data collection from the field bridge
- Journal manuscript drafting and submission
- Quarterly progress report

Appendix. Flyer of the Webinar to Tran-SET

JOINT TRAN-SET WEBINAR SERIES

Tran-SET

Use of Wireless Technologies for Transportation Infrastructure Management

- Friday September 23th, 2022 | 2:00 – 3:30 PM (CDT)
- **Free registration at:** https://bit.ly/3UgNpsF
- Information at: https://transet.lsu.edu/webinars/

Assessing the Impacts of Wireless Dynamic Charging Infrastructure: Electric Vehicle Adoption and Revenue Generation

Dynamic wireless power transfer (DWPT) has recently gained traction where electric vehicles (EVs) can be charged while moving on the pavement—using either magnetic resonance or induction methodology. Using data specific to the state of Kansas, this project will discuss: (a) the effectiveness of DWPT-based charging as a function of the transportation network features and traffic flow patterns, (b) the potential pricing strategies for DWPT technologies, and (c) the challenges associated with DWPT deployment and adoption by the EV owners.

Dr. Husain Aziz
Kansas State University

Dr. Shinae Jang
University of Connecticut

Wireless joint monitoring system for highway bridge resilience

This presentation will discuss the development of a wireless monitoring system for bridges' expansion joints and the deployment of the sensors on a state highway bridge under changes in temperature, humidity, and other live loads. This presentation will update the status of the project on the hardware and software development and data collection from an expansion joint from an in-service bridge in Coventry, CT. The eventual vision of the project is to increase the service life of the bridges through timely maintenance by real-time continuous monitoring.

Development and application of instrumented bike in cycling facility management

This presentation is to introduce an instrumented bike to the cycling community and agencies with a goal to provide "smart wheels" for day-to-day cycling operations, improve bike efficiency, safety, and mobility, promote cycling activities, and reduce emissions. It is paired with a mobile app to detect real-time quality of cycling infrastructure systems and share the results with cyclists (road users) and governments/authorities (road managers).

Dr. Chun-Hsing Ho
University of Nebraska-Lincoln

KS UCONN UNIVERSITY OF CONNECTICUT University of Nebraska Lincoln