

**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:** 4/1/2022 – 6/30/2022

**Submission Date:** 6/30/2022

**\*\*\*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) conducted preliminary installation of the sensing system on the selected field bridge.
- The RT finalized the sensing system (hardware) for field implementation and data collection using solar-based power stations and power banks.
- The RT worked on debugging the software for the wireless communications.

**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 preliminary installation on the field bridge is the critical step of the project.
- The sensing system (hardware) using a renewable power source is critical for long-term deployment.
- Software optimization for the wireless communication is critical for wireless cloud computing.

**Accomplishments:**

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

- Products: a conference paper drafted from the previous QPR was presented and paper in press
- Sensor board connection in the Wireless monitoring system was completed.
- A preliminary installation of the joint monitoring sensing system on a selected bridge was accomplished
- Field monitoring data using the preliminary sensor system were collected, and a report on field installation and data collection was prepared.
- RT met in bi-weekly basis.

**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)...

<b>Table 1: Task Progress</b>			
<b>Task Number: Title</b>	<b>Start Date</b>	<b>End Date</b>	<b>% Complete</b>
Task 1 Inputs from NE DOTs	10/1/2021	12/31/2021	100%
Task 2 Preliminary Sensor Development	1/1/2022	4/30/2022	75%
Task 3 Field Tests, Data Collection and Analysis: Adjustment on Sensor System	5/1/2022	5/31/2023	20 %
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			30%

<b>Table 2: Milestone Progress</b>			
<b>Milestone #: Description</b>	<b>Corresponding Deliverable</b>	<b>Start Date</b>	<b>End Date</b>
Milestone 1: Preliminary installation of the sensing system on the field bridge	- Preliminary monitoring system - A report on the preliminary testing	4/1/2022	5/31/2022
Milestone 2: Finalizing the sensing system (hardware) for field implementation	Updated sensing system	4/1/2022	6/30/2022
Milestone 3: QPR3 submission	Quarterly Progress Report 3		6/30/2022

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

N/A

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.)

- Continuous communication with the Technical Champion at Conn DOT was maintained.

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 8<sup>th</sup> 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)
N/A					

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	Technical survey and literature review on bridge joint monitoring practices	Ren, D., Fils, P. Jang, S., Malla, R. M. (2022). "Technical survey and literature review on bridge joint monitoring practices." <i>American Society of Engineering Education Northeast Conference 2022</i>	4/23/2022	The paper was presented at the ASEE-NE 2022 conference at WIT in Boston, MA. The proceeding is still 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?

*A preliminary joint monitoring system was developed and was deployed on 4/25 and 6/14 on the selected bridge in Tolland, CT and retrieved. For 4/25 deployment, a wireless displacement/temperature/humidity system with an LVDT, and accelerometers were deployed; for 6/14 deployment, a wireless displacement/temperature/humidity system with an LVDT was deployed. Please see Fig. 1 through Fig. 7 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 it 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. Testbed Bridge in Coventry, CT



Figure 2. Expansion Joints (a) side view, (b) through view, (c) road way view (showing this is an asphaltic joint)



*Figure 3. Wireless Expansion Joint Monitoring Sensor Deployment on 4/25 (a) Daisy (undergraduate researcher) holding the Arduino, (b) Prof. Jang (PI) adjusting LVDT's level, (c) Pierre (graduate researcher) checking incoming data from the sensors, (d) installed sensing system.*



*Figure 4. Wired Acceleration Data Acquisition System with a reference temperature/humidity sensor (a) system, (b) Pierre (graduate researcher) checking the data.*



Figure 5. Other graduate researchers who participated in the deployment (a) Rinchen and Celso, (b) Celso and Santosh, (c) accelerometer attached with a magnet base with Rinchen in the background.

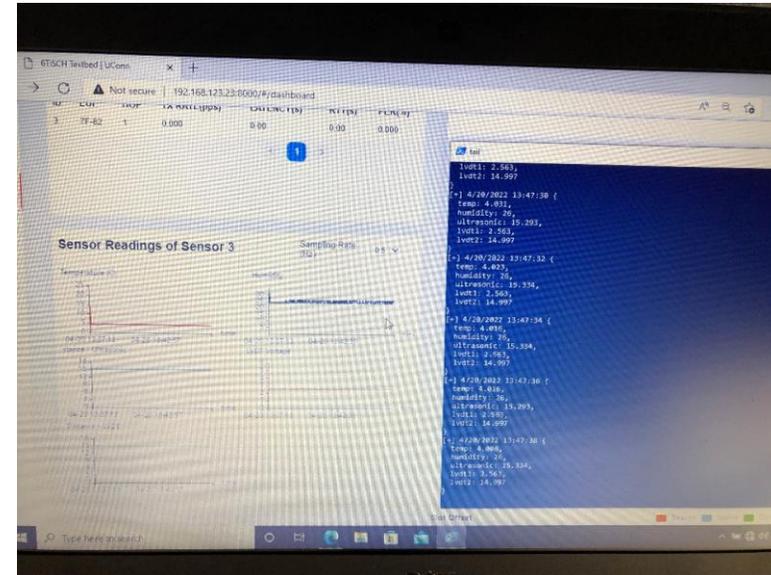
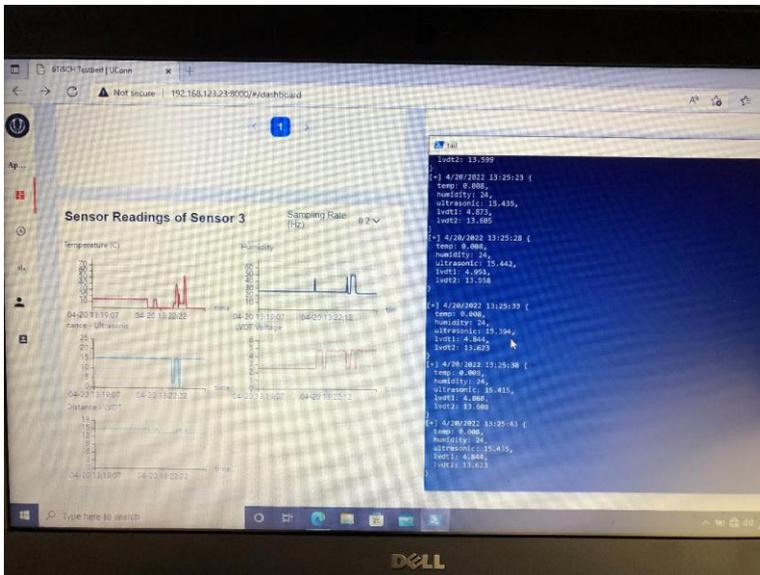


Figure 6. Wirelessly transmitted data at the gateway laptop. (a) data showing erroneous fluctuations due to secure power issues (Raspberry Pi supplied from one of the USB ports of the laptop), (b) data fixed (constant) after supplying power from a high-capacity power bank. Power and software debugging are still underway.



Figure 7. The second deployment on 6/14 using a Jackery power station with a solar panel – which supplied sufficient power to the system.

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

*A preliminary joint monitoring system developed in this project was deployed on 4/25 and 6/14 on a selected bridge in Tolland, CT and retrieved. For 4/25 deployment, a wireless displacement/temperature/humidity system with an LVDT, and accelerometers were deployed; for 6/14 deployment, a wireless displacement/temperature/humidity system with an LVDT was deployed. Please see Fig. 1 through Fig. 7 above.*

### **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.

<b>Table 6: Active Principal Investigators, faculty, administrators, and Management Team Members</b>				
<b>Individual Name &amp; Title</b>	<b>Dates involved</b>	<b>Email Address</b>	<b>Department</b>	<b>Role in Research</b>
Shinae Jang, Ph.D., P.E.; Associate professor in residence; Department of Civil & Environmental Engineering, University of Connecticut	4/1/2022 – 6/30/2022	Shinae.jang@conn.edu	Civil & Environmental Engineering	PI
Song Han, Ph.D.; Associate Professor; Department of Computer Science & Engineering, University of Connecticut	4/1/2022 – 6/30/2022	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	4/1/2022 – 6/30/2022	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
				<i>Email is not included in the external report and is only used for internal purposes.</i>	<i>(i.e. UG, MS, PhD)</i>			<i>What work are they conducting? Please be descriptive. Student research assistant is not enough info.</i>
Pierredens Fils	4/1/2022	6/30/2022	Shinae Jang		Ph.D.	Civil & Environmental Engineering	GAANN	Develop sensor prototype working with CS students, field deployment organization and performance tests
Daisy Ren	4/1/2022	6/30/2022	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	4/1/2022	6/30/2022	Song Han		Ph.D.	Computer Science & Engineering	Unpaid	Prototype sensor development, wireless communication Graphical User Interface (GUI) design, attending the field deployment, software debugging
Rinchen Sherpa	4/25/2022	4/25/2022	Shinae Jang		M.S.	Civil & Environmental Engineering	Unpaid	Attending field deployment

Celso Cruz De Oliveira	4/20/2022	4/25/2022	Ramesh Malla		Ph.D.	Civil & Environmental Engineering	Unpaid	Controlling gasoline power generator for field deployment, attending field deployment
Dhakai, Santosh	4/25/2022	4/25/2022	Ramesh Malla		Ph.D.	Civil & Environmental Engineering	Unpaid	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
		<i>List the amount</i>	<i>List the amount</i>	<i>Mark with an "x" where appropriate</i>		
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
	<i>For internal use only</i>			<i>(i.e. technical champion, technical advisory board, test samples, on-site equipment, data, etc.)</i>
Bao Chuong, P.E.; Transportation Supervising Engineer; Connecticut DOT – Bridge Design		Connecticut Department of Transportation, Newington, CT	4/1/2022 - 6/30/2022	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 2110	Applied Mechanics I: Statics	Undergraduate	University of Connecticut, Storrs, CT	Shinae Jang (PI)	Spring 2022	102
CE 3610	Basic Structural Analysis	undergraduate	University of Connecticut, Storrs, CT	Shinae Jang (PI)	Summer Session I, 2022	12
CE 4920W	Civil Engineering Project II	undergraduate	University of Connecticut, Storrs, CT	Shinae Jang (PI)	Spring 2022	18
CE 5122	Advanced Mechanics of Materials	graduate	University of Connecticut, Storrs, CT	Ramesh B. Malla (co-PI)	Spring 2022	9

**Changes:**

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

- Wireless communication software needs to be debugged, and the system must be environmentally hardened with security. Therefore, a delay in the full-scale permanent deployment is anticipated until the system is fully developed.

*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
- Finalizing the software for wireless communications
- Longer-term data collection from the field bridge
- 4<sup>th</sup> Quarterly progress report for this grant year submission (Due: September 30<sup>th</sup>. 2022)