**Quarterly Progress and Performance Indicators Report:**
**Project Number and Title: 1.15 Non-contact intelligent inspection of infrastructure**
**Research Area: #1 Transportation infrastructure monitoring and assessment for enhanced life**
**PI: Jiong Tang, Department of Mechanical Engineering, University of Connecticut**
**Co-PI(s): N/A**
**Reporting Period: 10/1/2021 – 12/31/2021**
**Submission Date: 12/31/2021**

*****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:**
*In this phase of research, we conduct literature review of non-contact sensing with the focus being on magnetic devices. We further develop the preliminary mathematical model of the magneto-mechanical sensor. The major highlights are*

- development of preliminary model of magneto-mechanical sensor;
- development of numerical demonstration of sensor performance improvement through resonant behaviors.

**Meeting the Overarching Goals of the Project:**
*The research highlights mentioned above benefit the project goals and objectives because*

- the mathematical model is the foundation toward the design and synthesis of the proposed new non-contact sensor;
- the resonant behavior has the potential of dramatically improve the non-contact sensing performance.

**Accomplishments:**
*The accomplishments achieved under the project goals are*

- numerical model of the proposed magneto-mechanical sensing mechanism;
- resonance sensing simulation demonstration.

**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: Magneto-mechanical sensor modeling | 10/1/2021 | 3/31/2022 | 50% |
| Task 2: Sensor design optimization and tuning | 4/1/2022 | 9/30/2022 | 0% |
| Task 3: Deep learning neural network establishment | 10/1/2022 | 3/31/2023 | 0% |
| Task 4: Network training for decision making | 4/1/2023 | 9/30/2023 | 0% |
| Phase 1 Overall | 10/1/2018 | 6/30/2022 | 85% |

| Phase 2 Overall | 10/1/2021 | 9/30/2023 | 15% |
| Phase 3 Overall | N/A | N/A | N/a |

| Table 2: Milestone Progress | | | |
|---|---|---|---|
| **Milestone #: Description** | **Corresponding Deliverable** | **Start Date** | **End Date** |
| Milestone 1: Magneto-mechanical sensor modeling | Sensor model | 10/1/2021 | 3/31/2022 |
| Milestone 2: Sensor design optimization and tuning | Sensor tuning criteria | 4/1/2022 | 9/30/2022 |
| Milestone 3: Deep learning neural network establishment | Neural network training | 10/1/2022 | 3/31/2023 |
| Milestone 4: Network training for decision making | Decision making | 4/1/2023 | 9/30/2023 |

| Table 3: Budget Progress | | |
|---|---|---|
| **Project Budget** | **Spend – Project to Date** | **% Project to Date (include the date)** |
| Phase 1: $277,400 | Enter Phase 1 Full Spend Amount (Federal + Cost Share) | Enter Phase 1 % Spent |
| Phase 2: $156,846.10 | Enter Phase 2 Full Spend Amount (Federal + Cost Share) | Enter Phase 2 % Spent |
| Phase 3: N/a | 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.*)

**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.)
N/A

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)** |
| i.e. Conference, Symposium, DOT/AOT presentation, Seminar, etc. | 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** |
| i.e. Peer-reviewed journal, conference paper, book, policy paper, magazine/newspaper article | N/A | N/A | | N/a |
| | | | | |

*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?
   N/A
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.*

**Insert figures here**

*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:*
- A new mathematical model of magneto-mechanical sensing has been developed.

**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:*
- The newly developed mathematical model can enable to development of tunable resonant magnet-mechanical sensor.

**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:*

- The new magneto-mechanical impedance sensor can lead to paradigm shift in non-contact sensing and inspection of infrastructure.

**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** |
| Jiong Tang, Professor | 10/1/21-present | jiong.tang@uconn.edu | Mechanical Engineering | 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** |
| | | | | Email is not included in the external report and is only used for internal purposes. | (i.e. UG, MS, PhD) | | (i.e. TIDC, Other university funds, , unpaid intern, etc. | What work are they conducting? Please be descriptive. Student research assistant is not enough info. |
| Yang Zhang | 10/1/21 | present | Jiong Tang | | PhD | Mechanical Engineering | TIDC, NASA | Carry out sensor design and inverse analysis |
| Ting Wang | 10/1/21 | present | Jiong Tang | | PhD | Mechanical Engineering | TIDC, NSF | Carry out energy |

| | | | | | | | harvesting and sensor networking analysis |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

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? |
| N/A | | | 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 | Degree/Certificate Earned | Graduation/Certification Date | Did the student enter the transportation field or continue another degree at your university? |
| N/A | | | Please list the organization or degree |
| | | | |

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 | | |
| CT DOT | Newington, CT | | | | X | |
| | | | | | | |

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** |
| Andrew Mroczkowski, Transportation Engineer 3 | Andrew.Mroczkowski@ct.gov | CT DOT | 10/1/2021 - present | 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** |
| ME5420 | Mechanical Vibrations | Grad | University of Connecticut | Jiong Tang | Fall 2021 | 26 |
| | | | | | | |

**Changes:**

List any actual or anticipated problems or delays and actions or plans to resolve them (list no-cost extension requests here)...
N/A
List any changes in approach and the reasons for the change...
N/A

**Planned Activities:**

List the activities planned during the next quarter.
- The next phase of research will focus on the resonant sensor mechanism investigation and preliminary experimental investigation.