Quarterly Progress and Performance Indicators Report:

Project Number and Title: Project 1.2: Condition/Health Monitoring of Railroad Bridges for Structural Safety, Integrity, and Durability
Research Area: Thrust 1 -Transportation Infrastructure Monitoring & Assessment for Enhanced Life
PI: Ramesh B. Malla, Ph.D., F. ASCE, F. EMI, Professor, Department of Civil & Environmental Engineering, University of Connecticut, and
Institutional Lead for US DOT Region 1 UTC-TIDC Program
Co-PI(s): N/A
Reporting Period: July 01, 2022, to September 30, 2022
Submission Date: October 07, 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 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** ….*

Research work performed over this reporting period include the following:

- The research team has updated the global Finite Element (FE) Model from Devon and Cos Cob bridges by comparing with the field test data collected during the research period (Figures 1 and 2).
- The Final report is being written in compliance with TIDC requirements, aiming to be informative and beneficial to DOTs, railroad industry, and future researchers.
- The research team held a meeting with the Technical Champions of the project and/or other representatives from CT DOT; Metro-North Railroad; Polytec Inc.; Amtrak, NH DOT; and Genesee & Wyoming on June 27th, August 12th, August 25th, and September 28, 2022.

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.

- Understanding the behavior of truss railroad bridges using a FE model, under the operation loading of different trains, such as, Acela Express, Amtrak Regional and Metro-North M8.
- Developing a procedure to better represent the dynamic behavior of old railroad bridges, using a computer models and field test data.
- Better understanding of the material behavior and mechanical properties of the ASTM A7 steel, usually used on old bridges such as Devon and Cos Cob bridge.

Accomplishments:

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

- Better understanding of the bridge's behavior using a computer simulation models under different operation scenarios.

- Dissemination of research results via conference papers.
- The team continue to maintain strong collaboration with State DoTs (CT DOT, ME DOT, and NH DOT), railroad management company (Metro North), device manufacturer (Polytec, Inc.) as well as other rail industries and operators, including Amtrak and Genesee & Wyoming, Inc..
- Preparation of the Quarterly report and good progress in preparing the project final report.

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: Literature search and review; communication with New England state DOTs for railroad bridge material collection and information/data	October 1, 2018	December 31, 2021	100%
Task 2: Existing railroad bridge material testing	January 1, 2019	August 31, 2022	100%
Task 3: Finite Element (FEM) modeling of railroad bridge	June 1, 2019	September 30, 2022	100%
Task 4: Determine number/types and locations of sensor for effective bridge condition monitoring	December 1, 2019	September 30, 2022	100%
Task 5: Determine from the analytical and FEM analysis effects of vehicle speed/type on bridge response	June 1, 2020	September 30, 2022	100%
Task 6: Prepare procedure to field test and data collection by applying a limited number of sensors to bridge, collect field data, update FEM, and verify that sensors give sufficient info to determine condition of bridge	October 1, 2020	September 30, 2022	100%
Final Report preparation and submission	June 1, 2022	Sept. 30, 2022 (Project end)/Oct. 30, 2022 (Final report due)	100%
Overall Project:	October 01, 2018	Sept. 30, 2022 (Project end) /Oct 30, 2022 (Final report)	100%

Table 2: Milestone Progress

Milestone #: Description	Corresponding Deliverable	Start Date	End Date
Milestones closely represent task items listed above	Quarterly and final reports	Milestones start dates follow closely task dates (See Table 1 above)	Milestones end dates follow closely task dates (See Table 1 above)

Table 3: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date (include the date)**
Enter Phase 1 Full Budget	*Enter Phase 1 Full Spend Amount (Federal + Cost Share)*	*Enter Phase 1 % Spent*
Will be provided separately	Will be provided separately	Will 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 interpret 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.)

    The research team held the quarterly meeting (virtual) on September 28, 2022, with the project Technical Champions and other representatives, . Total of 8 individuals attend the meeting, besides the research team members. Attendees included one from CT DOT, three from Metro-North Railroad Co., three from Amtrak, and one from Genesee & Wyoming Inc..The meeting served to provide the project update and receive feedback.
    - Research team met virtual on August 25, 2022, with the New Hemisphere Department of Transportation rail engineering division, to discuss collaborations and typical bridge issues found in the state.
    - A virtual meeting was held on August 12, 2022, with the Polytec Inc. application engineer, data processing metrology feedback.
    - Thee research team also held a meeting (virtual) on June 27, 2022, with 3 members of the Amtrak's Structures Maintenance & Inspection department, provide Amtrak's equipment details and bridge analysis methodology (This item was missed to report in last quarterly report.)

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.	*Presentation Title*	*Full Citation*	*Name of event (i.e. TIDC 1st Annual Conference) or who was the presentation given to?*		
Poster	Field Testing and Finite Element Analysis of Two Old Truss Railroad Bridges	de Oliveira, C., Dhakal, S., Raha, M., and Malla, R. B., "Field Testing and Finite Element Analysis of Two Old Truss Railroad Bridges," 2022 TIDC Annual Conference, poster sessions, Orono, ME, August 9-12, 2022	4th Annual Transportation Infrastructure Durability Conference (TIDC)	Orono, ME	August 9-12, 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
i.e. Peer-reviewed journal, conference paper, book, policy paper,	*Publication title*	*Full citation*		*i.e. Submitted, accepted, under review (by org. submitted to)*

magazine/newspaper article				
Conference Paper	Displacements and Loading Frequencies of an Old Truss Railroad Bridge Under Service Trains Using a Laser Doppler Vibrometer	de Oliveira, C., Dhakal, S., and Malla, R. B., "Displacements and Loading Frequencies of an Old Truss Railroad Bridge Under Service Trains Using a Laser Doppler Vibrometer", Transportation Research Board (TRB) 2023 Annual Meeting, Washington, D.C., January 08-12, 2023	08/01/2022 (Date submitted)	Under review

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

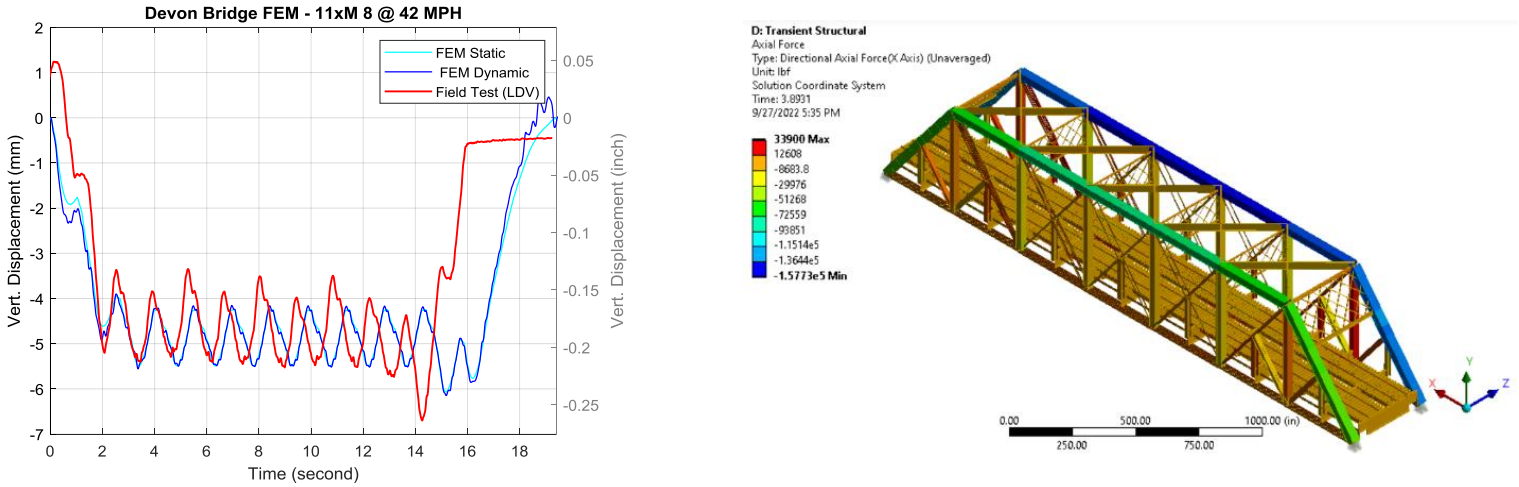

Figure 1 – Devon Bridge, CT, L13 node vertical displacement (left) and vertical velocity (right) of FE model and field test data from LDV

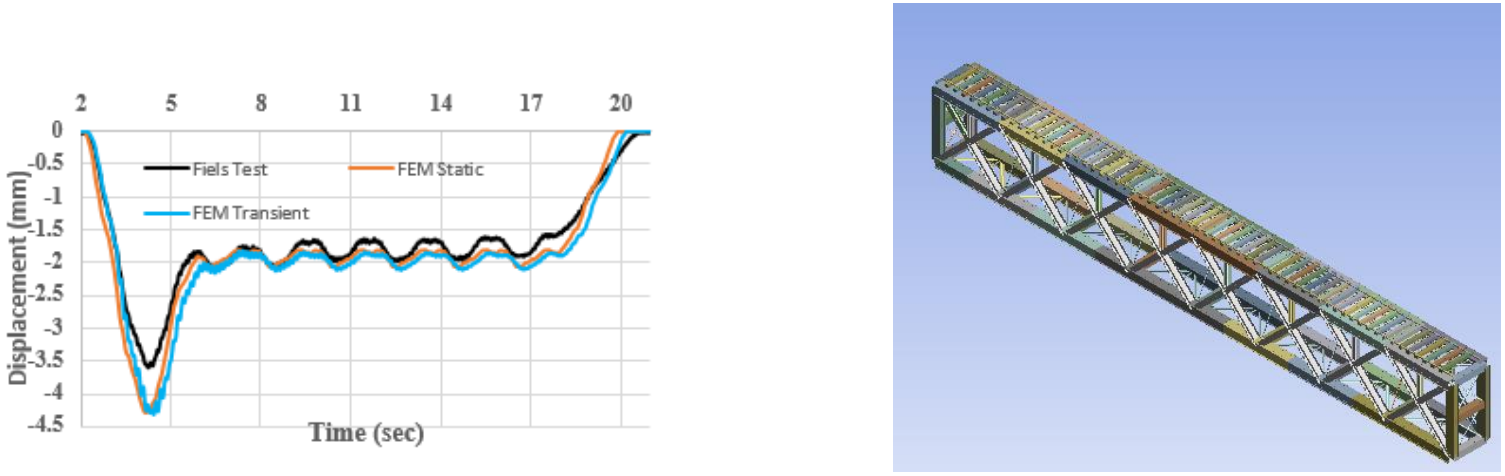

Figure 2 – Cos Cob bridge, Node U2 vertical displacement vs time diagram for Amtrak Regional moving at 28 mph from New York to New Haven with 8 cars

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:

- N/A

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:

- 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:

- 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**
Dr. Ramesh B. Malla, Professor (Principal Investigator)	Jul.-Sep. 2022	Ramesh.Malla@UCONN.EDU	Civil & Environmental Engineering, University of Connecticut, Storrs, CT	Principal Investigator (PI)/ TIDC Institutional Lead, UConn

*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.*
Celso de Oliveira	Jul. 01, 2022	Sep. 30, 2022	Dr. Ramesh Malla	Celso_Cruz.de_Oliveira@UCONN.EDU	Ph.D.	Structural Engineering/Civil Engineering.	TIDC, UConn	Field test data analysis, finite element modeling (FEM) ,and final report writing
Santosh Dhakal	Jul. 01, 2022	Sep. 30, 2022	Dr. Ramesh Malla	Santosh.Dhakal@UCONN.EDU	M.S.	Structural Engineering Civil Engineering.	TIDC, UConn	Field and lab test data analysis, finite element modeling (FEM) ,and final, report writing
Sachin Tripathi	Aug. 23, 2022	Sep. 30, 2022	Dr. Ramesh Malla	Sachin.Tripathi@ UCONN.EDU	Ph.D.	Structural Engineering Civil Engineering.	TIDC, UConn	Finite element analysis, vehicle load determination and assisting in final project report
Max Raha	Jul. 01, 2022	Aug. 19, 2022	Dr. Ramesh Malla	Max.Raha@ UCONN.EDU	B.S.	Civil Eng.	TIDC, UConn	Compiling references and other information and assisting final report preparation

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
N/A	*N/A*	*N/A*	*N/A*

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?**
			Please list the organization or degree
N/A	*N/A*	*N/A*	*N/A*

*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*		
Connecticut Department of Transportation (CT DOT) Contact persons: (1) Haresh Dholakia, P.E., Transportation Engineering Supervisor, Rail Design *(Technical Champion)* (2) Manesh Dodia, P.E., Supervising Rail Officer, Rail Construction (*Technical Champion)*	Newington, CT				X	
Metro-North Railroad Co. Contact persons: (1) Warren Best, P.E., Deputy Director- Structures *(Technical Champion)*	Bridgeport, CT				X	

(2) Hong McConnell, P.E.,Senior Structural Engineer						
Polytec, Inc., Contact Person: Mr. Mario Pineda, Territory Manager	Hudson, MA				X	
Amtrak Contact Person: Paul DelSignore, P.E., Deputy Chief Engineer – Structures	Philadelphia, PA				X	
Genesee & Wyoming Inc. Contact Person: Chad R. Boutet, P.E., Assistant Vice President - Engineering	Indianapolis, IN				X	
New Hampshire Department of Transportation (NHDOT) Contact Person: Chuck Corliss, P.E., Railroad Operations Engineer, Bureau of Rail and Transit, New Hampshire Department of Transportation	Concord, NH				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
	For internal use only			*(i.e. technical champion, technical advisory board, test samples, on-site equipment, data, etc.)*
Haresh Dholakia, P.E., Transportation Engineering Supervisor, Rail Design	HareshKumar.Dholakia@CT.GOV	Connecticut Department of Transportation (Conn DOT), Newington, CT	Jul.- Sep. 2022	Technical Champion

Manesh Dodia, P.E., Supervising Rail Officer, Rail Construction	Manesh.Dodia@CT.GOV	Connecticut Department of Transportation (Conn DOT), Newington, CT	Jul.- Sep. 2022	Technical Champion
Warren Best, P.E., Deputy Director- Structures	Best@MNR.ORG	Metro-North Railroad Company, Bridgeport, CT	Jul.- Sep. 2022	Technical Champion
McConnell Hong Sr. Structural Engineer	HMcConnell@MNR.ORG	Metro-North Railroad Company, Bridgeport, CT	Jul.- Sep. 2022	Senior Engineer/Logistic contact
Mario Pineda, Territory Manager	M.Pineda@POLYTEC.COM	Polytec Inc., Hudson, MA	Jul.- Sep. 2022	Technical /Logistics Contact person
Paul DelSignore, P.E., Deputy Chief Engineer – Structures	DelSigp@AMTRAK.COM	Amtrak, Philadelphia, PA	Jul.-Sep. 2022	Advice and logistic contact, information sharing
Chad R. Boutet, P.E., Assistant Vice President - Engineering	Chad.Boutet@GWRR.COM	Genesee & Wyoming Inc., Indianapolis, IN	Jul.-Sep. 2022	Advice and logistic contact, information sharing
Chuck Corliss, P.E., Railroad Operations Engineer	Charles.A.Corliss@DOT.NH.GOV	New Hampshire Department of transportation, Concord, NH	Aug-Sep, 2022	Advice and logistic contact, information sharing
McConnell Hong, P.E. Sr. Structural Engineer	HMcConnell@MNR.ORG	Metro-North Railroad Company, Bridgeport, CT	Jul.-Sep. 2022	Senior Engineer/Logistic contact
Rene Asuncion, Jr., P.E., Senior Principal Engineer - Structures Maintenance & Inspection	AsunciR@amtrak.com>	Amtrak, Philadelphia, PA	July- Sept. 2022	Advice and logistic contact, information sharing
David Inman, Senior Engineer, Structures-Movable Bridges	David.Inman@amtrak.com>	Amtrak, Philadelphia, PA	July- Sept. 2022	Advice and logistic contact, information sharing

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 2110-020	Applied Mechanics I	Undergrad	UConn	Dr. Ramesh B. Malla	Fall 2022	98
CE 5010-001	Seminar in Structures and Applied Mechanics	Grad	UConn	Dr. Ramesh B. Malla	Fall 2022	18
CE 3110-002	Mechanics of Materials	Undergrad	UConn	Sachin Tripathi (Teaching Assistant)	Fall 2022	118
CE 3520-001	Civil Engineering Material Laboratory	Undergrad	Storrs, CT	Santosh Dhakal (Teaching Assistant)	Fall 2022	29

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.

Research activities planned for next quarter include the following:

- Finalize and submit the Final Report.
- Disseminate the findings via journal paper and conferences.