A Summary of the 1st Quarterly Report

for the Technical Activities Council

Bridge Condition Assessment Using Remote Sensors

Michigan Technological University

USDOT Cooperative Agreement No. DTOS59-10-H-00001

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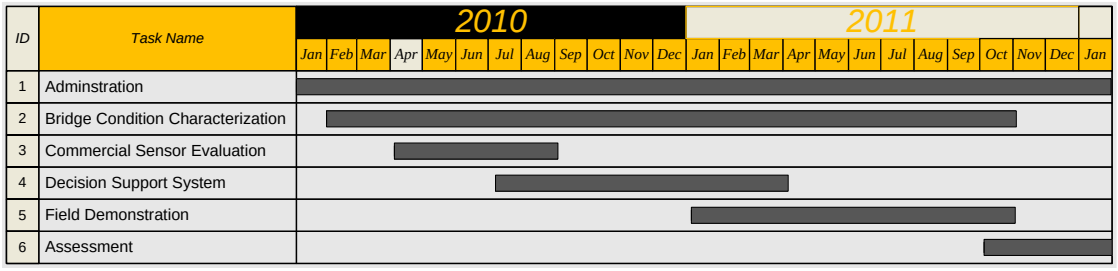
EXECUTIVE SUMMARY

This quarterly report documents progress for *"Bridge Condition Assessment Using Remote Sensors"* during the first quarter for the period of January 4, 2010 – March 31, 2010. Our Michigan Tech research team is investigating the use of remote sensing technologies to assess the structural health of bridges and provide additional inputs to bridge asset management systems. The project will explore correlations between commonly used inspection techniques and remote sensor systems, and develop a decision support system to combine various inputs to create a unique bridge signature that can be tracked over time.

The primary goals of this project are to:

1. Establish remotely sensed bridge health indicators.
2. Develop a baseline bridge performance metric, the "signature," for benchmarking overall bridge condition.
3. Provide a system that enhances the ability of state and local bridge engineers to prioritize critical repair and maintenance needs for the nation's bridges.

This project will be accomplished over six tasks. With an official project start date of January 4, 2010, the original project schedule is updated below to reflect the new start date.



Accomplishments for this quarter are discussed below and include finalizing a subcontract document, establishment of a Technical Advisory Council and progress on Tasks 1, 2, 3, and 5. Also, according to the Revised Cost Proposal submitted June 26, 2009, and included as Attachment 2 of that cost proposal, the following deliverables were cited for Quarter 1. All technical memos are located at the end of this document and are discussed in the relevant tasks below.

- ✓ Technical Memorandum No. 1 which outlines the creation and duties of the Technical Advisory Council (Task 1.1).
- ✓ Technical Memorandum No. 2 which identifies outcomes of the first TAC meeting and review of the proposed work plan (Task 1.2).
- ✓ Technical Memorandum No. 3 documenting progress toward the State of the Practice Synthesis (Task 2.1).

TECHNICAL STATUS

Progress of each of the six tasks is documented below and references Technical Memos and Appendices which are located at the end of this document.

Task 1: Administration

Several sub-tasks within the administration task have been initiated and completed.

A primary activity has been coordination of the teams and establishment of a Technical Advisory Council. **Technical Memorandum No. 1** documents the progress towards creating a TAC, and includes a list of invited council members. The membership was developed to include input from several stakeholders such as state and federal DOT representation, a bridge inspector, AASHTO regional representation, and representatives from academia, local agencies and the rail industry, as well as materials and sensor experts.

Technical Memorandum No. 2 was cited as a deliverable for Quarter 1 to describe the outcomes of the first TAC meeting and comments from review of the proposed work plan. As of the quarter's end, we were still accepting TAC membership and anticipate our first TAC meeting to be held May 19-20, 2010 in Ann Arbor, MI. We recognize that this sub-task is slightly behind schedule; however, we will revise this memo for the Quarter 2 Report to document the outcomes of the first TAC meeting.

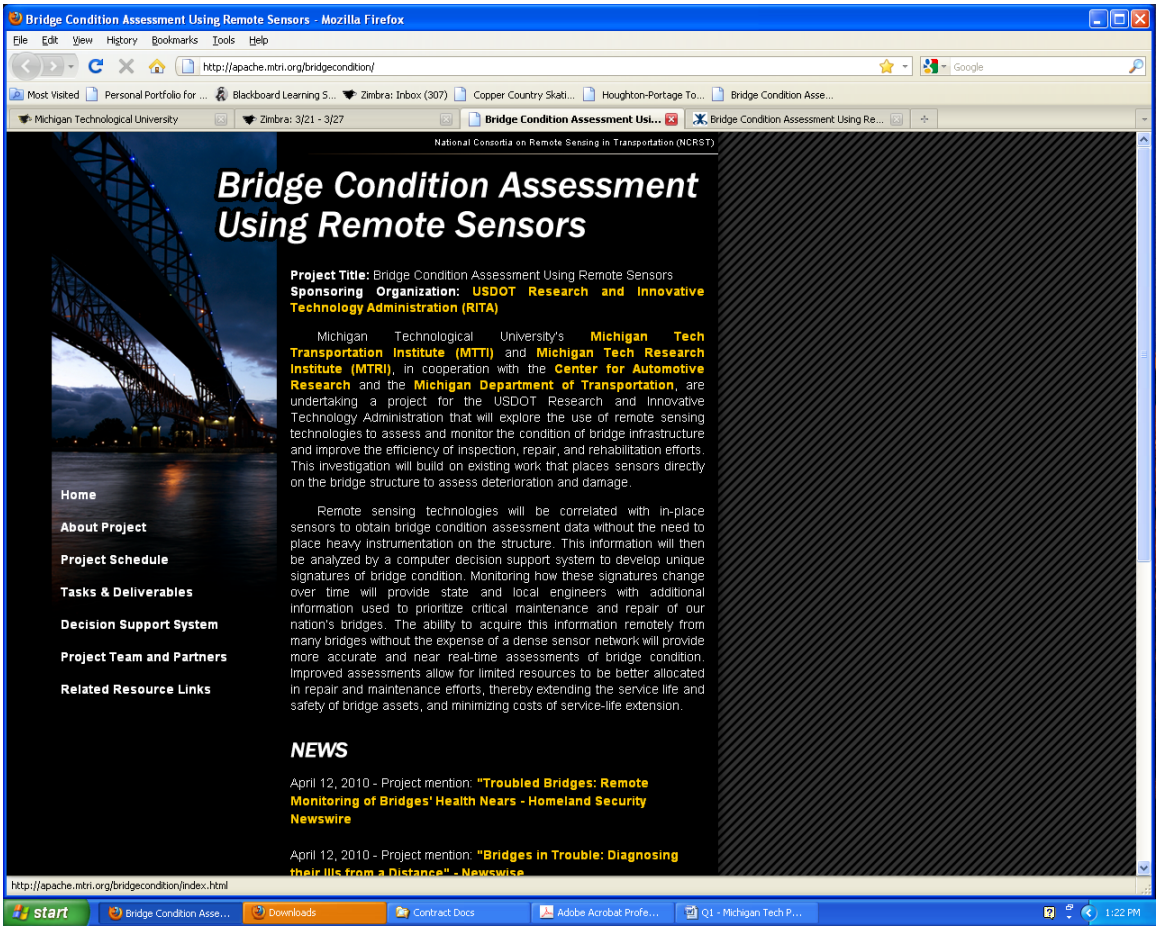
Technical Memorandum No. 3 documents progress toward the State of the Practice Synthesis and is described below in Task 2.

The subcontract with the Center for Automotive Research was finalized. A copy of the CAR subcontract is included in **Appendix A**.

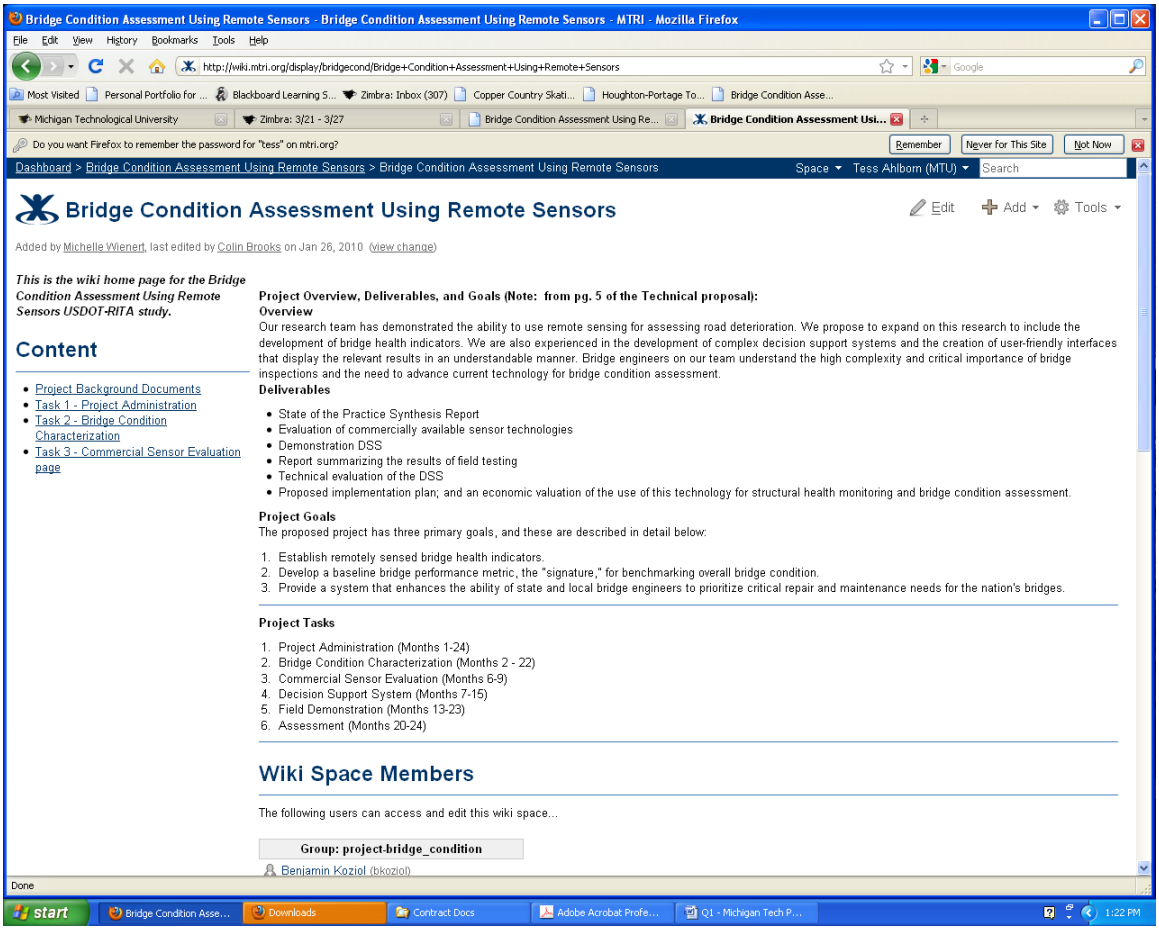
A project team kick-off meeting was held February 4, 2010 at the Michigan Tech Research Institute offices in Ann Arbor, MI. The primary objective of the meeting was for team members from the Houghton campus and Ann Arbor office to get a better appreciation of the roles of each team member for this project, to recognize the expertise of colleagues, and to ensure that team members had a full understanding of the scope and expectations of the project. The meeting notes, agenda, and handouts are included in **Appendix B**.

The Michigan Department of Transportation is a primary partner in this project. As such, a kick-off meeting with MDOT was held on February 5, 2010. The objective of the meeting was to introduce the project to MDOT personnel that would be closely involved with the project and to obtain input from MDOT regarding the top ten issues/concerns that they see with bridge condition assessment and bridge behavior. The meeting notes, agenda, and handouts are included in **Appendix C**.

A project Website has been established: www.mtti.mtu.edu/bridgecondition
This web site includes an overview of the project, taken from the original technical proposal. The site also includes information related to the project schedule, tasks and deliverables, the decision support system, project team partners, and key links for the project.



An internal project Wiki site has been established for internal correspondence related to the project and includes working copies of the state-of-practice report, project presentations, literature, and other documents that are shared within the research team. All team members have access to this project web site for updating information and keep members informed of progress.



Task 2: Bridge Condition Characterization

This task consists of three primary sub-tasks: the State-of-the-Practice Synthesis, laboratory investigation and demonstration, and structural modeling.

Technical Memorandum No. 3 documents progress toward the State-of-the-Practice Synthesis. The draft document outline is:

1. Abstract
2. Overview
3. In-Situ Monitoring Techniques
4. On-Site Monitoring Techniques
5. Remote Monitoring Techniques
6. Sensing of Exceptional Materials and Structures
7. Case Studies
8. References

The technical memo also expands on the details of sections that have been drafted, and the team's drive to establish an electronic technical reference database. The Synthesis Report will be completed during the next quarter.

Preliminary laboratory investigations have started with the casting of a test slab for initial sensor evaluation. Structural modeling has begun with exploring of basic finite element modeling capabilities. Simplified models are being developed to correspond with the preliminary laboratory investigations noted above. Models will be refined as compared to general structural theory and preliminary results of the sensor evaluation described below. Because the investigations and modeling are at such a preliminary development stage, no results are reported to date.

Also, seeking to establish solid project connections with a local road agency to augment its existing relationships with the Michigan DOT, the team met on March 1, 2010, with representatives of the Road Commission for Oakland County (RCOC). This meeting was arranged by the Center for Automotive Research (CAR) and both Richard Wallace from CAR and Colin Brooks from MTRI attended on behalf of the team. RCOC attendees included Dennis Kolar (Deputy Managing Director), Todd White (Programming Engineer), and Thomas Blust (Director of Engineering), all of whom play some role in RCOC's bridge programs (inspection, maintenance, etc.). This meeting was held at the RCOC's main business office.

At this meeting, Wallace and Brooks gave the RCOC attendees a brief overview of the RITA-funded bridge health monitoring project and sought their participation, most directly by providing technical guidance and access to Oakland Country bridges for testing. The RCOC team was agreeable on both fronts and offered to work with the project team as best as they could, including providing access to bridges for testing. Furthermore, later in the month, the project team formally invited RCOC to join its Technical Advisory Committee, and RCOC Executive Director Brent Bair assigned Dennis Kolar to that role.

The RCOC team also provided the bridge health research team members with an overview of how it runs its bridge inspection program. RCOC also provided its latest Bridge Condition Report (dated July 29, 2009), which shows that 15 (17%) A-Bridges are in poor condition, while only seven (4 %) B-Bridges are in poor condition. This report also identifies bridges posted for reduced posted load.

At the conclusion of the meeting, the attendees agreed to touch base again as the inspection season got closer, and the RCOC team offered that the research team could observe some inspections and possibly try to match remote sensed measurements to traditional bridge inspection data measurements.

Task 3: Commercial Sensor Evaluation

Based on discussions from the project kick-off meeting with MDOT, a number of problems and challenges were identified for bridges within the State of Michigan. The key challenges identified by MDOT and the project team included:

1. Scour/Settlement – The group agreed that scour is a project within itself and beyond the scope of this project. However, ***settlement*** is something that should be considered.
2. ***Corrosion damage*** of prestressed concrete beams is a serious concern, especially with end deterioration, section loss, and strand damage. Being able to detect the level of corrosion damage would be of value.
3. ***Steel beam section loss*** is also a serious concern, often most serious at the end of the beams and base of columns.
4. ***Vibration*** can be an indication of other concerns with the bridge
5. ***Large cracking*** is an indication of structural damage.
6. Decks - ***delamination***/spalling, one of the largest influences on public perceptions of road condition.
7. Decks – ***map cracking*** and other material related distresses.
8. ***Expansion joint failure*** – expansion joints have seen significant damage over the years and can be an indicator of other water damage that can lead to further problems.
9. ***Chloride ingress*** – if the DOT had a better way of estimating the chloride level, deck replacements would be scheduled differently.
10. ***Length of bridge*** – the typical bridge shortens over time, and they would like to track this. This is not related to settlement in item 1, rather this is a location item and length change concern.

These challenges were then paired with potential in-situ, stand-off, and remote sensing techniques that could be explored by the project team. These challenges will be revisited with the TAC as the proposed work plan is discussed. TAC input will provide a valuable national perspective, especially regarding the top ten concerns. By pairing challenges with non-remote and remote sensing techniques, the team can align potential remote sensing techniques with high priority concerns regarding bridges to allow for efficiency of this project.

To prove a basic proficiency of the sensing techniques (interferometric radar, speckle, high-resolution image analysis and spectroradiometry) for structural systems, preliminary test specimens were evaluated in the Michigan Tech Benedict and Dillman Laboratories during the latter part of the quarter. Specimens included a steel beam under load (speckle and interferometric radar) and concrete slabs with artificial defects (interferometric radar, high-resolution image analysis and spectroradiometry). Results are currently being reduced and evaluated with no findings to present to date.

Task 4: Decision Support System

No progress planned for this task in Quarter 1.

Task 5: Field Demonstration

No progress was planned for this task in Quarter 1; however, the project team initiated preliminary evaluations of potential bridge test sites using the Michigan Department of Transportation internal inventory database, Transportation Management System (TMS). Progress included familiarization with the Bridge Management System (BMS) included within TMS with an emphasis on locating specific structure types based on NBI condition ratings. It is expected that BMS will be used to develop a list of potential structures for the field demonstration.

Task 6: Assessment

No progress was planned for this task in Quarter 1.

PROBLEMS ENCOUNTERED

While we have significant experience from our highly qualified faculty and staff, we have experienced difficulty with hiring qualified students for this project. A position announcement was sent to chairs of Civil Engineering Departments throughout the U.S. Four offers have been made to potential PhD students since the project start date. As of the end of March, one PhD student had declined our offer, one had accepted but was having visa issues and will now arrive in mid-May, one student offer is pending, and one student is actively working on the project in the area of structural modeling. In addition, a master's student was added to the project team to assist with the literature review and preliminary laboratory investigations. We will continue to recruit highly qualified PhD students until we have 2-3 working on several aspects of the project.

We recognize that the sub-task to complete a review of the proposed work plan by the TAC is slightly behind schedule; however, we have identified TAC membership and are in the process coordinating the initial meeting. A revision of Technical Memo 2 will be included in the Quarter 2 Report to describe the outcomes of the first TAC meeting.

FUTURE PLANS

Quarter 2 activities will continue to follow the general schedule outlined within the technical project proposal. With Task 1 falling slightly off schedule regarding the Technical Advisory Committee (TAC), the initial focus of activities will center on finalizing the TAC and having the initial team meeting. From a technical perspective, the primary focus of the activities in Quarter 2 will center on the bridge condition characterization (Task 2) and the evaluation of commercial sensor technologies (Task 3).

Anticipated Activities and Deliverables for Quarter 2 include:

- Outcomes of the initial TAC meeting (Task 1).
- Draft State-of-the-Practice Synthesis Report presented to TAC (Task 2).
- Submission of technical paper (*"Evaluation of Remote Sensing Technologies for Detecting Bridge Deterioration and Condition Assessment"*) for NDE/NDT for Highways and Bridges: Structural Materials Technology (SMT) 2010 Conference.
- Finite element models of laboratory specimens developed and calibrated (Task 2). Laboratory work plan and specimen fabrication schedule established and coordinated with the sensor evaluation process.
- Preliminary findings summary report from initial sensor evaluation (Task 3). Results to be used for refined laboratory investigation of sensor technologies (additional evaluation of existing specimens and/or evaluation of new specimens). Measured results will be correlated with tradition in-situ sensor and finite element model results.

ADVISORY/STEERING COMMITTEE MEETING

The establishment of a Technical Advisory Council has begun. Several key members have been invited. See Technical Memorandum 1 for the invited individuals (with confirmation noted) and duties and responsibilities of the TAC. See Technical Memorandum 2 describing our first scheduled TAC meeting May 19-20, 2010 in Ann Arbor MI.