

**A Summary of the 4th Quarterly Report
for the Technical Activities Council**

**Bridge Condition Assessment
Using Remote Sensors**

Michigan Technological University
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EXECUTIVE SUMMARY

This quarterly report documents progress for “*Bridge Condition Assessment Using Remote Sensors*” during the fourth quarter for the period of October 1, 2010 – December 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 sensing 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.

The project schedule is shown below with Quarter 4 activities bounded by dashed lines:

ID	Task Name	2010												2011											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Administration	[Activity bar spanning all months]																							
2	Bridge Condition Characterization	[Activity bar spanning all months]																							
3	Commercial Sensor Evaluation	[Activity bar from Jan to Dec]												[Activity bar from Jan to Dec]											
4	Decision Support System	[Activity bar from Jul to Dec]												[Activity bar from Jan to Dec]											
5	Field Demonstration	[Activity bar from Jan to Dec]												[Activity bar from Jan to Dec]											
6	Assessment	[Activity bar from Jan to Dec]												[Activity bar from Jan to Dec]											

Accomplishments for this quarter are discussed below and include progress on Tasks 1, 2 and 4, namely with significant progress in the laboratory testing and validation. 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 4. All technical memos are located on our website http://www.mtri.org/bridgecondition/Tasks_and_Deliverables.html and are discussed in the relevant tasks below.

- ✓ Technical Memorandum No. 11 that defines the laboratory study progress (Task 2.2).
- ✓ Technical Memorandum No. 12 that describes the structural modeling development for component indicators, and finite element calibration with laboratory testing (Task 2.3).
- ✓ Technical Memorandum No. 13 that summarizes the outreach to stakeholders and meeting with TAC discussing useful metrics in the DSS for bridge management teams (Task 4.1).

- ✓ Technical Memorandum No. 14 explaining the method for implementing and testing algorithms of the DDS for bridge health (Task 4.4).

TECHNICAL STATUS

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

Task 1: Administration

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

The project website continues to be updated: www.mtti.mtu.edu/bridgecondition . This website includes an overview of the project, information related to the project schedule, tasks and deliverables, the decision support system, project team partners, and key links for the project. All presentations, papers and reports, including the State-of-the-Practice Synthesis completed during the previous quarter, are downloadable from our website under the “Tasks & Deliverables” link.

The following dissemination was documented for this quarter:

- The article “Intelligent Approach to Bridge Inspection” was submitted for consideration in the *FOCUS Newsletter*, a monthly publication by the U.S. DOT Federal Highway Administration.

Technical Memorandum No. 13 describes the outreach to stakeholders this quarter. Several meeting dates have been established for next quarter, including an annual project team meeting in Ann Arbor, a technical meeting with our experts at MDOT, and a progress update meeting with our Technical Activities Committee.

Task 2: Bridge Condition Characterization

This task consists of several sub-tasks including feasibility studies (through laboratory and small scale field investigation and demonstration) and structural modeling. Progress has been completed on these sub-tasks through several activities described below.

A significant activity of this task is to assess performance of commercially available sensors and their potential application to bridge health monitoring. While several technologies were identified previously in the commercial sensor evaluation, some technologies are proving to be more promising than others. These promising technologies and their appropriateness for addressing bridge health indicators for deck/girder surface condition, deck/girder subsurface condition, and global

performance include 3- D Photogrammetry, Thermal Infrared, Digital Image Correlation, and Radar.

Other promising technologies that are more field dependent will be included with the field demonstration. These are InSAR (Interferometric Synthetic Aperture Radar), and electro-optical airborne and satellite remote sensing. StreetView-style high-resolution digital photography is also being considered for implementation with the decision support system. In addition, the team considered spectral reflectance, optical interferometry, acoustics, and LiDAR. But these technologies were found to rate lower in the commercial sensor evaluation report, or, in the case of LiDAR, is being researched by our colleagues at UNC-Charlotte.

Technical Memorandum No. 11 summarizes the progress for the feasibility studies of each of the following technologies: 3- D optics, including photogrammetry, thermal infrared sensing, digital image correlation, and radar.

Refined work plans, progress reports and results are stored on the wiki project website for internal use. For all remote sensing technologies being evaluated in the work plans, we are focusing on understanding the measurement requirements for indicators of bridge condition important to DOTs. This enables us to select the remote sensing technologies that can meet those requirements, if they exist, and can be reasonably implemented.

Technical Memorandum No. 12 addresses the status of the structural modeling activities. The modeling is being coordinated with the feasibility study work plans related to global metrics and responses.

Task 3: Commercial Sensor Evaluation

The commercial sensor evaluation was completed during Quarter 3 and is documented in the report: *An Evaluation of Commercially Available Remote Sensors for Assessing Highway Bridge Condition*. The report can be downloaded from www.mtti.mtu.edu/bridgecondition by clicking on “Tasks and Deliverables” and “Deliverable 3-A”.

Task 4: Decision Support System

Design of the Decision Support System (DSS) continued in Quarter 4 after having started in the previous quarter. The need to provide bridge condition information derived from remote sensing in an easy-to-understand format and user-friendly interface continues to be a primary driver behind design of the DSS. The Commercial Sensor Evaluation (Deliverable 3-A) has been helping to influence the DSS design as well, through focusing on what remote sensing technologies are being evaluated and tested in the laboratory

and in small-scale field tests. Currently, the focus technologies are 3-D optics (including photogrammetry), thermal infrared sensing, digital image correlation, and radar. The current design of the DSS includes a multi-tiered structure that provides wide capabilities as our study determines what remote sensing data can be practically integrated into the DSS. The tiers are:

1. Providing a field data interface to allow DOT users to access existing bridge condition information and to enter bridge condition data while out in the field.
2. The ability to display already-processed remote sensing data from previous collects in an intelligent, easy-to-use format and DSS tool interface.
3. The ability to integrate, analyze, and display remote sensing data for bridge condition indicators collected “live” in the field.

We are currently focusing on tiers 1 and 2, which we believe can be accomplished within the scope and timing of this project. Tier 3 is a “stretch” goal that is the logical next phase of DSS development. Tier 1, providing a field data access and collection interface, was described in a previous Technical Memo (No. 10, available at http://www.mtri.org/bridgecondition/doc/Memo%2010_Decision%20Support%20System%20Update.pdf) and focuses on an inexpensive and lightweight but ruggedized tablet that provides access to existing bridge condition data and enables the user to enter data while out in the field, while also providing navigation capabilities. Tier 2, displaying data already analyzed to the user through an easy-to-understand interface, will incorporate data developed as part of the current lab work plan efforts so that the DSS team will have the information needed to understand how the data can best be interpreted and displayed. Further detail on this important step is included in **Technical Memorandum No. 14**, the current DSS update, which is being posted to http://www.mtri.org/bridgecondition/Tasks_and_Deliverables.html as well being part of this quarterly report.

The key point is that the DSS must be able to integrate remote sensing data, detect significant change if it has occurred, and take advantage of the strengths of remote sensing such as the ability to gain wide spatial and temporal data coverage.

Task 5: Field Demonstration

No progress was planned for this task in Quarter 4.

Task 6: Assessment

No progress was planned for this task in Quarter 4.

PROBLEMS ENCOUNTERED

A collaboration meeting with the University of North Carolina – Charlotte was tentatively scheduled at the end of Quarter 3. The meeting has been rescheduled for early in Quarter 5 (during the Annual TRB Meeting in Washington DC) to share information between the two USDOT/RITA CRS&SI bridge-related projects. The research teams will establish meeting objectives and anticipated outcomes prior to meeting.

FUTURE PLANS

Quarter 5 activities will continue to follow the general schedule outlined within the technical project proposal. Task 1 administrative activities are progressing well. From a technical perspective, the primary focus of the activities in Quarter 5 will continue on the bridge condition characterization (Task 2) progressing through the proof-of-concept testing and further evaluation of commercial sensor technologies. In addition, activities related to the decision support system described in Task 4 will be enhanced.

Anticipated Activities and Deliverables for Quarter 5 include:

- Progress on laboratory work plans, structural modeling and preliminary response correlation with remote sensors to demonstrate the feasibility of implementing several remote sensing techniques for bridge condition assessment (Task 2.2 and 2.3).
- Development of the integration of bridge health indicators into the DSS and development of the bridge condition signature (Task 4.5).
- the DSS beta version evaluation by TAC through a secure web portal (Task 4.6) and summarizing the capabilities of the DDS for integrated bridge assessment (Task 4.7) including how it integrates sensed and historical data to support assessment.
- A technical meeting will be held with the Michigan DOT, a primary project partner, to begin development of the field demonstration (Task 5.0) such that a quarterly outcome will be to summarize the site identification for the field demonstration and preliminary field instrumentation plan (Task 5.1).
- A group meeting of the Technical Advisory Council is planned during Quarter 5 to update the TAC on our activities and obtain feedback on our future planned activities (Task 1.0). This outreach to stakeholders will include a discussion of useful metrics in the DSS for bridge management teams.
- Preparation of a journal article for submission to introduce the results from the commercial sensor evaluation report to the bridge engineering community (Task 1.0).
- Preparation for the TRB workshop on remote sensing sponsored by Joint Committee ABJ50-ABJ60 scheduled for Sunday, January 23, 2011 (Task 1.0).

ADVISORY/STEERING COMMITTEE MEETING

Members of the Technical Advisory Committee include:

Steve Cook – Michigan Department of Transportation
C. Douglas Couto – Transportation Research Board
Charles Ishee – Florida Department of Transportation
Michael Johnson – CALTRANS
Dan Johnston – Independent Materials Consultant
Dennis Kolar – The Road Commission for Oakland County
Duane Otter – Transportation Technology Center, Inc.
Keith Ramsey – Texas Department of Transportation
Roger Surdahl – Federal Highway Administration
Peter Sweatman – University of Michigan Transportation Research Institute
Krishna Verma – Federal Highway Administration
Carin Roberts-Wollmann – Virginia Tech
Amy Trahey – Great Lakes Engineering Group

TAC members will be provided with a summary of Quarter 4 activities. The Technical Advisory Council is scheduled to meet during Quarter 5 for an update on our activities and to obtain feedback on our future planned activities. See **Technical Memo No. 13**.

ATTACHMENT Listing – Quarter 4

- Technical Memorandum No. 11 – updating the laboratory testing progress
- Technical Memorandum No. 12 – structural modeling development
- Technical Memorandum No. 13 – stakeholder outreach
- Technical Memorandum No. 14 – development of the decision support system