

**A Summary of the 8th Quarterly Report
for the Technical Advisory 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 eighth quarter for the period of September 30 – December 31, 2011. 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 is exploring correlations between commonly used inspection techniques and remote sensing systems, and developing 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 8 activities bounded by dashed lines; note that additional time was previously requested for the Decision Support System (Task 4) in order to incorporate field demonstration data results from Task 5:

ID	Task Name	2010												2011												2012											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep			
1	Administration	[Gantt bar spanning all months]																																			
2	Bridge Condition Characterization	[Gantt bar spanning all months]																																			
3	Commercial Sensor Evaluation	[Gantt bar spanning all months]																																			
4	Decision Support System	[Gantt bar spanning all months]																																			
5	Field Demonstration	[Gantt bar spanning all months]																																			
6	Assessment	[Gantt bar spanning all months]																																			

Accomplishments for this quarter are discussed below and include progress on all tasks.

Also, according to the Revised Cost Proposal submitted June 26, 2009, and included as Attachment 2 of that cost proposal, the following deliverables were updated for Quarter 8 based on the no cost time extension. All technical memos are located at the end of this document and are discussed in the relevant tasks below.

- ✓ Technical Memorandum No. 23 providing an update of the timeline and deliverables for the project due to no cost time extension (through September 30, 2012) and including an outline of final report.
- ✓ Technical Memorandum No. 24 describing health indicators for each technology with progress related to DSS and including a DSS progress update.
- ✓ Technical Memorandum No. 25 reporting on progress of the economic valuation of the technologies and the DSS tool, software and components for bridge condition assessment.

TECHNICAL STATUS

Progress of each of the six tasks is documented below with references to the 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 are downloadable from our website under the “Tasks & Deliverables” link.

The following publications were documented for this quarter:

- C. Brooks presented “Assessing Bridge Condition using Remote Sensing” at the **PECORA 18 Remote Sensing Symposium**, November 14-17, 2011 in Herndon, VA. The poster was authored by Colin Brooks, Tess Ahlborn; Devin Harris; Larry Sutter; Bob Shuchman; Joe Burns; Arthur Endsley; Khatereh Vaghefi; Chris Roussi; Rick Dobson; Ryan Hoensheid; Henrique de Melo e Silva; Renee Oats; Richard Wallace; Mike Forster.
- Vaghefi, K., Henrique de Melo e Silva, Harris, D.K., Ahlborn, T.M., “Application of Thermal IR Imagery for Concrete Bridge Inspection”, was presented by Khatereh Vaghefi at the **Precast/Prestressed Concrete Institute Convention and National Bridge Conference**, Salt Lake City, Utah, October 22-26, 2011.
- “Integration of Traditional Remote Sensing into a Framework for Structural Health Monitoring of Concrete Bridges”. Devin Harris, Tess Ahlborn, Larry Sutter and Colin Brooks. Presented in Cincinnati, OH at the **American Concrete Institute Fall Convention**, October, 2011.
- “Integration of Traditional and Non-Traditional Remote Sensing for Bridge Condition Assessment”, authored by T.M. Ahlborn, D.K. Harris, C.N. Brooks and L.L. Sutter, was presented by Dr. Tess Ahlborn at the **5th International Structural Health Monitoring of Intelligent Infrastructure Conference**, Cancun, Mexico, December 13, 2011.
- “Sensing Technologies for Transportation Applications”, authored by Colin Brooks, was presented to the **18th ITS World Congress**, Orlando, FL, - Special Session SS11 on “Using Information Technology to Better Manage ITS Operations and Investments”, 10/17/11. It included a prominent section on progress with the Bridge Condition study.

Task 2: Bridge Condition Characterization

This task consists of several sub-tasks including feasibility studies with limited laboratory and small scale field investigation and demonstration. As highlighted in the previous quarterly report, the structural model aspect has been moved forward as the technology selection has shifted towards condition assessment, however future modeling components will be necessary for correlation with global system response from digital image correlation and LiDAR. Progress has been completed on these sub-tasks through several activities; however, the majority of these activities were geared towards post-processing of the field demonstration results and limited follow-up laboratory studies necessary for including quality data in the DSS.

Specific activities in this quarter relevant to the bridge condition characterization focused on a review of the challenges observed during the field demonstration. This review included efforts to mitigate obstacles observed during the field deployment such as eliminating environmental noise for digital image correlation, image collection for the thermal infrared and mechanical issues for radar. These mitigation strategies were deemed essential to the assessment of whether a technology is feasible for implementation and future applications. Details of the specific post-processing and mitigation strategies are highlighted for the technologies in **Technical Memorandum No. 24**.

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”. It continues to inform our study and has served a steady reference during project work and will be integrated into the final report.

Task 4: Decision Support System

Progress on the Bridge Condition Decision Support System (DSS) has continued since the previous quarter in order to create a user-friendly, stable, and robust framework for integrating remote sensing results while providing access to existing bridge condition data. Since the last quarterly report, a number of improvements have been made to the DSS and development is ready to focus on the last major feature, the integration of remote sensing data, before testing and mobile app versioning. These include having the DSS's database model be based on Pontis schema, importing data from MDOT's Transportation Management System (TMS), utilization of new bridge information derived from remote sensing in the DSS through new display features, advancing plans for integrating more complex remote sensing data, and deriving a bridge condition signature. Details of the technical progress related to the DSS development are presented in **Technical Memorandum No. 24**.

With the remote sensing technologies producing results such as percent spalled, percent delaminated, and bridge deck roughness, the project has reached the intended stage of integrating indicators of bridge condition into a decision support system. This is a critical step to having an overall bridge condition assessment system (technologies plus the DSS) that is practical to use by transportation agencies. The next Quarterly Report will update the team's progress on reaching this important project milestone.

Task 5: Field Demonstration

The only technology that was field deployed (redeployment due to complications during initial deployment) in this quarter was the Ultra Wide Band Imaging Radar System (UWBIRS). UWBIRS was again deployed in December 2011 to fill in some missing data areas of the August 2011 collect for the Freer Road Bridge. For the other technologies, the field demonstration was completed in the previous quarter, but a significant portion of the post-processing (**Technical Memorandum No. 24**) of acquired data was performed in this quarter and will continue into the next quarter.

Task 6: Assessment

The assessment-related activities of this quarter made significant progress this quarter as the performance evaluation of the technologies progressed. The evaluation team summarized research findings related to the national bridge program in the context of shrinking transportation revenue, current bridge inspection practices and cost estimates, field cost data collection using remote sensing technologies, and outcomes of the Michigan Department of Transportation (MDOT) stakeholder interviews. The major activities for this task included: (1) reviewing economic evaluation methods, (2) estimating costs of using remote sensing technologies, (3) estimating costs to road users, and (4) documenting costs of bridge scoping. **Technical Memorandum No. 25** includes a detailed summary of these activities. The majority of the work related to this task will occur in the coming quarters and include:

- Finalizing cost estimates (both research stage and within a concept of operations (CONOPS) for sustainable adoption within a bridge operations and maintenance program).
- Finalizing assumptions, application scenarios, and evaluation approaches.
- Conducting additional interviews with MDOT stakeholders in March, 2012, with a focus on agency valuation of the outputs of the tested remote sensing technologies.
- Analyzing how the DSS can enable more cost-efficient bridge asset management if used as part of MDOT planning processes.
- Preparing a final study report that compares costs and benefits and provides recommendations on cost-effective use of remote sensing for bridge condition assessment (i.e., documents which technologies provide the highest added value per implementation and operation cost).

PROBLEMS ENCOUNTERED

No technical problems were encountered during this quarter. Bridge LiDAR data has taken longer to process than anticipated but a more effective way forward has been found using the commercial QT Modeler software package.

FUTURE PLANS

From a technical perspective, the primary focus of the activities in Quarter 9 will follow the revised project plan included in **Technical Memorandum No. 23**, but will generally focus on finalizing the technology performance evaluation, including completion of post-processing and development of individual technology reports (technical manuscripts). Additional activities will include progress on the economic valuation of remote sensing technologies for bridge condition assessment, beta testing of the DSS, and preliminary preparation of the final report.

ADVISORY/STEERING COMMITTEE MEETING

Members of the Technical Advisory Committee include:

Steve Cook – Michigan Department of Transportation
C. Douglas Couto – Transportation Research Board
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
Carin Roberts-Wollmann – Virginia Tech
Amy Trahey – Great Lakes Engineering Group

Members will be provided with a summary of Quarter 8 activities. Technical memorandums are posted to the website.