

Integration of Traditional and Non-Traditional Remote Sensing for Bridge Condition Assessment

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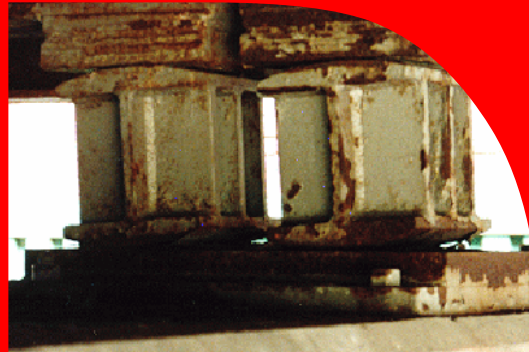
Michigan Technological University

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Bridge Condition in the U.S. > \$150B to repair today



Settlement



Deteriorated Bearing



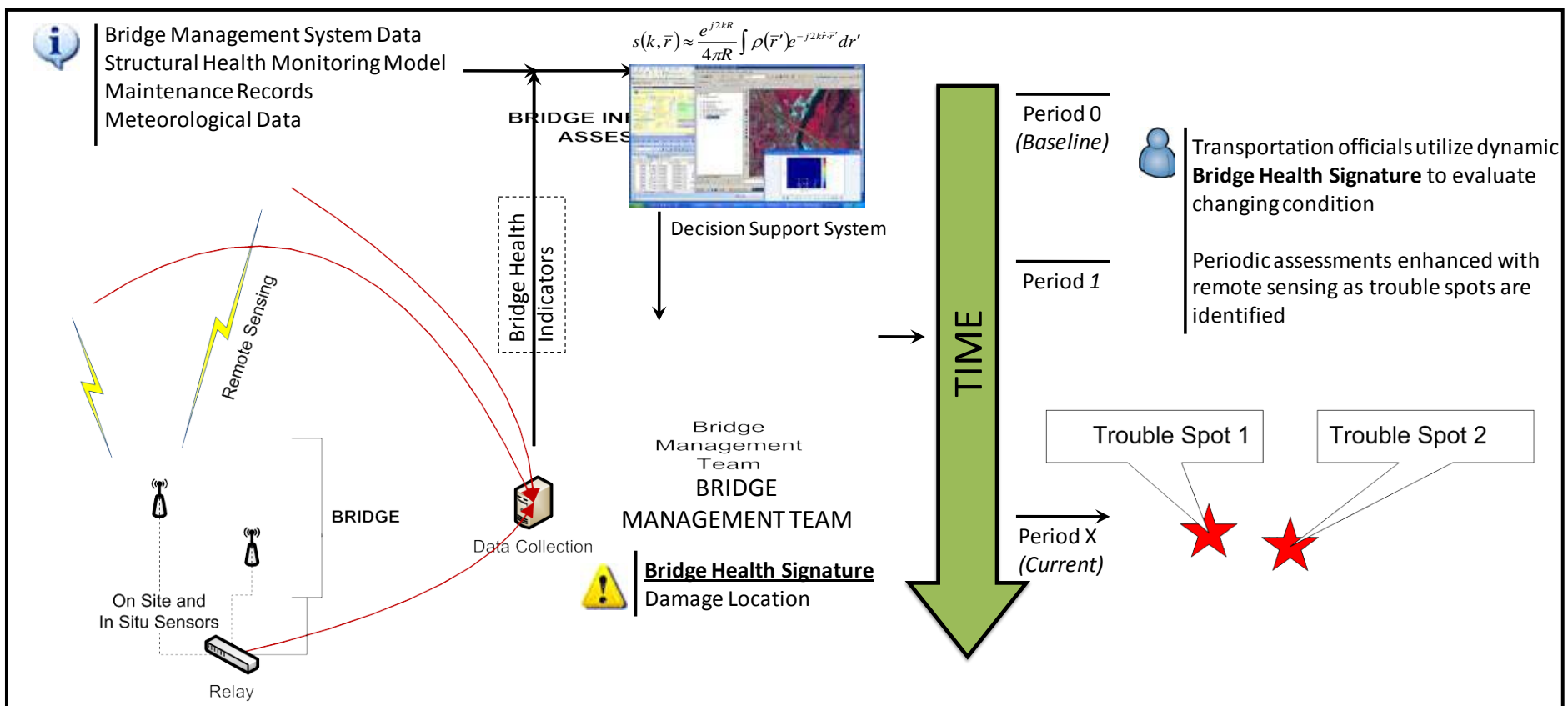
Corrosion and Section



Deteriorated Concrete Element

Project Concept

Remote Sensing – for bridge engineers: enhanced bridge inspection at highway speed without traffic disruption (e.g. collecting information at a distance)



Top Priorities / Challenges

Location	Applicable Technologies
Surface	3-D Optics, Street-view Style Photography, LiDAR, GigaPan
Subsurface	Infrared Thermography (Thermal IR), Synthetic Aperture Radar (SAR) 2D and 3D
Global System <u>Technology Selection:</u> current inspection processes, including safety, while minimizing traffic disruption.	Digital Image Correlation, LiDAR, Interferometric Synthetic Aperture Radar (InSAR) to enhance

3D Optical Bridge Evaluation System (3DOBS)



Deployment on Willow Road over US-23 during August 2011 field demonstrations



Visual of percent spalled area for the Willow (6.08% spalled) Road bridge using 3DOBS data as the input and ArcGIS as the analysis software

BridgeViewer RCS



Deployed on Freer Rd to capture a bridge photo inventory



location of the digital photographs being displayed in Google Earth; each box contains a hyperlink to a full-resolution view of the photo taken at that location

GigaPan



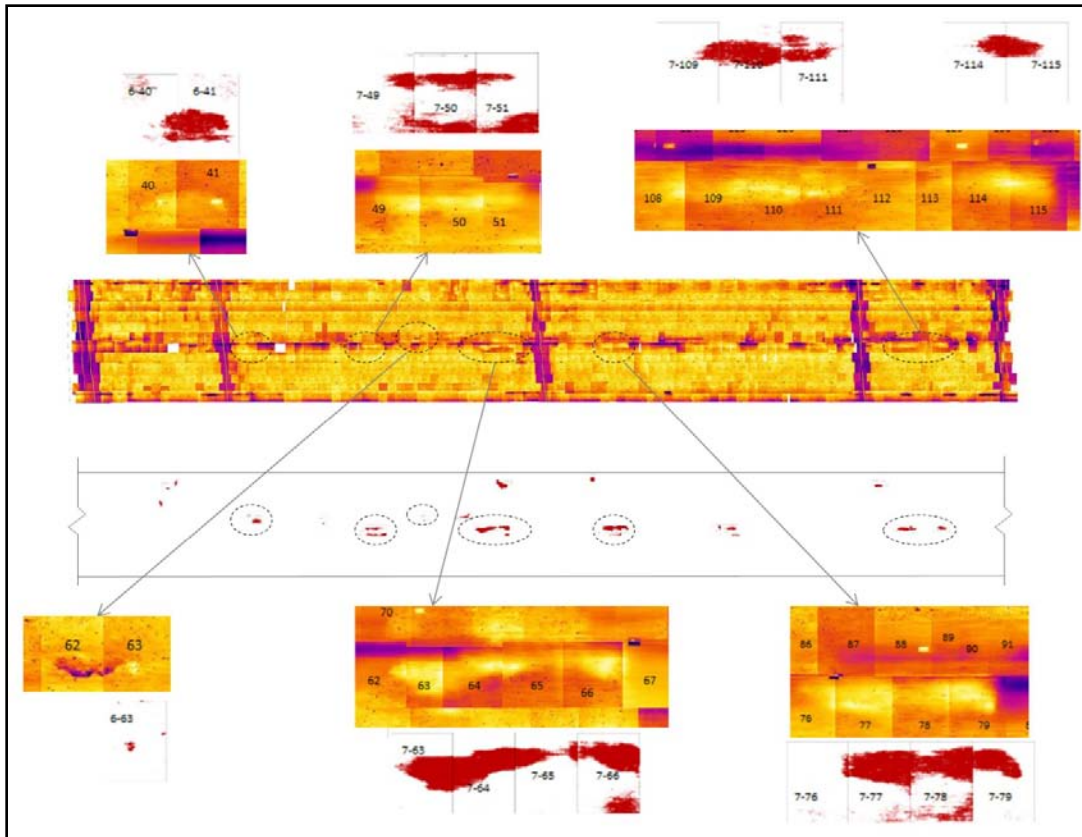
Profile view of Willow Rd from a GigaPan image.
The full resolution version of this photo captures the entire side of the bridge at very high resolution.

GigaPan system being used to collect high-resolution bridge inventory photos

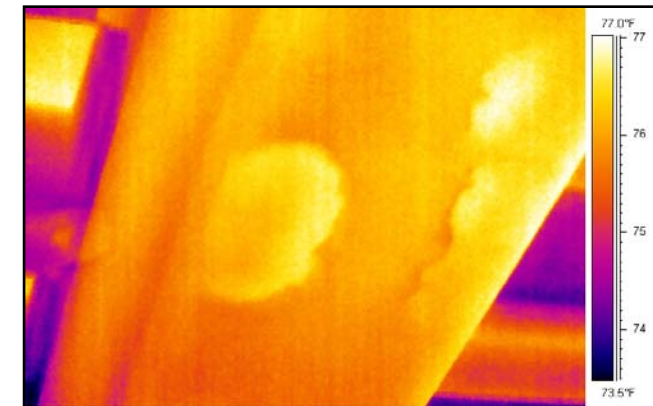
Surface: 3DOBS, BVRCS, GigaPan

- Benefits
 - Low cost components, rapid deployment, limited time to collect data
 - Useful metrics: % area and volume & location of spalls, geo-tagged and very high resolution inventory
- Limitations
 - 5mm resolvable features, automation of analysis, not yet at highway speed, gigapan storage
- Implementation
 - Near user ready, value added metrics aligned with current bridge rating process

Thermal IR



Bridge deck delamination map created by thermal IR images and output data

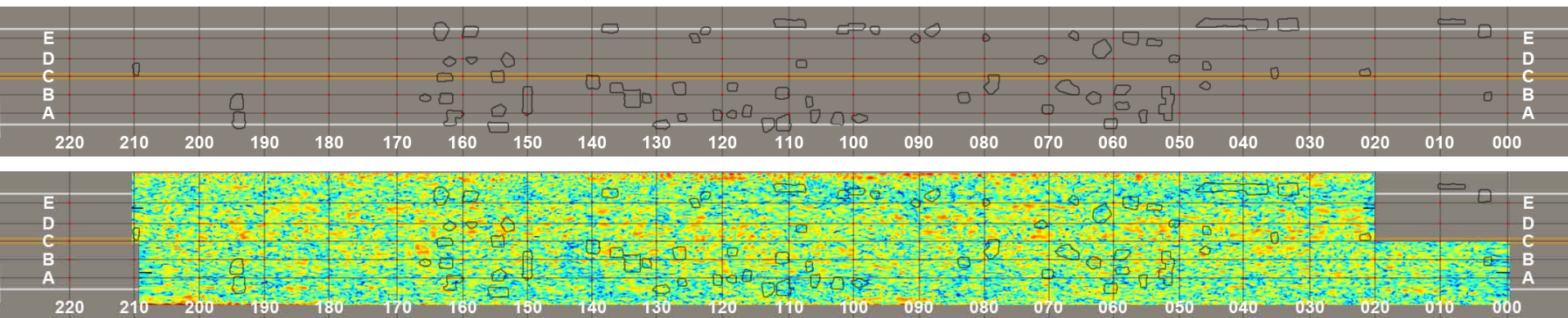


Optical and Thermal Image highlighting observable subsurface defect

Radar (Synthetic Aperature Radar, 2D, 3D)



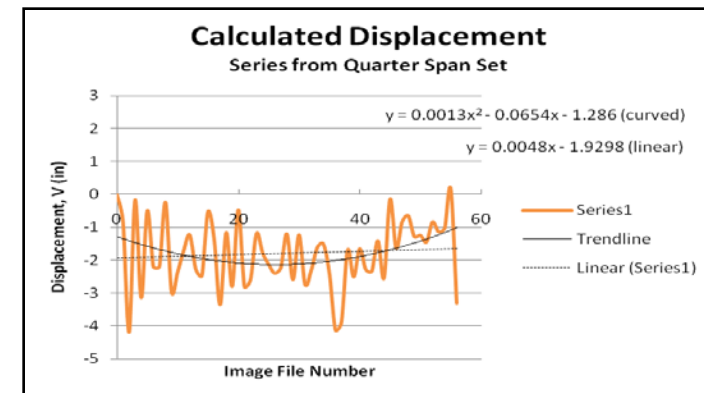
Lateral translator and radar equipment.
Such a system could be adapted for use on a moving vehicle.



Subsurface: Thermal IR, SAR

- Benefits
 - Useful metrics: % spall and delamination, detects surface and subsurface defects
 - Qualitative and quantitative assessment tool
- Limitations
 - Collection time, camera/equipment specifics, data processing and user interpretation, cost
- Implementation
 - ThIR: Near user ready, Advanced equipment, “how to deploy” manual; Radar: further development to 3D

Digital Image Correlation



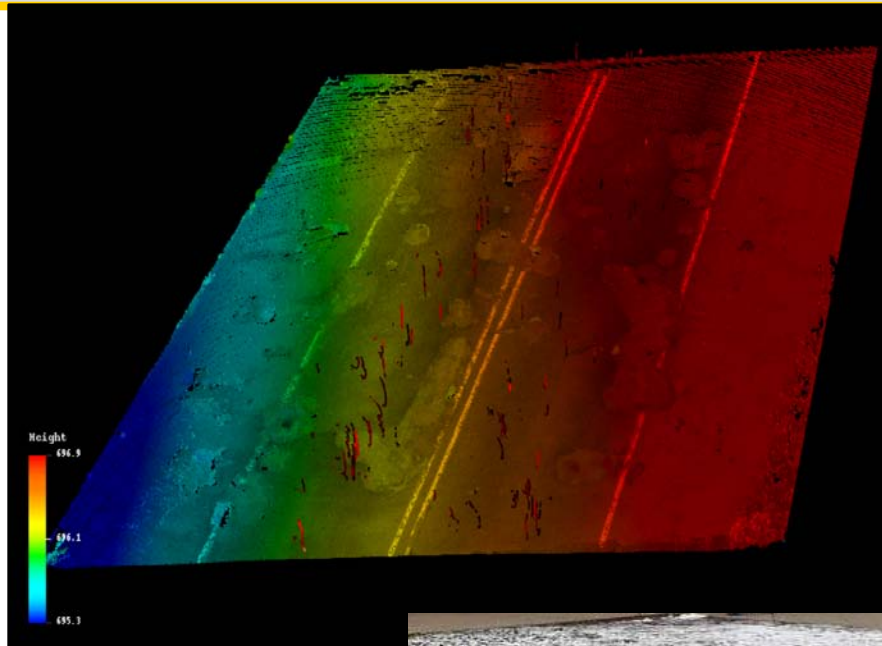
Graphical plot of calculated displacement

Scaffolding setup at Mannsiding Rd. bridge facing exterior girder with speckle patterns

Digital Image Correlation

- Benefits
 - Can track changes in mechanical behavior over time
 - Useful metrics: remotely captures deflection, strain field and vibration (global system metric)
- Limitations
 - Environmental effects: error induced by wind and traffic flow, more ideally suited in current form for controlled environments
- Implementation
 - Not recommended for deployment without significant technology improvements, consideration of complementary technologies (laser vibrometry, LiDAR)

LiDAR



Composite LiDAR intensity and elevation image.

- Surface condition (% spalled, location & volume of spalls, related metrics) can be assessed from the intensity image.
- Global features (e.g. static deflection, high load hits) can also be determined

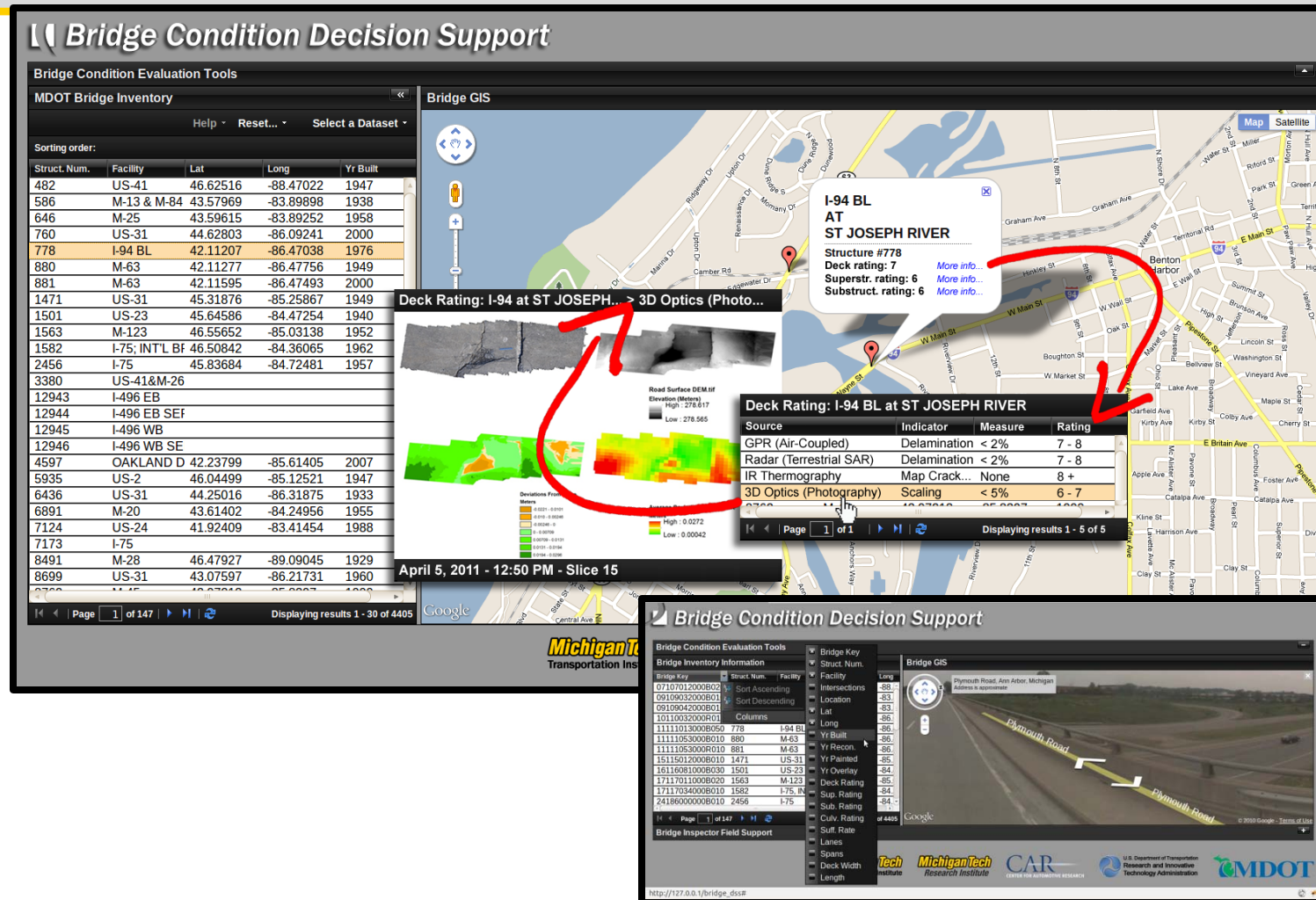
LiDAR

- Benefits
 - Some DOTs own equipment for non-bridge assessment activities (familiarity with technology) or have contract access to it – just a new deployment
 - Useful metrics: Deck condition (% spalled and surface condition) and Global metrics (static deflection and clearance)
- Limitations
 - High capital cost, speed of deployment, appropriate integration in bridge condition assessment framework
- Beyond Phase II
 - Close to user ready, “how to deploy” manual

Decision Support System and Result Integration

Current design:

- Access to Bridge Operations tools (in the field)
- Access to Bridge Condition data in GIS format
- Access to remote sensing results – mission planning & in the field
- Access to existing mapping tools
- Accessible via ruggedized tablets



Moving Forward – The GAP

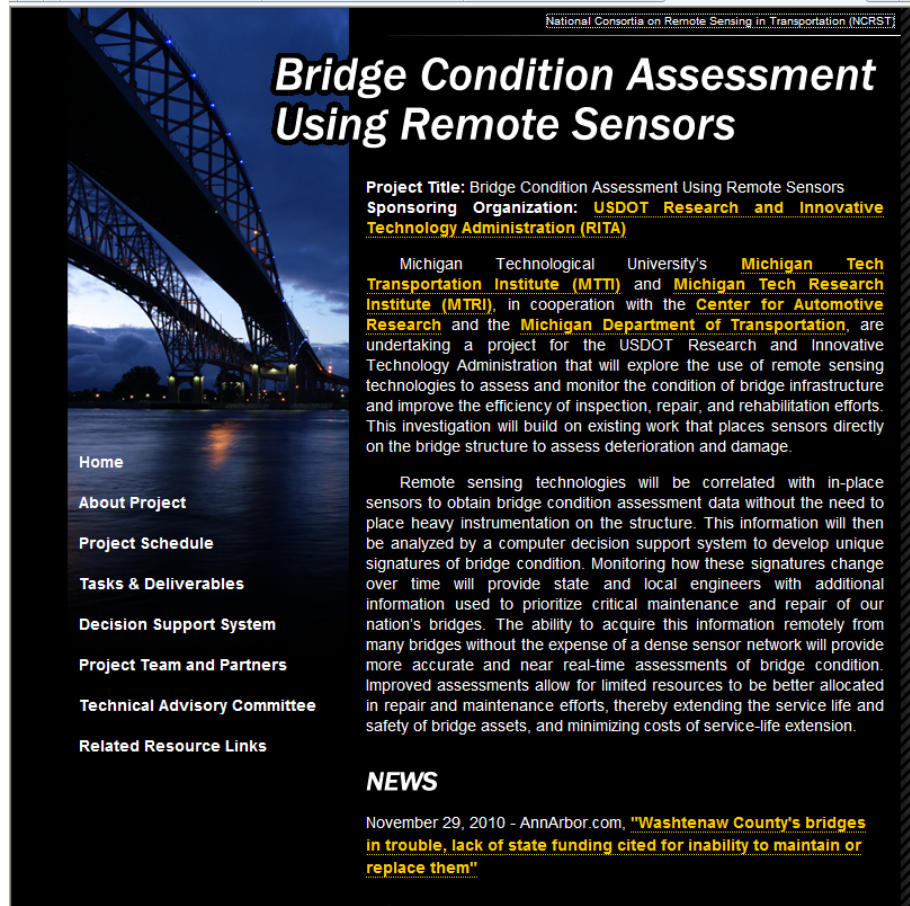
- Determining value-added measures from remote sensing results:
 - e.g. % spall in wheel paths or relative to joints
 - Aligning data analysis with advanced DOT judgments
- Closing the gap between technology, demonstrations and DOT use
 - Getting the DOTs to show interest
 - DOT and industry collaborations
 - DOT buy-in nationwide (dependable, reliable)
- Refining the “How-to” manuals for DOT use
 - Guides on how to implement & use these technologies
- Implementing through pooled fund studies, workshops and training

Project Team / Disclaimer

- USDOT – Research and Innovative Technology Administration
 - Commercial Remote Sensing and Spatial Information
 - Program Manager: Caesar Singh
 - Cooperative Agreement #DTOS59-10-H-00001
 - Project: Bridge Condition Assessment Using Remote Sensors
- Project Partners
 - Michigan Department of Transportation
 - Michigan Tech Transportation Institute
 - Michigan Tech Research Institute
 - Center for Automotive Research

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Website: www.mtti.mtu.edu/bridgecondition/



National Consortium on Remote Sensing in Transportation (NCRST)

Bridge Condition Assessment Using Remote Sensors

Project Title: Bridge Condition Assessment Using Remote Sensors
Sponsoring Organization: USDOT Research and Innovative Technology Administration (RITA)

Michigan Technological University's **Michigan Tech Transportation Institute (MTTI)** and **Michigan Tech Research Institute (MTRI)**, in cooperation with the **Center for Automotive Research** and the **Michigan Department of Transportation**, are undertaking a project for the USDOT Research and Innovative Technology Administration that will explore the use of remote sensing technologies to assess and monitor the condition of bridge infrastructure and improve the efficiency of inspection, repair, and rehabilitation efforts. This investigation will build on existing work that places sensors directly on the bridge structure to assess deterioration and damage.

Remote sensing technologies will be correlated with in-place sensors to obtain bridge condition assessment data without the need to place heavy instrumentation on the structure. This information will then be analyzed by a computer decision support system to develop unique signatures of bridge condition. Monitoring how these signatures change over time will provide state and local engineers with additional information used to prioritize critical maintenance and repair of our nation's bridges. The ability to acquire this information remotely from many bridges without the expense of a dense sensor network will provide more accurate and near real-time assessments of bridge condition. Improved assessments allow for limited resources to be better allocated in repair and maintenance efforts, thereby extending the service life and safety of bridge assets, and minimizing costs of service-life extension.

NEWS

November 29, 2010 - AnnArbor.com, "[Washtenaw County's bridges in trouble, lack of state funding cited for inability to maintain or replace them](#)"

Questions and Comments

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