

# Measuring and Communicating Bridge Performance with Remote Sensing Technologies

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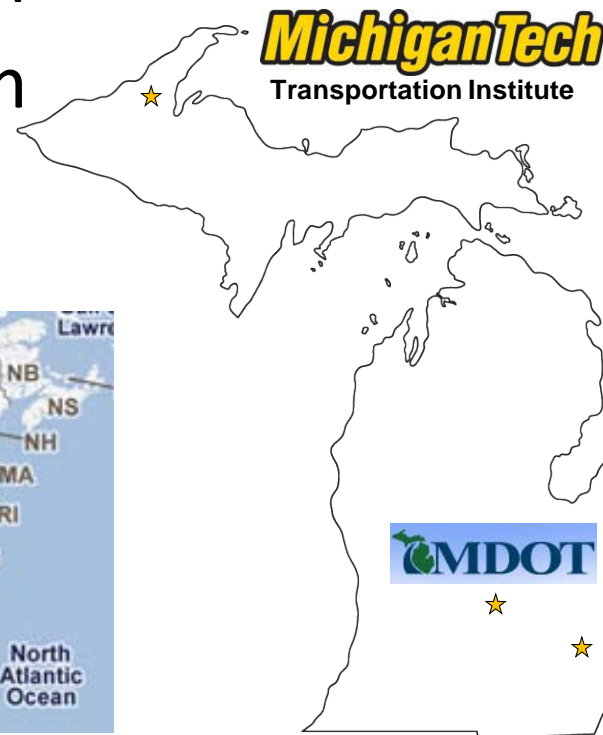
**Michigan Technological University**

January 25, 2012

91<sup>th</sup> Annual TRB meeting, Washington D.C.

# Presentation Outline

- Project Concept
- Remote Sensing Technologies and Field Demonstration
- Decision Support System
- Moving forward



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



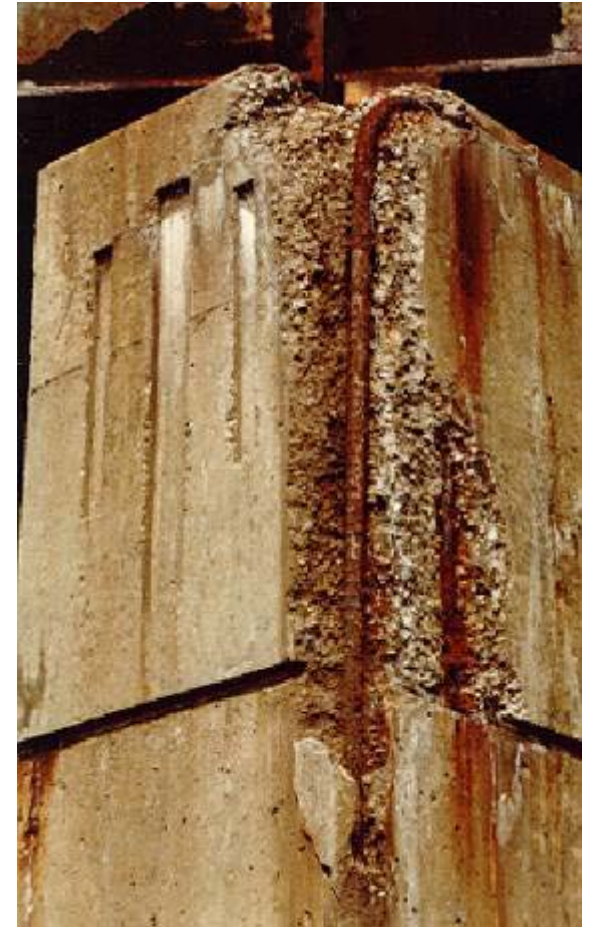
Settlement



Deteriorated Bearing



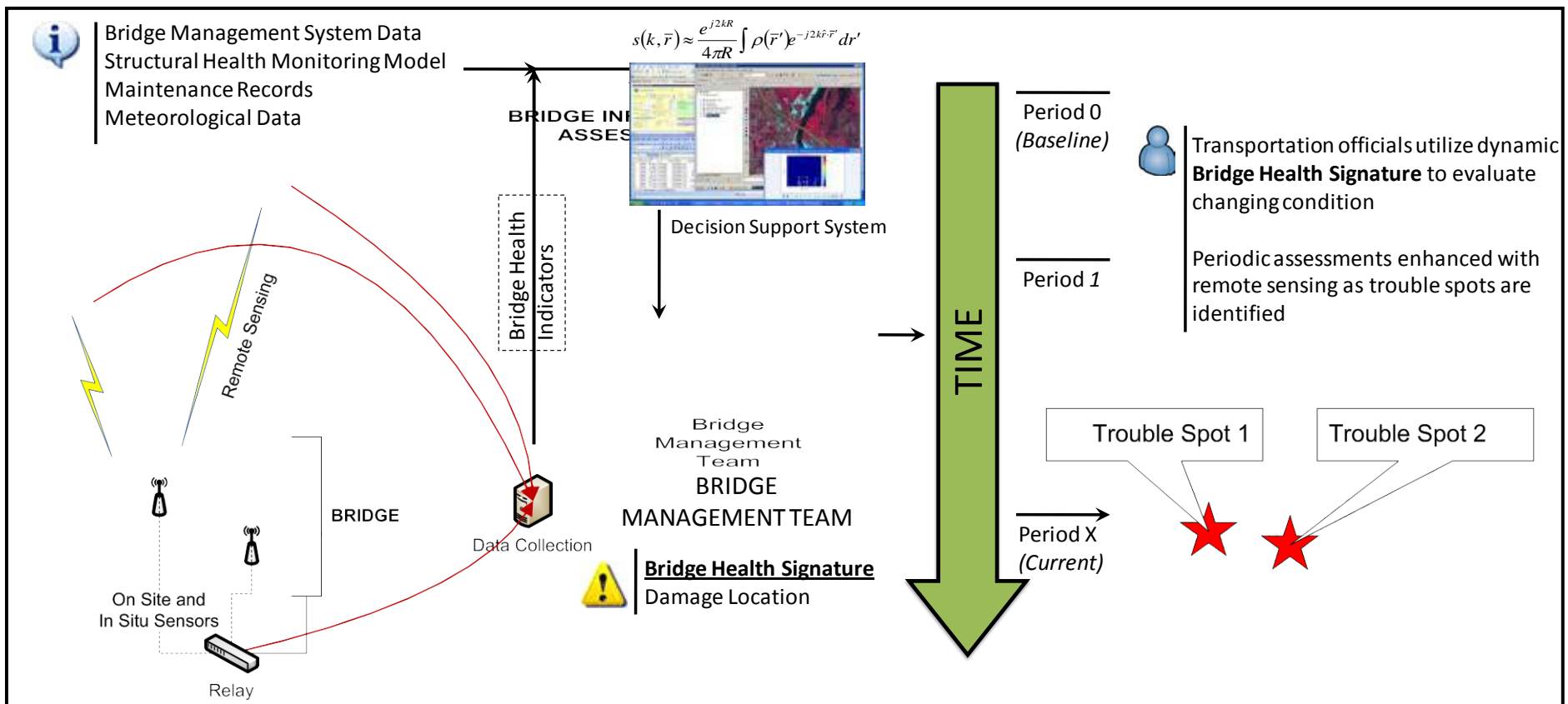
Corrosion and Section



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)



# Technology Selection

Location	Applicable Technologies
Surface	3-D Optics, Street-view Style Photography (GigaPan & BVRCS), LiDAR,
Subsurface	Infrared Thermography (Thermal IR), Ultra Wide Band Imaging Radar System (UWBIRS)
Global System	Digital Image Correlation, LiDAR, Interferometric Synthetic Aperture Radar (InSAR)

Technology Selection: commercially available technologies to enhance current inspection processes, including safety, while minimizing traffic disruption.



# 3D Optical Bridge-Evaluation System (3DOBS)



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

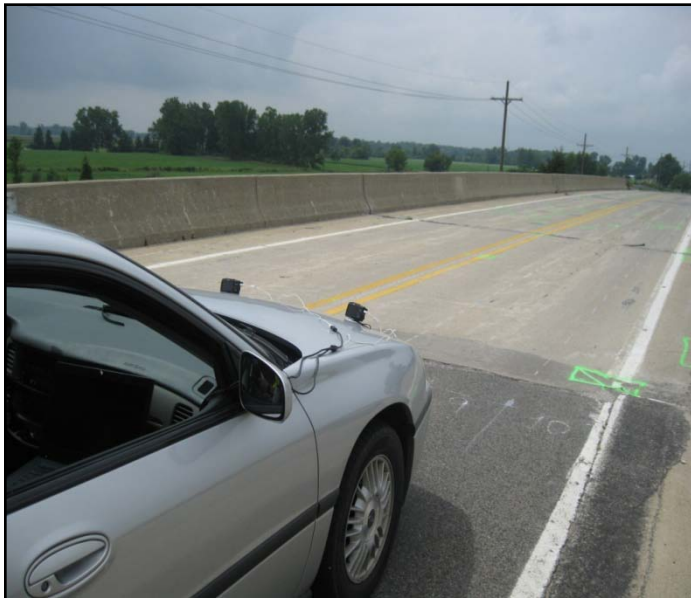


**Visual of percent spalled area for the Willow (6.99% spalled) Road bridge using 3DOBS data as the input and ArcGIS as the analysis software**

# 3DOBS

- Benefits
  - Low cost components, rapid deployment, limited time to collect data
  - Useful metrics: % area and volume & location of spalls, International Roughness Index (IRI)
- Limitations
  - Speed of collection, 5mm resolvable features (with current deployment; capable of higher-resolution)
- Implementation
  - Near user ready, value added metrics aligned with current bridge rating process, automation of analysis

# StreetView Style Photography - BridgeViewer RCS



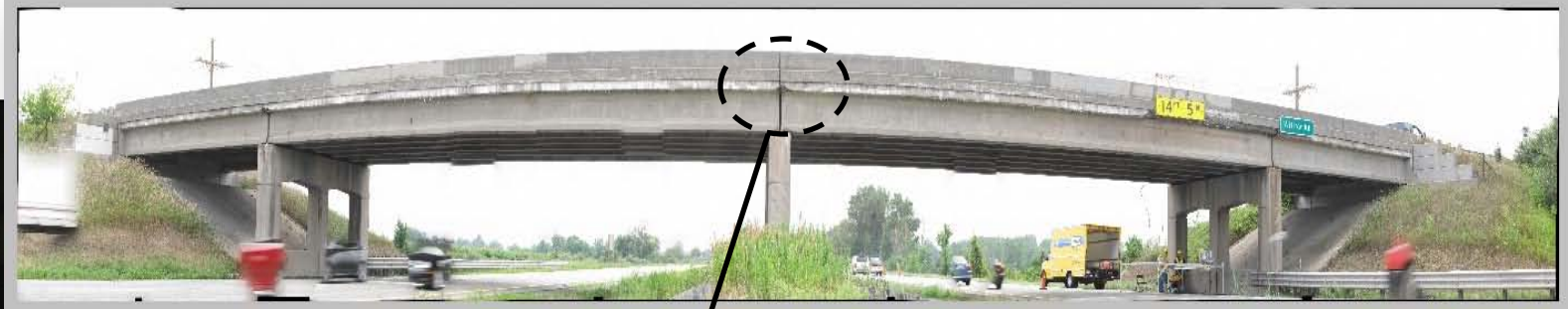
Deployed on Freer Rd to capture a bridge photo inventory



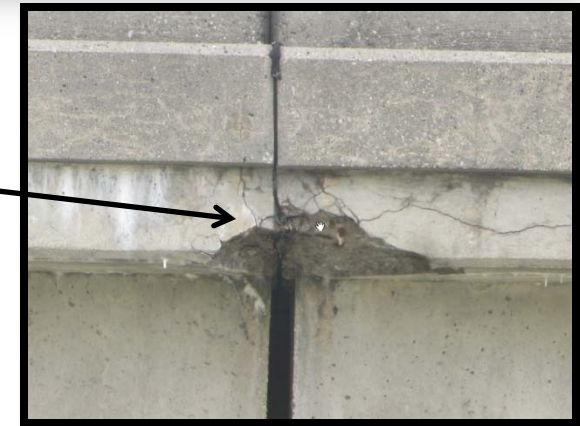
location of the digital photographs being displayed in Google Earth; each box contains a hyperlink to a full-resolution view of the photo taken at that location



# StreetView Style Photography - GigaPan



GigaPan system

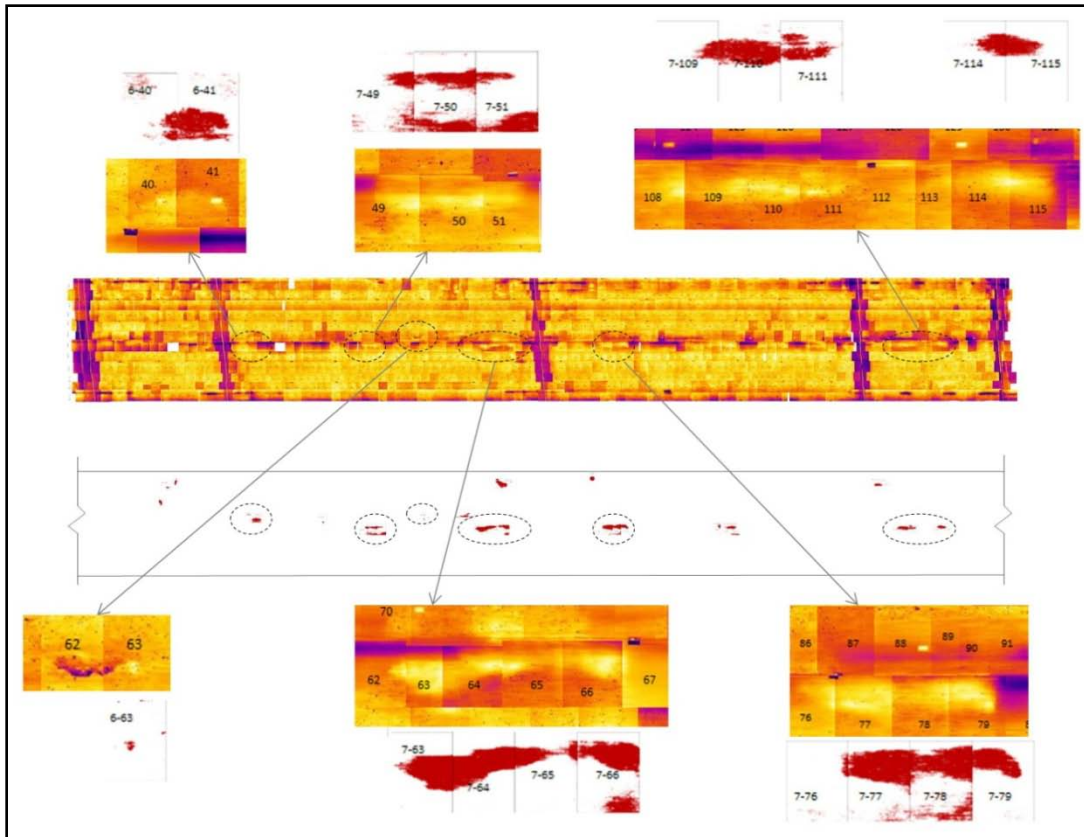


**Profile view of Willow Rd from a GigaPan image.**  
*The full resolution version of this photo captures the entire side of the bridge.*

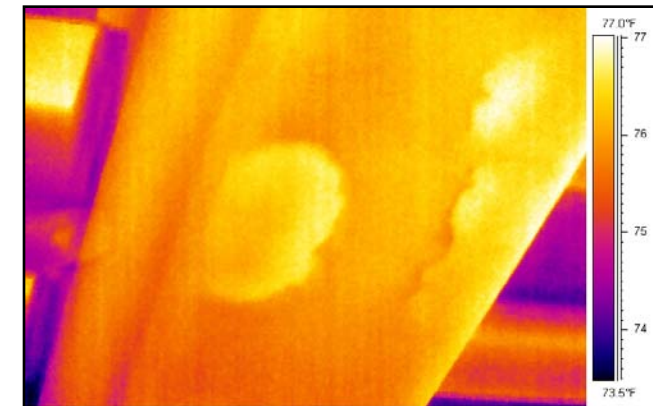
# StreetView Style Photography (BVRCS, GigaPan)

- Benefits
  - Low cost components, rapid deployment, limited time to collect data
  - Useful metrics: easily viewable geo-tagged photo inventory, can compare condition over time with multiple inventories
- Limitations
  - Automation of analysis, not yet at highway speed, GigaPan storage
- Implementation
  - Very close to user ready, “how to deploy” manual

# Thermal IR



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



Optical and Thermal Image highlighting observable subsurface defect

# Thermal IR

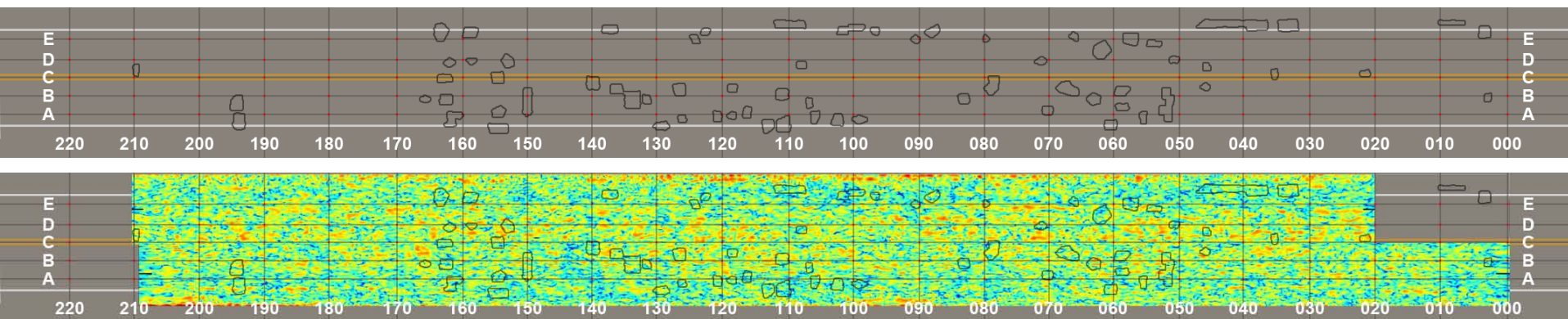
- Benefits
  - Useful metrics: % delamination, detects subsurface defects
  - Qualitative and quantitative assessment tool
- Limitations
  - Collection time, camera specifics, data processing and user interpretation, cost
- Implementation
  - Near user ready, Advanced equipment, “how to deploy” manual



# Ultra Wide Band Imaging Radar System (UWBIRS)



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



# Ultra Wide Band Imaging Radar System (UWBIRS)

- Benefits
  - Potential for useful metrics: % spall and delamination, detects surface and subsurface defects
- Limitations
  - Data processing and user interpretation, cost
- Implementation
  - Advanced equipment, further development to 3D

# Digital Image Correlation



Laboratory set-up



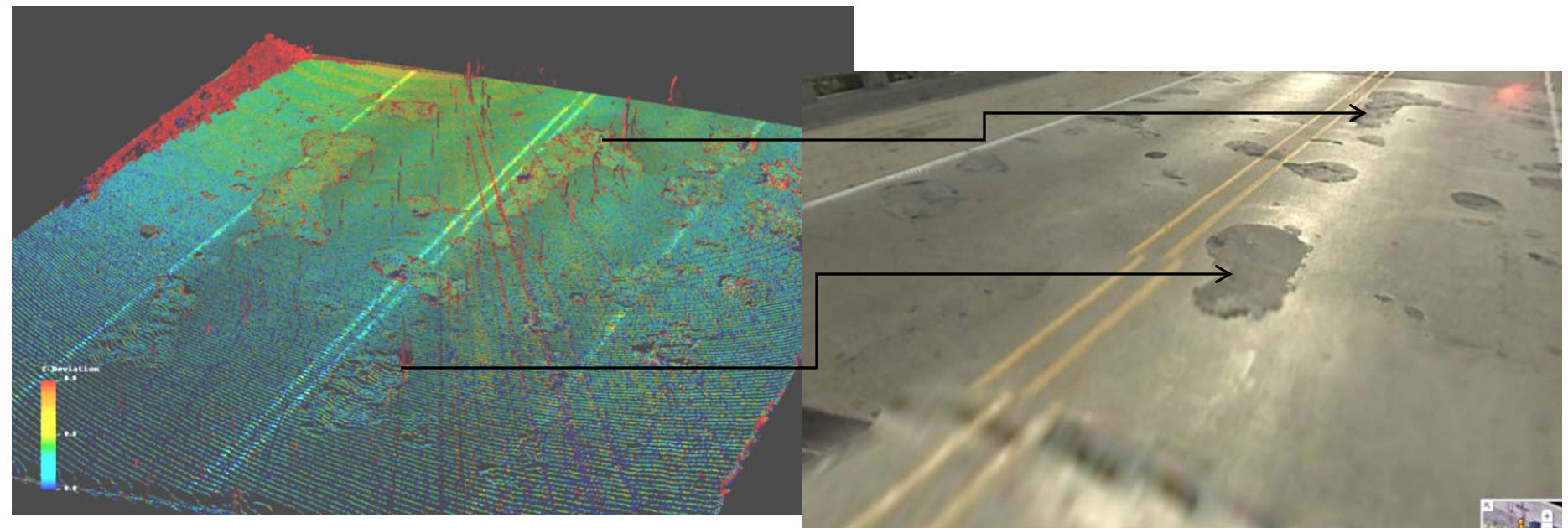
Scaffolding setup at Mannsiding Rd. bridge  
facing exterior girder with speckle patterns

# 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 (LiDAR)



# LiDAR



Composite LiDAR intensity and elevation image.

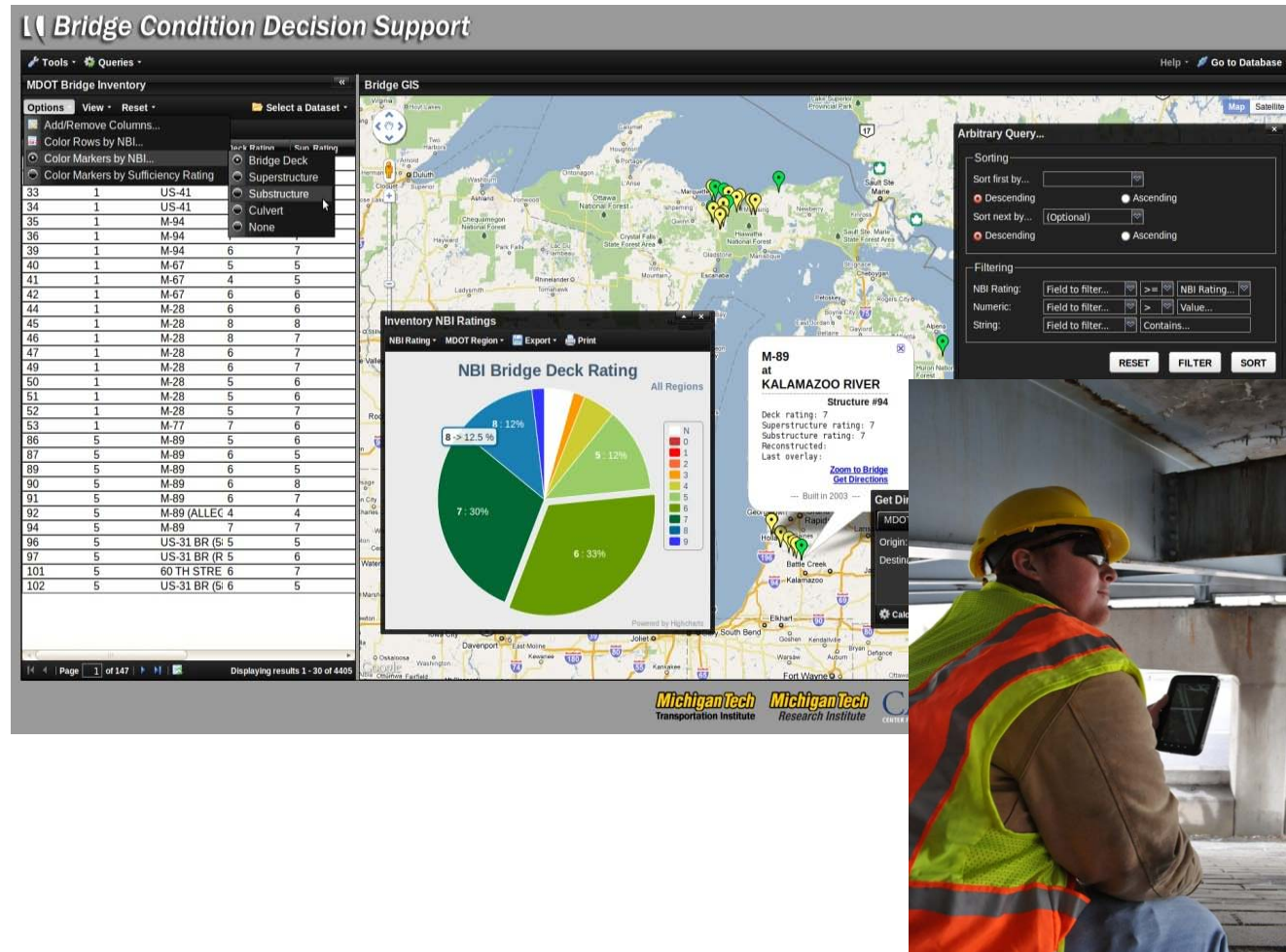
- Surface condition (% spalled, location & volume of spalls, related metrics)
- Global features (e.g. static deflection, high load)

# 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
- Implementation
  - Close to user ready, “how to deploy” manual

# Decision Support System

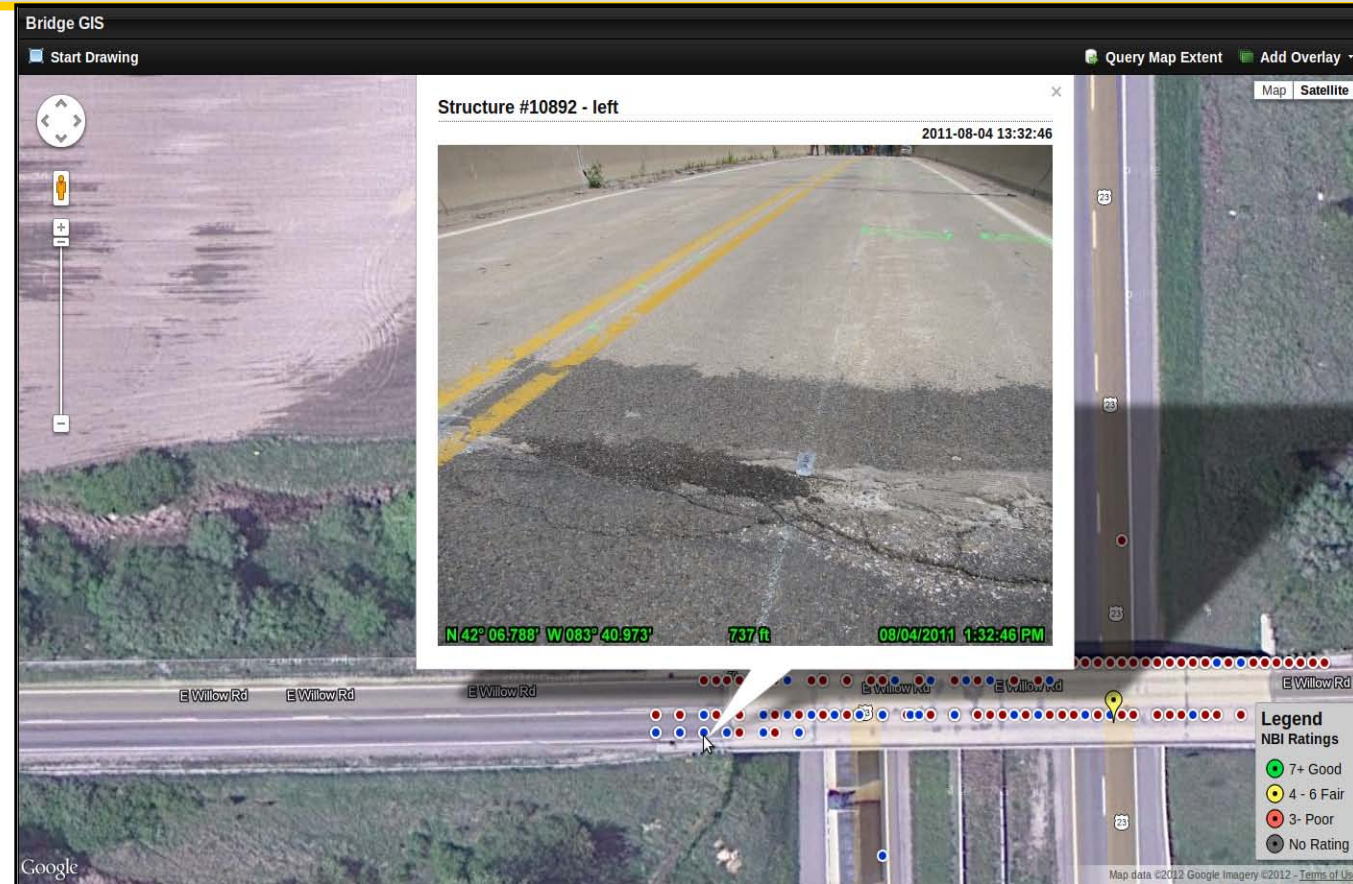
- Bridge Condition data in GIS format
- Web-based interface
- Support bridge management team
- Useful for understanding bridge condition
- Accessible via ruggedized tablets in the field





# Decision Support System and Result Integration

- Integrating existing DOT bridge data as well as remote sensing results
- Combining the results of remote sensing data sets and identifying the relationship with NBI rating



**Geo-tagged photographs from the BVRCS are available as a Points layer in Bridge GIS**



# Decision Support System and Result Integration

- DSS now uses Pontis schema; more portable & updateable
- Bridge condition data is more easily accessible for users, including mapping & custom queries

The screenshot displays a map of Washtenaw County, Michigan, with a pop-up window for 'Structure #10892 - Attributes'. The window has three tabs: 'Summary', 'Bridge Attributes', and 'Latest Inspection'. The 'Bridge Attributes' tab is active, showing a table of bridge data. To the right of the table is a sidebar with links: 'Bridge Attributes', 'Zoom to Bridge', 'Get Directions', 'Bridge Photos', and 'Last Inspection Report'. Below the links, it says 'Region 6 | Washtenaw County'. The map in the background shows the location of the bridge near Ann Arbor and Detroit.

Name	Value
Bridge median	0
County	161
Custodian	1
Date modified	2011-11-07
Deck area	599.000
Deck membrane type	0
Deck protection	0
Deck struct. type	1
Deck surface type	1
Deck width	9.400

**WILLOW RD at US-23**

**Structure #10892**

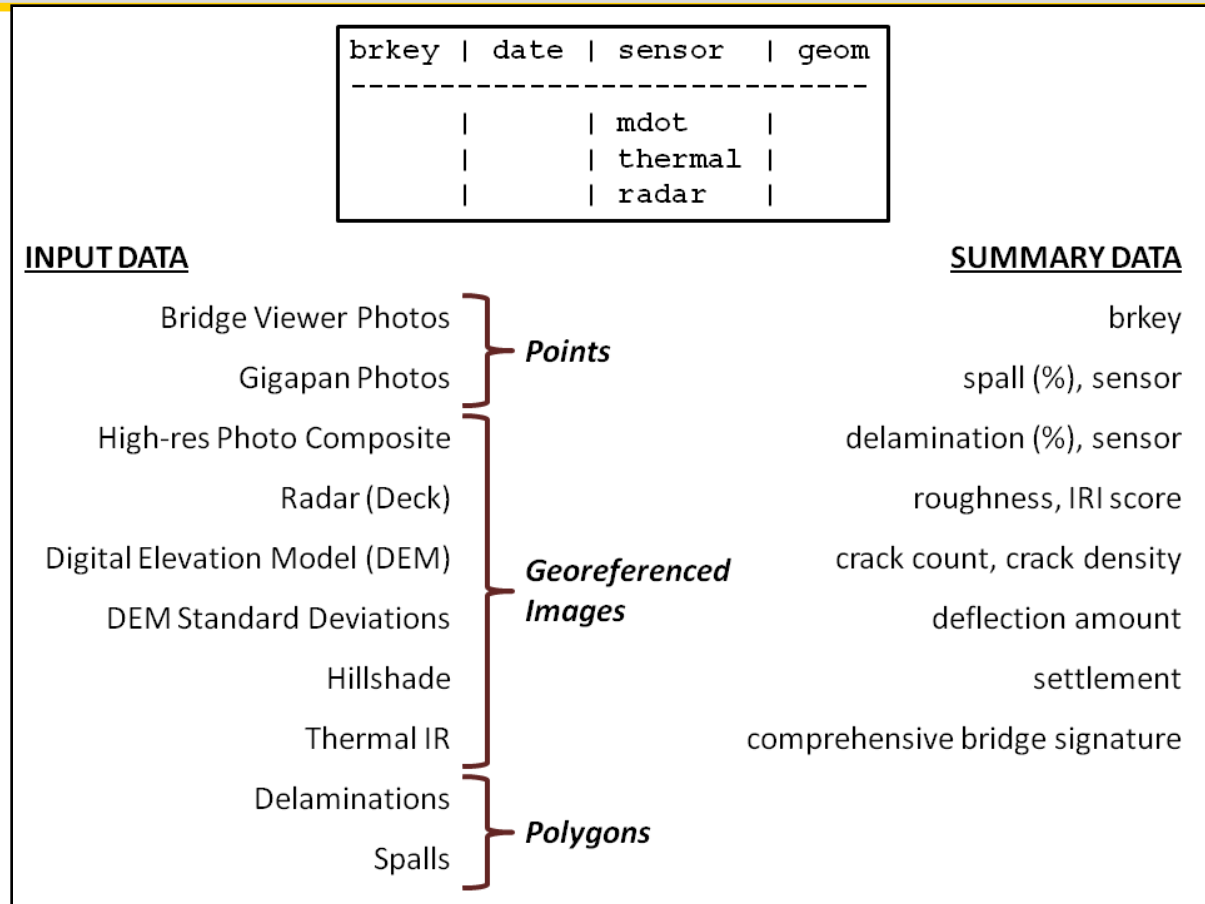
- [Bridge Attributes](#)
- [Zoom to Bridge](#)
- [Get Directions](#)
- [Bridge Photos](#)
- [Last Inspection Report](#)

Region 6 | Washtenaw County

Individual bridge data along with remote sensing results are made available through the DSS

# Decision Support System and Result Integration

- Input remote sensing data can be integrated to create a bridge deck health signature
- Ex: % spalled, % delaminated, roughness



**Concept diagram for remote sensing datasets and their role in the DSS.**

# Closure

- 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
  - Establishing a unique bridge signature
- Closing the gap between technology, demonstrations and DOT use
  - DOT and industry collaborations
  - DOT buy-in nationwide (quantifiable, reliable)
- Refining the “How-to” manuals for DOT use
  - Guides on how to implement & use these technologies

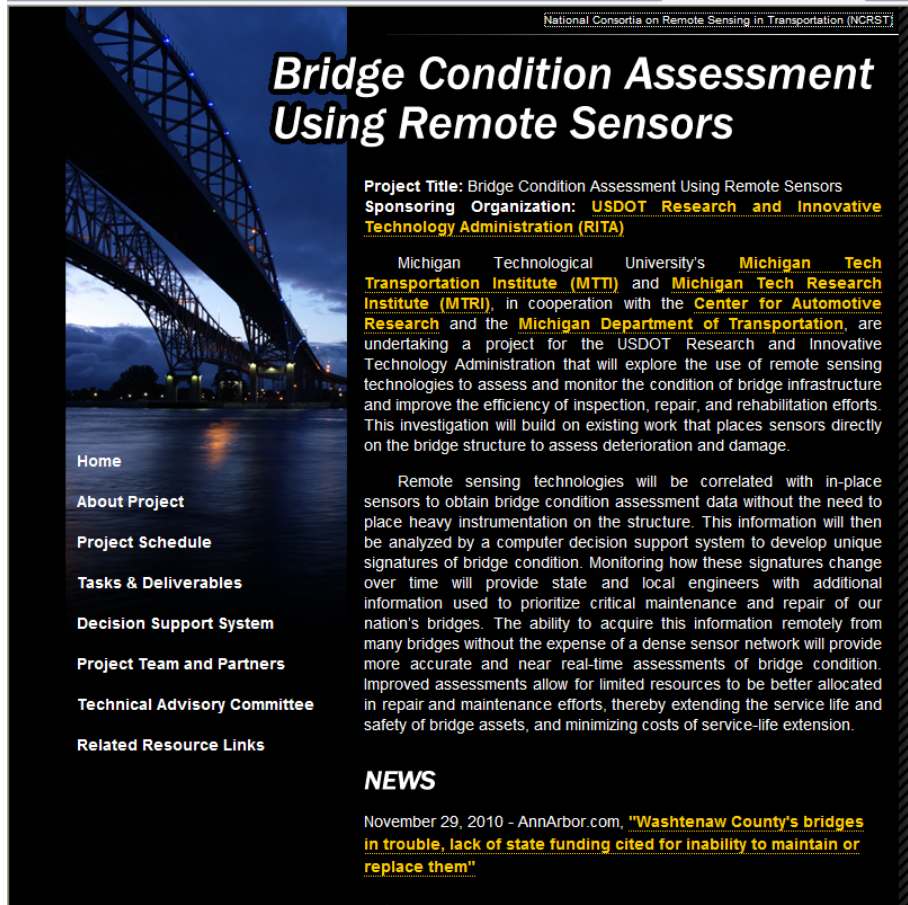
## Project Team / Disclaimer

- 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

**DISCLAIMER:** The views, opinions, findings and conclusions reflected in this presentation are the responsibility of the authors only and do not represent the official policy or position of the USDOT/RITA, or any State or other entity.



Website: [www.mtti.mtu.edu/bridgecondition/](http://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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