Measuring and Communicating Bridge Performance with Remote Sensing Technologies

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Michigan Tech CAR CENTER FOR AUTOMOTIVE RESEARCH RITA MDOT Department of Transportation

Presentation Outline

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

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

Settlement

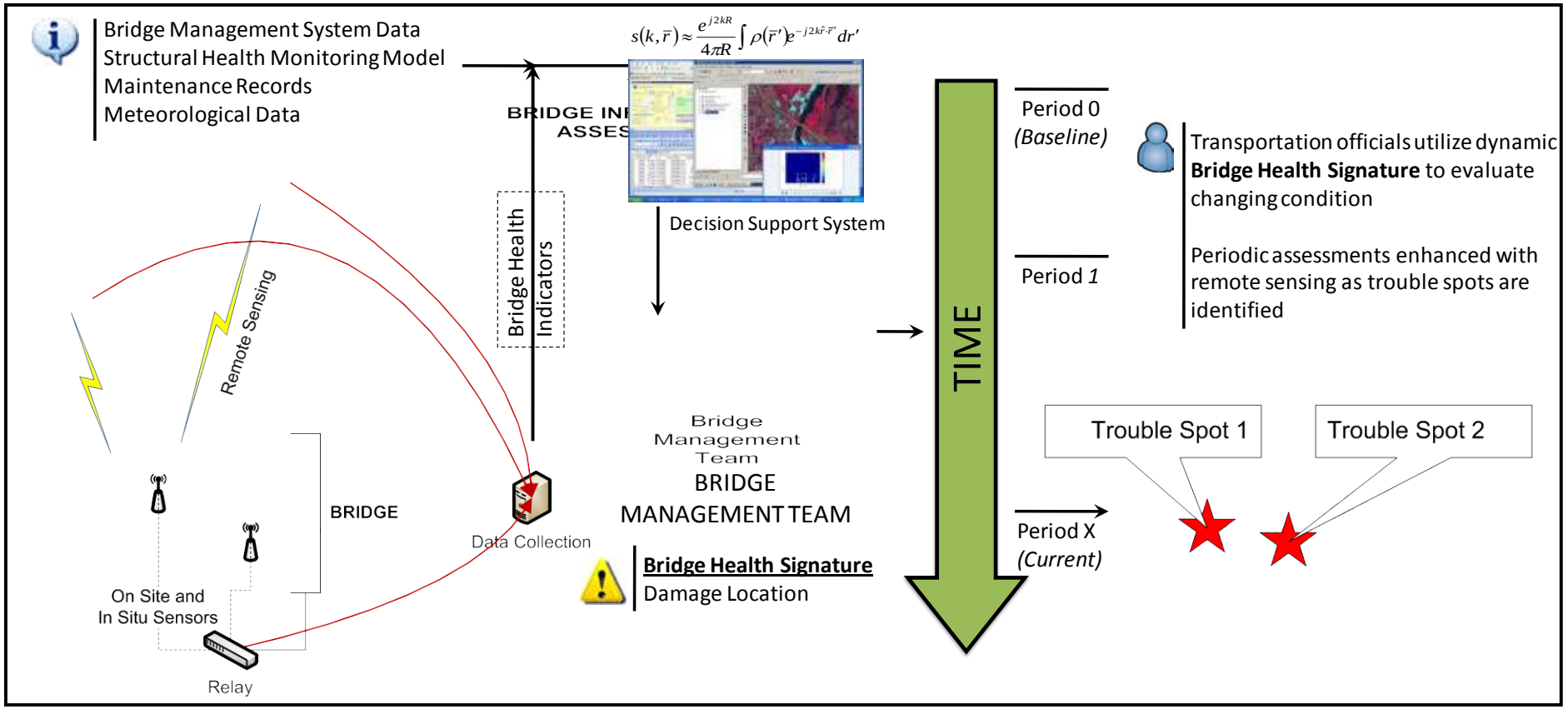
Deteriorated Bearing

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)



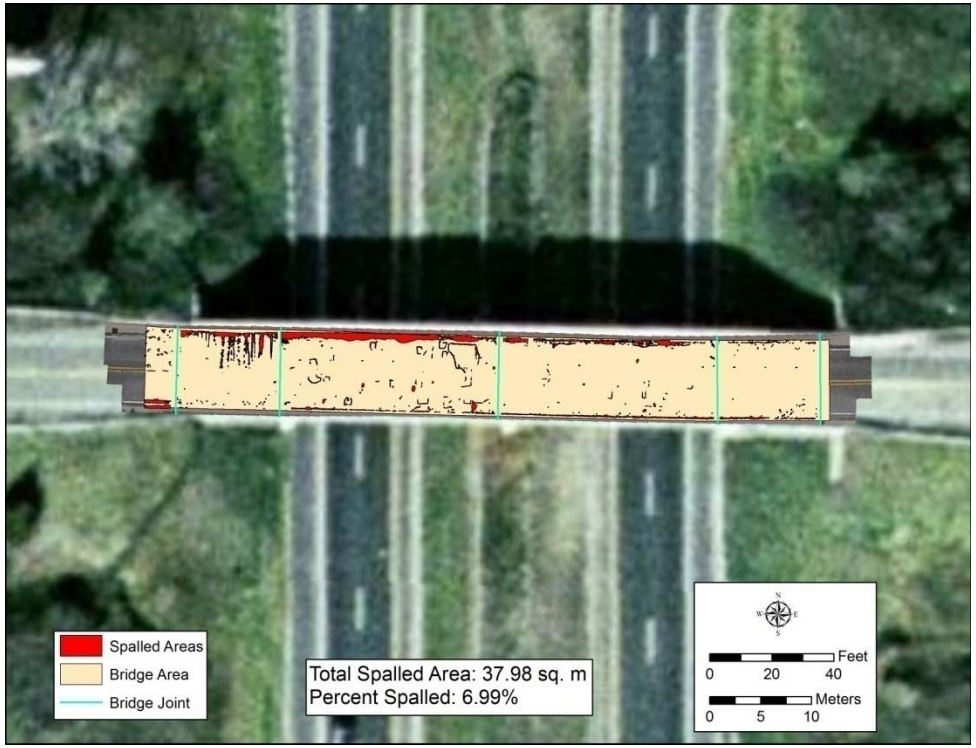
Technology Selection

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

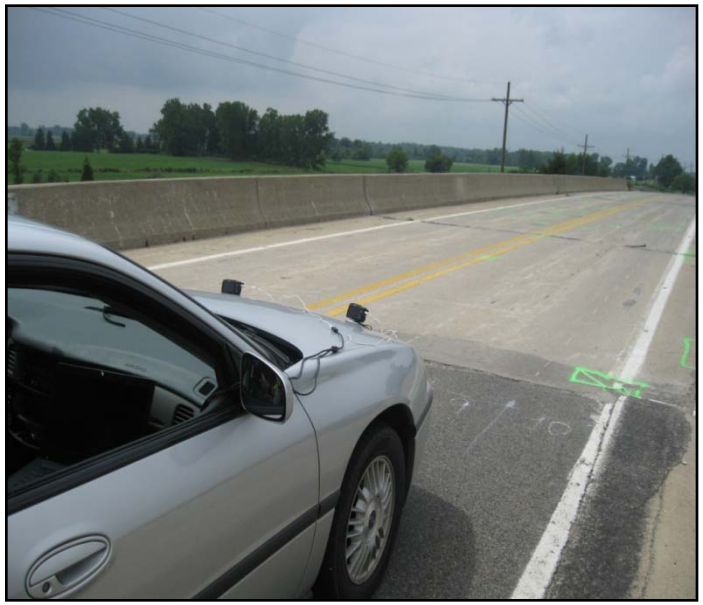


Visual of percent spalled area for the Willow (6.99% spalled) Road bridge using 3DOBS data as the input and ArcGIS as the analysis software

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

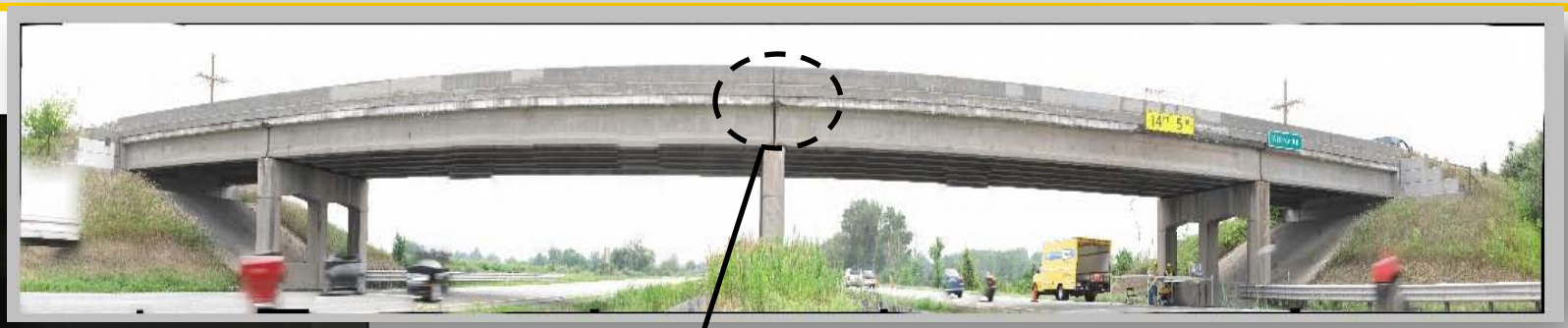


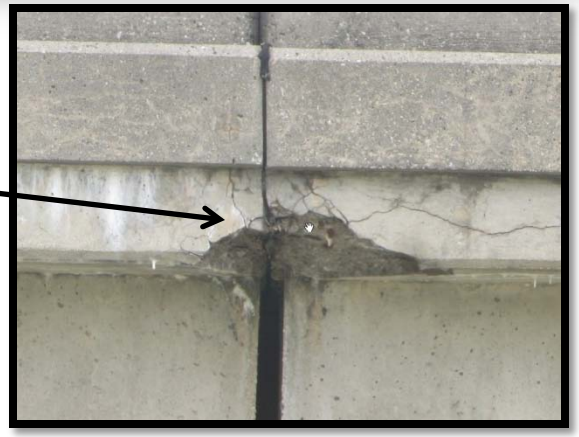
Deployed on Freer Rd to capture a bridge photo inventory

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



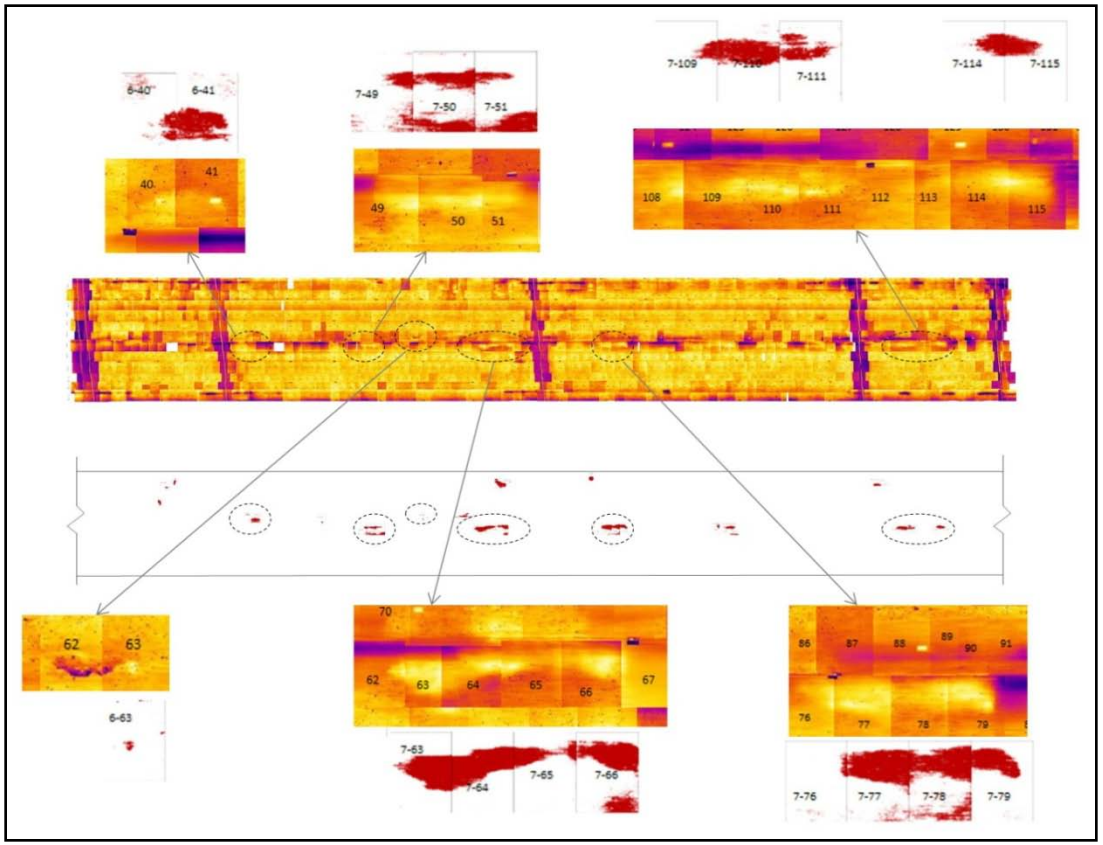


Profile view of Willow Rd from a GigaPan image.
The full resolution version of this photo captures the entire side of the bridge.

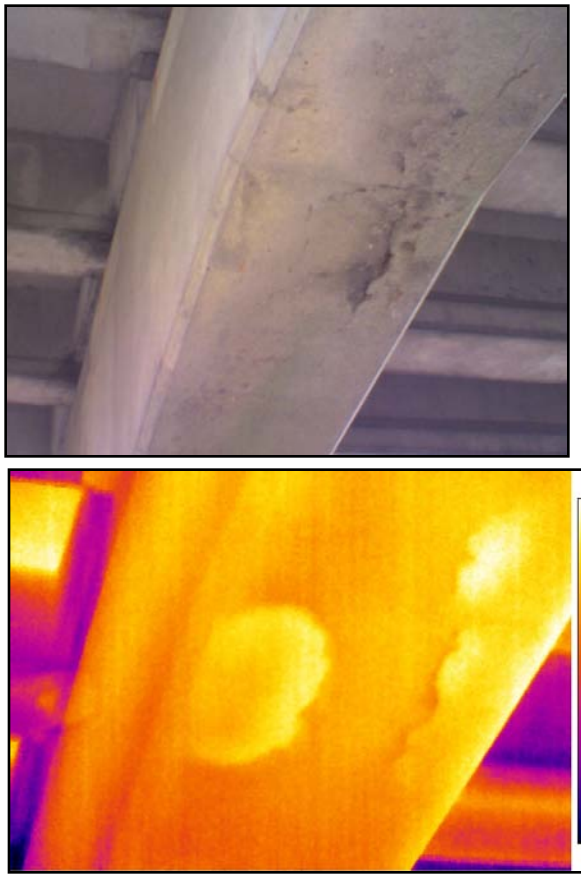
StreetView Style Photography (BVRCS, GigaPan)

- 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



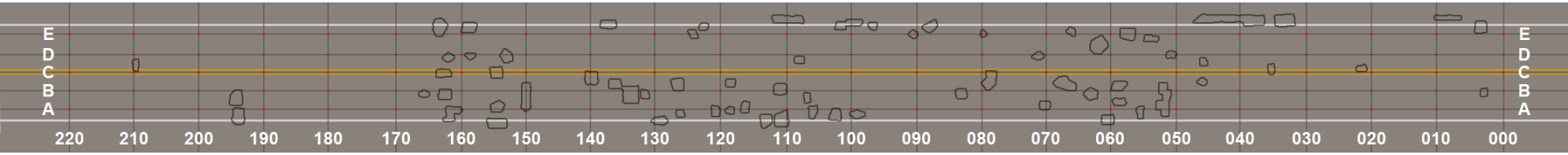
Optical and Thermal Image highlighting observable subsurface defect

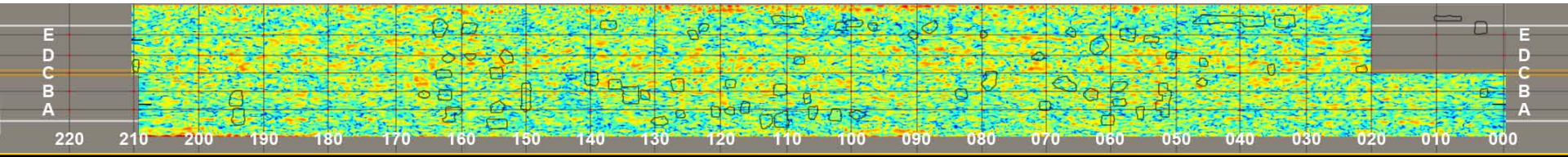
Thermal IR

- 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

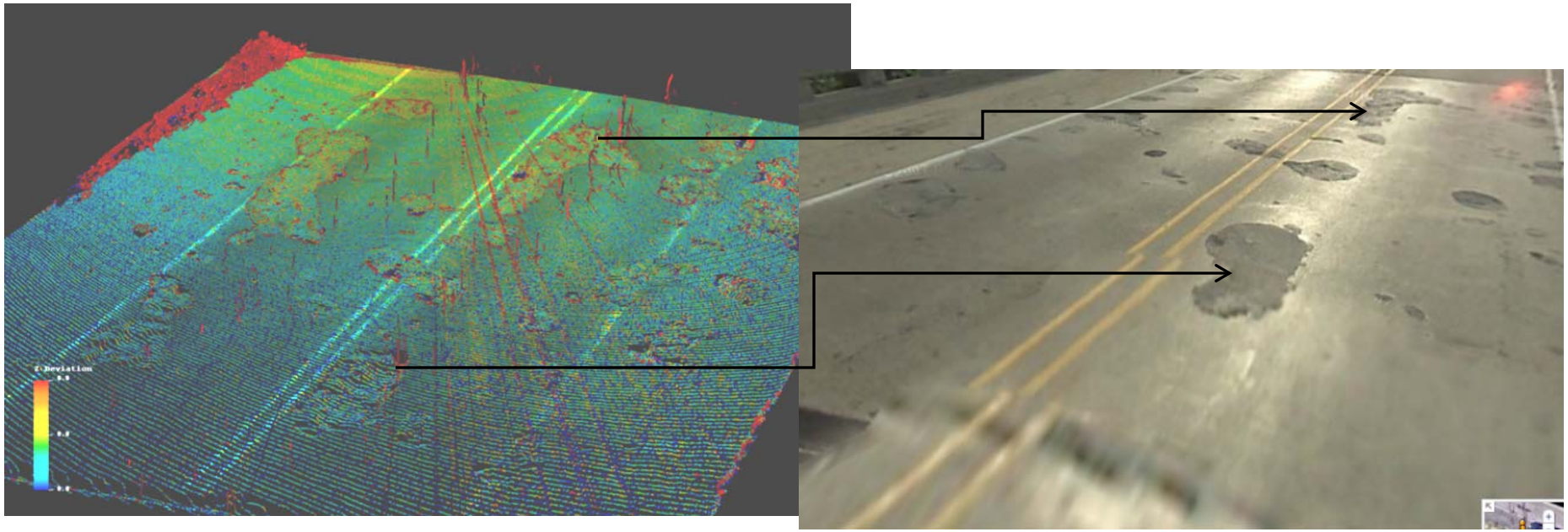
Laboratory set-up

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.

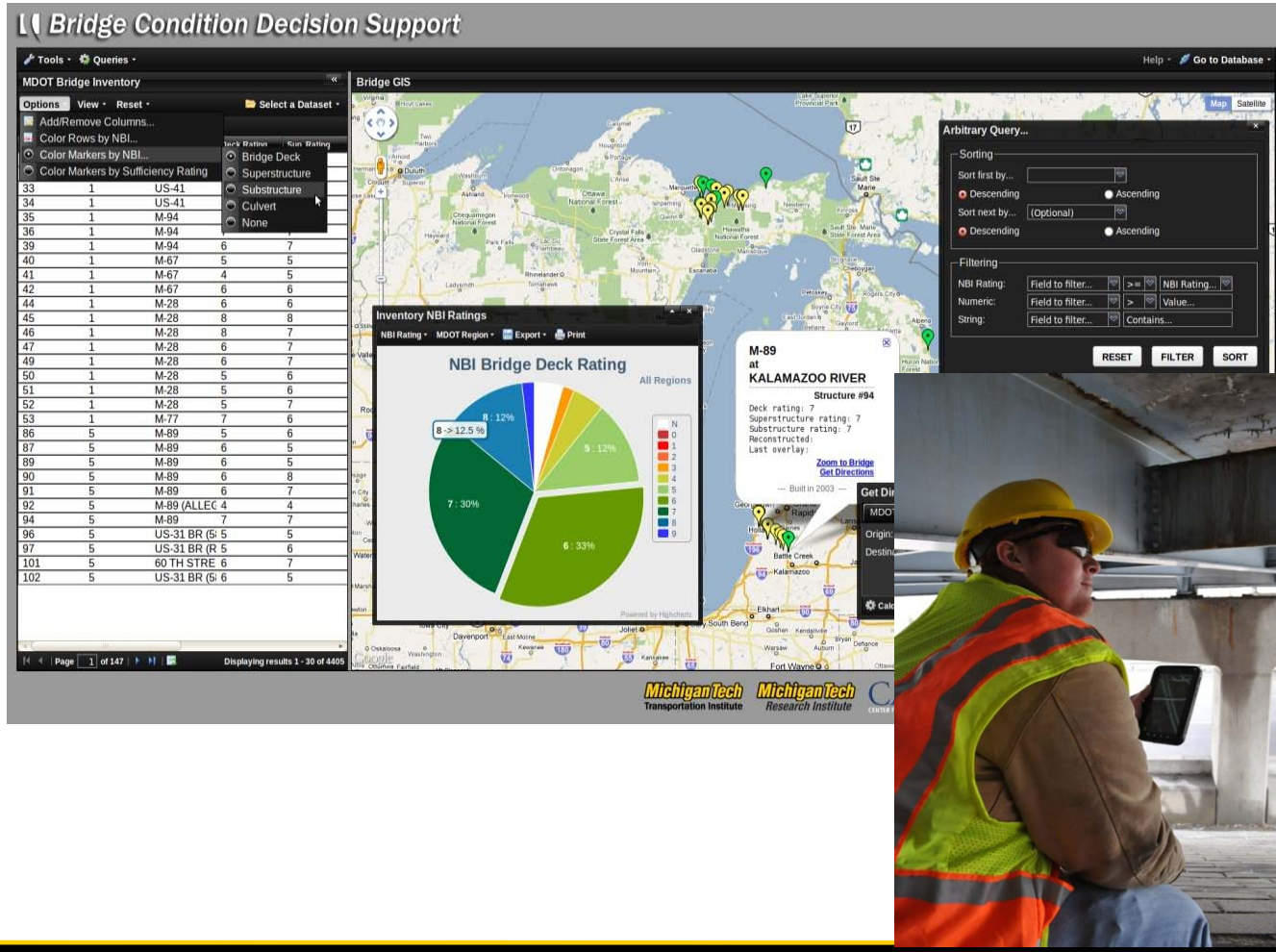
- Surface condition (% spalled, location & volume of spalls, related metrics)
- Global features (e.g. static deflection, high load)

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

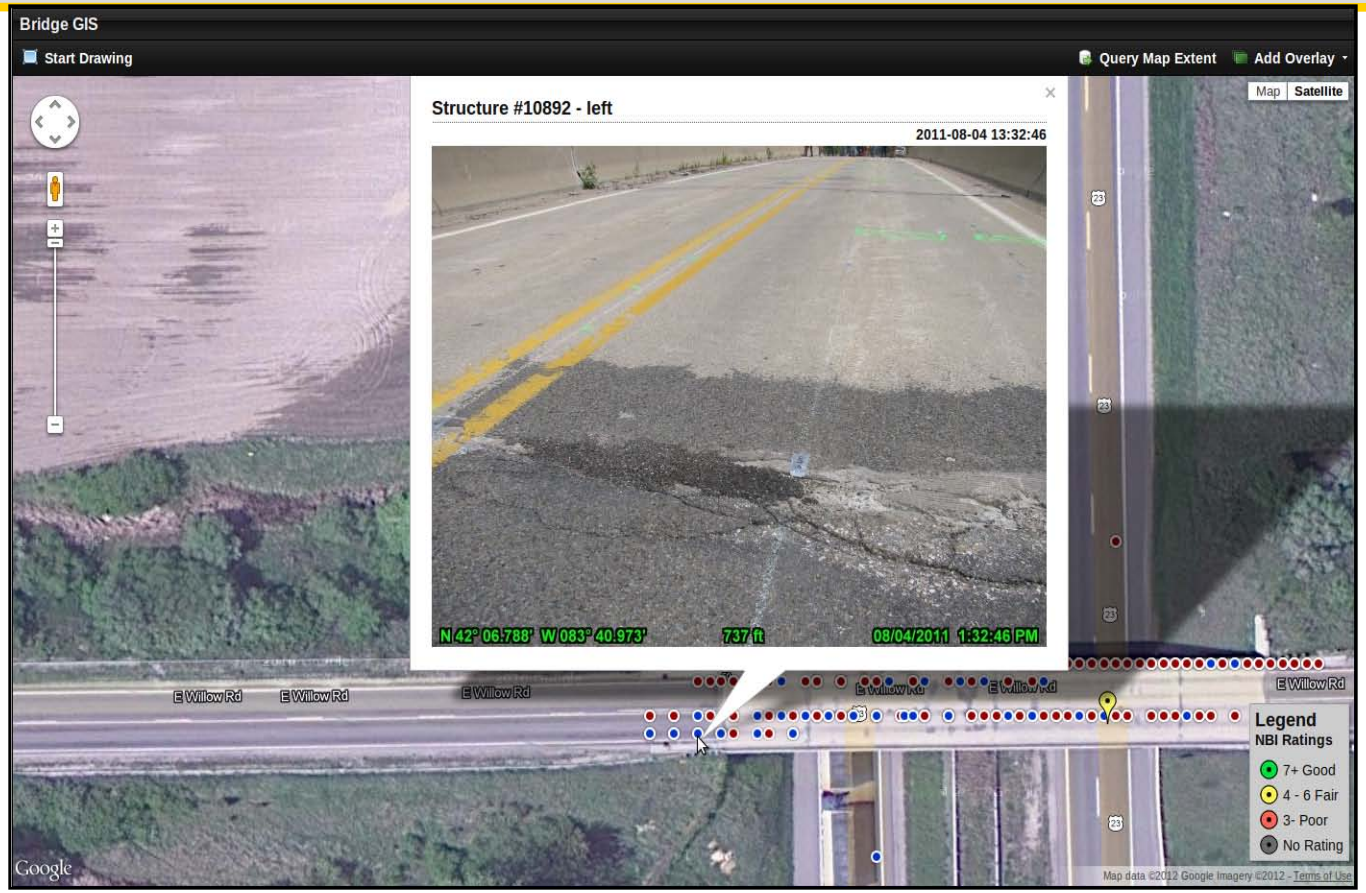
- Bridge Condition data in GIS format
- Web-based interface
- Support bridge management team
- Useful for understanding bridge condition
- Accessible via ruggedized tablets in the field



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

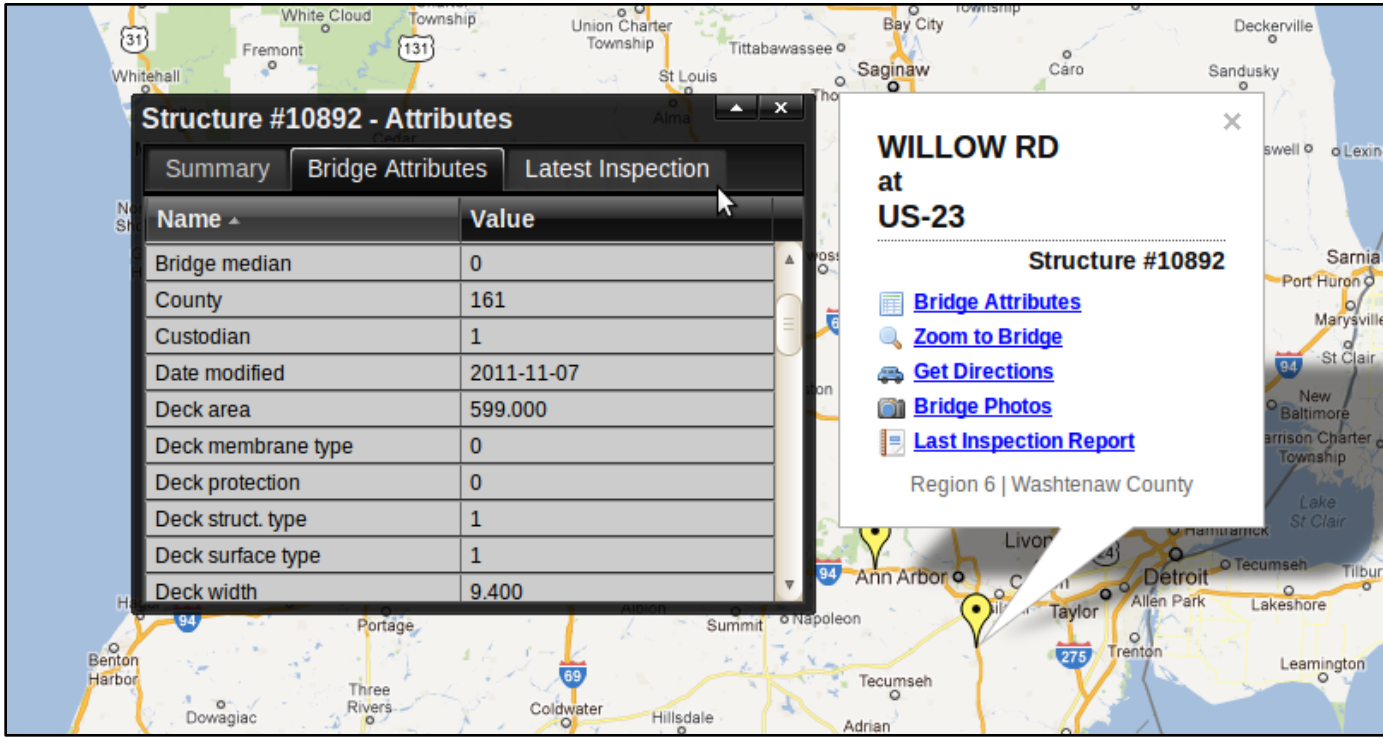


Geo-tagged photographs from the BVRCS are available as a Points layer in Bridge GIS

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

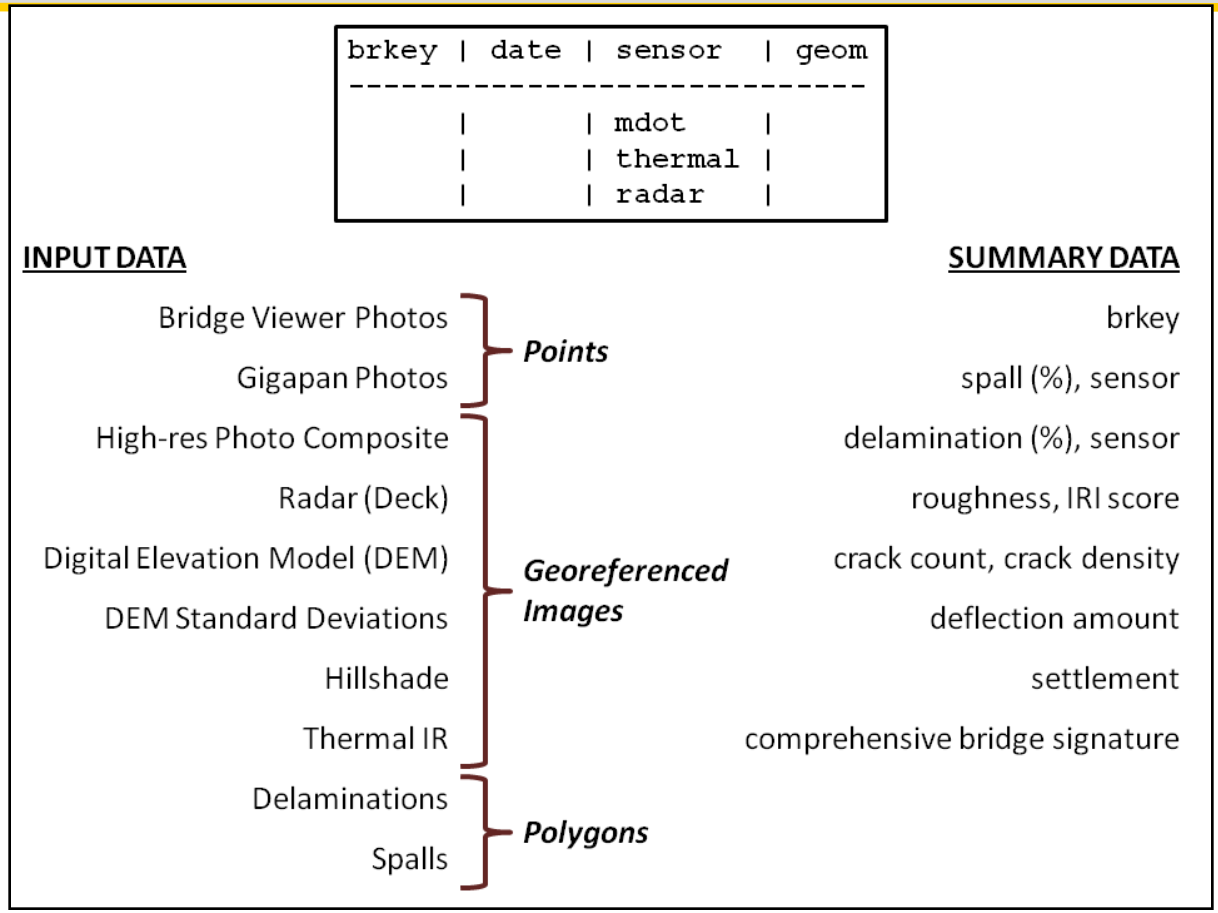


Individual bridge data along with remote sensing results are made available through the DSS

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

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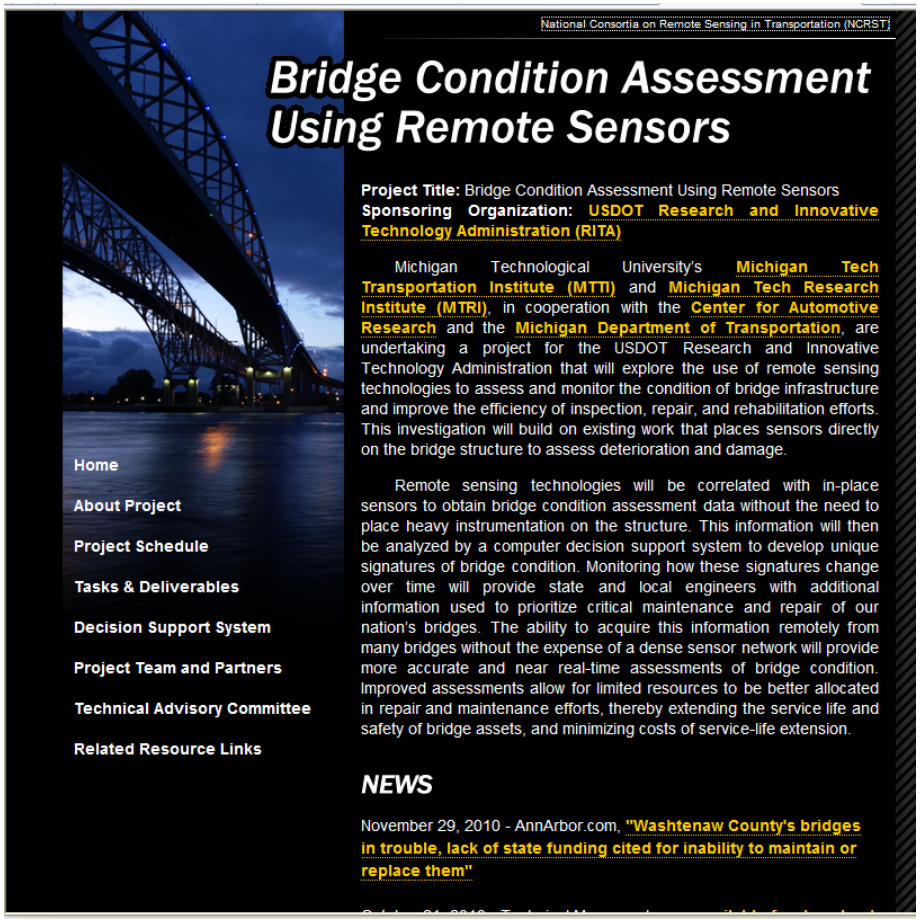
Website: www.mtti.mtu.edu/bridgecondition/



Questions and Comments

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