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

Tess Ahlborn, Ph.D., P.E., FPCI
Devin Harris, Ph.D., Colin Brooks and Larry Sutter, Ph.D.
Michigan Technological University

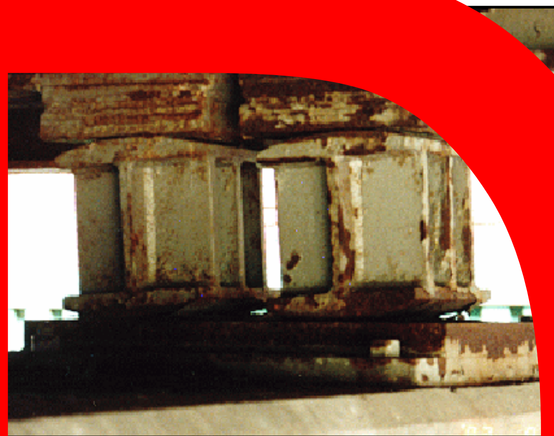
SHMII-5: 5th International Conference on Structural Health Monitoring of Intelligent Infrastructure
December 13, 2011; Cancun Mexico

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

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

D

Settlement



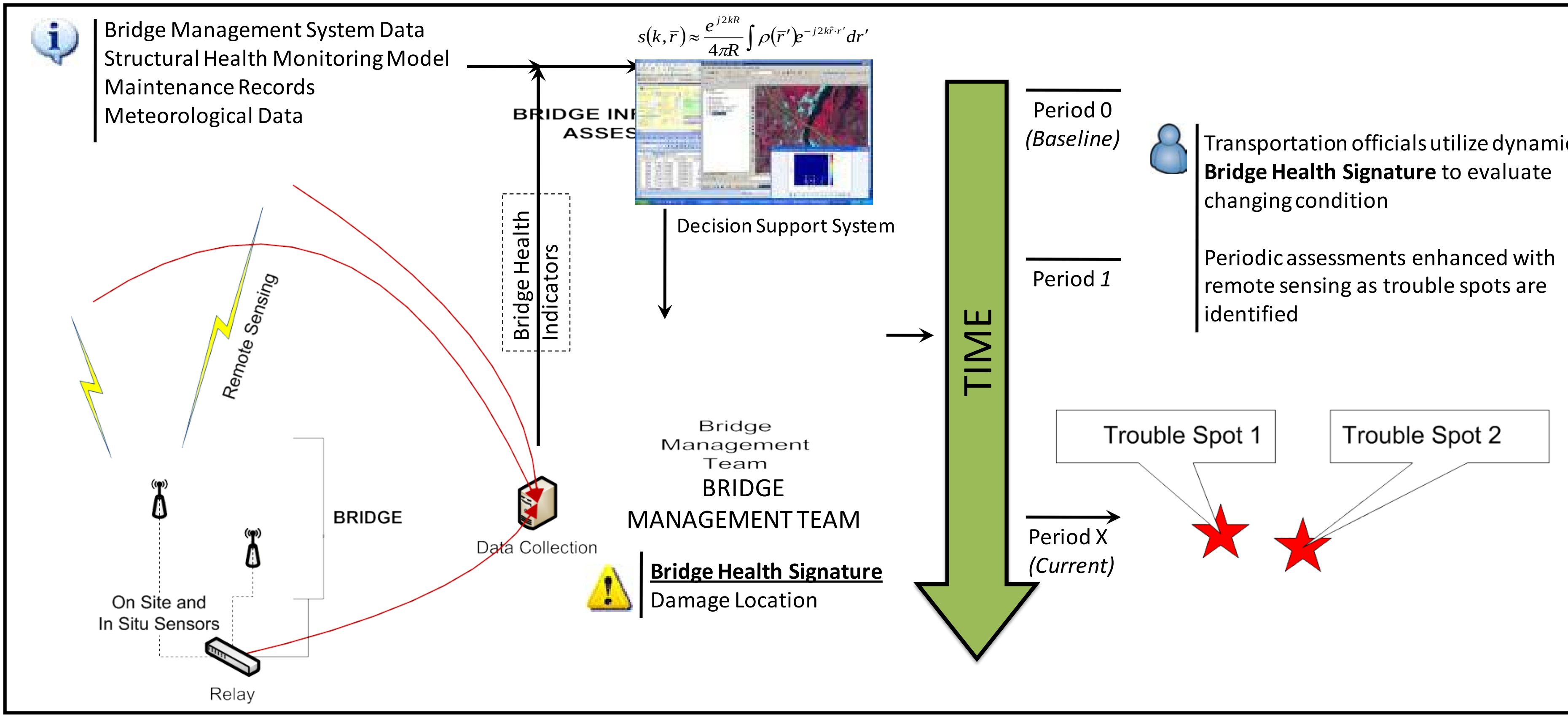
Deteriorated Bearing

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	Digital Image Correlation, LiDAR, Interferometric Synthetic Aperture Radar (InSAR)

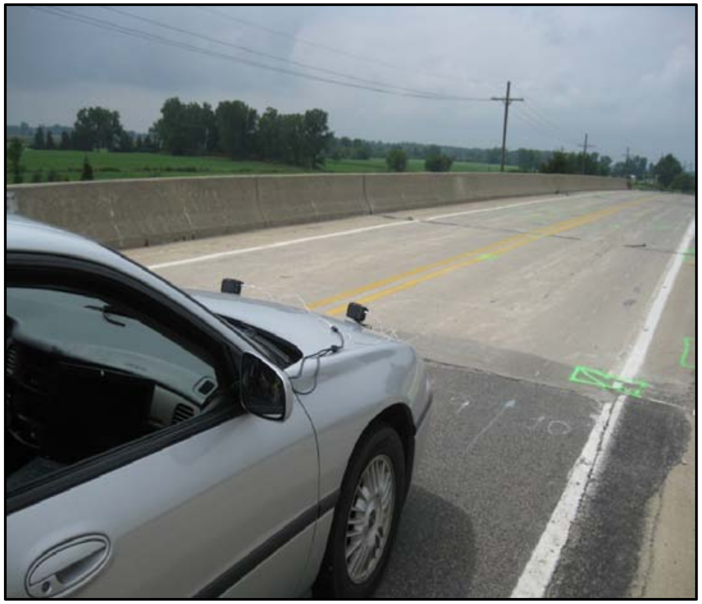
Technology Selection: commercially available technologies to enhance current inspection processes, including safety, while minimizing traffic disruption.

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 (6.08% 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

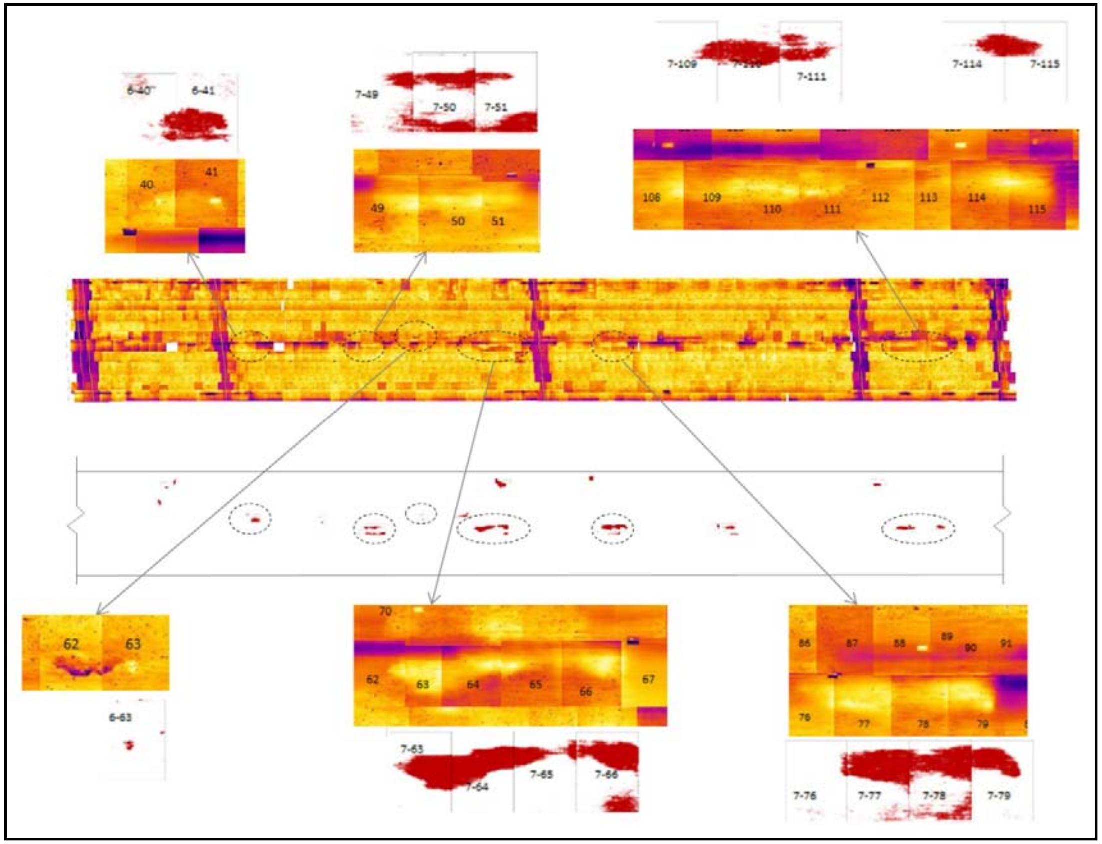
Profile view of Willow Rd from a GigaPan image. ***The full resolution version of this photo captures the entire side of the bridge at very high resolution.***

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

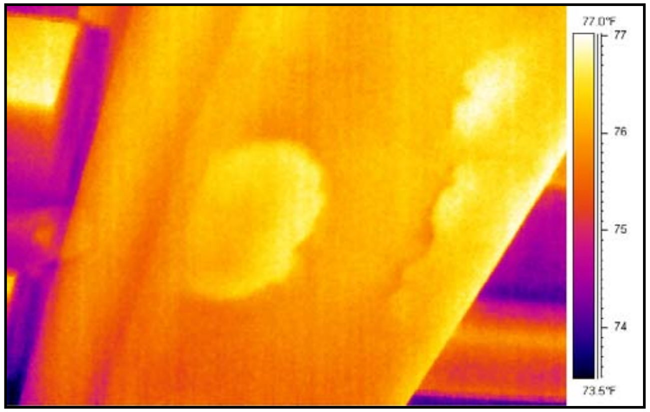
Surface: 3DOBS, BVRCS, GigaPan

- 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



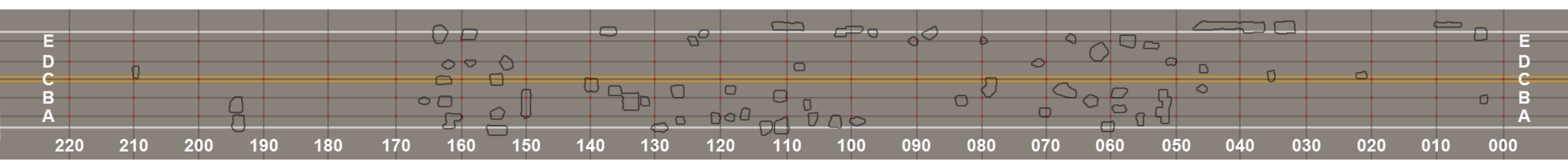
Bridge deck delamination map created by thermal IR images and output data

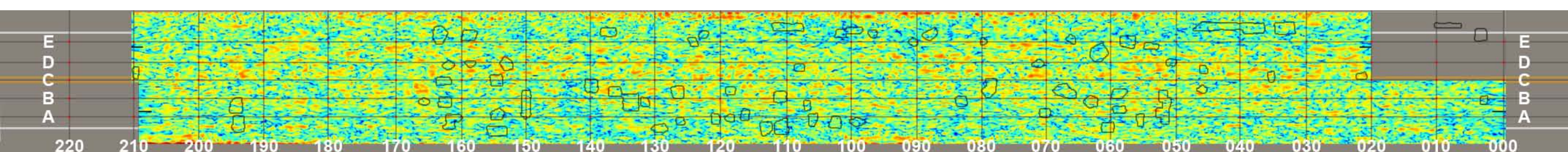


Optical and Thermal Image highlighting observable subsurface defect

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

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



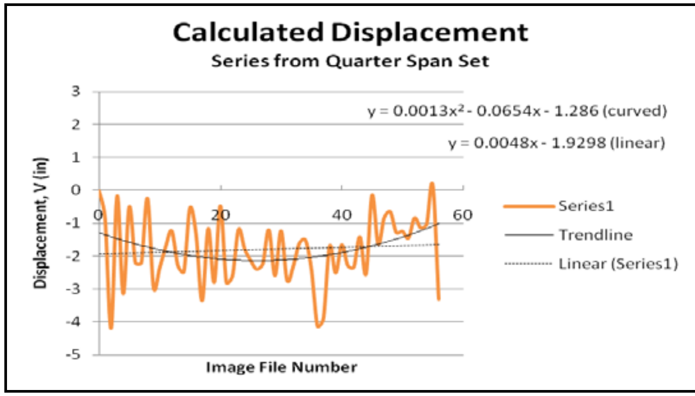


Subsurface: Thermal IR, SAR

- 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

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

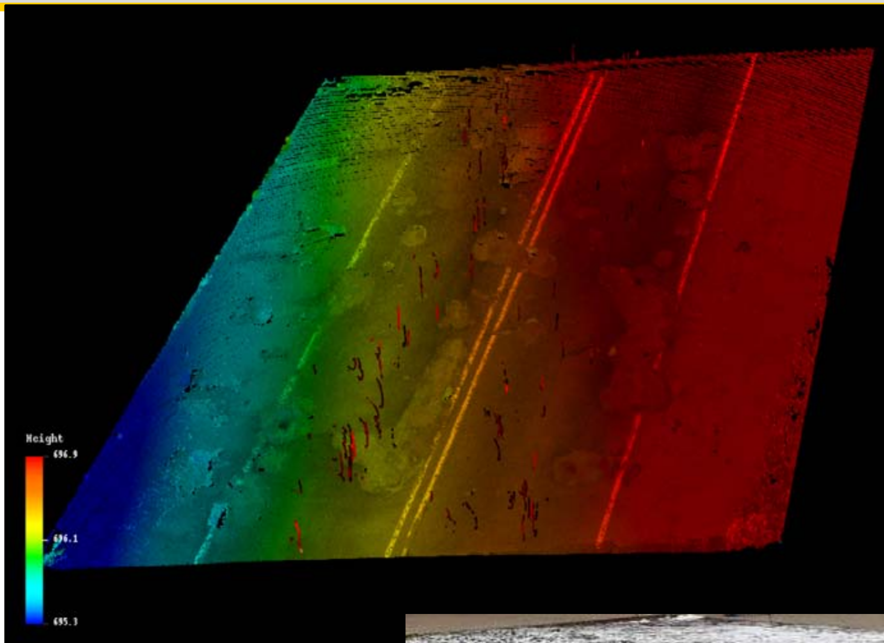


Graphical plot of calculated displacement

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**

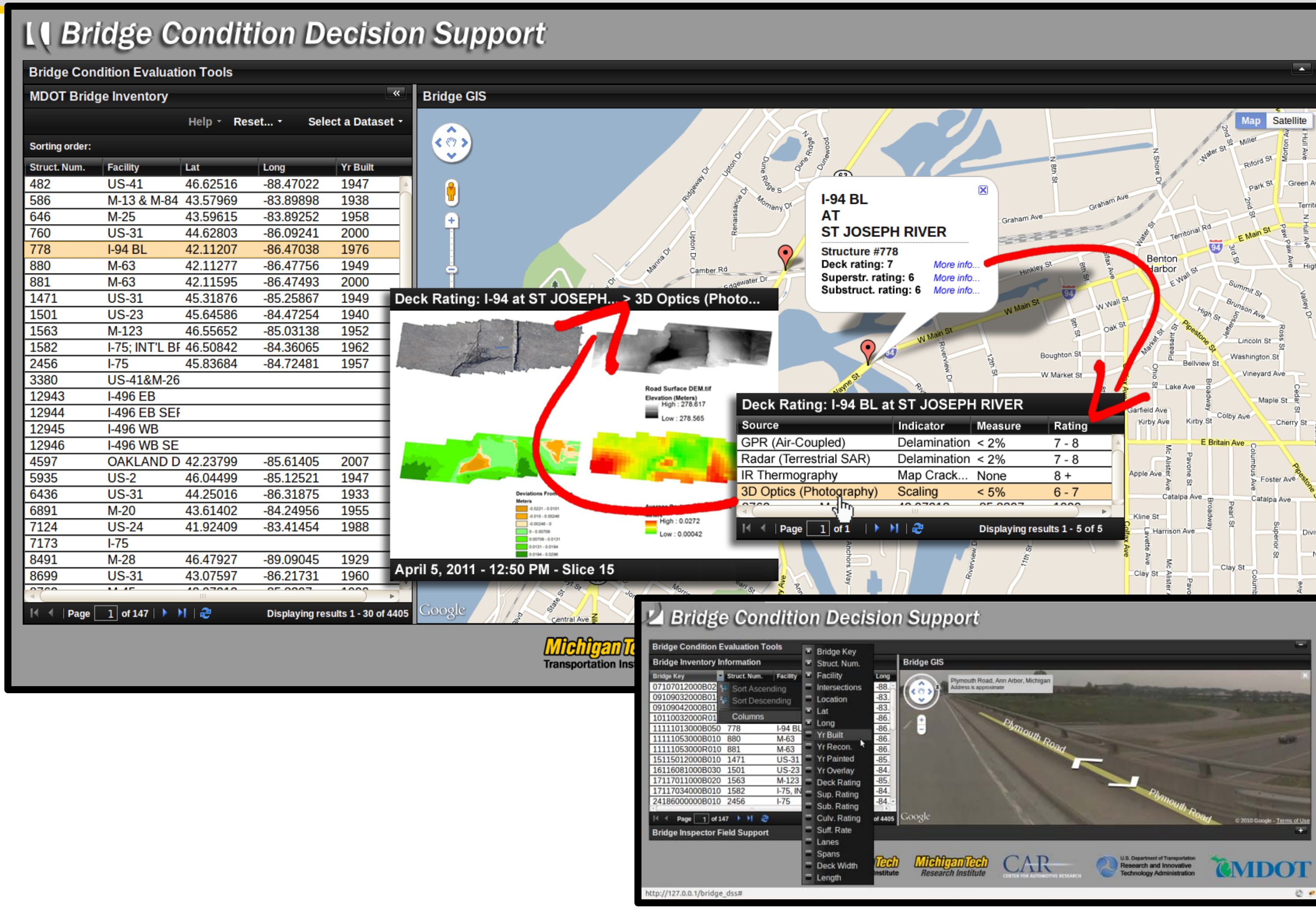
LiDAR

- 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)

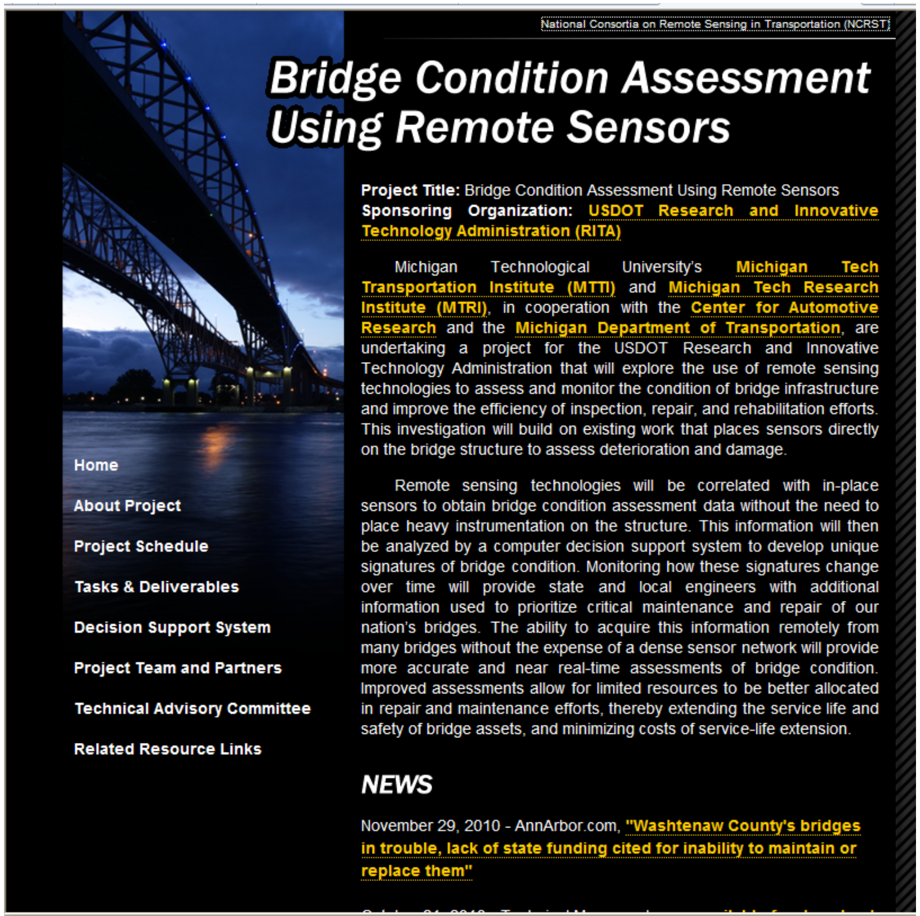
- Refining the "How-to" manuals for DOT use
  - Guides on how to implement & use these technologies

- 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

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



Questions and Comments

Contact Information: Prof. Tess Ahlborn, tess@mtu.edu