Michigan Tech Research Institute

# Using UAV Collected Bridge Condition Data for a Rating Exercise

## Intro to UAV-enabled methods to collect & process bridge condition data

*Michigan Bridge Conference, 3/21/2017*

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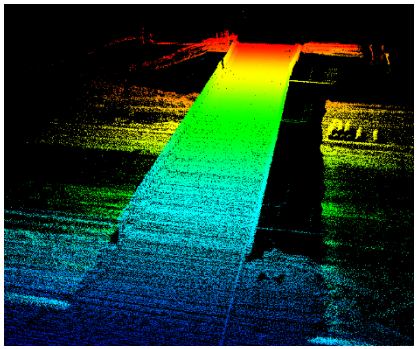
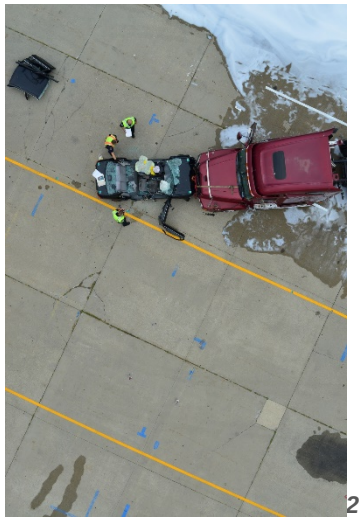
Michigan Tech Research Institute

# MDOT 2nd phase project focused on implementation of UAVs

- "Implementation of Unmanned Aerial Vehicles (UAVs) for Assessment of Transportation Infrastructure"
- Project duration 5/1/16 – 5/31/18
- Building from first phase, "Evaluating the Use of Unmanned Aerial Vehicles for Transportation Purposes", 5/22/13 – 11/30/14, focused on demonstrations
  - Bridge condition data
  - Traffic monitoring
  - Confined space inspection
  - Crash scene reconstruction





- http://www.mtri.org/mdot_uav.html

# Objectives of MDOT Phase II Study

**The objectives of the Phase II research project are:**

1. Develop, deploy, and implement **near-time data** collection communication backhaul and data storage capabilities proof of concept for the most viable UAV platforms and sensing capabilities.
2. Develop, deploy, and implement (via **pilot projects**) UAV data uses, analysis, and processing systems delivered from on-board sensors for two (2) to three (3) specific business functions/activities identified by MDOT.
3. Demonstrate, deploy, and implement (via pilot projects) **data quality protocols** to ensure data collected is accurate and within tolerance requirements when compared to current data collection systems at MDOT for the same two (2) to three (2) specific business functions/activities identified by MDOT.
4. Demonstrate a proof of concept for data collection uses UAVs for transportation purposes, beyond those proven during Phase 1, from **various highway assets**.
5. Coordinate/leverage ongoing and past research of UAV sensing and data collection technologies. **Provide device training and deployment/implementation plan**, including a user/operation guidance document.
6. Determine the **return on investment** (benefit/cost analysis) performed on UAVs and sensory technologies deployed for pilot studies performed for this research project.
7. Secure a **Federal Aviation Administration** (FAA) Certificate of Authorization (COA) to complete the below tasks and deliverables.



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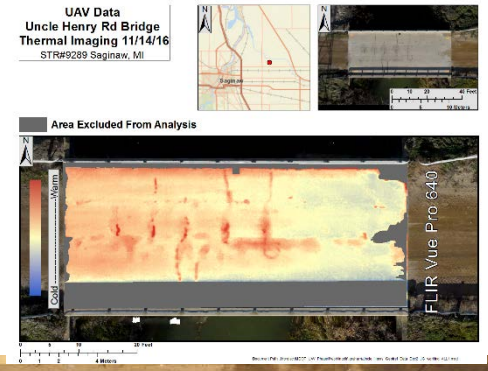
# Bridge Field Data Collections

Warren Road (Maple River) – Str: 9852 – Shiawassee Co.

Gordonville Road (Little Salt Crk) - Str: 6999 – Midland Co.

Uncle Henry Road (U.Henry Drain) - Str: 9298 – Saginaw Co.

Beyer Road (Cheboyganing Crk) - Str: 9293 – Saginaw Co.



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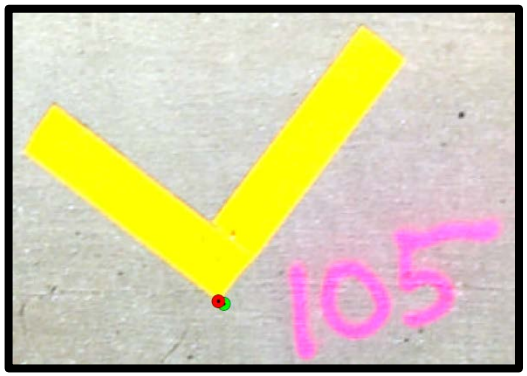
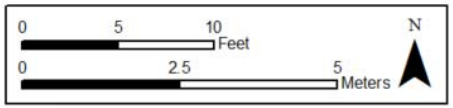
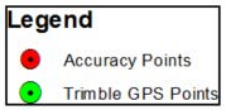
# Methods – ground control needed

- Survey-quality ground control (cm accuracy) with Leica GPS to enable high-resolution referencing of point clouds, imagery, other UAV results

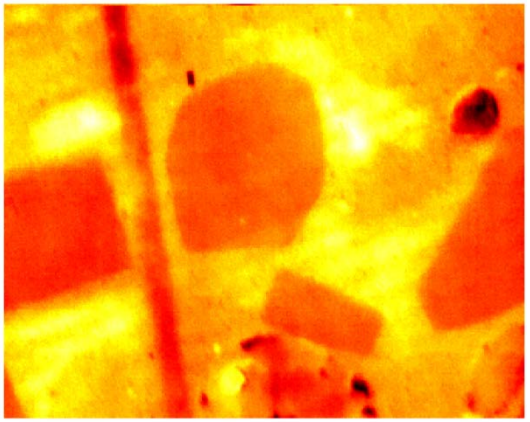


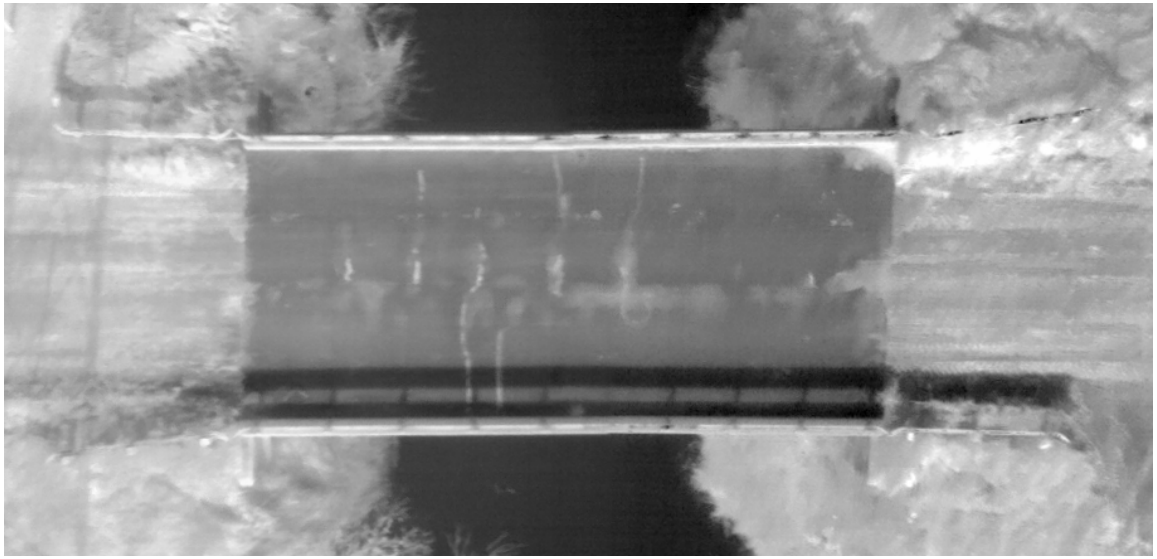



# Methods: Thermal Sensors

FLIR Tau 2 – 640 x 512 sensor



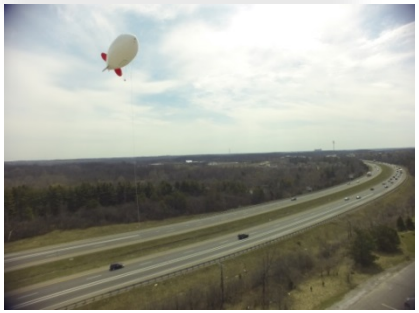
FLIR Vue Pro -640 x 512 sensor (Pro R now available)

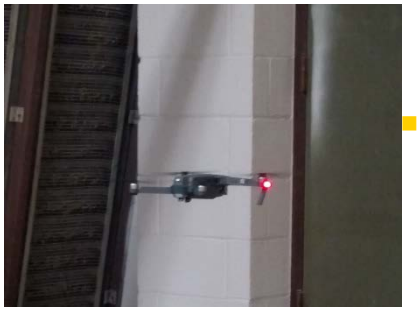


# Methods: Optical Sensor

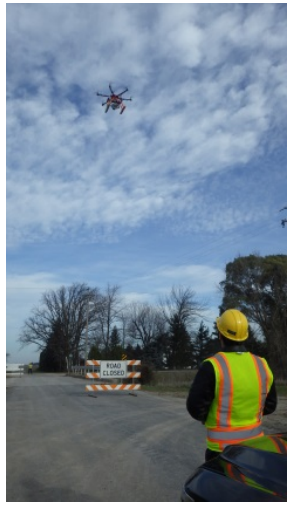

- Nikon D800 – full-sized (FX) sensor, 36.3 MP, 4 fps - $3,000
- 50mm prime lens ($800)
- Collect stereo overlapping imagery to create cm-resolution 3D surfaces
- New LiDAR sensor (Velodyne 16) coming


# Methods: UAV Platforms



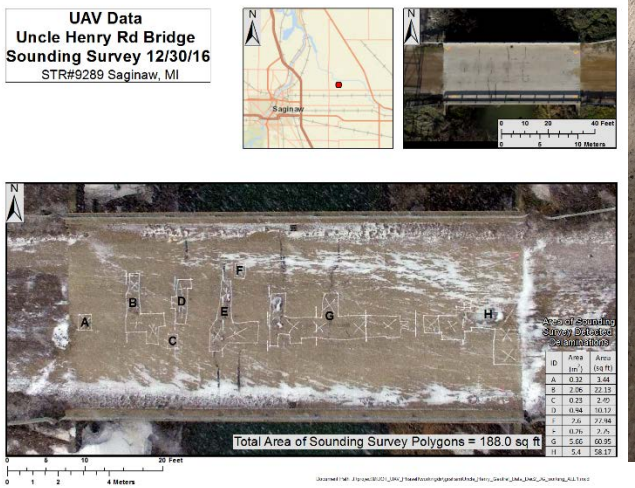


- Multiple platforms have been used based upon space and sensor size restrictions
- **Bergen Hexacopter** (made in MI)
  - Price: ~ $5,000
  - Flight time: 20 min
  - Payload: 4.5 kg (~10 lbs)
  - Built from USDOT OST-R CRS&SI project on Unpaved Road Assessment project http://www.mtri.org/unpaved/
- Aerostat / Tethered Blimp
  - Price: ~ $900
  - Diameter: 1.7 m
  - Net lift: 3.6 kg (~8 lbs)

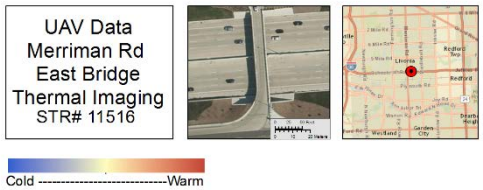


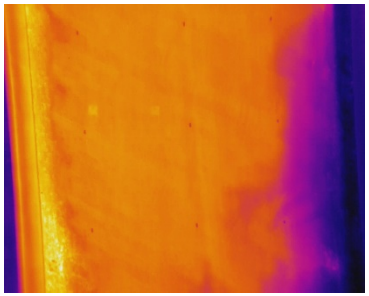
- Imaging small quadcopters
  - DJI Phantom 2 Vision, 3 Advanced
  - 3D Robotics IRIS+
  - Mariner (waterproof)
  - DJI Mavic Pro
- Micro-UAS quadcopters
  - Heli-Max 1Si, Walkera QR 100s, & Qualcomm Snapdragon
  - Flight time: < 10 min
  - Snapdragon has sense & avoid capabilities
  - Size: fits in palm of hand
  - Weight: < 1 lb

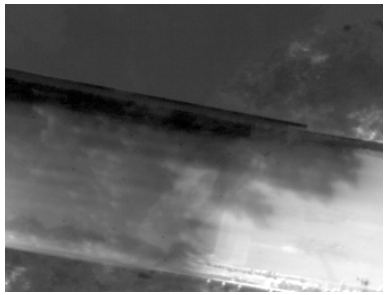
# Method: Collect ground comparison data using existing tested NDT methods

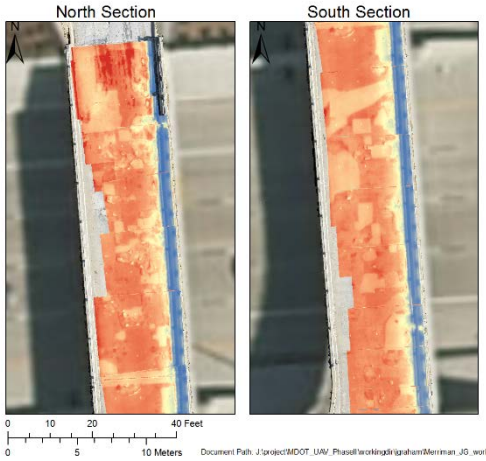


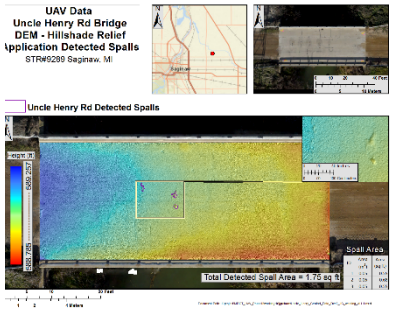
# Results: Georeferenced, high resolution optical, 3D, & thermal data



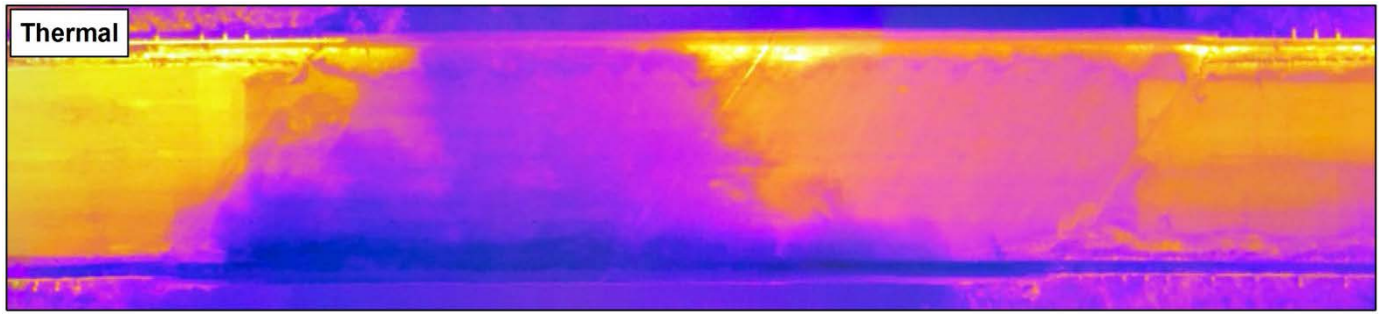



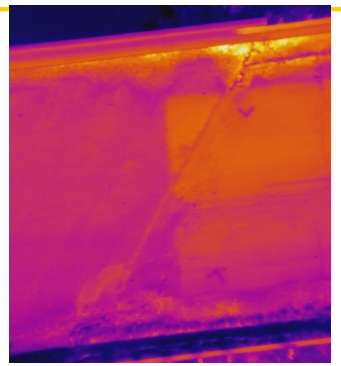


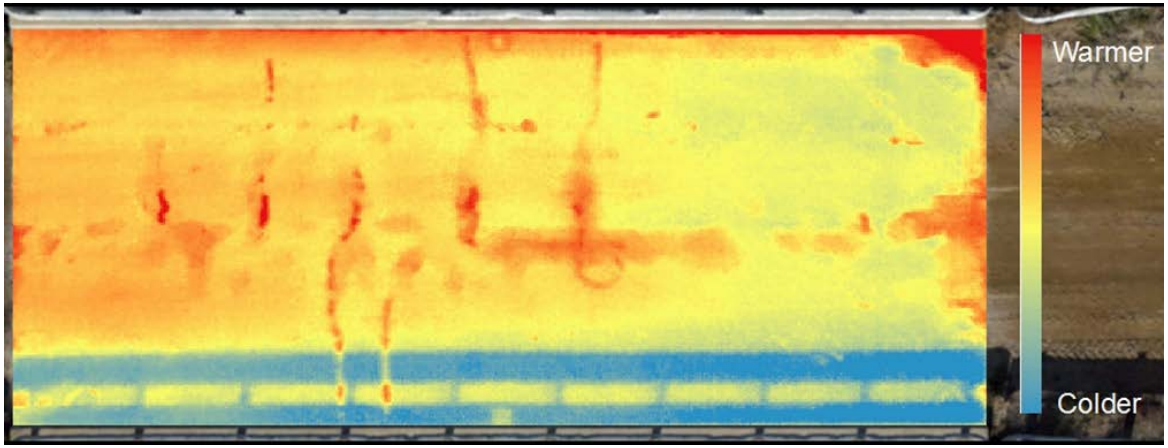


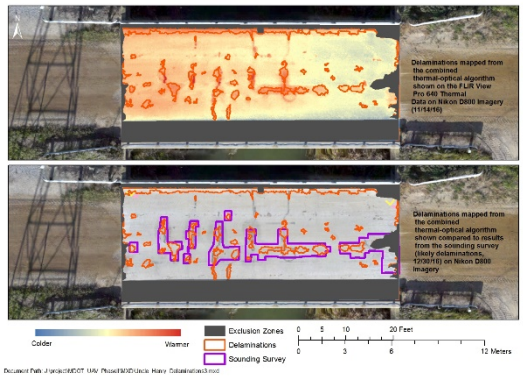

# Results: UAV-based thermal imagery

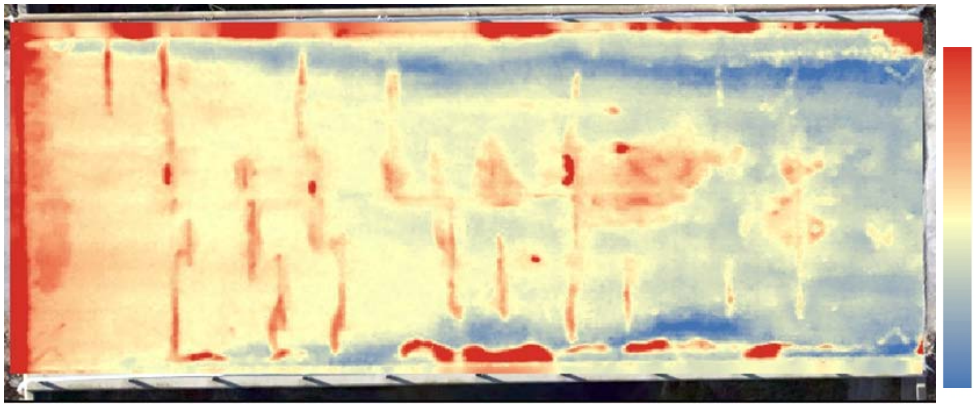


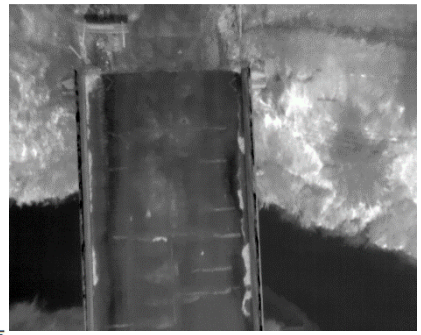



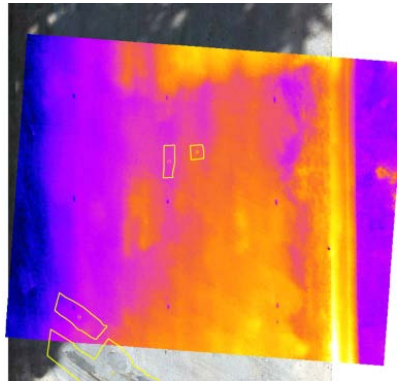



Uncle Henry Rd Bridge Delaminations

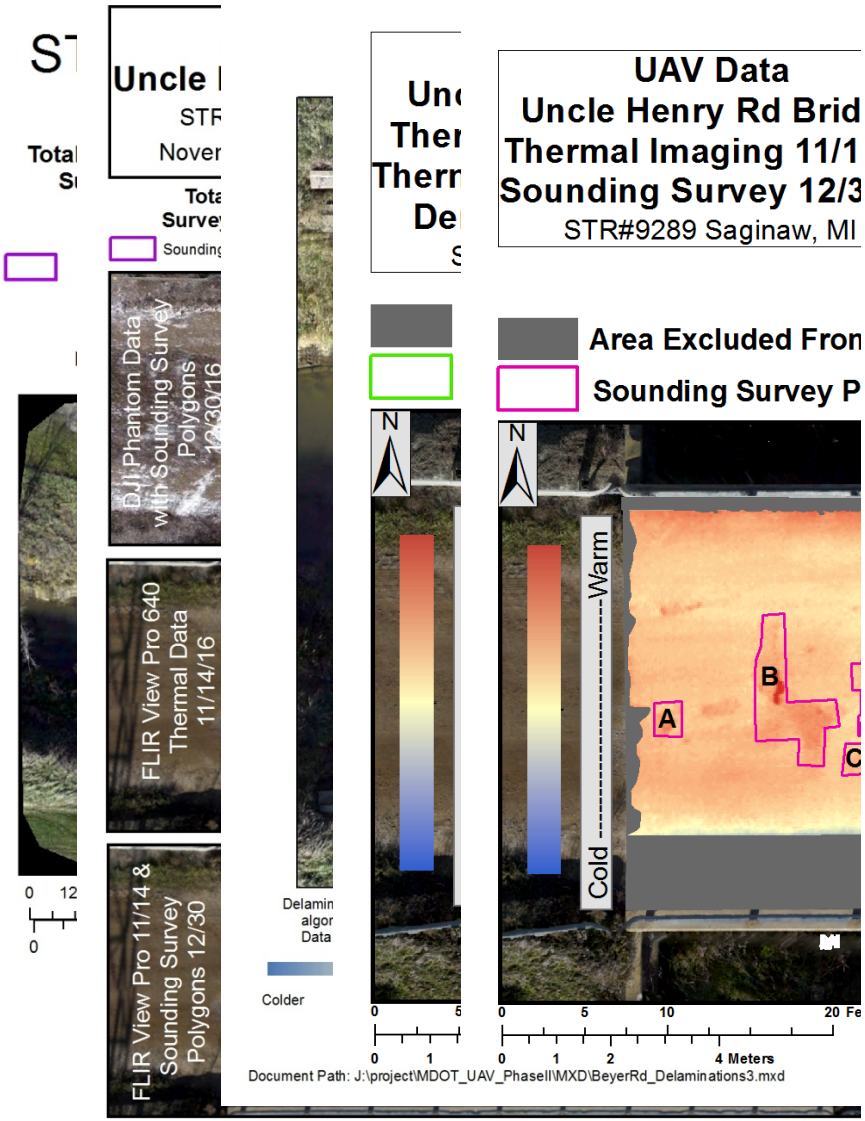


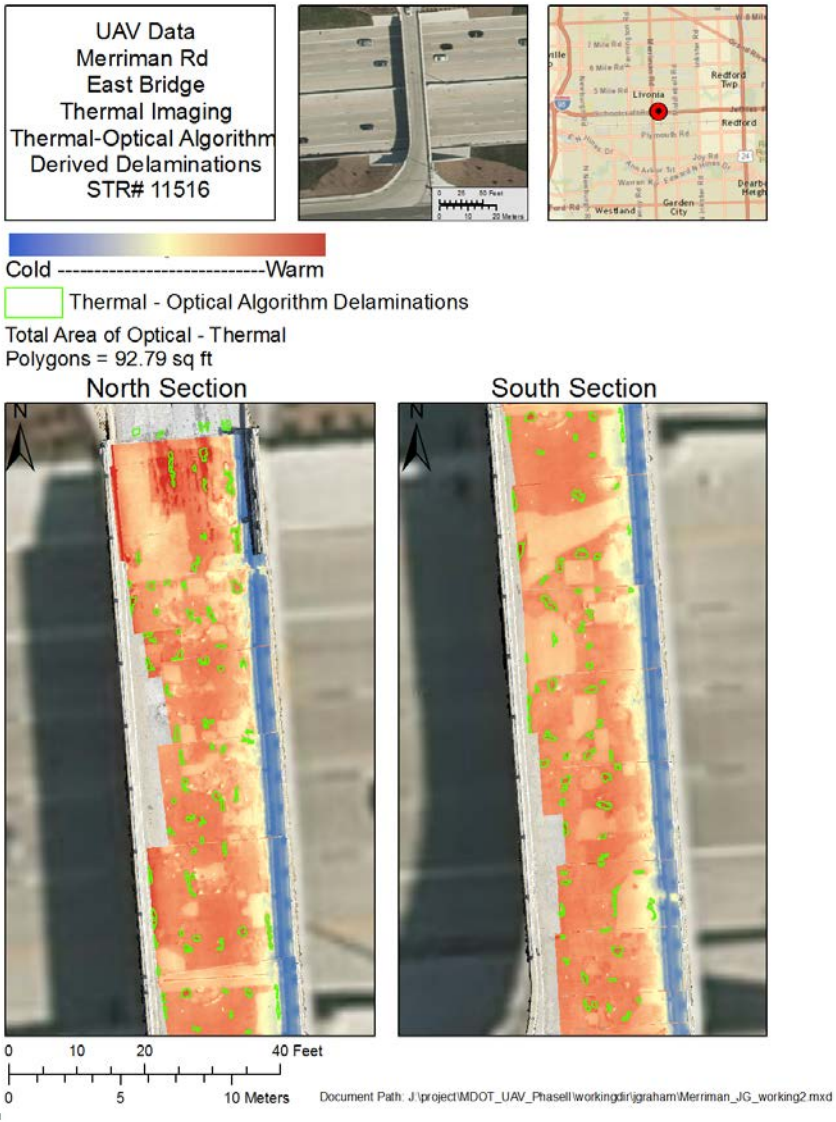





# Analyzing thermal results

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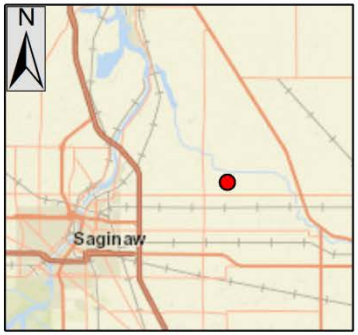
# Results: Optical and 3D data, Uncle Henry Rd bridge

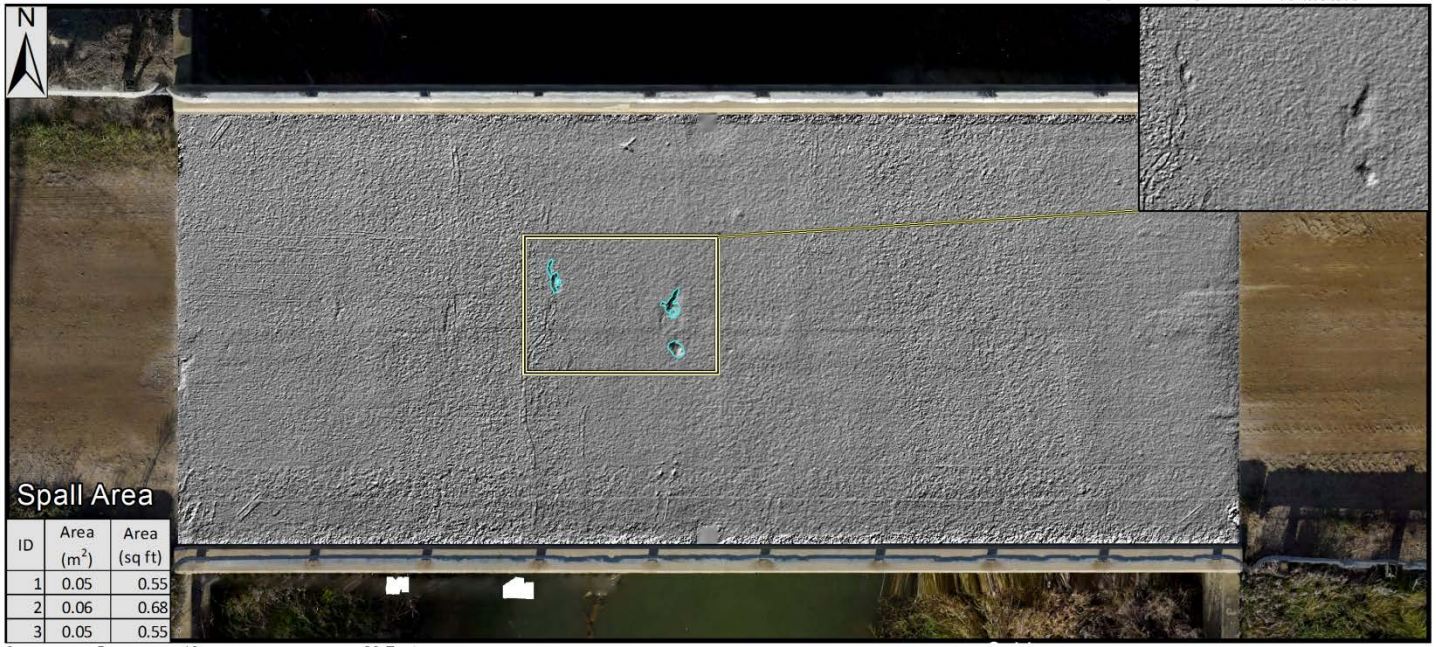
**UAV Data**
**Uncle Henry Rd Bridge**
**Hillshade Relief**
**Application Detected Spalls**
STR#9289 Saginaw, MI





0 10 20 40 Feet
0 5 10 Meters

Uncle Henry Rd Detected Spalls

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# Results: Seven standard geospatial datasets

Orthoimage

DEM

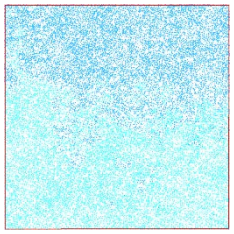
Hillshade

Thermal

Spalls

Delaminations

Point Cloud



# Data Management: Framework

- A meeting was held with MDOT Survey Support staff and SSI; plan developed:
- Develop meta-data standards for the data that is being captured by UAV.
- Using NCHRP Report 748, Table 1 & ASPRS Positional Accuracy Standards (2014) to classify the data quality.
- Analyze work flows for two MDOT business processes:
  - Processes: Survey/Design and Construction Monitoring,
  - Map the decision-points in the workflows to data collected.
  - Address, the question: how does the collected data affect decision-making?
- Conduct a life cycle cost analysis for alternative workflows.

| Accuracy | HIGH<br>< 0.05 m<br>(< 0.16 ft) | MEDIUM<br>0.05 to 0.20 m<br>(0.16 to 0.66 ft) | LOW<br>> 0.20 m<br>(> 0.66 ft) |
|---|---|---|---|
| Density | 1A | 2A | 3A |
| FINE<br>>100 pts/m² (>9 pts/ft²) | • Engineering surveys<br>• Digital terrain modeling<br>• Construction automation/ Machine control<br>• ADA compliance<br>• *Clearances**<br>• *Pavement analysis*<br>• Drainage/Flooding analysis<br>• Virtual, 3D design<br>• CAD models/Baseline data<br>• BIM/BRIM**<br>• Post-construction quality control<br>• As-built/As-is/Repair documentation<br>• Structural inspections | • *Forensics/Accident investigation**<br>• *Historical preservation*<br>• Power line clearance | • Roadway condition assessment (general) |
| | 1B | 2B | 3B |
| INTERMEDIATE<br>30 to 100 pts/m² (3 to 9 pts/ft²) | • Unstable slopes<br>• Landslide assessment | • General mapping<br>• *General measurements*<br>• Driver assistance<br>• Autonomous navigation<br>• Automated/Semi-automatic extraction of signs and other features<br>• Coastal change<br>• *Safety*<br>• Environmental studies | • Asset management<br>• Inventory mapping (e.g., GIS)<br>• Virtual tourism |
| | 1C | 2C | 3C |
| COARSE<br><30 pts/m² (<3 pts/ft²) | • *Quantities (e.g., earthwork)*<br>• Natural terrain mapping | • *Vegetation management* | • Emergency response<br>• Planning<br>• Land use/Zoning<br>• Urban modeling<br>• Traffic congestion/ Parking utilization<br>• Billboard management |

**Network accuracies may be relaxed for applications identified in red italics.*
***BIM/BRIM: BIM = Building Information Modeling; BRIM = Bridge Information Modeling.*
*These are only suggestions; requirements may change based on project needs and specific transportation agency requirements.*

TABLE B.3 COMMON HORIZONTAL ACCURACY CLASSES ACCORDING TO THE NEW STANDARD[6]

| Horizontal Accuracy Class $RMSE_x$ and $RMSE_y$ (cm) | $RMSE_r$ (cm) | Orthoimage Mosaic Seamline Maximum Mismatch (cm) | Horizontal Accuracy at the 95% Confidence Level (cm) |
|---|---|---|---|
| 0.63 | 0.9 | 1.3 | 1.5 |
| 1.25 | 1.8 | 2.5 | 3.1 |
| 2.50 | 3.5 | 5.0 | 6.1 |
| 5.00 | 7.1 | 10.0 | 12.2 |
| 7.50 | 10.6 | 15.0 | 18.4 |
| 10.00 | 14.1 | 20.0 | 24.5 |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# Data Management: Make data accessible through software tools; Integrate into agency workflows and databases DUAP, MiBRIDGE data sharing

Michigan Tech Research Institute

## Geospatial Portal

Map Content
Search ERDAS APOLLO Catalog
Browse ERDAS APOLLO Catalog
Maps (WMS)
Coverages (WCS)
Coverage Catalog
ROOT
ClientTests
SSI
WarrenRD_Bridge
DEM
HillShade
Optical
Point Cloud
Thermal
Refresh
Clip-Zip-Ship
Geoprocessing
Analyses
3D View Settings
Settings

Data Sources | Tools | Selection | Edit | Time | Measurements | Authentication

Logged user: SSI  Log out

EMEA & Asia | North America

E: -84°20'36.26"  N: 42°59'37.76"

0

WarrenRD_Bridge | Optical | Thermal

Add to map | Metadata | Add to Clip-Zip-Ship | Download | Zoom | Open with...

Name: Thermal
Title: Thermal
Description: Undefined

Access: WMS,CZS
Registration Date: 2016-08-31T15:42:24Z
SRS: EPSG:2898

Select All  Page 1 of 1  10 Items per page

ERDAS Apollo – data push, pull capabilities

# Contact Info

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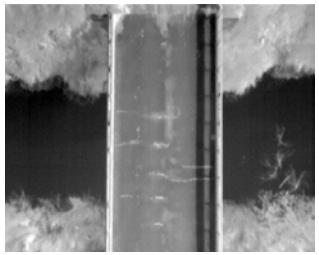
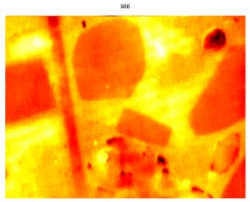
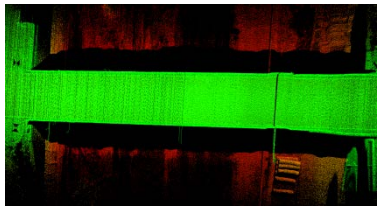
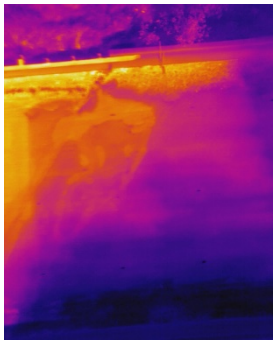








Steve Katenhus, P.E.

Bay Region Bridge Engineer

# Routine Surface Visual Inspection of a Bridge Deck Exercise

Uncle Henry Road over Uncle Henry Drain, Saginaw County.

Length of 59.7’ and width of 26.2’ (1564 sft)

Single span bridge built in 1960.

Concrete Deck

# MDOT NBI Rating Guidelines

## BSIR #1 SURFACE (SI&A Item 58A)

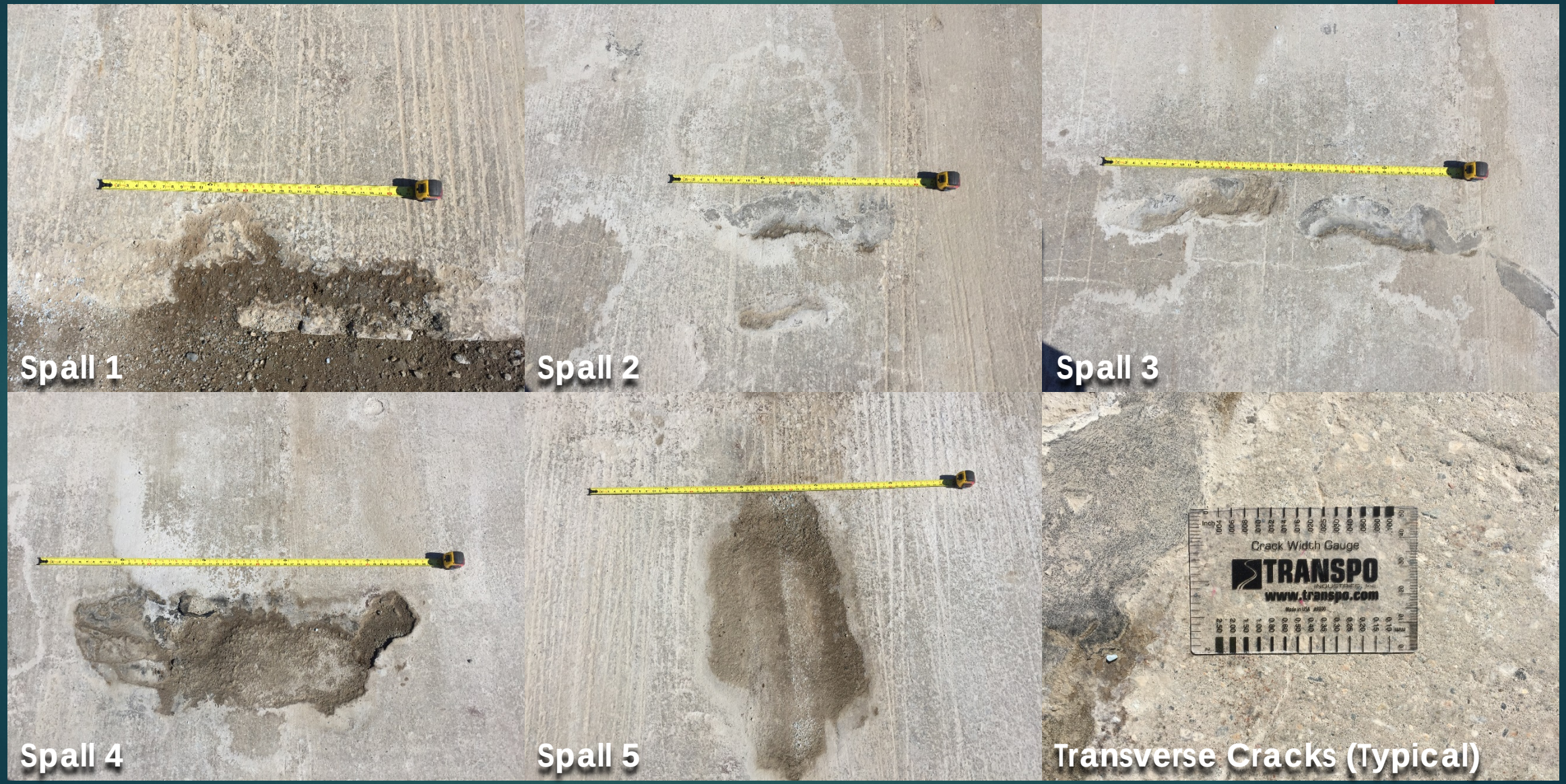
A concrete or bituminous wearing surface should be inspected for spalling, cracking, scaling, and delamination. Timber wearing surfaces should be inspected for deterioration, splitting, and crushing. Rate and code the condition in accordance with the following guidelines. Concrete patches or concrete repaired areas that are sound and functioning properly should not be counted as deteriorated or deficient area. Concrete patches that are loose, delaminated, or generally in poor condition shall be counted as deteriorated or deficient area. Refer to Michigan Structure Inspection Manual (MiSIM) Section 5.05 for inspection procedures related to common surface materials.

# Photos of Bridge






# Photos of Bridge



# Previous Inspection Surface Notes

Concrete deck has scattered gravel. There is approximately 12 sft of spalls in 5 locations and approximately 15 sft of delamination in 5 locations. Largest spall at midspan centerline. Block cracking in the southeast corner in a 6'x6' area. Moderate map cracking in south lane. There are 6 transverse half width cracks. There is a monument in the deck near west abutment. There is debris along brush blocks. (10/16)

Conditions had minimal change over the last three inspections of the surface.

Total Deck Area = 1564 sft

Refer to the MDOT NBI Rating Guidelines provided to rate the surface with information provided.

# National Bridge Inventory Rating Scale

BSIR #1 Surface (SI&A Item 58A) Only Concrete Deck Descriptions are listed.

| | |
|---|---|
| 9 | GOOD CONDITION – NO NOTICABLE OR NOTEWORTHY DEFICIENCIES WITH AFFECT THE CONDITION OF THE SURFACE. |
| 8 | GOOD CONDITION - CRACKING LESS THAN 1/32" WIDE WITH NO SPALLING, SCALLING, OR DELAMINATION. |
| 7 | GOOD CONDITION - OPEN CRACKS LESS THAN 1/16" WIDE OR SEALED CRACKS SPACED AT 10' OR MORE. LIGHT SHALLOW SCALING MAY BE PRESENT. |
| | DELAMINATION AFFECTING 2% OR LESS OF THE AREA. SURFACE SCALING MAY BE ¼" TO ½" DEEP. |
| 5 | FAIR CONDITION - DELMANINATION OR SPALLING AFFECTING BETWEEN 2% AND 10% OF THE AREA. EXCESSIVE CRACKING OR HEAVY SCALING UP TO 1" DEEP. |
| 4 | POOR CONDITION - DELAMINATION OR SPALLING AFFECTING BETWEEN 10% AND 25% OF THE AREA. |
| 3 | SERIOUS CONDITION - SPALLING AFFECTING MORE THAN 25% OF THE SURFACE AREA. |
| 2 | CRITICAL CONDITION - EMERGENCY SURFACE REAPRES ARE REQIRTED FOR THE BRIDGE TO REMAIN OPEN |
| 1 | "IMMINENT" FAILURE CONDITION – BRIDGE IS CLOSED TO TRAFFIC DUE TO THE SURFACE CONDITION, BUT CORRECTIVE ACTION MAY ALLOW THE BRIDGE TO REOPEN. |
| 0 | FAILED CONDITION – BRIDGE IS CLOSED TO TRAFFIC DUE TO THE SURFACE CONDITION. COORDINATE WITH SI&A ITEM 41 AND NOTIFY BRIDGE FIELD SERVICES. |
| N | NOT APPLICABLE – CULVERTS, FULLED ARCH BRIDGES, AND OTHER BRIDGES WITHOUT DECKS. |

# Surface Rating

Roughly 4% of the deck has spalls, delaminations and heavy block cracking.

Moderate map cracking in left lane.  Moderate crack thickness ranges from 0.012 to 0.05 inches.

Surface Rating is:

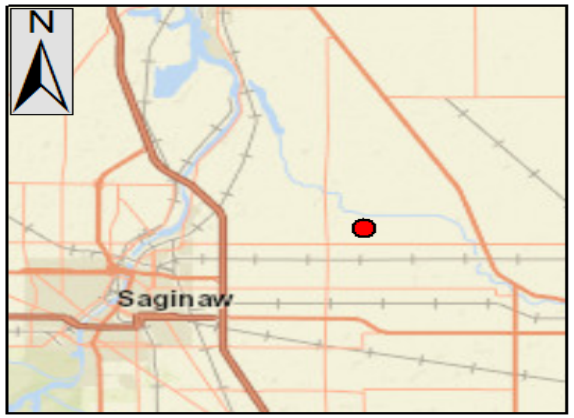
5

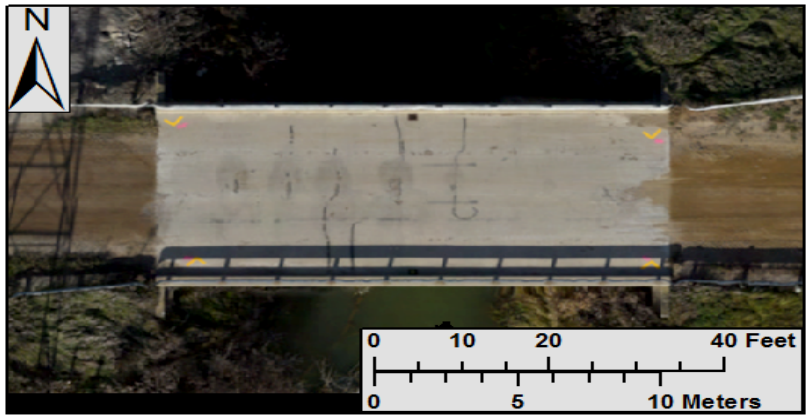
# Detailed Inspection and Equipment

- Utilizing UAV Derived Thermal Results
  - MTU Research with Colin Brooks
- Traditional Methods
  - Field Inspection Sounding Deck by the Chain Drag Method

# UAV Data
# Uncle Henry Rd Bridge
# Sounding Survey 12/30/16
# Thermal - Optical Algorithm
# Derived Delaminations

STR#9289 Saginaw, MI

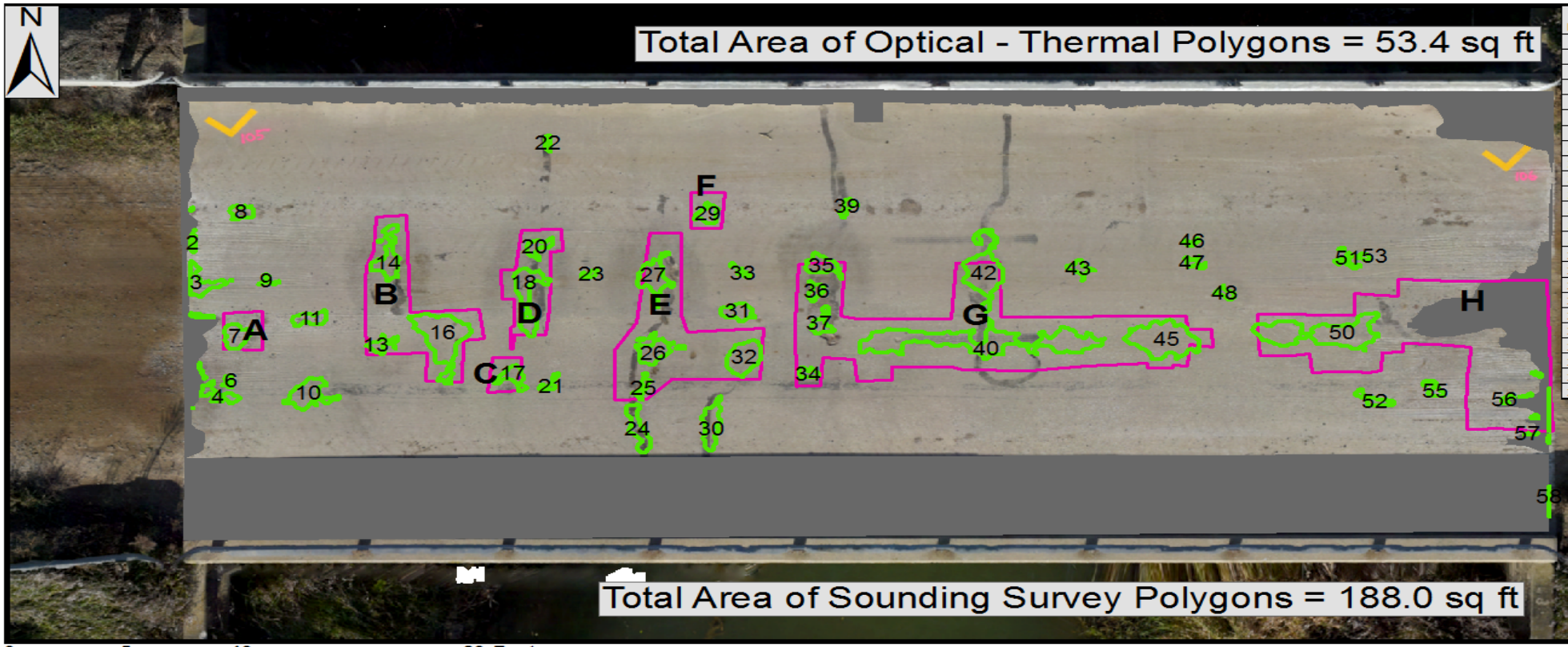



Sounding Survey Polygons

Thermal - Optical Algorithm Delaminations

Area Excluded From Analysis




| ID | Area ($m^2$) | Area (sq ft) | ID | Area ($m^2$) | Area (sq ft) |
|---|---|---|---|---|---|
| 2 | 0.021 | 0.23 | 31 | 0.084 | 0.91 |
| 3 | 0.103 | 1.11 | 32 | 0.187 | 2.01 |
| 4 | 0.090 | 0.97 | 33 | 0.014 | 0.15 |
| 6 | 0.017 | 0.19 | 34 | 0.030 | 0.33 |
| 7 | 0.103 | 1.11 | 35 | 0.099 | 1.07 |
| 8 | 0.056 | 0.60 | 36 | 0.036 | 0.39 |
| 9 | 0.012 | 0.13 | 37 | 0.061 | 0.66 |
| 10 | 0.172 | 1.85 | 39 | 0.026 | 0.28 |
| 11 | 0.073 | 0.79 | 40 | 0.740 | 7.96 |
| 13 | 0.052 | 0.56 | 42 | 0.297 | 3.20 |
| 14 | 0.141 | 1.52 | 43 | 0.042 | 0.45 |
| 16 | 0.395 | 4.25 | 45 | 0.399 | 4.29 |
| 17 | 0.074 | 0.80 | 46 | 0.012 | 0.13 |
| 18 | 0.183 | 1.97 | 47 | 0.026 | 0.28 |
| 20 | 0.059 | 0.63 | 48 | 0.030 | 0.33 |
| 21 | 0.020 | 0.22 | 50 | 0.506 | 5.45 |
| 22 | 0.017 | 0.18 | 51 | 0.027 | 0.29 |
| 23 | 0.015 | 0.16 | 52 | 0.049 | 0.52 |
| 24 | 0.112 | 1.20 | 53 | 0.014 | 0.15 |
| 25 | 0.029 | 0.31 | 55 | 0.030 | 0.33 |
| 26 | 0.130 | 1.40 | 56 | 0.029 | 0.31 |
| 27 | 0.171 | 1.84 | 57 | 0.005 | 0.05 |
| 29 | 0.059 | 0.64 | 58 | 0.003 | 0.03 |
| 30 | 0.127 | 1.36 | | | |

| ID | Area ($m^2$) | Area (sq ft) |
|---|---|---|
| A | 0.32 | 3.44 |
| B | 2.06 | 22.13 |
| C | 0.23 | 2.49 |
| D | 0.94 | 10.12 |
| E | 2.6 | 27.94 |
| F | 0.26 | 2.75 |
| G | 5.66 | 60.95 |
| H | 5.4 | 58.17 |

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# Surface Rating Utilizing UAV Derived Data and Deck Sounding

Total Deck Area = 1564 sft .

Results show 188 sft of delamination and spalls.

Results do not account for moderate to heavy cracks however we have the past inspection notes that will apply.

Concrete deck has scattered gravel. There is approximately 12 sft of spalls in 5 locations and approximately 15 sft of delamination in 5 locations. Largest spall at midspan centerline. Block cracking in the southeast corner in a 6'x6' area. Moderate map cracking in south lane. There are 6 transverse half width cracks. There is a monument in the deck near west abutment. There is debris along brush blocks. (10/16)

# National Bridge Inventory Rating Scale

BSIR #1 Surface (SI&A Item 58A) Only Concrete Deck Descriptions are listed.

| | |
|---|---|
| 9 | GOOD CONDITION – NO NOTICABLE OR NOTEWORTHY DEFICIENCIES WITH AFFECT THE CONDITION OF THE SURFACE. |
| 8 | GOOD CONDITION - CRACKING LESS THAN 1/32" WIDE WITH NO SPALLING, SCALLING, OR DELAMINATION. |
| 7 | GOOD CONDITION - OPEN CRACKS LESS THAN 1/16" WIDE OR SEALED CRACKS SPACED AT 10' OR MORE. LIGHT SHALLOW SCALING MAY BE PRESENT. |
| 6 | FAIR CONDITION - OPEN CRACKS GREATER THAN 1/16" WIDE SPACED AT LESS THAN 10'. SPALLING AND DELAMINATION AFFECTING 2% OR LESS OF THE AREA. SURFACE SCALING MAY BE ¼" TO ½" DEEP. |
| 5 | FAIR CONDITION - DELMANINATION OR SPALLING AFFECTING BETWEEN 2% AND 10% OF THE AREA. EXCESSIVE CRACKING OR HEAVY SCALING UP TO 1" DEEP. |
| 4 | POOR CONDITION - DELAMINATION OR SPALLING AFFECTING BETWEEN 10% AND 25% OF THE AREA. |
| 3 | SERIOUS CONDITION - SPALLING AFFECTING MORE THAN 25% OF THE SURFACE AREA. |
| 2 | CRITICAL CONDITION - EMERGENCY SURFACE REAPRES ARE REQIRTED FOR THE BRIDGE TO REMAIN OPEN |
| 1 | "IMMINENT" FAILURE CONDITION – BRIDGE IS CLOSED TO TRAFFIC DUE TO THE SURFACE CONDITION, BUT CORRECTIVE ACTION MAY ALLOW THE BRIDGE TO REOPEN. |
| 0 | FAILED CONDITION – BRIDGE IS CLOSED TO TRAFFIC DUE TO THE SURFACE CONDITION. COORDINATE WITH SI&A ITEM 41 AND NOTIFY BRIDGE FIELD SERVICES. |
| N | NOT APPLICABLE – CULVERTS, FULLED ARCH BRIDGES, AND OTHER BRIDGES WITHOUT DECKS. |

# Surface Rating

Roughly 12+% of the deck surface has spalls, delaminations and heavy block cracking.

Moderate map cracking in left lane. Moderate crack thickness ranges from 0.012 to 0.05 inches.

UAV determined that there was 188 sft of delaminations (included in the 12+%)

Surface Rating is:

4-POOR

# Traditional Field Method Performing Detailed Deck Inspection

- Chain Drag Method Video
- Rock Hammer Video
- Steel Rod Sounding Method

# Photos of Bridge

Looking North

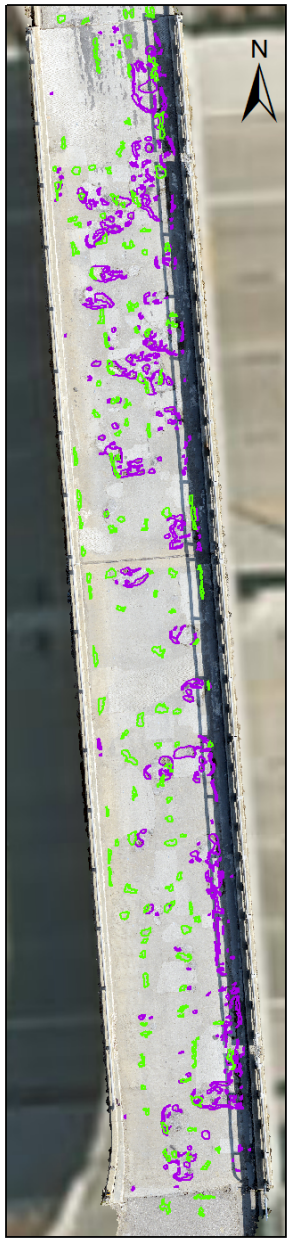
Typical Spalls, HMA patching, concrete patches

# Photos of Bridge

North Section


South Section

# Photos of Bridge




0 10 20 40 Feet

0 5 10 Meters

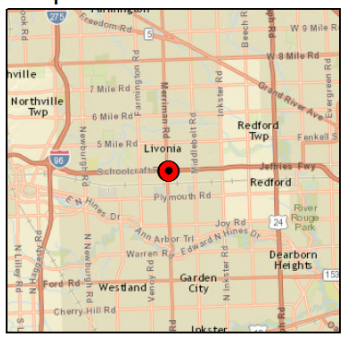
UAV Data
Merriman Rd East Bridge
Themal-Optical Algorithm
Derived Delaminations
Application Detected Spalls
STR# 11516

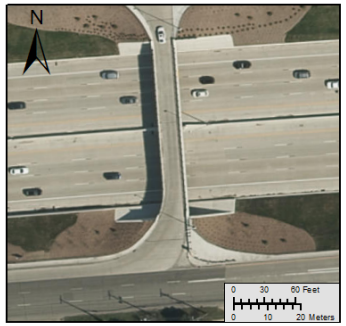
Thermal - Optical Algorithm Delaminations

Application Detected Spalls

Total Detected Spall Polygon Area = 150.44 sq ft

Total Area of Optical - Thermal Polygons = 92.79 sq ft

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# Surface Rating Utilizing UAV Derived Data

Merriman Road over I-96, City of Livonia.

Inspection notes noted numerous open spalls, bit filled spalls, and concrete patches throughout the entire deck.  Most concrete patches were in good condition.

Length of 176’ and width of 22.4’ (3,942 sft)

UAV detected 243 sft of delamination and spalls

Two span bridge built in 1973.

Concrete Deck

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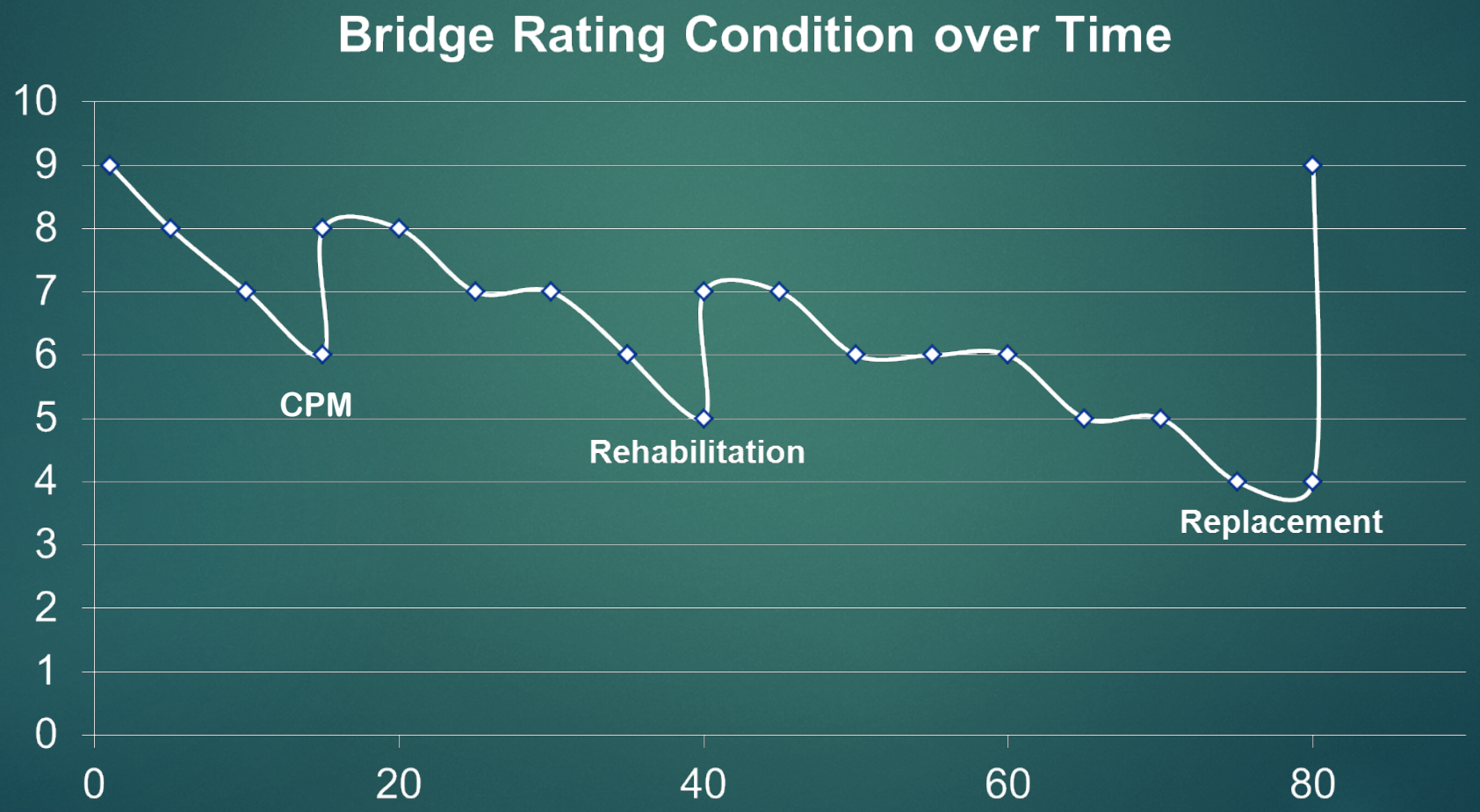
| 0 | FAILED CONDITION – BRIDGE IS CLOSED TO TRAFFIC DUE TO THE SURFACE CONDITION. COORDINATE WITH SI&A ITEM 41 AND NOTIFY BRIDGE FIELD SERVICES. |
| N | NOT APPLICABLE – CULVERTS, FULLED ARCH BRIDGES, AND OTHER BRIDGES WITHOUT DECKS. |

# Surface Rating

- Roughly 6+% of the deck surface has spalls, delaminations, from UAV data
- Results do not account for moderate to heavy cracks.
- Deficiencies could not be picked up in the shaded areas
- Surface Rating is:

4-POOR

# So how can we utilize the detailed inspection data?



## BRIDGE DECK PRESERVATION MATRIX – Decks with Uncoated "Black" Rebar

| DECK CONDITION STATE | | | | REPAIR OPTIONS | POTENTIAL RESULT TO DECK BSIR | | ANTICIPATED FIX LIFE |
|---|---|---|---|---|---|---|---|
| Top Surface | | Bottom Surface | | | Top Surface BSIR #58a | Bottom Surface BSIR #58b | |
| BSIR #58a | Deficiencies % (a) | BSIR #58b | Deficiencies % (b) | | | | |
| ≥ 5 | N/A | N/A | N/A | Hold (c)<br>Seal Cracks/Healer Sealer (d) | No Change | No Change | 1 to 4 years |
| | ≤ 5% | > 5 | ≤ 2% | Epoxy Overlay | 8, 9 | No Change | 10 to 15 years |
| | ≤ 10% | ≥ 4 | ≤ 25% | Deck Patch (e) | Up by 1 pt. | No Change | 3 to 10 years |
| 4 or 5 | 10% to 25% | 5 or 6 | ≤ 10% | Deep Concrete Overlay (h) | 8, 9 | No Change | 25 to 30 years |
| | | 4 | 10% to 25% | Shallow Concrete Overlay (h, i) | 8, 9 | No Change | 20 to 25 years |
| | | | | HMA Overlay with water-proofing membrane (f, h, i) | 8, 9 | No Change | 8 to 10 years |
| | | 2 or 3 | > 25% | HMA Cap (g, h, i) | 8, 9 | No Change | 2 to 4 years |
| ≤ 3 | >25% | > 5 | < 2% | Deep Concrete Overlay (h) | 8, 9 | No Change | 20 to 25 years |
| | | 4 or 5 | 2% to 25% | Shallow Concrete Overlay (h, i) | 8, 9 | No Change | 10 years |
| | | | | HMA Overlay with water-proofing membrane (f, h, i) | 8, 9 | No Change | 5 to 7 years |
| | | 2 or 3 | >25% | HMA Cap (g, h, i) | 8, 9 | No Change | 1 to 3 years |
| | | | | Replacement with Epoxy Coated Rebar (ECR) Deck | 9 | 9 | 60+ years |

(a) Percent of deck surface area that is spalled, delaminated, or patched with temporary patch material.
(b) Percent of deck underside area that is spalled, delaminated or map cracked.
(c) The "Hold" option implies that there is on-going maintenance of filling potholes with cold patch and scaling of incipient spalls.
(d) Seal cracks when cracks are easily visible and minimal map cracking. Apply healer sealer when crack density is too great to seal individually by hand. Sustains the current condition longer.
(e) Crack sealing can also be used to seal the perimeter of deck patches.
(f) Hot Mix Asphalt overlay with waterproofing membrane. Deck patching required prior to placement of waterproofing membrane.
(g) Hot Mix Asphalt cap without waterproofing membrane for ride quality improvement. Deck should be scheduled for replacement in the 5 year plan.
(h) If bridge crosses over traveled lanes and the deck contains slag aggregate, do deck replacement.
(i) When deck bottom surface is rated poor (or worse) and may have loose or delaminated concrete over traveled lanes, an in-depth inspection should be scheduled. Any loose or delaminated concrete should be scaled off and false decking should be placed over traveled lanes where there is potential for additional concrete to become loose.

# Uncle Henry Road Bridge Potential Repair Work Example

Single span bridge built in 1960.

Assuming it has the original concrete deck

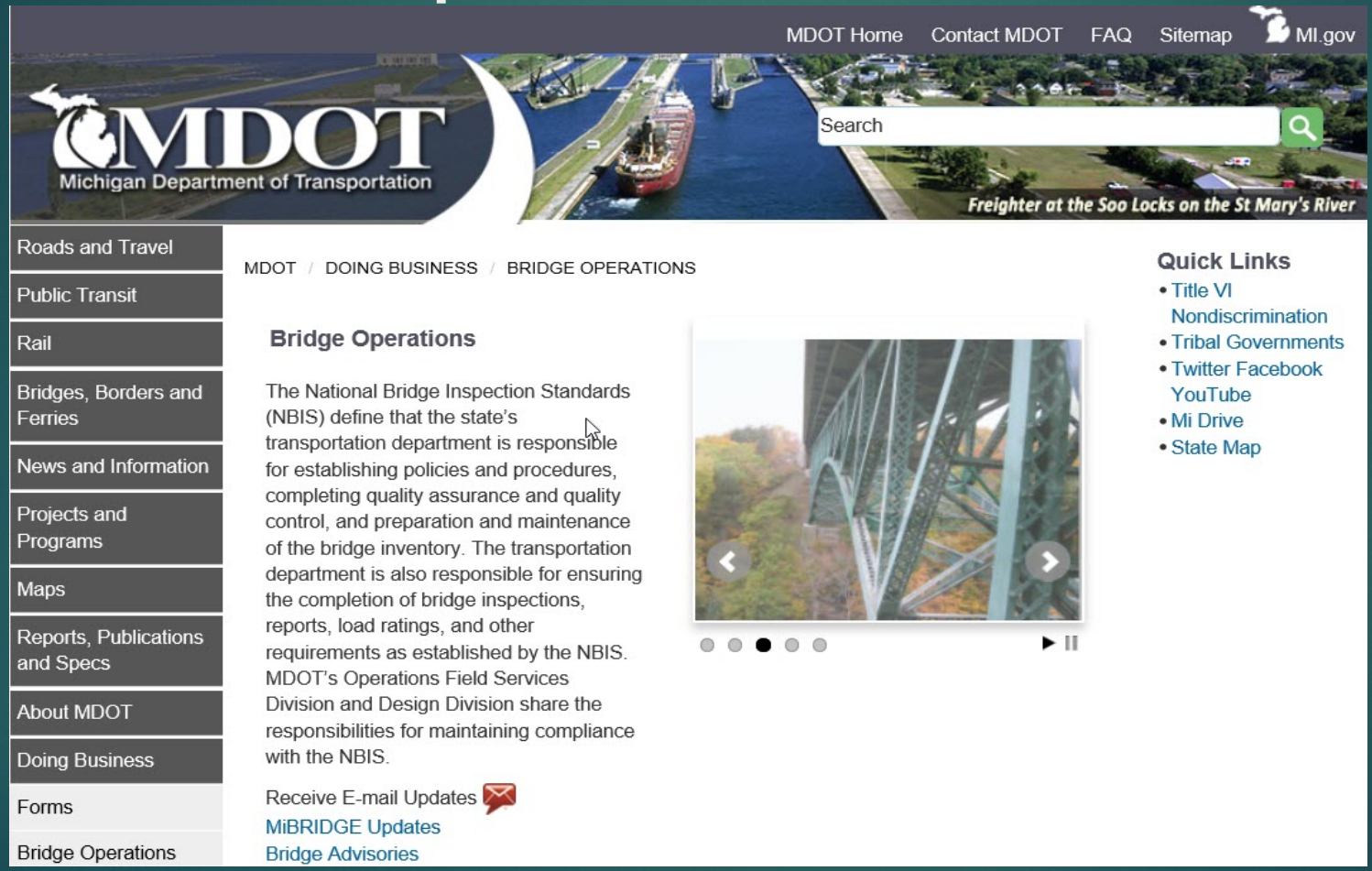
Deck Bottom surface rating as Good (7).

We will be using the detailed inspection rating. Rated the Deck Surface as Poor (4).

## BRIDGE DECK PRESERVATION MATRIX – Decks with Uncoated "Black" Rebar

| DECK CONDITION STATE | | | | REPAIR OPTIONS | POTENTIAL RESULT TO DECK BSIR | | ANTICIPATED FIX LIFE |
|---|---|---|---|---|---|---|---|
| Top Surface | | Bottom Surface | | | Top Surface BSIR #58a | Bottom Surface BSIR #58b | |
| BSIR #58a | Deficiencies % (a) | BSIR #58b | Deficiencies % (b) | | | | |
| ≥ 5 | N/A | N/A | N/A | Hold (c)<br>Seal Cracks/Healer Sealer (d) | No Change | No Change | 1 to 4 years |
| | ≤ 5% | > 5 | ≤ 2% | Epoxy Overlay | 8, 9 | No Change | 10 to 15 years |
| | ≤ 10% | ≥ 4 | ≤ 25% | Deck Patch (e) | Up by 1 pt. | No Change | 3 to 10 years |
| 4 or 5 | 10% to 25% | 5 or 6 | ≤ 10% | Deep Concrete Overlay (h) | 8, 9 | No Change | 25 to 30 years |
| | | 4 | 10% to 25% | Shallow Concrete Overlay (h, i) | 8, 9 | No Change | 20 to 25 years |
| | | | | HMA Overlay with water-proofing membrane (f, h, i) | 8, 9 | No Change | 8 to 10 years |
| | | 2 or 3 | > 25% | HMA Cap (g, h, i) | 8, 9 | No Change | 2 to 4 years |

# For this and additional bridge information please visit:




http://www.michigan.gov/mdot/0,4616,7-151-9625_70811---,00.html

# Thanks to:

Bay County Road Commission

Isabella County Road Commission

Tuscola County Road Commission

# Special Thanks to:

Midland County Road Commission

Saginaw County Road Commission