Bridge Management Systems
A Practical Tour

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Michigan Department of Transportation
Vice-Chair AASHTO SC OBS T-18 (Bridge Evaluation and Management)
Chair AASHTO SC OB T-11 (Research)
AASHTO Manual For Bridge Evaluation: Section 3, Bridge Management Systems

- AASHTO SCOBS T-18 (Bridge Evaluation and Management) has recently updated Section 3, “Bridge Management Systems
- Up for Ballot at the 2017 AASHTO SCOBS meeting
AASHTO Manual For Bridge Evaluation: Section 3, Bridge Management Systems

3.2 - Objectives of Bridge Management Systems
3.3 - Components of a Bridge Management System
   3.3.1- Information Management
      3.3.1.1- Bridge Inventory, General Condition Ratings and Bridge Element Ratings
         3.3.1.1.1 - Bridge Inventory
         3.3.1.1.2 - General Condition Ratings
         3.3.1.1.3 - Bridge Element Ratings
      3.3.1.2 - Agency Performance Measures
      3.3.1.3 - Preservation and Improvement Action Data
      3.3.1.4 - Cost Data and Financial Plans
   3.3.2 - Data Integration
      3.3.2.1 - Data Analysis
         3.3.2.2 - Risk Assessment
         3.3.2.3 - Agency Rules
      3.3.2.4 - Cost/Benefit Analysis
         3.3.2.4.1 - Condition Driven Cost/Benefit Analysis
         3.3.2.4.2 - Improvement Cost/Benefit Analysis
         3.3.2.4.3 - Life-Cycle Cost/Benefit Analysis
      3.3.2.5 - Prioritization and Optimization
         3.3.2.5.1 Multi-Objective Optimization
   3.3.3—Decision Support
MBE Chapter 3 – Quote, “A BMS should meet the needs of both upper management, where it is a strategic planning tool, and technical decision makers, where it is an engineering tool.
Network Management of Bridges

- **Bridge Inventory**
  - General Condition Ratings
  - National Bridge Inventory (NBI)
  - Bridge Element Ratings - AASHTO Manual for Bridge Element Inspection (MBEI)

- **Performance Measures**
  - National Performance Measures (FHWA)
    - Report Good (NBI 7-9), Poor (0-4) by Deck Area (Fair (5-6) is calculated)
  - **State Defined Performance Measures**
State Defined Performance Measures

- **Michigan Performance Measures**
  - Take care of all critical needs
  - Freeway 95% Good or Fair
  - Non-Freeway 85% Good or Fair
  - Reduce the number of scour critical bridges carrying the interstate
  - **Reduce reactionary actions on our bridges**
Deterioration Modeling

Michigan: All Highway Bridges: 2015 - 2016 Deterioration Curve

Years to Reach Condition State

Deterioration Rate - Statewide

Number of NBI Bridges going from Good/Fair to Poor
Bridge Related Cost Models

- Project Costs
  - Direct
  - Indirect
    - Mobilization
    - Traffic Control

- Michigan Averages
  - Preventive Maintenance Cost = $550,000 per bridge project
  - Rehabilitation Cost = $1,400,000 per bridge project
  - Replacement Cost = $4,200,000 per bridge project

Inflation
Strategy, Funding and Agency Rules

- Do cyclic maintenance when ….
- Do preventive maintenance when ….
- Do rehabilitation when ….
- Replace the Bridge when ….
Forecasting Bridge Condition

- Bridge Condition Forecasting
- Help justify budget
- Needs to be responsive
- Easy to understand

![Bridge Condition Forecast - Statewide Graph](image)

**Statewide 10-yr Trend of Condition - Program Strategy - NBI only**

- **Minimum NBI Condition Rating**
- **Number of Bridges**

**Bridge Condition Forecast - Statewide**

- **Goal - 95%**
- **Goal - 85% Non-Freeway**
Project Level Bridge Management

- Detailed Bridge Decisions
  - Bridge Element Ratings - AASHTO Manual for Bridge Element Inspection (MBEI)
  - National Bridge Elements (NBEs)
  - Bridge Management Elements (BMEs)
  - Agency-Defined Elements (ADEs)
- Project Prioritization
- Cost/Benefit Analysis
- Risk Assessment
- Managing Fair Bridges
  - Remaining Service Life or Time to Poor
- Multi-objective Optimization
Managing Fair Bridges

- Reduce the number of bridges becoming poor each year.
- Prioritize by Time to poor (Remaining Service Life)
- Touch every bridge every 8-10 years
- Bundle projects and coordination with road projects
Managing Poor Bridges

- Reduce the number of poor
- Coordinate with road program
- Prioritize by risk assessment

NCHRP 20-07/Task 378 [Final]
Assessing Risk for Bridge Management
[ NCHRP 20-07 (Research for AASHTO Standing Committee on Highways) ]

<table>
<thead>
<tr>
<th>Project Data</th>
</tr>
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<tbody>
<tr>
<td>Funded: $100,000</td>
</tr>
<tr>
<td>Research Agency: Western Management &amp; Consulting LLC</td>
</tr>
<tr>
<td>Principal Investigator: Mr. Jeffrey L. Western</td>
</tr>
<tr>
<td>Effective Date: 8/29/2015</td>
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<tr>
<td>Completion Date: 9/30/2016</td>
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CONTRACTOR’S FINAL REPORT
A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection

Figure 2 – Staffing the Vulnerability Assessment Process
Managing the Serious/Critical

- Regions must justify **NOT** working on serious or critical bridges. Must indicate how the bridge will be kept safe until work can be done.
- Request For Action Program
RFA Coordination Committee

Bridge Development
Bridge Field Services
Region Bridge Engineers

Responsible for Reviewing, Prioritizing, Initiating Action, Monitoring, and/or Ensuring Resolution
Multi-objective Optimization

- Michigan Bridge Multi-Objectives
  - Meet and maintain freeway bridge condition goal (95%) good or fair
  - Reduce scour critical bridges carrying the interstate.
  - Make bridges more resilient to reactive activities resulting from advanced deterioration. (Reduce need to close traffic lanes because of advanced bridge deterioration.)
Michigan’s Project Level Objectives of our BMS

- For every bridge not already programed, deteriorate the network five years, then using bridge elements and the AASHTOWare BrM software, indicate what the needs are for that bridge, what category of work it fits into, and estimate the cost for the work.
Agency Rules

- **Cyclic**
  - Example - Do bridge washing when ....

- **Condition**
  - Example - Replace seals in strip seal expansion joints when quantity in Condition State 2 (fair) exceeds 20%

- Conditional rules most often need to be considered concurrently with related elements that could impact how the rules should be applied.
# Example Bridge Project
(44th AVENUE OVER I-196)

<table>
<thead>
<tr>
<th>Element Name</th>
<th>Quantity</th>
<th>Units</th>
<th>Good (CS1)</th>
<th>Fair (CS 2)</th>
<th>Poor (CS 3)</th>
<th>Serious (CS4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decks/slabs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>600 Reinf. Conc Deck Black Bars</td>
<td>6966</td>
<td>SF</td>
<td>61%</td>
<td>13%</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>810 Reinforced Concrete Deck Top Surface</td>
<td>6965</td>
<td>SF</td>
<td>31%</td>
<td>22%</td>
<td>47%</td>
<td>0%</td>
</tr>
<tr>
<td>811 Reinf. Conc. Deck Bottom Surf.</td>
<td>6965</td>
<td>SF</td>
<td>92%</td>
<td>5%</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td>812 Rein. Concrete Fascia</td>
<td>444</td>
<td>LF</td>
<td>95%</td>
<td>5%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>331 Metal Bridge Railing</td>
<td>444</td>
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<td>60%</td>
<td>0%</td>
<td>0%</td>
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<td>Joints</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>401 Pourable Joint Seal</td>
<td>96</td>
<td>LF</td>
<td>0%</td>
<td>85%</td>
<td>16%</td>
<td>0%</td>
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<td></td>
<td></td>
</tr>
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<td>109 Prestressed Girder/Beam</td>
<td>1182</td>
<td>LF</td>
<td>98%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Bearings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>310 Elastomeric Bearings</td>
<td>32</td>
<td>EACH</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>313 Fixed Bearing</td>
<td>8</td>
<td>EACH</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>515 Steel Protective Coating</td>
<td>8</td>
<td>SF</td>
<td>0%</td>
<td>6%</td>
<td>100%</td>
<td>0%</td>
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<tr>
<td>Substructure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>215 Reinforced Concrete Abutment</td>
<td>80</td>
<td>LF</td>
<td>98%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
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<tr>
<td>205 Reinforced Concrete Column</td>
<td>4</td>
<td>EACH</td>
<td>43%</td>
<td>22%</td>
<td>33%</td>
<td>0%</td>
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<tr>
<td>234 Reinforced Concrete Pier Cap</td>
<td>40</td>
<td>LF</td>
<td>47%</td>
<td>2%</td>
<td>51%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Deck Surface Condition

- Deck surface
- 47% Poor
Typical Deck Joint Condition

- Pourable Joint Seals
  - 85% Fair
  - 15% Poor
Deck Bottom Surface Condition

- Deck Bottom Surface
- 3% Poor
Prestressed Beam End Condition

- Beams
  - 2% Poor (at the Beam Ends)
Pier Condition

- Columns
  - 33% Poor
- Pier caps
  - 51% Poor
Bridge Railing with Thrie-Beam Retrofit

- Concrete/Steel Railing with Thrie-Beam retrofit
  - 85% Good
  - 15% Fair

Decision - do you bring up to current standard?
### Bridge Deck Preservation Matrix - Decks with Uncoated “Black” Rebar

<table>
<thead>
<tr>
<th>Top Surface BSIR %58a</th>
<th>Bottom Surface BSIR %58b</th>
<th>Repair Options</th>
<th>Potential Result to Deck BSIR</th>
<th>Anticipated Fix Life</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hold (c)</td>
<td>No Change</td>
<td>1 to 4 years</td>
</tr>
<tr>
<td>Seal Cracks-Sealer Sealer (d)</td>
<td></td>
<td>Epoxy Overlay</td>
<td>No Change</td>
<td>10 to 16 years</td>
</tr>
<tr>
<td>Deck Patch (e)</td>
<td>Up by 1 pt.</td>
<td>No Change</td>
<td>3 to 10 years</td>
<td></td>
</tr>
<tr>
<td>≥ 5 or 6</td>
<td>10% to 25%</td>
<td>Deep Concrete Overlay (h)</td>
<td>25 to 30 years</td>
<td></td>
</tr>
<tr>
<td>4 or 5</td>
<td>10% to 25%</td>
<td>Shallow Concrete Overlay (h, i)</td>
<td>No Change</td>
<td>20 to 25 years</td>
</tr>
<tr>
<td>or 5</td>
<td>2% to 25%</td>
<td>HMA Overlay with waterproofing membrane (t, h, i)</td>
<td>No Change</td>
<td>5 to 7 years</td>
</tr>
<tr>
<td>≤ 5 or 4</td>
<td>≥ 25%</td>
<td>HMA Cap (g, h, i)</td>
<td>No Change</td>
<td>1 to 3 years</td>
</tr>
<tr>
<td>4 or 5</td>
<td>&gt; 5 or 6, &lt; 2%</td>
<td>Deep Concrete Overlay (h)</td>
<td>No Change</td>
<td>20 to 25 years</td>
</tr>
<tr>
<td>or 5</td>
<td>2% to 25%</td>
<td>Shallow Concrete Overlay (h, i)</td>
<td>No Change</td>
<td>10 years</td>
</tr>
<tr>
<td>≤ 5 or 4</td>
<td>2% to 25%</td>
<td>HMA Overlay with waterproofing membrane (t, h, i)</td>
<td>No Change</td>
<td>5 to 7 years</td>
</tr>
<tr>
<td>or 5</td>
<td>≥ 25%</td>
<td>HMA Cap (g, h, i)</td>
<td>No Change</td>
<td>1 to 3 years</td>
</tr>
</tbody>
</table>

- **Deck Top Surface**
  - 47% Poor

- **Deck Bottom Surface**
  - 3% Poor

- **Repair Chosen**
  - Deep Concrete Overlay

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1. BSIR: Bridge System Inspection Report
2. BSIR %58: Percentage of deck surface area that is spalled, delaminated, or patch with temporary patch material.
3. BSIR %58a: BSIR %58a indicates BSIR above or equal to 50%.
4. BSIR %58b: BSIR %58b indicates BSIR between 25% and 50%.
5. BSIR %58c: BSIR %58c indicates BSIR less than or equal to 25%.

- **Hold (c)**: Repair by holding the concrete in place and sealing cracks or spalls.
- **Seal Cracks-Sealer Sealer (d)**: Sealing cracks and sealing spalls or spalling areas.
- **Epoxy Overlay**: Applying a concrete overlay to seal and reinforce the deck surface.
- **Deck Patch (e)**: Patching the deck surface with a concrete mix.
- **Deep Concrete Overlay (h)**: Applying a deep concrete overlay to restore the deck surface.
- **Shallow Concrete Overlay (h, i)**: Applying a shallow concrete overlay to seal and reinforce the deck surface.
- **HMA Overlay with waterproofing membrane (t, h, i)**: Applying a hot mix asphalt overlay with a waterproofing membrane.
- **HMA Cap (g, h, i)**: Applying a hot mix asphalt cap on top of the waterproofing membrane.
- **Concrete Deck with Epoxy Coated Rebar (COR)**: Applying a concrete deck with epoxy coated rebar.
Rehab Project ($590,000).
Hydro deck to expose top mat of rebar
Deep Overlay (Silica Fume Modified Concrete Overlay).

New concrete deck surface

New Expansion Joints
Prestressed concrete beam end repair, bearing replacement, substructure repair, concrete surface coating.
## Post Construction Element Inspection

<table>
<thead>
<tr>
<th>Decks/slabs</th>
<th>Element Name</th>
<th>Quantity</th>
<th>Units</th>
<th>Good (CS1)</th>
<th>Fair (CS 2)</th>
<th>Poor (CS 3)</th>
<th>Serious (CS4)</th>
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<tbody>
<tr>
<td>800</td>
<td>Reinforced Concrete Deck Black Bars</td>
<td>6965</td>
<td>SFT</td>
<td>95%</td>
<td>3%</td>
<td>2%</td>
<td>0%</td>
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<tr>
<td>815</td>
<td>Rigid Overlay</td>
<td>6965</td>
<td>SFT</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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<tr>
<td>811</td>
<td>Reinforced Concrete Deck Bottom Surf.</td>
<td>6965</td>
<td>SFT</td>
<td>92%</td>
<td>5%</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td>812</td>
<td>Reinforced Concrete Fascia</td>
<td>444</td>
<td>LFT</td>
<td>95%</td>
<td>5%</td>
<td>0%</td>
<td>0%</td>
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<tr>
<td>331</td>
<td>Metal Bridge Railing</td>
<td>444</td>
<td>LFT</td>
<td>40%</td>
<td>60%</td>
<td>0%</td>
<td>0%</td>
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<table>
<thead>
<tr>
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<th>Element Name</th>
<th>Quantity</th>
<th>Units</th>
<th>Good (CS1)</th>
<th>Fair (CS 2)</th>
<th>Poor (CS 3)</th>
<th>Serious (CS4)</th>
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<tr>
<td>300</td>
<td>Strip Seal Expansion Joint</td>
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<td>LFT</td>
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<td>0%</td>
<td>0%</td>
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<tr>
<td>301</td>
<td>Pourable Joint Seal</td>
<td>48</td>
<td>LFT</td>
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<td>0%</td>
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<th>Superstructure</th>
<th>Element Name</th>
<th>Quantity</th>
<th>Units</th>
<th>Good (CS1)</th>
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<th>Serious (CS4)</th>
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<td>521</td>
<td>Concrete Protective Coating</td>
<td>1444</td>
<td>SFT</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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</table>

<table>
<thead>
<tr>
<th>Bearings</th>
<th>Element Name</th>
<th>Quantity</th>
<th>Units</th>
<th>Good (CS1)</th>
<th>Fair (CS 2)</th>
<th>Poor (CS 3)</th>
<th>Serious (CS4)</th>
</tr>
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<tbody>
<tr>
<td>310</td>
<td>Elastomeric Bearings</td>
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<td>EACH</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>313</td>
<td>Fixed Bearing</td>
<td>8</td>
<td>EACH</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>515</td>
<td>Steel Protective Coating</td>
<td>8</td>
<td>SFT</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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<th>Element Name</th>
<th>Quantity</th>
<th>Units</th>
<th>Good (CS1)</th>
<th>Fair (CS 2)</th>
<th>Poor (CS 3)</th>
<th>Serious (CS4)</th>
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<td>0%</td>
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<td>0%</td>
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<tr>
<td>234</td>
<td>Reinforced Concrete Pier Cap</td>
<td>40</td>
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<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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<tr>
<td>521</td>
<td>Concrete Protective Coating</td>
<td>1062</td>
<td>SFT</td>
<td>100%</td>
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</table>
A BMS is Decision Support

- The function of a BMS is to provide bridge information and data analysis capabilities to improve the decision-making abilities of bridge managers.
- Bridges cannot be managed without the practical, experienced, and knowledgeable input of the engineer/manager.
- Managers should use the BMS as a tool to evaluate various policy initiatives, often referred to as “what if” analysis.
- The available choices may relate to network-level decisions or project-level decisions.
BMS - The many things you learn on the journey are as valuable as the finished product.

Thank You!