Element Guide Manual
and
Improved Bridge Management

Paul Jensen
Montana Department of Transportation
pjensen@mt.gov
406.444.9245
Presentation Topics

► Element Implementation Plan
► Development of Elements
  ► National Bridge Elements
  ► Bridge Management Elements
  ► Agency Elements
► Development of Bridge Preservation With A Bridge Management System

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New Element Process

AASHTO BRIDGE ELEMENT INSPECTION GUIDE MANUAL

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Element Implementation Plan

- SCOBS T-18 Meeting Last Week
- Development of Element Migration Software
- Update the Element-to-NBI Translator
- Update BRIDGEWare Pontis Inspection Module
- Develop Training on New Elements
- AASHTO Publications Release Quarter 1 2011
- Pontis RFP for Contractor for Inspection Module
- Migration Software to be Public Domain
Significant Changes

- Four Condition States For All Elements.
  - Follow – Good, Fair, Poor, Severe Convention.
- Wearing Surfaces Separated From Deck Element.
  - Deck Element Units Changed To Square Feet.
- Steel Protective Coatings Separated From Steel.
- All Smart Flags Have Been Incorporated Into Condition State Language.
Element Presentation

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Element Presentation

**Description**
This element defines all reinforced concrete bridge deck/slab regardless of the wearing surface or protection systems used.

<table>
<thead>
<tr>
<th>Condition State Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Defect</strong></td>
</tr>
<tr>
<td>Cracking</td>
</tr>
<tr>
<td>Spalls / Delaminations/ Patched Areas</td>
</tr>
<tr>
<td>Efflorescence</td>
</tr>
<tr>
<td>Load Capacity</td>
</tr>
</tbody>
</table>

**Quantity Calculation**
The quantity for this element should include the area of the deck/slab from edge to edge including any median areas and accounting for any flares or ramps present.
### Feasible Actions

<table>
<thead>
<tr>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
<th>Condition State 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do Nothing Protect</td>
<td>Do Nothing Protect Repair</td>
<td>Do Nothing Protect Repair Rehab</td>
<td>Do Nothing Protect Replace</td>
</tr>
</tbody>
</table>

### Element Commentary

The deck/slab evaluation is three dimensional in nature with the defects observed on top and/or bottom surface being captured using the defined condition states. Deck/Slab top or bottom surfaces that are not visible for inspection shall be assessed based on the available visible surface. If both top and bottom surfaces are not visible, the condition shall be assessed based on destructive, non-destructive testing or indicators in the materials covering the surfaces.

### Element Definitions

<table>
<thead>
<tr>
<th>Defect</th>
<th>Minor</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracking</td>
<td>$&lt; 0.02$ inches (0.5 mm)</td>
<td>$0.02 - 0.08$ inches (0.5 - 2.0 mm)</td>
<td>$&gt;0.08$ inches (2.0 mm)</td>
</tr>
<tr>
<td>Cracking Density</td>
<td>N/A</td>
<td>1.0 and 3.0 feet apart (0.33 - 1.0 m)</td>
<td>$&lt; 1$ foot (0.33 m)</td>
</tr>
<tr>
<td>Efflorescence</td>
<td>NA</td>
<td>Surface white without build-up or leaching</td>
<td>Heavy build-up with rust staining</td>
</tr>
</tbody>
</table>

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19
National Bridge Elements (NBE’s)

► Provide The Minimum Element Set To Define Safety And Load Capacity Of Bridges.
► Includes All Primary Structural Elements.
  ► Decks, Slabs, Girders, Columns, Abutments Etc.
► Condition State Language Is Not Editable.
► Elements Intended For NBI Condition Assessment.
► Minimal Implementation Level For Non-element Inspection Agencies.
Bridge Management Elements (BME’s)

- Elements Define Secondary Bridge Components.
  - Joints, Wearing Surfaces, Protective Coatings, Bearings, Barrier Rails Etc.
- Provide And Added Level Of Condition Assessment For Agencies Utilizing Bridge Management Systems.
- Can Be Extended To Capture Other Components As Desired By The Agency.
- Can Influence Deterioration Modeling.
Agency Elements

- Require Fours States Following General Definition.
- May Be Sub-sets Of NBE’s Or BME’s.
  - Sub-sets Of NBE’s Require Same Condition State Language.
  - Can Be Sub-sets Of BME’s.
- May Be Unrelated To Any Defined Element.
- May Be Subject To Deterioration Modeling Or Not.
- Allows The Incorporation Of Non-bridge Assets.
Agency Element
Beam Ends/Middle Section

- Sub-set of NBE
- Must Use NBE Language
- Must Associate Element With NBE Parent
- Reporting by Role-up of Two Elements to One
- Deterioration On Different Paths
## Steel (107) Element Language

<table>
<thead>
<tr>
<th>Defect</th>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
<th>Condition State 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion</td>
<td>None</td>
<td>Freckled Rust</td>
<td>Section Loss</td>
<td></td>
</tr>
<tr>
<td>Cracking/Fatigue</td>
<td>None</td>
<td>Arrested Cracks Exist</td>
<td>Moderate Exists</td>
<td></td>
</tr>
<tr>
<td>Connections</td>
<td>Sound</td>
<td>Sound</td>
<td>Isolated Failures</td>
<td></td>
</tr>
<tr>
<td>Load Capacity</td>
<td>No Reduction</td>
<td>No Reduction</td>
<td>No Reduction</td>
<td></td>
</tr>
</tbody>
</table>

The condition is beyond the limits established in condition state three (3) and/or warrants a structural review to determine the strength or serviceability of the element or bridge.
## Steel (187) Element Language

<table>
<thead>
<tr>
<th>Defect</th>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
<th>Condition State 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion</td>
<td>None</td>
<td>Freckled Rust</td>
<td>Section Loss</td>
<td></td>
</tr>
<tr>
<td>Cracking/Fatigue</td>
<td>None</td>
<td>Arrested Cracks Exist</td>
<td>Moderate Exists</td>
<td></td>
</tr>
<tr>
<td>Connections</td>
<td>Sound</td>
<td>Sound</td>
<td>Isolated Failures</td>
<td></td>
</tr>
<tr>
<td>Load Capacity</td>
<td>No Reduction</td>
<td>No Reduction</td>
<td>No Reduction</td>
<td></td>
</tr>
</tbody>
</table>

The condition is beyond the limits established in condition state three (3) and/or warrants a structural review to determine the strength or serviceability of the element or bridge.
### Beam End/Middle Section NBE/BME

**No New BMS Elements**

<table>
<thead>
<tr>
<th>Element</th>
<th>Quantity</th>
<th>State 1</th>
<th>State 2</th>
<th>State 3</th>
<th>State 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Painted Steel Girder</td>
<td>50 Ft</td>
<td>48 ft</td>
<td></td>
<td>1 ft</td>
<td>1 ft</td>
</tr>
<tr>
<td>Fatigue Flag</td>
<td>1 ft</td>
<td></td>
<td></td>
<td></td>
<td>1 ft</td>
</tr>
<tr>
<td>Section Loss Flag</td>
<td>1 ft</td>
<td></td>
<td></td>
<td></td>
<td>1 ft</td>
</tr>
</tbody>
</table>

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## Beam End Example

![Diagram of a painted steel girder with sections for fatigue crack and section loss.](image)

### Table of Element, Quantity, and States

<table>
<thead>
<tr>
<th>Element</th>
<th>Quantity</th>
<th>State 1</th>
<th>State 2</th>
<th>State 3</th>
<th>State 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>107 Steel Girder</td>
<td>46 ft</td>
<td>45 ft</td>
<td></td>
<td></td>
<td>1 ft</td>
</tr>
<tr>
<td>Fatigue Flag (girder)</td>
<td>1 ft</td>
<td></td>
<td></td>
<td></td>
<td>1 ft</td>
</tr>
<tr>
<td>187 Steel Girder Ends</td>
<td>4 ft</td>
<td></td>
<td></td>
<td></td>
<td>1 ft</td>
</tr>
<tr>
<td>Section Loss Flag (girder)</td>
<td>1 ft</td>
<td></td>
<td></td>
<td></td>
<td>1 ft</td>
</tr>
</tbody>
</table>

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#### Beam End/Middle Section NBE Only (Rollup)

<table>
<thead>
<tr>
<th>Element</th>
<th>Quantity</th>
<th>State 1</th>
<th>State 2</th>
<th>State 3</th>
<th>State 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Girder</td>
<td>50 ft</td>
<td>48 ft</td>
<td></td>
<td>1 ft</td>
<td>1 ft</td>
</tr>
</tbody>
</table>

![Diagram of Beam End/Middle Section NBE Only](image)
### Concrete Decks

**Deck Element 12**

<table>
<thead>
<tr>
<th>Defect</th>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
<th>Condition State 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracking</td>
<td>None to hairline</td>
<td>Narrow size and/or density</td>
<td>Medium size and/or density</td>
<td>The condition is beyond the limits established in condition state three (3) and/or warrants a structural review to determine the strength or serviceability of the element or bridge.</td>
</tr>
<tr>
<td>Spalls / Delaminations/ Patched Areas</td>
<td>None</td>
<td>Moderate spall or patch areas that are sound</td>
<td>Severe spall or patched area showing distress</td>
<td></td>
</tr>
<tr>
<td>Efflorescence</td>
<td>None</td>
<td>Moderate without rust</td>
<td>Severe with rust staining</td>
<td></td>
</tr>
<tr>
<td>Load Capacity</td>
<td>No reduction</td>
<td>No reduction</td>
<td>No reduction</td>
<td></td>
</tr>
</tbody>
</table>

**Deck Protective System 521**

<table>
<thead>
<tr>
<th>Defect</th>
<th>Condition State 1</th>
<th>Condition State 2</th>
<th>Condition State 3</th>
<th>Condition State 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wear</td>
<td>None</td>
<td>Underlying Concrete Not Exposed. Coating Showing Wears From UV Exposure. Friction Course Missing.</td>
<td>Underlying Concrete Is Not Exposed. Thickness Of The Coating Is Reduced.</td>
<td>Underlying Concrete Exposed. Treated Cracks Are Exposed</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>Good condition, fully effective</td>
<td>Fair condition, substantially effective</td>
<td>Poor condition, limited effectiveness</td>
<td>The protective system has failed or is non-operational</td>
</tr>
</tbody>
</table>

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### Elements Generic

#### General Language For Element Development

<table>
<thead>
<tr>
<th>Defect</th>
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<th>Condition State 3</th>
<th>Condition State 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>Good Condition</td>
<td>Fair Condition</td>
<td>Poor Condition</td>
<td>The element condition is severe or is non-operational</td>
</tr>
</tbody>
</table>

#### General Language For Protective System Development

<table>
<thead>
<tr>
<th>Defect</th>
<th>Condition State 1</th>
<th>Condition State 2</th>
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<td>Effectiveness</td>
<td>Good condition, fully effective</td>
<td>Fair condition, substantially effective</td>
<td>Poor condition, limited effectiveness</td>
<td>The protective system has failed or is non-operational</td>
</tr>
</tbody>
</table>
New Element Conclusion

- NBE’s Must Have Same Language
- Subsets Must Rollup
- BME’s Must Have GFPS Language
- Must Consider Protective VS Other Systems
- Model Or Not In the Bridge Management System
Beyond the Elements

DEVELOPMENT OF BRIDGE PRESERVATION WITH A BRIDGE MANAGEMENT SYSTEM

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FHWA’s Guidance for Approval Systematic Process

► Define How The Needs Are Identified.
► Outline How The Needs Are Prioritized And Programmed.
► Define The Outcome Or Goal, Including Resources Necessary & Timeframes To Reach The Outcome/Goal.
► Dedicate Resources Necessary To Reach Defined Outcome/Goal.
► Annually Track, Evaluate, And Report On Progress In Reaching Outcome/Goal And Adjust Resources Accordingly.

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Three Track Nominations

- **Reactionary Maintenance (by Bridge)**
  - Emergency Repairs
  - Limited Contract Repairs
  - DOT In-house Repairs

- **Preventive Maintenance (by Corridor)**
  - Contract Deck Sealing
  - Contract Surface Rehab

- **Rehab, Replacement (by Bridge - Capital)**
  - Contract Work
  - Tied to State Transportation Improvement Plan (STIP)

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Need

► Determine Capital Program
► Determine Preventive Maintenance Program
► Determine Reactionary Maintenance Activities
► Develop Performance Measurements
► Develop Reporting System to Other Business Units

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Project Need Evaluation

NBI Condition
FAIR Condition
SR = 72
Synthesized Condition
HI=75

Element Condition
7 Total Bananas
4 Good
3 Rotten
HI=57

NBI Work Item – Rehabilitate All Of The Bananas – Cost $3.00

Synthesized Element Work Item – Do Nothing

Element Work Item – Replace Only The Rotten Bananas – Cost $1.28

Variance with the NBI Evaluation and Element Evaluation:
Erroneous Statement Condition and Need

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Bridge Management

- Collecting NBI Data Since 1980
- Collecting AASHTO CoRe Data Since 1995
  - CoRe: Commonly Recognized Elements
- All Data Warehoused in Oracle Database
- Data Structure Uses AASHTOWare Pontis Schema
- Data Analysis Uses Pontis and “Home Grown” Applications
## Historical Review (NBI)

- **Breakdown of NBI Data**
- **Deck, Superstructure and Substructure**
- **Snapshot Past 25, 10, 5, 1 Years**
- **Review for Trends and Limit the Program Scope**

### Breakdown of NBI Data

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worse than 5</td>
<td>1.8%</td>
<td>0.9%</td>
<td>0.8%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Equal to 5</td>
<td>2.9%</td>
<td>3.6%</td>
<td>4.3%</td>
<td>4.8%</td>
</tr>
<tr>
<td>Better than 5</td>
<td>95.2%</td>
<td>95.2%</td>
<td>84.1%</td>
<td>91.4%</td>
</tr>
<tr>
<td>Superstructure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worse than 5</td>
<td>2.3%</td>
<td>1.6%</td>
<td>1.1%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Equal to 5</td>
<td>3.1%</td>
<td>4.3%</td>
<td>4.3%</td>
<td>6.1%</td>
</tr>
<tr>
<td>Better than 5</td>
<td>94.7%</td>
<td>94.0%</td>
<td>83.8%</td>
<td>93.5%</td>
</tr>
<tr>
<td>Substructure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worse than 5</td>
<td>3.3%</td>
<td>2.6%</td>
<td>2.6%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Equal to 5</td>
<td>3.9%</td>
<td>4.5%</td>
<td>6.3%</td>
<td>3.6%</td>
</tr>
<tr>
<td>Better than 5</td>
<td>92.9%</td>
<td>92.9%</td>
<td>91.1%</td>
<td>89.5%</td>
</tr>
</tbody>
</table>

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Overall Conclusion

- Need To Develop A Long Term Preventive Maintenance Strategy
- Decks And Associated Elements As A Focus
- Use Deterioration Models From Pontis
- Develop A Performance Measure For The Constrained Data
Deck Performance Measure

► Best Practice Is the Health Index
► Dose Not Account for Smart Flags
► Range of Values Small for Large Change in Condition

► Calculated by Equation 4.2.1 of Pontis Technical Manual (Page 4-9)

\[
\text{Health Index} = \frac{\sum_{n} \text{Element Cost} \times \text{Element Quantity} \times \text{Percent Condition State}}{\sum_{n} \text{Element Cost} \times \text{Total Element Quantity}} \times 100
\]
Deck Performance Measure
Montana Modified

- Used Core Computation
- Included Smart Flags in Calculation
- Used Grouping From NBI Translator
- Smart Flag Cost From Total Cost of Element Group (Deck, Bearings, Joints, Approach Slabs)
- Limited One Smart Flag by Span Group

\[
HI_{mt} = \left( \frac{\sum_e \text{Cost} \times \text{Qty} \times \text{Pct in State}}{\sum_e \text{Cost} \times \text{Qty}} + \left( \sum_s \left( \sum_e \text{Cost} \times \text{Qty} \right) \times \text{Qty} \times \text{Pct in State} \right) \right) * 100
\]

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Reporting

► Development of “Indifference Curve”
► Report
► By Bridge (by Year)
  ► Recommended Action
  ► Benefit / Cost Ratio
  ► Hi_{mt}
  ► Categorize by Good, Watch, Bad
► By Route (Break on County and Year)
  ► Average Hi_{mt}
  ► Network Indifference Curve
  ► Network Benefit / Cost Ratio
  ► Network Cost to Improve
  ► Count by Good, Watch, Bad Groupings

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Groupings

► Good Condition
  ► Hi_{mt} Greater Than 70
  ► No Defects

► Watch
  ► Hi_{mt} Between 50 and 69
  ► Bridges Have Defects That Need Monitoring

► Bad
  ► Hi_{mt} Less Than 50
  ► Defects Needing Corrective Action

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Check for Corridor Improvement

- Input Projects, Scopes and Cost Into Pontis
- Run the Scenario With Proposed Budgets
- Compare Network Level Results
  - Fulfill Performance Goals?
  - Budgets Adequate for Scope?
  - Peaks and Valleys of Needs Smooth Out?

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## Development Results

<table>
<thead>
<tr>
<th>Year</th>
<th>Need to Correct</th>
<th>Deck Health Index</th>
<th>Accumulative Expenditures</th>
<th>Deck Health Index</th>
<th>Accumulative Expenditures</th>
<th>Deck Health Index</th>
<th>Accumulative Expenditures</th>
<th>Deck Health Index</th>
<th>Accumulative Expenditures</th>
<th>Deck Health Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>$1,485,733</td>
<td>84.9</td>
<td>$1,485,733</td>
<td>93.7</td>
<td>$437,341</td>
<td>88.9</td>
<td>$114,927</td>
<td>85.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>$6,936,027</td>
<td>55.9</td>
<td>$3,590,750</td>
<td>81.1</td>
<td>$1,798,384</td>
<td>74.3</td>
<td>$1,233,546</td>
<td>70.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2028</td>
<td>$12,276,500</td>
<td>34.5</td>
<td>$7,093,280</td>
<td>73.5</td>
<td>$4,453,960</td>
<td>70.5</td>
<td>$1,202,671</td>
<td>59.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2038</td>
<td>$24,551,826</td>
<td>9.2</td>
<td>$10,910,317</td>
<td>71.4</td>
<td>$6,279,637</td>
<td>56.6</td>
<td>$1,260,291</td>
<td>43.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2048</td>
<td>$35,136,686</td>
<td>0.7</td>
<td>$17,972,034</td>
<td>88.3</td>
<td>$11,744,147</td>
<td>70.1</td>
<td>$2,439,881</td>
<td>41.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2058</td>
<td>$35,696,378</td>
<td>0.4</td>
<td>$22,354,797</td>
<td>82.8</td>
<td>$13,603,630</td>
<td>64.3</td>
<td>$1,693,066</td>
<td>34.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Goal DHI for Performance Level of Service

Deck Health Index Over Time

Do Nothing

Unconstrained Budget

$1.0 Million Budget

$500 Thousand Budget

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Field Review and Set Scope

- Rank Corridors From Worst to Best
- Review Recommended Action From Pontis With Field Observations
  Kick Some Rocks
- Develop Scopes for Each Bridge
- Detailed Estimate for Each Bridge in the Corridor

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Conclusion

- Developed a PM Program
- Used Pontis Derived Data
- Used Home-grown Computer Programs and Reporting
- Extended the Pontis Database
- Added Value to the Initial Pontis Product
- Follow FHWA’s Guide for Systematic Process
- Implement PM Program
Thank For Your Time

Paul Jensen
Montana Department of Transportation

Email : pjensen@mt.gov

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