Incorporating Preservation Strategies in Bridge Management Systems

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Formerly

AASHTOWare Bridge Management

www.AASHTOWareBridge.com
AASHTOWare Bridge Management

• Utilized by 44 DOTs plus local and intl. agencies
• BrM/Pontis 5.2 is funded by a voluntary participation from more than 20 state DOTs, under DOT guidance and expertise
• Tools that are easier to use and understand:
  – Planning
  – Deterioration
  – Risk
  – Multi-objective analysis
  – Lifecycle costs
  – Project models
  – Dashboards
  – Corridor planning
Basic Approach of 5.2

• Utilize extensive research and lessons learned over past 20 years
  • Continue to evaluate best approach and layout
  • Interactively working with Task Force
  • TRT Expert Panel of State Representatives
• Multiple Phased implementation
• Integrate full AASHTO and FHWA requirements
Key Parts of Pontis/BrM 5.2

• What do I have?
• What Condition is it in?
Key Parts of Pontis/BrM 5.2

• What Risks Do I have?
Key Parts of Pontis/BrM 5.2

- What are my identified needs?

- Bridge Inventory
- Bridge Conditions
- Identified Work Candidates
- Risk
Key Parts of Pontis/BrM 5.2

• What are the benefits of the work candidates?
Key Parts of Pontis/BrM 5.2

- How do I compare benefits of very different actions?

- Bridge Inventory
- Bridge Conditions
- Risk
- Identified Work Candidates
- Library of Actions with Benefits/Costs
- Agency Goals
  - Condition / Mobility / Risk
  - Multi-Objective Analysis / Utility Functions

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Key Parts of Pontis/BrM 5.2

- What actions should I possibly take?

- Bridge Inventory
- Bridge Conditions
- Risk
- Identified Work Candidates
- Library of Actions with Benefits/Costs
- Condition / Mobility / Risk
- Multi-Objective Analysis / Utility Functions
- Computer Recommended Actions
- Agency Goals
Key Parts of Pontis/BrM 5.2

- What are the benefits of preservation actions?

- Bridge Inventory
- Bridge Conditions
- Risk
- Identified Work Candidates
- Library of Actions with Benefits/Costs
- Preservation / Life Cycle Cost
- Condition / Mobility / Risk
- Multi-Objective Analysis / Utility Functions
- Computer Recommended Actions

Agency Goals
Key Parts of Pontis/BrM 5.2

- What is the effect of future time and deterioration?
Key Parts of Pontis/BrM 5.2

- Grouping/comparing needs across bridges into projects and programs

- Bridge Inventory
- Bridge Conditions
- Risk
- Identified Work Candidates
- Library of Actions with Benefits/Costs
- Preservation / Life Cycle Cost
- Condition / Mobility / Risk
- Multi-Objective Analysis / Utility Functions
- Computer Recommended Actions
- Deterioration Models
- Project and Program Planning and Analysis
Incorporating Preservation

• Main Questions Answered:
  – What is the utility value of an action being proposed on the bridge?
    • Evaluates user identified actions against library of benefits
    • Utilizes multi-objective analysis framework to define value
  – What actions might be taken to achieve the greatest value?
    • Utilizes library of all possible actions and default costs to determine potential benefits of each
Improved Decision Making Tools

Better fit for agency workflow and business processes

Better Tradeoff Analysis

- Mobility
- Life cycle cost
- Condition
- Risk and vulnerability

New functionality:
- Balance multiple objectives
- More control of results
- More transparency
- Risk
- Time-sensitive deterioration
- Indirect Costs
Implementing Utility Functions

• Multi-objective framework that can be used to show the value (utility) of an action for a bridge
• Utility will also be shown for each sub-area
  – Mobility
  – Condition
  – Risk
  – Life Cycle Cost (deterioration models + preservation benefits)
• Work candidates (preservation and others) are evaluated for how they contribute to mobility, lifecycle cost, condition and risk weightings
• Allow for comparison of current and future status and benefits of actions
Multi-Objective Analysis Framework

- The model will score each work candidate identified.

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Performance Measure</th>
<th>Scaling Functions</th>
<th>Single-Criterion Utility</th>
<th>Amalga-mation Function</th>
<th>Multiple-Criterion Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood</td>
<td>Likelihood of flood</td>
<td>Scour risk assessment (e.g. 0-100)</td>
<td>Cost value function (0-100)</td>
<td>Relative Weights</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consequences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earthquake</td>
<td>Likelihood of quake</td>
<td>Seismic risk assessment (e.g. 0-100)</td>
<td>Mobility value function (0-100)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consequences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fracture</td>
<td>Likelihood of fracture</td>
<td>Fatigue risk assessment (e.g. 0-100)</td>
<td>Condition value function (0-100)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consequences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road Vehicle Impact</td>
<td>Likelihood of collision</td>
<td>Traffic impact risk assessment (e.g. 0-9)</td>
<td>Condition value function (0-100)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Event</td>
<td>Likelihood of event</td>
<td>Other risk assessment (e.g. 0-5)</td>
<td>Other risk value function (0-100)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consequences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adv. Deterioration</td>
<td>Adverse likelihood</td>
<td>Deterioration risk assessment (e.g. 100-0)</td>
<td>Condition value function (0-100)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adverse consequences</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subsid Width</td>
<td>Likelihood of crash injuries or deaths</td>
<td>Crash risk assessment (e.g. 100-0)</td>
<td>Crash risk value function (0-100)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Utility function (0-100)
Multi Objective Analysis

- In this example, the bridge has a utility value of 49.92.
- In this example, the Condition component is weighted the most heavily of all components of a bridge (weighted to be more important than Risk, Mobility, and Life Cycle).
- In this example, an agency is able to see exactly how every component and subcomponent exactly impacts the overall utility of the asset.
By incorporating utility functions, BrM is able to combine elements of Risk, Lifecycle Cost, Condition, Mobility, and other agency defined criteria to calculate the utility or value of a particular bridge.
Full Transparency for Utility Values

<table>
<thead>
<tr>
<th>Condition Item</th>
<th>Base Value</th>
<th>Scaled Value</th>
<th>Weight</th>
<th>Adjusted Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck</td>
<td>4</td>
<td>42</td>
<td>10.00</td>
<td>420.00</td>
</tr>
<tr>
<td>Superstructure</td>
<td>6</td>
<td>81</td>
<td>1.00</td>
<td>81.00</td>
</tr>
<tr>
<td>Substructure</td>
<td>7</td>
<td>91</td>
<td>1.00</td>
<td>91.00</td>
</tr>
<tr>
<td>Culverts</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element ratings</td>
<td>22.74</td>
<td>22.74</td>
<td>1.00</td>
<td>22.74</td>
</tr>
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</table>

**Risk Value**

<table>
<thead>
<tr>
<th>Risk Item</th>
<th>Base Value</th>
<th>Scaled Value</th>
<th>Weight</th>
<th>Adjusted Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scour</td>
<td>6</td>
<td>58</td>
<td>1.00</td>
<td>58.00</td>
</tr>
<tr>
<td>Accident</td>
<td>20.00</td>
<td>53.81</td>
<td>1.00</td>
<td>53.81</td>
</tr>
</tbody>
</table>

**Mobility Value**

<table>
<thead>
<tr>
<th>Mobility Item</th>
<th>Base Value</th>
<th>Scaled Value</th>
<th>Weight</th>
<th>Adjusted Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of truck detoured</td>
<td>10</td>
<td>34.20</td>
<td>1.00</td>
<td>34.20</td>
</tr>
</tbody>
</table>

**LifeCycle Value**

<table>
<thead>
<tr>
<th>LifeCycle Item</th>
<th>Base Value</th>
<th>Scaled Value</th>
<th>Weight</th>
<th>Adjusted Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No records to display</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Preservation (and other) Actions

- Default Actions supplied by State TRT members
- Actions have a default cost
- Attach actions to benefit groups
Benefit Groups

- Benefit Groups which define what effects an action has
- Benefit Groups can apply to any elements, fields, and/or risks.
Individual Bridge Analysis Pages show benefits of preservation actions

• Provides snapshot of work candidates and a detailed view of effect of each

• View includes all related utility value information and criterion
Recommended Preservation Actions

• Calculates the cost/benefit ratio for all possible actions

• Ranks all available actions providing recommendations on what should be applied to a bridge
Visualize Needs with Maps
Bridge Analysis Groups to Assist with Preservation

- Ability to create groups based on any inventory criteria combination
  - i.e. Steel bridges with ADT over 30,000.
- Apply analysis to groups.
Deterioration Modeling

- Implement new deterioration model logic
  - Weibull approach to include time factor
- Easy to construct/new elicitation process
- Utilize AASHTO Elements
  - Protective Systems
  - Defect Flags
- Allow for Multi-path deterioration
Deterioration Modelling

• An agency is able to see the direct impact of performing work on an asset, and how it will impact the bridge currently, as well as years into the future.
• Also able to see the *direct impact of performing work at a later point in time*. This aids an agency in the decision to determine when the optimized time would be to perform the selected work.
Deterioration Modeling and Multi Objective Analysis (example)

<table>
<thead>
<tr>
<th>Work Candidate</th>
<th>Utility</th>
<th>Utility Change</th>
<th>Cost</th>
<th>Benefit / Cost ($k)</th>
<th>Cost ($k) / Benefit</th>
<th>Action Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do Nothing</td>
<td>49.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>04-0759-NMDO-041614-27F109E125 - Approach Railing-Repair</td>
<td>50.5</td>
<td>0.58</td>
<td>$2,000.00</td>
<td>0.29</td>
<td>$3</td>
<td>0</td>
</tr>
</tbody>
</table>

**Effects on Each Utility Criterion**

<table>
<thead>
<tr>
<th>Category name</th>
<th>Before WC</th>
<th>After WC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Utility</td>
<td>49.92</td>
<td>50.5</td>
</tr>
<tr>
<td>Condition</td>
<td>58.32</td>
<td>59.73</td>
</tr>
<tr>
<td>Deck</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Superstructure</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td>Substructure</td>
<td>91</td>
<td>91</td>
</tr>
<tr>
<td>Scour</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>Element ratings</td>
<td>63.35</td>
<td>100</td>
</tr>
<tr>
<td>(12) Reinforced Concrete Deck</td>
<td>70.95</td>
<td>100</td>
</tr>
<tr>
<td>(331) Reinforced Concrete Bridge Railing</td>
<td>63.85</td>
<td>100</td>
</tr>
<tr>
<td>(510) Wearing Surfaces</td>
<td>55.26</td>
<td>100</td>
</tr>
<tr>
<td>Risk</td>
<td>53.81</td>
<td>53.81</td>
</tr>
<tr>
<td>Accident</td>
<td>53.81</td>
<td>53.81</td>
</tr>
<tr>
<td>Mobility</td>
<td>34.2</td>
<td>34.2</td>
</tr>
<tr>
<td>Percent of truck detoured</td>
<td>34.2</td>
<td>34.2</td>
</tr>
</tbody>
</table>

**Deterioration**

- **Bridge**
  - Graph showing Health Index (%)
  - Action vs Default
  - Years on x-axis, Health Index (%) on y-axis

- **Element: 331**
  - Graph showing Health Index (%)
  - Action vs Default
  - Years on x-axis, Health Index (%) on y-axis
Deterioration Modeling and Multi Objective Analysis (example)
Project Planning Preservation Actions

• Project Planning
  – Ability to create and view projects.
  – Define projects by grouping together work items and bridges.
  – Determine cost and effectiveness of projects and the end result of performing the selected work on the selected bridges.
  – Dashboards to view higher level numbers and effects, while also being able to drill down to specific results and details.
Goal: 100 Years Indefinite Operation

- Preservation and detailed data is key
- 3D design/as-built model loaded directly into structure management system for BIM
- Component hierarchy and inventory data
- Data can be viewed and linked on interactive 3D model accessible via the Web
Detailed 3D views for Preservation

- Collect and report condition data
- Plan maintenance actions with full history
Preservation Support – Usable Data
Conclusions

• Software solutions are rapidly developing the analytical engines to quantifying and describe benefits of preservation actions
• Need data on benefits of each action
  – What is the benefit of bridge washing?
• Goal is to provide easy to use, understandable tools for practitioners
Questions?

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