Bridge Management Update

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California Department of Transportation

AASHTO SCOB Meeting
May 2008 – Omaha Nebraska
Presentation outline

• Bridge Management Background
• Condition Assessment
• Element Translation
• Bridge Management System Software Tools
• New Modeling Approaches
• A Future Vision for BMS
Bridge Management Background

• To manage bridges effectively we need the following primary components:
  – Inventory definition
  – Current condition assessment
  – Knowledge of bridge vulnerabilities.
  – Tracking of needs and projects
  – Economic evaluation of potential actions
  – Forecasting of deterioration and needs
  – Photo and document archive
Condition Assessment

• The Coding Guide permits the collection of bridge condition information in two ways.
  – NBI (0-9) condition scale as defined in the coding guide.
  – Translation of the AASHTO element level inspection data using the FHWA translator program.

• The two condition assessment methods can produce very different results.
Condition Assessment

- Element inspection data is viewed by most as superior to the NBI (0-9) scale because it captures the severity and extent of the condition.
- The presence of two systems inevitably leads to a comparison of results.
- The resulting condition values are considered in the development of project eligibility, state funding and influence the transportation bill.
Condition Assessment Comparison

NBI Condition
FAIR COND

Element Inspection
7 Total Bananas
4 Good
3 Rotten
Element Inspection Data Translation
Element Translator (BMSNBI)

- The NBI translator program is used to aggregate element inspection data up to the NBI condition scale.
- The Translator program is used to develop performance metrics while looking at forecasted conditions.
- Two major areas of divergence when translating element inspection information to NBI scales.
  - Painted steel elements (paint)
  - Deck condition ratings (cracking)
Big Picture (National Perspective)

Condition & Inventory
- CoRe Elements
- NBI Condition
- Coding Guide

Translation

National Bridge Inventory
- Defense
- Studies
- Funding
- Reporting

Bridge Eligibility
- Sufficiency Rating
- Structurally Deficient Functionally Obsolete

Preservation Program

Funds allocation

Transportation Bill
- Condition & Performance Report

Re-translate
Bridge Management Software Tools
Bridge Management Software Tools

• Pontis
  – Pontis has been the mainstay for the majority of States for over 15 years.
  – Pontis addresses all the BMS components.
  – Newest release (Pontis 5.1) includes a web based inspection module.

• Pontis 5.2 (2009)
  – Software will feature a project focus with vastly improved project analysis capabilities.
  – Multiple objective modeling framework.
  – Incorporation of bridge risks.
Pontis License Map

Other Licensees:
- FHWA, District of Columbia & Puerto Rico

Map Key
- Licensee
- Non-Licensee

County/City | State
--- | ---
Los Angeles Co | CA
Santa Clara Co | CA
City of Phoenix | AZ

International
- Manitoba, Canada
- Italy
- Portugal
- Japan
Bridge Management Software Tools

• National Bridge Investment Analysis (NBIAS)
  – NBIAS is used by the FHWA to forecast bridges needs for the Condition and Performance Report to congress.
  – NBIAS models are the same as the Pontis models.
  – NBIAS contains limited NBI bridge level info.
  – Element level condition information is required for NBIAS to forecast future needs.
  – NBIAS performs high level economic analysis based on a wide variety of performance objectives.
NBIAS Screens
NBIAS Screens

[Graph showing total cumulative spending and structural/functional needs from 2000 to 2050 with specific years highlighted for different categories.]
Bridge Optimization Models
The current Pontis and NBIAS models

- Pontis and NBIAS utilize the same two models when forecasting future needs.
  - The MR&R models use deterioration rates, action cost and action effectiveness to select the least long term cost actions.
  - The improvement model determines user costs of deficiencies based on defined policies and costs.
The MR&R Model

Element (Environment): 110 (2) Reinforced Conc Oper (Low)

Action
(>> = recommended)

State: 1 No deterioration
  >> 0 Do Nothing

State: 2 Minor cracks/spalls
  >> 0 Do Nothing
  1 Seal cracks and minor patches

State: 3 Delams/spalls
  >> 0 Do Nothing
  1 Clean rebar and patch (and seal cracks)

State: 4 Analysis warranted
  0 Do Nothing
  >> 1 Rehab unit
  2 Replace unit
## Improvement Model Policy & Costs

### Legal

<table>
<thead>
<tr>
<th>ADT Class</th>
<th>Functional Class</th>
<th>Lane Width m</th>
<th>Shoulder Width m</th>
<th>Vertical Clearance m</th>
<th>Operating Rating m</th>
<th>Inventory Rating m</th>
<th>Other Rating m</th>
<th>Lane Width m</th>
<th>Shoulder Width m</th>
<th>Vertical Clearance m</th>
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### Unit Costs

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<tr>
<th>Dimensions</th>
<th>Functional Class</th>
<th>Replace per sq.m.</th>
<th>Widening per sq.m.</th>
<th>Raise per sq.m.</th>
<th>Strengthen per sq.m.</th>
<th>Detour per hr</th>
<th>Detour per km</th>
<th>Avg per accident</th>
<th>Weight</th>
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<td>00</td>
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<td>860.00</td>
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<td>14 Urban Other Prnc</td>
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<td>640.00</td>
<td>320.00</td>
<td>320.00</td>
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<td>19.34</td>
<td>0.25</td>
<td>12,600</td>
<td>50.00</td>
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</tbody>
</table>
The MR&R model solution is referred to as the “optimal” solution.
- Optimal means the least long term cost for each element state and environment combination.
Optimal Preservation

Long Term Cost

Cost Minimization Point

Typical DOT Practices

Low

High

Poor

Good

Condition
Least Cost Optimization Results

Health Index

Time

Near Term
Long Term

Unconstrained Curve
The Current Pontis/NBIAS Models

- MR&R benefits can be measured in two ways: future cost avoidance or change in element value (Bridge Health Index).
- Improvement model benefits are determined by calculating the reduction in user costs associated with improvements.
- Project prioritization is done by maximizing benefit cost ratios.
  - Future net benefits / Current costs
## Current Model Summary

<table>
<thead>
<tr>
<th>BMS Attribute</th>
<th>Pontis 4.X &amp; NBIAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR&amp;R Model Solution</td>
<td>Least Long Term Costs</td>
</tr>
<tr>
<td>MR&amp;R Model Benefits</td>
<td>Future Cost Avoidance or Net Change in Value</td>
</tr>
<tr>
<td>Improvement Benefits</td>
<td>Net Reduction in User Costs</td>
</tr>
<tr>
<td>Action Benefit cost ratio</td>
<td>Future Net Benefits divided by Current Costs</td>
</tr>
<tr>
<td>Combining Benefits</td>
<td>MR&amp;R agency benefits and Improvement user benefits are added using a reduction factor.</td>
</tr>
<tr>
<td>Project Ranking Criteria</td>
<td>Highest unit benefit/ cost ratio</td>
</tr>
</tbody>
</table>
Hot Topics in Bridge Management
Commonly Recognized Elements

• Efforts are underway to propose new language for many of the CoRe elements.
• The changes will impact most deck/slab elements and all painted steel elements.
• For all painted steel elements the proposal is to:
  – separate into two elements; one steel and one coating.
• For decks and slabs the proposal is to:
  – Change the elements to measure square area.
  – Separate wearing surfaces from the elements.
Commonly Recognized Elements

• The changes are being proposed to more effectively capture the information needed to manage bridges.
• The changes will result in better condition assessments, modeling and performance measurement.
• CoRe elements changes require:
  – T-18 Approval
  – Coordination with the Pontis Task Force.
  – Consideration of the impacts on agencies.
  – NBI translator changes.
  – Changes to training course and related manuals.
Multi-Objective Optimization
BMS Modeling using Utility Functions

• A utility is a 0 to 1 unit less measure that quantifies action/project benefits.
• Dissimilar benefits can be combined using utility functions.
• Utility curves can be user defined and can include.
  – Condition, load capacity, risks, functional needs, etc.
• The total utility of a project is equal to the weighted sum of the component utilities.
  \[
  \text{Total Utility} = W_1(U_1) + W_2(U_2) + W_3(U_3) \ldots
  \]
Sample Utility Curve

Superstructure Rating Utility Curve

- Utility
- Superstructure Rating

The graph illustrates the utility curve for superstructure ratings, showing how utility increases with higher superstructure ratings.
## Example Calculation

<table>
<thead>
<tr>
<th>Bridge ID</th>
<th>Health (BHI)</th>
<th>Scour 113</th>
<th>Load Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge A</td>
<td>70</td>
<td>7</td>
<td>15 tons</td>
</tr>
<tr>
<td>Bridge B</td>
<td>70</td>
<td>3</td>
<td>40 tons</td>
</tr>
<tr>
<td>Bridge C</td>
<td>70</td>
<td>5</td>
<td>40 tons</td>
</tr>
</tbody>
</table>
Bridge Health Index Utility Curve

Health Index Utility Curve

Utility

Health Index
**Example Calculation - Condition Component**

<table>
<thead>
<tr>
<th>Bridge ID</th>
<th>Health (BHI)</th>
<th>$U_{BHI}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge A</td>
<td>70</td>
<td>0.20</td>
</tr>
<tr>
<td>Bridge B</td>
<td>70</td>
<td>0.20</td>
</tr>
<tr>
<td>Bridge C</td>
<td>70</td>
<td>0.20</td>
</tr>
</tbody>
</table>
NBI Scour Utility Curve

NBI Scour Utility Curve

Utility

NBI Rating

Bridge B

Bridge C

Bridge A
Example Calculation – Scour Component

<table>
<thead>
<tr>
<th>Bridge ID</th>
<th>Scour 113</th>
<th>( U_{113} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge A</td>
<td>7</td>
<td>1.0</td>
</tr>
<tr>
<td>Bridge B</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>Bridge C</td>
<td>5</td>
<td>0.95</td>
</tr>
</tbody>
</table>
Load Capacity Utility Curve

Load Rating Utility Curve

Utility

Inventory Rating (tons)

Bridges B&C

Bridge A
Example Calculation – Load Component

<table>
<thead>
<tr>
<th>Bridge ID</th>
<th>Load Rate</th>
<th>$U_{LR}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge A</td>
<td>15 tons</td>
<td>0.5</td>
</tr>
<tr>
<td>Bridge B</td>
<td>40 tons</td>
<td>0.95</td>
</tr>
<tr>
<td>Bridge C</td>
<td>40 tons</td>
<td>0.95</td>
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</tbody>
</table>
## Example Calculation

<table>
<thead>
<tr>
<th>Bridge</th>
<th>BHI</th>
<th>Scour</th>
<th>Load</th>
<th>$U_{BHI}$</th>
<th>$U_{113}$</th>
<th>$U_{LR}$</th>
<th>$W_{BHI}$</th>
<th>$W_{SC}$</th>
<th>$W_{LR}$</th>
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</thead>
<tbody>
<tr>
<td>Bridge A</td>
<td>70</td>
<td>7</td>
<td>15</td>
<td>0.20</td>
<td>1.0</td>
<td>0.50</td>
<td>0.50</td>
<td>0.30</td>
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<tr>
<td>Bridge B</td>
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<td>0.20</td>
<td>0.50</td>
<td>0.95</td>
<td>0.50</td>
<td>0.30</td>
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<tr>
<td>Bridge C</td>
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<td>0.95</td>
<td>0.95</td>
<td>0.50</td>
<td>0.30</td>
<td>0.20</td>
</tr>
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</table>

Bridge A  $U_T = (1-0.20)*0.5+(1-1)*0.3+(1-0.5)*0.2= 0.50$

Bridge B  $U_T = (1-0.20)*0.5+(1-0.5)*0.3+(1-0.95)*0.2= 0.56$

Bridge C  $U_T = (1-0.20)*0.5+(1-0.95)*0.3+(1-0.95)*0.2= 0.52$

Introducing the estimated project cost allows for the development of a Utility/Cost ratio for prioritization.
Multi-Objective Summary

- Least cost solutions yield a lower condition than most agencies can tolerate.
- Utilities can combine condition attributes, safety components and risk into a single value that can be compared across bridges.
- Utilities offer a way to optimize a model for any number of defined parameters.
- The concepts are promising and are being implemented in Pontis and other asset management systems.
A Vision for the Future of Bridge Management
Vision

• Adopt a single element based condition assessment protocol based on an updated CoRe element set.
  – Capitalize on the pending changes in the CoRe.
  – Quality condition data defining severity and extent.
  – Decisions are based on objective condition data.
  – Gain nationwide consistency.
Vision

• Modify the National Bridge Inventory to collect element inspection data and risks parameters.
  – Vast majority of agencies already doing element inspection.
  – Provide better data at the national level to fully define the nation’s bridge needs.
  – Allows needs forecasting at the national level.
  – Elimination of the translator for element inspection data.
Vision

• Separate the apportionment of bridge dollars from project level eligibility.
  – Improvement of the Coding Guide is hampered by the tie to apportionment.
  – Provide more flexibility at the State level in eligible project selection.
Vision

- Develop improved formulations for the Sufficiency Rating.
  - Use improved element conditions.
  - Incorporate bridge risk factors such as scour, seismic, and fatigue.
  - Revised terminology and formulas for structural deficiency and functional obsolescence.
Vision

• Better integrate Bridge Management analysis into daily practice.
  – Routine use of life cycle cost analysis on bridge projects.
  – Incorporate bridge risks into funding and project level decisions.
  – Use consist modeling philosophies at the state and national levels.
Making the Vision Happen

- AASHTO working with FHWA and the Bridge Management community can make the vision happen.
- Consider the proposed suggestions when discussing new T-18 initiatives.

Thank You