Deck Preservation Strategies with a Bridge Management System

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Development Of A Roadmap

Definitions
Outcomes
Culture
Models
Performance Measures
Data Collection

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Everyone On The Same Page

- New Construction
- Preservation Includes (Deck, Super, Sub)
  - Preventive (Not Always Condition Responsive),
  - Rehabilitation
  - Reconstruction
- Reactive Maintenance (Unplanned Activities)

- Key Words:
  - Life Extension
  - Cost Effectiveness
  - Proactive
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 (Mill-And-Fill)
- Rehab, Replacement (by Bridge - Capital)
- Contract Work
- Tied to State Transportation Improvement Plan (STIP)
Culture Of Change

- Upper Management (Across All Areas)
  - High Level
  - Performance Goals
  - Resource Allocation
  - Political Considerations
- Mid Management (Infrastructure)
  - Detail Roll-up Of Expectations
  - Priority Over Costs
  - Area Of Performance
- Technical Experts
  - Models
  - Development Of Program Levels
  - Area Of Performance
Basis For Measurement Development

- Current Vs. Needed
- Monitor Trends
- Develop Both Short And Long Term Goals

- Return On Investment
- Funding Constraints
- Higher Expectations From The Public
- Affordable Level-of-Service
FHWA’s Guidance for Approval Systematic Process

3. Define The Outcome Or Goal, Including Resources Necessary & Timeframes To Reach The Outcome/Goal.
5. Dedicate Resources Necessary To Reach Defined Outcome/Goal.
6. Annually Track, Evaluate, And Report On Progress In Reaching Outcome/Goal And Adjust Resources Accordingly.
Deck Performance Measure

- Best Practice Is the Health Index
- Does 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

\[
HI_{mt} = \frac{(\sum_{e} \text{Cost} \times \text{Qty} \times \text{Pct in State}) + (\sum_{s} (\sum_{e} \text{Cost} \times \text{Qty}) \times \text{Qty} \times \text{Pct in State}))}{(\sum_{e} \text{Cost} \times \text{Qty}) + (\sum_{s} (\sum_{e} \text{Cost} \times \text{Qty}) \times \text{Qty}))} \times 100
\]
Montana HI

- Larger Spread of HI Values
- Gave Better Feel for Need
- Inventory Averages
  - $H_{I_{avg}}$ (No SF in Computation) = 90
  - $H_{I_{avg}}$ (SF in Computation) = 88
- Bridges With Smart Flags
  - $H_{I_{avg}}$ (No SF in Computation) = 83
  - $H_{I_{avg}}$ (SF in Computation) = 59
Data Collection

- Deterioration - From Field Observation
  - NBI Inspections
  - Element Inspections
- Cost Data
- Contract Data
- Scheduled Contract Work
  - State Transportation Improvement Plan (STIP)
- Maintenance Work Records
MDT Data Collection

- 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

<table>
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<th></th>
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<tbody>
<tr>
<td><strong>Deck</strong></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>
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<td>Better than 5</td>
<td>95.2%</td>
<td>95.2%</td>
<td>84.1%</td>
<td>91.4%</td>
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<td><strong>Superstructure</strong></td>
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<td>2.3%</td>
<td>1.6%</td>
<td>1.1%</td>
<td>0.4%</td>
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<tr>
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<td>3.1%</td>
<td>4.3%</td>
<td>4.3%</td>
<td>6.1%</td>
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<tr>
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<td>94.7%</td>
<td>94.0%</td>
<td>83.8%</td>
<td>93.5%</td>
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<tr>
<td><strong>Substructure</strong></td>
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<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>
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</table>
Conclusion From NBI Data

- **Superstructure and Substructure**
  - Work Condition (Worse Than 5) Down Trend
  - Watch Condition (5) Went up
  - Do Nothing (Better Than 5) No Trend
- **Factors**
  - Removal of Short Span Timber Bridges
  - Seismic Retro Fitting
- **Replacement of Older Inventory**

- **Deck**
  - Work Condition Upward Trend
  - Watch Condition Went up
  - Do Nothing - No Trend
- **Factor**
  - Increase in Traffic
  - Increase Use in Liquid Deicers
### Historical Review (AASHTO CoRe)

- **Breakdown of Deck Elements**
  - **Snapshot Past 10, 5, 1 Years**

<table>
<thead>
<tr>
<th>Deck CoRe Elements</th>
<th>1995</th>
<th>2000</th>
<th>2004</th>
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<tbody>
<tr>
<td>States 4 &amp; 5</td>
<td>0.3%</td>
<td>0.7%</td>
<td>1.2%</td>
</tr>
<tr>
<td>State 3</td>
<td>1.0%</td>
<td>3.7%</td>
<td>4.3%</td>
</tr>
<tr>
<td>States 1 &amp; 2</td>
<td>98.7%</td>
<td>95.7%</td>
<td>94.6%</td>
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</tbody>
</table>

- **Deck Smart Flags Use**

| States 2 thru 5    | 0.6% | 8.3% | 7.3% |

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Conclusion From Element Data

- Data Collection Started in Year 10
- Cracking and Soffit Defects on the Rise
- Deck Ride Quality on Downward Trend
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
Issues Effecting Preservation Activities

- **Data**
  - Process Misalignment
    - Safety Compliance
    - Asset Management
  - Data Misalignment
    - Structural Defects
    - Protection Defects
- Predicting Deterioration
  - Dependent On Expert Option
- Replacement-in-kind
- Strategic Approach
  - Remaining Live
  - Life Cycle
BMS (Pontis) Parameters

- Limit the Data Set
  - Decks and Slabs
  - Bearing
  - Joints
  - Deck Smart Flags
- Develop Probabilistic Model for Elements
- Develop Deterministic Rules for Smart Flags
- Limit the Work to Scheduled Work
- Allow a Zero Budget
- Store Element Deterioration by Year
- Simulate for 10 Years
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
Groupings

- **Good Condition**
  - $H_{mt}$ Greater Than 70
  - No Defects
- **Watch**
  - $H_{mt}$ Between 50 and 69
  - Bridges Have Defects That Need Monitoring
- **Bad**
  - $H_{mt}$ Less Than 50
  - Defects Needing Corrective Action

Outcomes

- Bridges with $H_{mt}$ Greater Than 70 and No Defects are in Good Condition.
- Bridges with $H_{mt}$ Between 50 and 69 have Defects That Need Monitoring.
- Bridges with $H_{mt}$ Less Than 50 have Defects Needing Corrective Action.

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Indifference Curve

- Need Cost or Bridge Count by Year
- Plot Cost (Bridge) and Year
- Take Action Before Going Near Vertical

Outcomes

Maximum PM Cost < Capital Cost

First Time to Consider Work (Lest Cost)

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Program Development

- Develop Different Budgets
- Run Scenarios
- Plot Long Term Effects
- Settle on Program Parameters and Budget

Outcomes

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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?
## 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>
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<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>
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<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>
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<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>
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<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>
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<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>
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<td>2058</td>
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<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>
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</tbody>
</table>
Deck Heath Index Over Time

- Outcomes

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- Do Nothing
- $1.0 Million Budget
- Unconstrained Budget
- $500 Thousand Budget

Year:

- 2008
- 2018
- 2028
- 2038
- 2048
- 2058
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
Development Of A Roadmap

- Definitions
- Outcomes
- Models
- Culture
- Performance Measures
- Data Collection
Conclusion

- Defining The Difference Between Reactive Maintenance, Preventive Maintenance, Preservation And Rehabilitation.
- Development And Definition Of Bridge Preservation Strategies.
- Developing Deterioration Models For The Bridge As A Whole And For The Preservation Work.