Element Guide Manual and Improved Bridge Management

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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

New Element Process

AASHTO BRIDGE ELEMENT INSPECTION GUIDE MANUAL

2010 Midwest Bridge Preservation Partnership Meeting

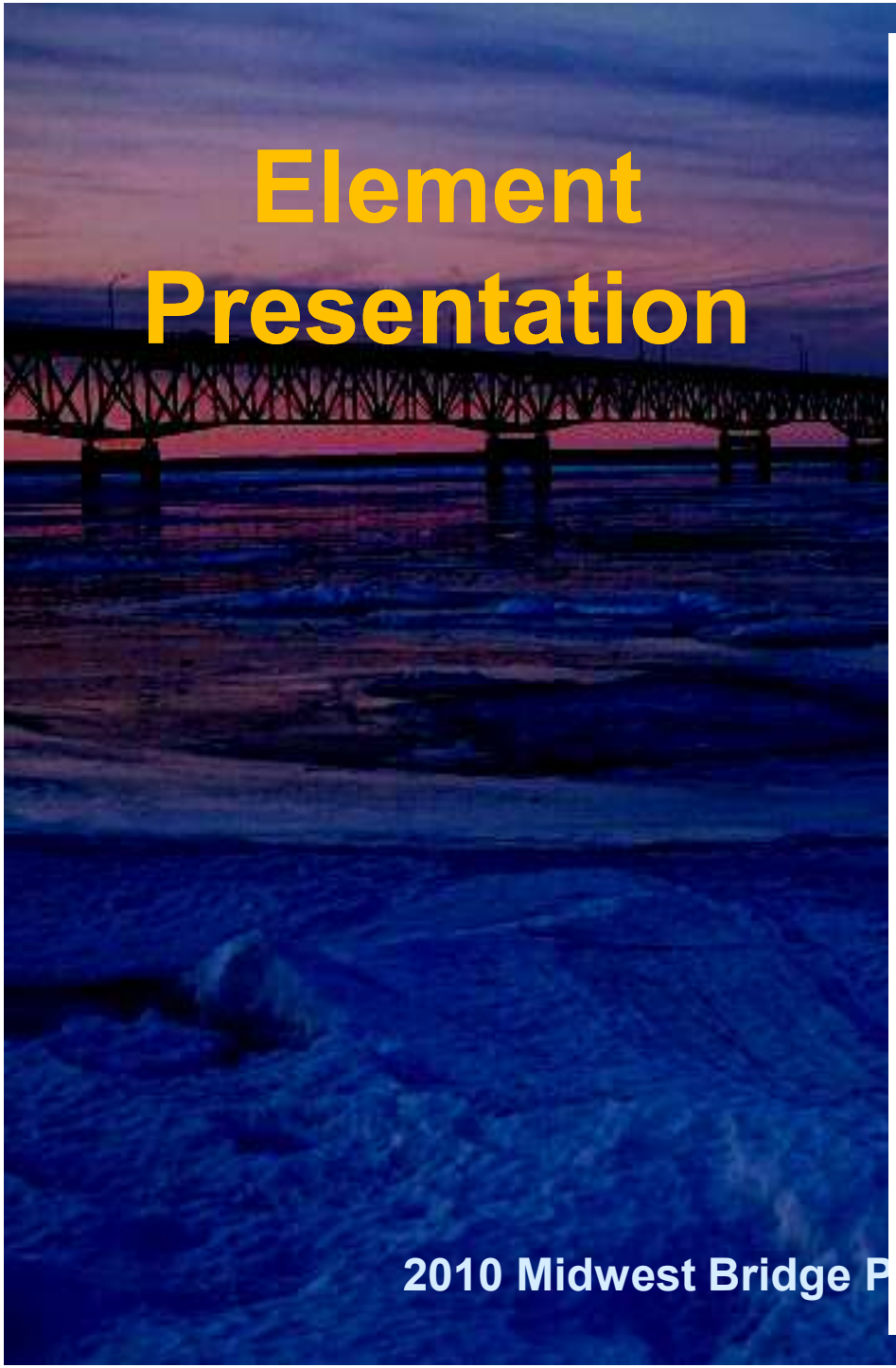
Element Implementation Plan

- 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



Description	Element # 12/38 Reinforced Concrete Deck/Slab Square Feet (Square Meters) National Bridge Elements
This element defines all reinforced concrete [illegible]dge deck/slab regardless of the wearing surf[illegible] or protection systems used.	

1

Quantity Calculation

The quantity for this element shou[illegible]nclude the area of the deck/slab from edge to edge including any median areas and accounting for any flares or [illegible]mps present.

2

Condition State Definitions

Defect	Condition State 1	Condition State 2	Condition State 3	Condition State 4
Cracking	None to hairline	Narrow size and/or density	Medium size and/or density	The condition warrants a structural review to determine the strength or serviceability of the element or bridge.
Spalls / Delaminations Patched Areas	None	Moderate spall or patch areas that are s[illegible]d	Severe spall or patched area showing distress	
Efflorescence	None	M[illegible]erate without r[illegible]	Severe with rust staining	
Load Capacity	No reduction	No reduction	No reduction	

3

Feasible Actions

Condition State 1	Condition State 2	Condition State 3	Condition State 4
Do Nothing Protect	Do Nothing Protect [illegible]pair	Do Nothing Protect Repair Rehab	Do Nothing Protect Replace

4

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 destru[illegible]e, non-destructive testing or indicators in the materials covering the surfaces.

5

Element Definitions

Defect	Hairline - Mi[illegible]	Narrow-Moderate	Medium-Severe
Cracking	< 0.0625 inches (1.6 mm)	0.0625 – 0.125 inches (1.6 – 3.2 mm)	>0.125 inches (3.2 mm)
Spalls/ Delaminations	N/A	Spall less than 1 inch (25 mm) deep or less than [illegible]es in diam[illegible]	Spall greater than 1 inch (25 mm) deep or greater than 6 inches in diameter or exposed rebar
Cracking Density	Spacing Greater than 3.0 feet (0.33 m)	Spaci[illegible] 1.0 - 3.0 feet ([illegible] - 1.0 m)	Spacing of less than 1 foot (0.33 m)
Efflorescence	NA	Surface white without build-up or leaching	Heavy build-up with rust staining

6

Element Presentation

Description		Element # 12/38 Reinforced Concrete Deck/Slab Square Feet (Square Meters) National Bridge Elements
This element defines all reinforced concrete bridge deck/slab regardless of the wearing surface or protection systems used.	1	

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. 2

Condition State Definitions

Defect	Condition State 1	Condition State 2	Condition State 3	Condition State 4
Cracking	None to hairline	Narrow size and/or density	Medium size and/or density	The condition warrants a structural review to determine the strength or serviceability of the element or bridge.
Spalls / Delaminations/ Patched Areas	None	Moderate spall or patch areas that are sound	Severe spall or patched area showing distress	
Efflorescence	None	Moderate without rust	Severe with rust staining	
Load Capacity	No reduction	No reduction	No reduction	

3

Element Presentation

Feasible Actions

4

Condition State 1	Condition State 2	Condition State 3	Condition State 4
Do Nothing Protect	Do Nothing Protect Repair	Do Nothing Protect Repair Rehab	Do Nothing Protect Replace

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.

5

Element Definitions

Defect	Minor	Moderate	Severe
Cracking	< 0.02 inches (0.5 mm)	0.02 – 0.08 inches (0.5 – 2.0 mm)	>0.08 inches (2.0 mm)
Cracking Density	N/A	1.0 and 3.0 feet apart (0.33 – 1.0 m)	< 1 foot (0.33 m)
Efflorescence	NA	Surface white without build-up or leaching	Heavy build-up with rust staining

6

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

Defect	Condition State 1	Condition State 2	Condition State 3	Condition State 4
Corrosion	None	Freckled Rust	Section Loss	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.
Cracking/ Fatigue	None	Arrested Cracks Exist	Moderate Exists	
Connections	Sound	Sound	Isolated Failures	
Load Capacity	No Reduction	No Reduction	No Reduction	

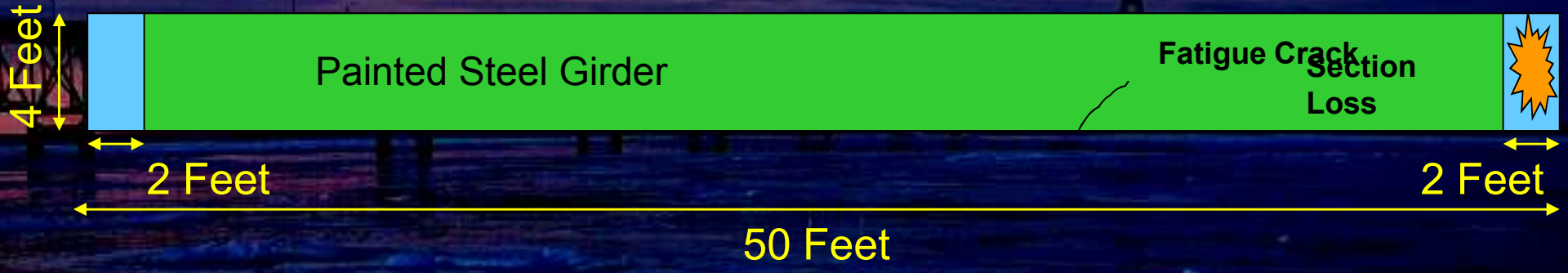
Steel (187) Element Language

Defect	Condition State 1	Condition State 2	Condition State 3	Condition State 4
Corrosion	None	Freckled Rust	Section Loss	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.
Cracking/ Fatigue	None	Arrested Cracks Exist	Moderate Exists	
Connections	Sound	Sound	Isolated Failures	
Load Capacity	No Reduction	No Reduction	No Reduction	

Beam End/Middle Section NBE/BME
No New BMS Elements

Element	Quantity	State 1	State 2	State 3	State 4	
Painted Steel Girder	50 Ft	48 ft		1 ft	1 ft	NBE
Fatigue Flag	*1 ft*				*1 ft*	BME
Section Loss Flag	*1 ft*			*1 ft*		

Beam End Example



Element	Quantity	State 1	State 2	State 3	State 4
107 Steel Girder	**46 ft**	**45 ft**			**1 ft**
Fatigue Flag (girder)	*1 ft*				*1 ft*
187 Steel Girder Ends	**4 ft**			**1 ft**	
Section Loss Flag (girder)	*1 ft*			*1 ft*	

Beam End/Middle Section NBE Only (Rollup)

Element	Quantity	State 1	State 2	State 3	State 4
Steel Girder	**50 ft**	**48 ft**		**1 ft**	**1 ft**

Concrete Decks

- Deck Element 12

Defect	Condition State 1	Condition State 2	Condition State 3	Condition State 4
Cracking	None to hairline	Narrow size and/or density	Medium size and/or density	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.
Spalls / Delaminations/ Patched Areas	None	Moderate spall or patch areas that are sound	Severe spall or patched area showing distress	
Efflorescence	None	Moderate without rust	Severe with rust staining	
Load Capacity	No reduction	No reduction	No reduction	

- Deck Protective System 521

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

Elements Generic

- General Language For Element Development

Defect	Condition State 1	Condition State 2	Condition State 3	Condition State 4
Condition	Good Condition	Fair Condition	Poor Condition	The element condition is severe or is non-operational

- General Language For Protective System Development

Defect	Condition State 1	Condition State 2	Condition State 3	Condition State 4
Effectiveness	Good condition, fully effective	Fair condition, substantially effective	Poor condition, limited effectiveness	The protective system has failed or is non-operational

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

2010 Midwest Bridge Preservation Partnership Meeting

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.
- Demonstrate That The Proposed Activity Is A Cost-effective Means Of Extending The Service Life Of A Bridge.
- Dedicate Resources Necessary To Reach Defined Outcome/Goal.
- Annually Track, Evaluate, And Report On Progress In Reaching Outcome/Goal And Adjust Resources Accordingly.

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)

Need

- Determine Capital Program
- Determine Preventive Maintenance Program
- Determine Reactionary Maintenance Activities

- Develop Performance Measurements
- Develop Reporting System to Other Business Units

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

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

Deck	1980	1995	2000	2004
Worse than 5	1.8%	0.9%	0.8%	1.3%
Equal to 5	2.9%	3.6%	4.3%	4.8%
Better than 5	95.2%	95.2%	84.1%	91.4%
Superstructure				
Worse than 5	2.3%	1.6%	1.1%	0.4%
Equal to 5	3.1%	4.3%	4.3%	6.1%
Better than 5	94.7%	94.0%	83.8%	93.5%
Substructure				
Worse than 5	3.3%	2.6%	2.6%	1.9%
Equal to 5	3.9%	4.5%	6.3%	3.6%
Better than 5	92.9%	92.9%	91.1%	89.5%

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)

$$\text{Health Index} = \frac{\sum_n \text{Element Cost} * \text{Element Quantity} * \text{Percent Condition State}}{\sum_n \text{Element Cost} * \text{Total Element Quantity}} * 100$$

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

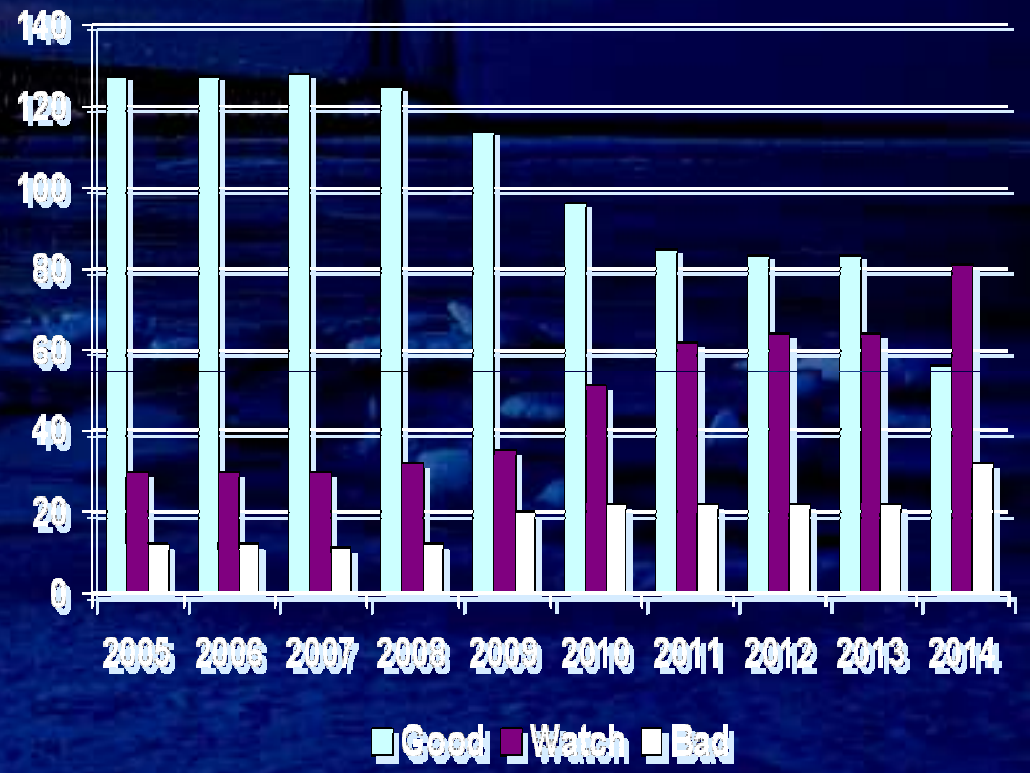
$$HI_{mt} = \frac{(\sum_e \text{Cost} * \text{Qty} * \text{Pct in State}) + (\sum_s (\sum_e \text{Cost} * \text{Qty}) * \text{Qty} * \text{Pct in State}))}{(\sum_e \text{Cost} * \text{Qty}) + (\sum_s (\sum_e \text{Cost} * \text{Qty}) * \text{Qty}))} * 100$$

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
  - 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

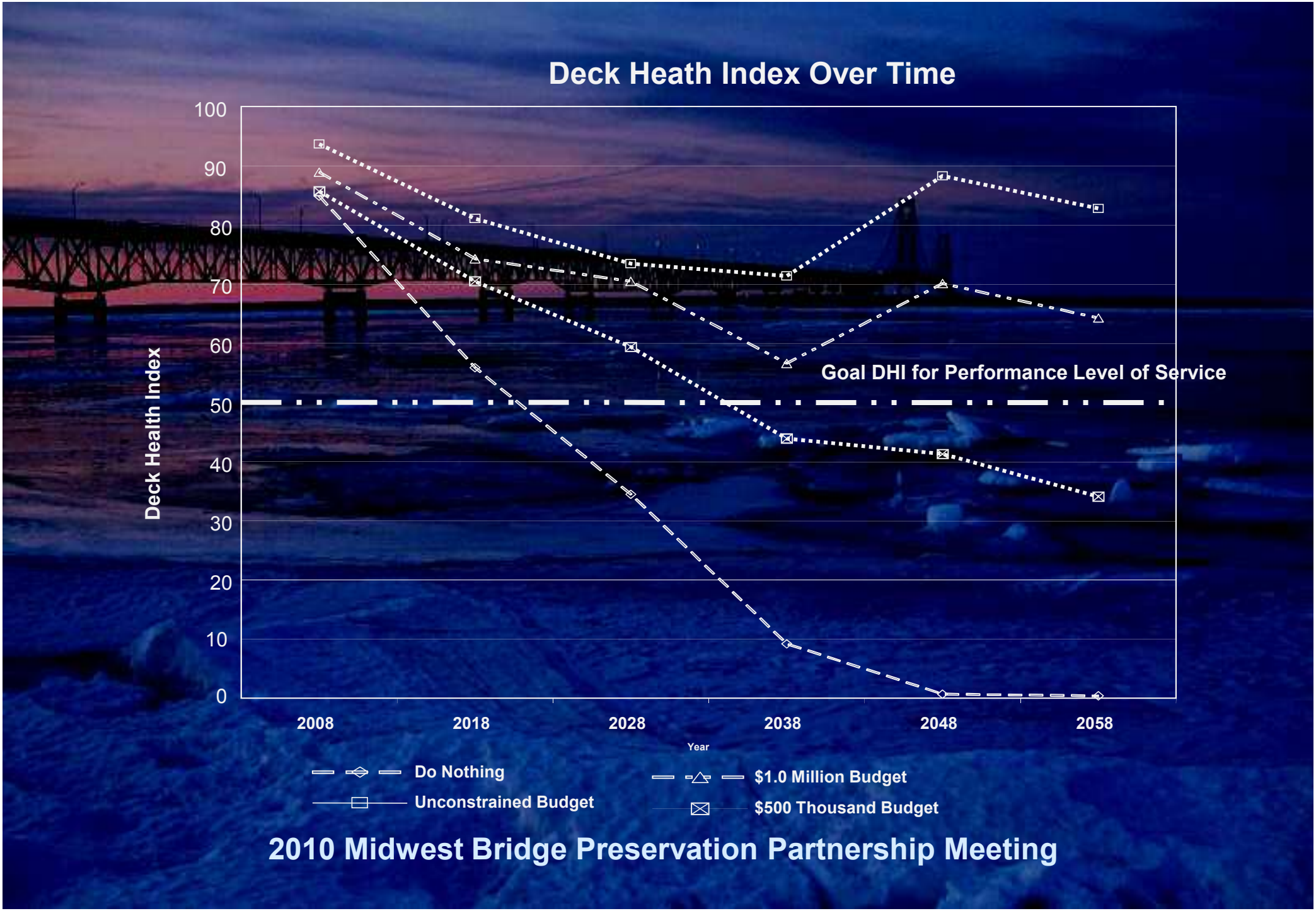


Check for Corridor Improvement

- 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

Year	Do Nothing		Unconstrained Budget		Maximum $1.0 Million Annual Budget		Maximum $500 Thousand Annual Budget	
	Need to Correct	Deck Health Index	Accumulative Expenditures	Deck Health Index	Accumulative Expenditures	Deck Health Index	Accumulative Expenditures	Deck Health Index
2008	$1,485,733	84.9	$1,485,733	93.7	$437,341	88.9	$114,927	85.7
2018	$6,936,027	55.9	$3,590,750	81.1	$1,798,384	74.3	$1,233,546	70.5
2028	$12,276,500	34.5	$7,093,280	73.5	$4,453,960	70.5	$1,202,671	59.4
2038	$24,551,826	9.2	$10,910,317	71.4	$6,279,637	56.6	$1,260,291	43.9
2048	$35,136,686	0.7	$17,972,034	88.3	$11,744,147	70.1	$2,439,881	41.3
2058	$35,696,378	0.4	$22,354,797	82.8	$13,603,630	64.3	$1,693,066	34.1


Deck Heath Index Over Time
100
90
80
70
60
50
40
30
20
10
0
Deck Health Index
2008
2018
2028
2038
2048
2058
Year
Goal DHI for Performance Level of Service
Do Nothing
Unconstrained Budget
$1.0 Million Budget
$500 Thousand Budget
2010 Midwest Bridge Preservation Partnership Meeting

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

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
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