1995 I-5 Bridge Over Arroyo Pasajero

- March 10, 1995
- Scour Was Cause. El’ Niño Blamed!
- 7 People Died
1996 Great Pennsylvania Flood

- Numerous Bridges Collapsed
- Several Bridges Were Closed and Weighed Down
- USGS had Just Begun a 1995 Scour Evaluation Program
- Engineer-Divers Assessed 600 Bridges w/in 3 Months
Hoan Bridge Failure

- From Minor to Major Cracks
- NBIS inspection could not determine cause
- Brittle failure from triaxial shear stresses
- Inherent design problem

Inspectors need to know about design issues
“Majority of bridges do not have pier protection. The bridges that have protection usually only have cells on upstream side in front of the channel piers.”

Roger Wiebusch
U.S.C.G. 05/28/02
I-40 Barge Impact, May 26, 2002

“Bridge Built in 1967, Prior to vessel Impact Design Code”
Reconstructed I-40 Bridge

Vulnerability Assessments now Conducted. Focus on Impact Critical Bridges.
The Inspection Process in 21st Century

• Bridge Owners are Responsible for Inspections
  - Biennial, Fracture Critical, Scour, Underwater, as well as Security
• Data Collected, Synthesized and Documented
• Focus on Maintenance; Even Moving Towards Preventative Maintenance
Current NBI Data Reporting Requirements

- Composition Information
- Condition Ratings
- Appraisal Ratings
- Sufficiency Ratings

Used For

- Reporting Conditions of Nation’s Roadway Bridges
- Prioritization for Replacements
- Determining Eligibility for Funding
Composition Information

• Description of Geometry, Location, Service Characteristics, Etc.

Condition Ratings

• Deck (58), Superstructure (59), Substructure (60), Channel & Channel Protection (62), Culverts (61)

• Ten-Point Scale Based on Visual Assessment
  - 9 – Excellent
  - 8 – Very Good
  - 1 – Imminent Failure
  - 0 – Failed Component

Safety ★★
Appraisal Ratings

- They are “Calculated Ratings”
- Assess the Functional Adequacy of the Structure
- Based on “Level of Service” and “Inspection Data”
- Ratings Developed for:
  - Structural Evaluation (67)
  - Deck Geometry (68)
  - Under Clearances (69)
  - Bridge Posting (70)
  - Waterway Adequacy (71)
  - Approach Roadway Alignment (72)
**Sufficiency Ratings**

- They are “Performance Measures”
- Best = 100%
- Worst = 0%
- Ratings Consider:
  - (55%) Structural Adequacy Based on 4 NBI Coding Items
  - (30%) Serviceability and Functional Obsolescence
  - (15%) Public Need
  - Reductions – (1%-13%)
B.M.S. – Element Level Data

♦ Hundreds of Elements in a Bridge

♦ AASHTO has defined CoRe Elements

♦ Each Element has “specific language” to define its particular condition state.
AASHTO Deck Elements

♦ “Major Change in the Percentages for Condition State Definitions since 2002”
AASHTO’s New Rating Criteria

Concrete Deck and Slab Elements
Distressed Deck Area

<table>
<thead>
<tr>
<th>Current</th>
<th>Condition State</th>
<th>Old</th>
</tr>
</thead>
<tbody>
<tr>
<td>No distressed repair areas</td>
<td>1</td>
<td>No Defects</td>
</tr>
<tr>
<td>&lt; 10%</td>
<td>2</td>
<td>&lt; 2%</td>
</tr>
<tr>
<td>&gt; 10% &lt; 25%</td>
<td>3</td>
<td>&gt; 2% &lt; 10%</td>
</tr>
<tr>
<td>&gt; 25% &lt; 50%</td>
<td>4</td>
<td>&gt; 10% &lt; 25%</td>
</tr>
<tr>
<td>&gt; 50%</td>
<td>5</td>
<td>&gt; 25%</td>
</tr>
</tbody>
</table>
Result of AASHTO Changes

♦ Many Deck Ratings Will Improve Unless Significant Deterioration Has Occurred Since Last Inspection.

♦ Inspectors must be aware of this fact, and adjust ratings accordingly.
Future Trends

- B.I.R.M. Published
- NBIS Updates
- NBI Updates
- Greater NDT / BMS Use
- Proactive StateDOT’s
- Additional Focus on Ancillary Structures
NBIS – Proposed Rulemaking

- National Bridge Inspection Standards
  - Last Updated in 1988

- Notice of Proposed Rulemaking, Since March 2002

- Comment Period Closed November 10, 2003

- FHWA Evaluating Comments

- Unknown Implementation Date
NBI Updates with Coding Guide

• Recording and Coding Guide for the Structure Inventory and Appraisal for the Nation’s Bridges – Last Updated in 1995

• Major Rewrite/Update Currently Underway
  - Started in July 2000 (FHWA Office of Bridge Technology)
  - Presented at the 2002 AASHTO T-18 Meeting
  - Unknown Implementation Date
Coding Guide Updates (Con’t.)

• Goals for the Re-Write Effort
  • A new format for the guide
  • Simplified language for the inspectors with graphics
  • New rating scheme - move from element level criteria into a guide which supports “Bridge Management System” principles
• Guidance on emerging technologies
• Guidance for non-destructive evaluation
Greater NDT / BMS Use

- Need for Better Data to Make Life-Cycle Cost Decisions
- Element Level Inspections With Quantification of Conditions
- Better Non-Destructive Evaluation/Testing Techniques
  - Advanced bridge deck inspections
  - Embeddable sensors
  - Advanced fatigue crack detection technology
Greater NDT / BMS Use (Con’t.)

• Gain a Better Understanding of:
  - Deterioration causes and rates
  - Effectiveness of maintenance and preservation programs
  - Relationships between bridge condition and load carrying capacity
  - Models for network and project-level decision support

Data Input Into a Bridge Management System (BMS)
Proactive State Highway Departments

- All Required to Have Documented Inspection Policies and Follow USDOT (FHWA) Requirements.
- Follow AASHTO Guidelines
- Additionally, Majority Have Internal Manuals and Guidelines.
WisDOT Structure Inspection Manual

- Qualifications
- Emergency Notification Requirements
- Proactively Includes NDT/BMS
- Proactively Involves All Structures
Element 911: Priority Maintenance Actions (P.95)

♦ C.S. 1 – Action Completed
♦ C.S. 2 – Safety Action
♦ C.S. 3 – Needed Response
♦ C.S. 4 – Urgent Response
Element 911: Priority Maintenance Actions
Railway Companies

- All Required to Have Documented Inspection Policies and Follow USDOT (FRA) Mandates.

- Additionally, Majority Have Internal Manuals and Follow AREMA Guidelines.
Bridge Inspections are moving from the historical safety (only) inspections to inspections which include:

- **Safety** and

- the collection of data necessary to support a “Bridge Management System” to be used for future network bridge life-cycle cost analysis with an increased emphasis on facility maintenance, extending bridge service life over replacement
Bridge Safety Inspections

1967

2004 Inspections for Bridge Safety + Data Collection for Bridge Management
Worldwide State-of-the-Art Bridge Management Systems (B.M.S.)

By Terry Browne, P.E. Collins Engineers, Inc.

January 16, 2004
Columbia, Missouri
Midwest Transportation Consortium
Numerous Structure Failures Around the World
Basis For Our Discussion

• Annual International Bridge Management Conferences
• 2001 BRIME Report
• Personal International Experience
Bridge Inspection Systems (B.I.S.)

- Traditional Practices – Produced Information Without Prioritization
- Resultant Organizations are “Data Rich and Information Poor” (DRIP)
Bridge Management Systems (B.M.S.)

- Establishes a Computerized System Program
- Develops a Systematic Approach to Prioritizing the Allocation of Funds to Construction and Maintenance
- Centralizes and Condenses Pertinent Information
Conditions Established for Ratings

1. Advanced Deterioration
2. Deteriorating
3. Fair / Mid-Life
4. Good
5. New
Importance Ratings Established

A - Critical Access – To and Within Terminal
B - High Revenue Generation
C - Medium Value Revenue Generation
D - Low Revenue Generation
E - Not in Use
## Project Priority Matrix

<table>
<thead>
<tr>
<th>OPERATIONAL IMPORTANCE</th>
<th>CONDITION RATING</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
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<tr>
<td></td>
<td>Advanced Deterioration</td>
<td>Deteriorating</td>
<td>Mid-Life</td>
<td>Good</td>
<td>New</td>
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<tr>
<td>Critical Access</td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>IV</td>
<td>V</td>
<td></td>
<td></td>
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<tr>
<td>High Revenue</td>
<td>II</td>
<td>II</td>
<td>IV</td>
<td>V</td>
<td>VI</td>
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<td>Medium Revenue</td>
<td>III</td>
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<td>V</td>
<td>VI</td>
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<td>Low Revenue</td>
<td>IV</td>
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<td>VI</td>
<td>VII</td>
<td>VIII</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not In Use</td>
<td>V</td>
<td>VI</td>
<td>VII</td>
<td>VIII</td>
<td>IX</td>
<td></td>
<td></td>
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<table>
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<th>Project Group</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>X</th>
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<tr>
<td>Priorities Highest</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
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<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
<td>&gt;</td>
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</tbody>
</table>

The matrix above illustrates the prioritization of projects based on their operational importance and condition rating. Each cell represents the priority level, with higher numbers indicating higher priority.
Who Utilizes B.M.S.?

- Railway and Highway Departments in Over 40 States in America
- Over 28 Countries around World
<table>
<thead>
<tr>
<th>Who Utilizes B.M.S.?</th>
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</thead>
<tbody>
<tr>
<td>Belgium</td>
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<td>Canada</td>
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<td>Norway</td>
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<td>Columbia</td>
</tr>
<tr>
<td>Croatia</td>
</tr>
<tr>
<td>Denmark</td>
</tr>
<tr>
<td>Finland</td>
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<tr>
<td>France</td>
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<tr>
<td>Germany</td>
</tr>
<tr>
<td>Honduras</td>
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<tr>
<td>Hungary</td>
</tr>
<tr>
<td>Indonesia</td>
</tr>
<tr>
<td>Ireland</td>
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<td>Japan</td>
</tr>
<tr>
<td>Mexico</td>
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<tr>
<td>Mexico</td>
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<td>Norway</td>
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<td>Poland</td>
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<td>Portugal</td>
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<td>Saudi Arabia</td>
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<td>Slovenia</td>
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<td>Spain</td>
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<td>Sweden</td>
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<td>Switzerland</td>
</tr>
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<td>Taiwan</td>
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<td>Thailand</td>
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<tr>
<td>United Kingdom (U.K.)</td>
</tr>
<tr>
<td>United States (U.S.)</td>
</tr>
<tr>
<td>Venezuela</td>
</tr>
<tr>
<td>Zambia</td>
</tr>
</tbody>
</table>
Who Really Uses B.M.S. To Its Fullest Potential?

- Fraction of Owners
B.I.S. vs. B.M.S.

**B.I.S.**
- Global Approach (Parts)
- Focus on Safety and Maintenance

**B.M.S.**
- Element Based Approach (Units)
- Focus on Safety, Maintenance, Budgeting, and Planning
Advantages of B.M.S.

• Powerful Tool
• Empowers Manager
• Element Specific
Disadvantages of B.M.S.

- Technology Can be Overwhelming
- Garbage In = Garbage Out
Most Common B.M.S.

- PONTIS
- BRIDGIT
- DANBRO
- Custom Designed Systems
Condition State Levels

- Typically, 1 - 4
Most Advanced B.M.S. Software

PONTIS

- According to the BRIME (Bridge Management in Europe) Report Published in 2001.
- Oracle Database (Typical).
- Used by 40 States and Many Other Countries.
But, Do You Really Need the Most Advanced System?
B.M.S. Provides Historic Information

- Date, Type, Cost, and Maintenance
- Work Location
- Work Method
- Contractor Used
B.M.S. Provides Prediction Models

- Only a Few Softwares, Such as PONTIS, Have Capabilities to Predict Future Deterioration Rates and Costs.

- DANBRO Philosophy is Not to Try to Predict Future.
B.M.S. Provides Information on Costs

- Maintenance
- Major Construction
- Inspection

(U.K. and Sweden Include Financial Consequences of Disruption.)
B.M.S. Provides Prioritization and Maintenance / Repair Option Decisions

• Program Recommendation Based on Cost-Benefit Ratio
• Engineer’s Judgment
Custom Designed Systems

“Allows Client Ability To Pick Needed Features”

Common For Highway Ancillary Structures and Port Terminals
Facilities Management, Maintenance Prioritization and GIS Coordination
GIS - Terminal Data

- Orthorectified Aerial Photographs as Base
- Boundary Surveys
- Internal Parcel Identification
- State Plan Coordinate System/Geodetic Survey Control Network
- Every Facility as a Polygon with Unique Name and Alpha-Numeric Facility Code
- Topographic Data as Available
GIS - Facility Maintenance Data

- Facility Importance
- Facility Condition
- Current Permit Status for Each Dredging Polygon
- Photos of Each Facility
- Link to Digital Files of Record Drawings / As-Built Drawings for Each Facility
GIS – Structural Load Capacity Ratings

- Structural Calculations
- Structural Capacity Maps for Equipment and Material Loadings
Additional GIS Information Derived from Assessment

- Geotechnical Data
- Stormwater Drainage Basins and Master Plans
- Utility Systems
Chicago River Program – “Queries for Bridges Tab”
Chicago River Program – “Structure Report”
Chicago River Program – “Queries for Dockwalls Tab”
Document Impact Events

VIRGINIA PORT AUTHORITY
WATERFRONT FACILITIES

1960
1970
1980
1990
2004
Incident Management Plan (IMP)

• Procedures for Immediate Accidental Impact Incident Notification

• Procedures for Post-Event Assessment
  (Rapid Damage Assessment, Detailed Damage Assessment, and Final Engineering Evaluation)

• Required Action Plans
### PONTIS B.M.S.

**Release 4 User's Manual**

![Image of PONTIS Bridge Management System]

---

**Bridge Inspection Report**

<table>
<thead>
<tr>
<th>Facility</th>
<th>1110195000000014</th>
<th>Size (ft)</th>
<th>720</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge No.</td>
<td>123</td>
<td>Span (ft)</td>
<td>150</td>
</tr>
<tr>
<td>Year Inspected</td>
<td>2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspector Name</td>
<td>Smith, John</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date Inspected</td>
<td>02/20/2000</td>
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<td></td>
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#### SAFETY, APPRAISAL, AND GENERAL NOTES

<table>
<thead>
<tr>
<th>Item</th>
<th>Priority</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Surfacing</td>
<td>4</td>
<td>20% of total evaluated. Heavy longitudinal cracks and mortar cracking with delaminations.</td>
</tr>
<tr>
<td>2. Expansion Joints</td>
<td>3</td>
<td>Heavy concrete, spalled, and cracked.</td>
</tr>
<tr>
<td>3. Joints</td>
<td>3</td>
<td>Seals are deficient. Heavy concrete, spalled, and cracked.</td>
</tr>
<tr>
<td>5. Approach Plate</td>
<td>5</td>
<td>Some concrete is spalled and cracked.</td>
</tr>
<tr>
<td>6. Deck planks</td>
<td>6</td>
<td>Spalls of rail on tony rail at deck plate. Failure of base plates and flanged channel.</td>
</tr>
<tr>
<td>7. Springs (Superstructures)</td>
<td>5</td>
<td>Delamination of planks, delamination of base plates.</td>
</tr>
<tr>
<td>8. Paint</td>
<td>4</td>
<td>Heavy rust on base plates and flanges.</td>
</tr>
<tr>
<td>9. Paint at Joints</td>
<td>2</td>
<td>Taped support under BM &amp; ST. Heavy concrete and clear joint could be lifted.</td>
</tr>
<tr>
<td>10. Bearings</td>
<td>4</td>
<td>Base plates rusty. Some section line. Heavy corrosion and clear joints could be lifted.</td>
</tr>
<tr>
<td>11. Abutments</td>
<td>5</td>
<td>Some concrete cracks and spalls on col NW &amp; SW. Caps have delaminations.</td>
</tr>
<tr>
<td>12. Hairs</td>
<td>5</td>
<td>Super concrete cracks and spalls on col NW &amp; SW. Caps have delaminations.</td>
</tr>
</tbody>
</table>

#### CREW RECOMMENDATIONS

<table>
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<th>Priority</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Deck Paint</td>
<td>Repair concrete deck</td>
</tr>
<tr>
<td>Armor Paint</td>
<td>1</td>
</tr>
<tr>
<td>Jt Repair</td>
<td>Repair joints</td>
</tr>
<tr>
<td>Rail Repair</td>
<td>1</td>
</tr>
<tr>
<td>Deteriorated Inspections</td>
<td>1</td>
</tr>
<tr>
<td>Span Ph</td>
<td>1</td>
</tr>
<tr>
<td>Bridge Ph</td>
<td>1</td>
</tr>
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#### CONTRACT RECOMMENDATIONS

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<tr>
<td>Bridge Repairs</td>
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<tr>
<td>Super Repairs</td>
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<tr>
<td>Deck Repairs</td>
<td>1</td>
</tr>
<tr>
<td>Deck Only</td>
<td>1</td>
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<tr>
<td>Whirring</td>
<td>1</td>
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<tr>
<td>Full Paint</td>
<td>1</td>
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<tr>
<td>Zone Paint</td>
<td>1</td>
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<tr>
<td>Hoist</td>
<td>1</td>
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<tr>
<td>Subsea Repairs</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
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</table>
PONTIS B.M.S. (Cont’d.)
DANBRO B.M.S.

Create/Modify/Lookup Structure

Create Structure
DANBRO B.M.S. (Cont’d.)

Create Passage One

Create Passage Two
DANBRO B.M.S. (Cont’d.)

Administrative Structure Data

Technical Data 1
DANBRO B.M.S. (Cont’d.)

Passage Data (for Passages 1 and 2)
DANBRO B.M.S. (Cont’d.)

Structure Remarks

Miscellaneous Data
Component Details (1 Through 14)
DANBRO B.M.S. (Cont’d.)

Component Overview
(Categories 1-14)

Component Photos
(1-14)
Example of Posted Bridge - Germany
Load Posted due to Floor Beams
Temporary Shoring with New Columns
Temporary Supports with Hangers
Retrofit Beams Supported by Hangers
Presentation Wrap-Up

- United States Bridge Inspection Program
- Worldwide Structure Management Systems
Consortium Discussions

For more information, contact

tbrowne@collinsengr.com