Federal Highway Administration
Long-Term Bridge Performance Program

**LTBP Program Update**
for South East Bridge Preservation Partnership
April 13, 2011

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Virginia Center for Transportation Innovation and Research
LTBP Objective

- Detailed inspection, periodic evaluation and monitoring (representative sample of bridges)
- Taking advantage of legacy data and existing research activities

Desired/Anticipated Outcomes

- Improved knowledge of bridge performance
- Development of improved predictive and deterioration models
- Means to quantify effectiveness of various maintenance, preservation, repair and rehabilitation strategies
- Tools for bridge management
- Standards for testing and monitoring
Team Organization

FHWA
Turner Fairbanks Laboratory
LTBP Program Manager

Rutgers University
Center for Advanced Infrastructure & Transportation (CAIT)
- Principal Investigator
- Contract Management
- Outreach / Communications
- NDT / NDE
- Modelling

Parsons Brinckerhoff
- Coordination
- Oversight
- QA/QC
- Visual Inspection

Consultants
- Highway R&D Services
- Intelligent Infrastructure Systems

Utah State University
Utah Transportation Center
(Covering Western Half)
- Bridge Health Monitoring

Virginia Transportation Research Center (VTRC)
Virginia Tech
(Covering Eastern Half)
- Bridge Health Monitoring

Siemens America
- Data Infrastructure
- Data Model
- Database

Institute for Transportation Studies UC Berkeley
- Life Cycle Cost Analysis
- Bridge Asset Management

Bridge Diagnostic Inc.
- Diagnostic Testing
- Instrumentation

Advitam
- Data Interface Management
Focus Groups - Participating State DOTs
Design of experimental program

**Input from Stakeholders**
- Government
- Industry
- Academe

**Knowledge Gaps → Sampling**

**Data Mining and Analysis**
- NBI data
- Pontis data
- Inspection reports
- Maintenance records
- Weather data
- Traffic data

**Pilot Bridges**

**Visual Inspection**
- Non-standard Arms length
- Quantitative Conventional Tools

**Global Testing**
- Load Testing
- Modal Testing
- Monitoring

**NDE**
- Impact Echo
- GPR
- Ultrasonic
- Seismic
- Resistivity

**Intrusive Testing**
- Material Sampling
- Stiffness
- Strength
- Porosity
- Chloride Content
Pilot Bridges - Participating State DOTs

[Map showing participating state DOTs highlighted in orange: California, Minnesota, New Jersey, and Florida.]
US 15 over I-66
Haymarket, VA
I-195 Eastbound over Sharon Station Rd. near Allentown, NJ
I-5 over Lambert Road near Sacramento, California
Cannery Road, US 15, North of Salt Lake City, Perry, Utah
NY RTE 21 over Karr Valley Creek near Almond, New York
Trunk Highway 123 over Kettle River near Sandstone, MN
RT 430 WB over ICW
Daytona, FL
Deck Surface Damage Survey

Virginia Bridge

Long-Term Bridge Performance Program
Corrosion Testing and Physical Sampling

Virginia Bridge

[Diagram of a bridge with labeled cores and chloride locations]

[Images of workers conducting tests and samples of concrete cores]

Long-Term Bridge Performance Program
### Interpretation of Corrosion Data

#### Half-cell Potentials (mV)

<table>
<thead>
<tr>
<th>Indication of Active Corrosion</th>
<th>Range (mV CSE)</th>
<th>No. of data</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Low Probability</td>
<td>&gt; -200</td>
<td>3</td>
<td>10</td>
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<tr>
<td>Indeterminate</td>
<td>-200 to -300</td>
<td>14</td>
<td>47</td>
</tr>
<tr>
<td>High Probability</td>
<td>&lt; -300</td>
<td>13</td>
<td>43</td>
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<tr>
<td>Total</td>
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<td>30</td>
<td>100</td>
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</table>

**Virginia Bridge**
Delamination Assessment by Impact Echo
Concrete Degradation Assessment

Ultrasonic Surface Waves  Ground Penetrating Radar (GPR)
Deck Surface Damage Survey versus Cover Depth (via GPR)
Deck Surface Damage Survey versus Impact Echo
Deck Surface Damage Survey versus Ground Penetrating Radar

Virginia Bridge
Load Test Instrumentation

- Strain Transducers
- Deflectometers & LVDTs
- Tilt meters
- Thermocouples
Live Load Testing

Truck type varies

Quasi-Static Test Plan
Looking in Direction of Traffic

1. Maximize loading on Girder 1 and Girder 2.

2. Maximize loading in Girder 3 given the placement of Run 4 in the center of the traffic lane.

3. Run 7 centers a truck in the left hand lane.

4. Maximize loading on Girder 6 while observing the required traffic control restrictions.
Modeling Deterioration

Visual Inspection:
- light red - delaminations
- dark red - patches

GPR Condition Map:
- yellow - poor
- red - serious
Three FE Models created:
1. Undamaged (Scenario E haunched)
2. Realistic Damage: loss of 2 in. deck depth (E 4000 2)
3. Extreme Damage: loss of 4 in. deck and reduced modulus (E 1000 4)
Dynamic Testing

Virginia Bridge

Long-Term Bridge Performance Program
Conclusions

- FE results & live load test results both show lower NA near damage
- Insignificant change in bottom flange strain
- Maximum of ~6” lowering of NA near damage
- Structural performance of bridge is not justification alone for deck replacement
# LTBP Pilot Study Status

<table>
<thead>
<tr>
<th>Activity</th>
<th>VA</th>
<th>UT</th>
<th>CA</th>
<th>NJ</th>
<th>MN</th>
<th>NY</th>
<th>FL</th>
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<tbody>
<tr>
<td>Bridge Selection</td>
<td>✔️</td>
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<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Finite Element Model</td>
<td>✔️</td>
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<tr>
<td>Live Load Testing</td>
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<tr>
<td>Visual Inspection</td>
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<tr>
<td>NDE Deck Survey</td>
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<tr>
<td>Coring &amp; Physical Testing</td>
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<tr>
<td>Analysis of Results</td>
<td>❌</td>
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</table>

*Initial testing on all pilot bridges to be done by 9/30/2011*

- ✔️ = Complete
- ❌ = In progress
- ❌️ = Future
# BridgePortal

**Key technologies**

<table>
<thead>
<tr>
<th>Data Security</th>
<th>Content Management</th>
<th>Data Mining</th>
<th>Advanced Visualization</th>
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<tbody>
<tr>
<td>- <strong>User access control</strong>: Prevent unauthorized data access.</td>
<td>- <strong>Solution for collaboratively creating, editing, searching and archiving bridge performance data.</strong></td>
<td>- <strong>Cross-data querying</strong>: Search for bridges based on cross-data criteria. <strong>Clustering</strong>: Group bridges based on common properties. <strong>Deterioration analysis</strong>: Detect patterns in deterioration processes.</td>
<td>- Map and mash bridge assets on GIS systems from different providers. <strong>Multidimensional, interactive charting.</strong></td>
</tr>
<tr>
<td>- <strong>Decentralized security model</strong>: Owners of data have full control of their data by deciding who can access the data.</td>
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*Long-Term Bridge Performance Program*
Data Infrastructure

Data Collection
- Inspection Reports
- Temperature
- Strain Gauge
- Traffic
- Wind
- NDE/NDT

Data Management
- Online Monitoring
- Data Mining
- Data Integration

Data Access
- Data Access
- Visualization
- Query

Integration
- Data Integration
- PowerMonitor

Data Warehouse
- Data Mining
- BridgePortal

Historical Databases
- GIS
- Weather
- Seismic
- NBI
- Pontis
- Safety Maintenance Cost
GIS visualization of searched bridges
- Size of circles encodes ADT
- Color encodes deck condition of 2007
- Blue squares indicate WIM stations
Performance distribution of this cluster
Each bar indicates the number of bridges with a certain deck condition
The blue bar indicates the subgroup which contains Bridge I-15

Map shows the location of those 3 bridges that have deck condition 9
What is the expected condition in 5 years?
- The substructure condition is predicted to decrease to 7 whereas the deck condition is most likely to stay at 7.

How fast did the deterioration progress compared to similar bridges?
- Past performance
- Deterioration time to condition:
  - Deck Condition: 7 years
  - Substructure Condition: 8 years
  - Superstructure Condition: 7 years

Deterioration rate:
- Fast deterioration
- Medium deterioration
- Slow deterioration
Reference Bridge – Data Collection

Visual Inspection
- Non-standard Arms length
- Segmental
- Conventional Tools

NDE
- Impact Echo
- GPR
- Ultrasonic
- Seismic
- Resistivity

Global Testing
- Load Testing
- Modal Testing
- Continuous Monitoring

Material Testing
- Material Sampling
- Stiffness
- Strength
- Porosity
- Chloride Content

Scale: 200 ft
Reference Bridge and Supporting Cluster

Visual Inspection
- Non-standard
- Arms length
- Segmental
- Conventional
- Tools

Comparison: Reference vs. Cluster
- Identify discrepancies – establish root causes
- Establish typical levels of variability

Long-Term Bridge Performance Program
Approximate Scale: 30 mi
Multiple Clusters of Similar Bridges

Comparison: Cluster vs. Cluster
Identify influences of climate, traffic, maintenance practices, etc.

Approximate Scale: 3000 mi
Clusters of Different Bridge Types

Comparison: Bridge Type A vs. Bridge Type B
Establish relative importance controlling for local variability, climate effects, maintenance, etc.
## Program Timeline

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
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<tbody>
<tr>
<td>May 2008</td>
<td>Development phase commences</td>
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<tr>
<td>August 2008</td>
<td>Focus Groups – 15 DOTs through December 2009</td>
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<tr>
<td>August 2009</td>
<td>Pilot phase commences – VA pilot bridge</td>
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<tr>
<td>March 2010</td>
<td>Workshop on Performance Issues related to geotechnology</td>
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<tr>
<td>Dec 2010</td>
<td>Bridge Portal deployment</td>
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<tr>
<td>Spring 2011</td>
<td>TRB LTBP Advisory Board meeting (tentative)</td>
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<tr>
<td>August 2011</td>
<td>Planned completion of the pilot phase</td>
</tr>
<tr>
<td>Fall 2011</td>
<td>LTBP State Coordinators Group meeting (tentative)</td>
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*Long-Term Bridge Performance Program*
Moving Forward

- Data collection of remaining Pilot Bridge
- Data fusion and evaluation of information collected during Pilot Program
- Continue development and roll out of Bridge Portal
- International Guideline for Structural Health Monitoring
- Begin the Long Term Data Collection phase of program
LTBP Program Information

LTBP Program Website

http://www.tfhrc.gov/ltbp

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