Title: FHWA Long-term Bridge Performance Program

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FHWA Long-term Bridge Performance Program

Hamid Ghasemi

ABSTRACT

The Federal Highway Administration initiated a major program in early 2006 with the objective of improving knowledge regarding bridge performance over a long period of time. The FHWA Long-Term Bridge Performance (LTBP) program will instrument, monitor, and evaluate a large number of bridges throughout the United States in order to capture performance data over a 20-year period of time and, on the basis of the information collected from these structures, provide significantly improved life-cycle cost and performance and predictive models that can be used for bridge and asset-management decision-making. The LTBP program will also conduct forensic investigations on decommissioned bridges, as the opportunity arises.
INTRODUCTION

In the United States, the stewardship and management of more than 590,000 bridges are ongoing planning, operational, maintenance, and economic challenges faced by Federal, State, and local transportation agencies.

To help overcome these challenges and foster the next generation of bridge and bridge management systems, in April 2008, the Federal Highway Administration's (FHWA's) Office of Infrastructure Research and Development launched the Long Term Bridge Performance (LTBP) Program, a major new strategic initiative designated as a flagship research project. The LTBP program is intended to be a 20-year undertaking, with the global objective of collecting scientific quality data from the Nation's highway bridges, as critical node-points of the highway transportation network. The data and information collected in this program will provide a more detailed and timely picture of bridge health, improve knowledge of bridge performance, and ultimately promote the safety, mobility, longevity, and reliability or the Nation's highway transportation assets.

Funding for the program was included in legislation for surface transportation enacted by the U.S. Congress in 2005: the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU).

OVERVIEW

Need

Federal Highway Administration's (FHWA's) National Bridge Inspection Standards (NBIS) facilitated the creation of one of the most comprehensive sources of bridge information in the world, the National Bridge Inventory (NBI). The NBI contains information on the conditions of more than 590,000 bridges, tunnels, and culverts located on public roads. In 2007, according to the NBI, there were approximately 152,136 structurally deficient or functionally obsolete bridges. This number is likely to increase in coming years due, in large part, to increased traffic demand, continued bridge aging and deterioration, and limited funds for rehabilitation and maintenance.

A number of States have adopted and implemented the American Association of State Highway and Transportation Officials' (AASHTO) AASHTOWare® Pontis® bridge management system or a similar system with advanced asset management decisionmaking capabilities. Some States augment the NBI data used in advanced bridge management systems by also collecting element level bridge data. Even with these bridge management tools and data, however, there remain many unknowns about the performance and degradation of structures and materials over time, and the effectiveness of maintenance, repair, and rehabilitation strategies for a given component or a complete bridge system. In addition, with the recent move to higher performance materials and advanced structural systems, high-level, long-term performance and durability are assumed, but not demonstrated at this time.

For the Nation's bridge network to meet these increasing demands without similar increases in funding, future bridge management systems will require improved life cycle cost and performance models, and information on the effectiveness of maintenance and repair strategies. Such improvements will require high-quality quantitative data on which to base the development of new models and decision making algorithms.
Objective of the LTBP Program

The objective of the LTBP program is to compile a comprehensive database of quantitative information from a representative sample of bridges nationwide, looking at every element of a bridge. By taking a holistic approach and analyzing all of the physical and functional variables that affect bridge performance, the study will provide a more detailed and timely picture of bridge health and better bridge management tools.

LTBP researchers will conduct detailed periodic inspections, monitoring, and evaluation of the population of bridges representing the national bridge inventory by taking advantage of nondestructive evaluation (NDE) techniques and visual inspections. NDE techniques may include ground-penetrating radar to detect flaws and corrosion inside the structures—and sensor technologies that monitor traffic loading, cracks due to fatigue and corrosion, overloads, environmental conditions, etc. For selected bridges in the study, researchers will conduct recurrent, periodic evaluations throughout the life of the program and may perform forensic autopsies of decommissioned bridges to learn more about their capacities, reliabilities, and failure modes.

Data Collection Goals

The wealth of data collected through the LTBP program, and the subsequent data analysis, will lead to:

- Improved knowledge of bridge performance
- Advances in deterioration and predictive models
- Deterioration models that can simulate interactions between pavement, bridges, and traffic
- Effective use of life cycle cost analysis
- Improved inspection/condition information through NDE and structural health monitoring; and the fostering of technology for assessment of critical but invisible bridge elements and components
- Support for development of improved design methods and maintenance/bridge preservation practices
- Quantification of the effectiveness of various maintenance, repair, and rehabilitation strategies
- Improvement of the operational performance of bridges with the potential to reduce congestion, delay, and crashes
- The fostering of the next generation of bridge and bridge management systems
- Contributions for setting national policy

Ultimately, improved understanding of bridge performance will promote safety, mobility, longevity, and reliability of the Nation's highway transportation assets.

Approach

The research team will conduct the work in two phases for achieving the objectives of the FHWA LTBP program. These phases are the following: 1) Developmental Phase, and 2) Execution Phase. The current activities of the program are related to the Developmental Phase, which includes identifying specific data to be collected that are most relevant to the objectives of the program; establishing an open, scalable, and extensible data management and data analysis infrastructure; developing protocols for data sampling and collection, and quality assurance; and developing a
methodology and rationale for sampling bridges from the National Bridge Inventory database to determine the types, numbers, and locations of bridges to be inspected, monitored, evaluated, and instrumented in the pilot phase of the program. This table shows task descriptions for the Developmental Phase and associated responsibilities by the research team.

<table>
<thead>
<tr>
<th>Task Number</th>
<th>Task Description</th>
<th>CAIT</th>
<th>PB</th>
<th>UTC</th>
<th>VTRC</th>
<th>Siemens</th>
<th>Advitam</th>
<th>BDI</th>
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<tr>
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<td>✓</td>
<td>✓</td>
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</tbody>
</table>

X Indicates team member with primary responsibility
✓ Indicates team member that will provide significant contributions to the task

In the pilot portion of the program (which is part of the Execution Phase), researchers will validate protocols for data collection and management and ensure that all of the components needed to achieve the long-term objectives of the LTBP program are specified before initiating work on the large population of bridges nationwide. Both phases require an active engagement between the research team, FHWA, bridge owners, industry, other government agencies, and the international community. It is also essential to coordinate with other long-term strategic research programs undertaken by the FHWA, AASHTO, Transportation Research Board, American Society of Civil Engineers, National Cooperative Highway Research Program, Strategic Highway Research Program 2 (SHRP2), National Institute of Standards and Technology, National Science Foundation, and the U.S. Army Corps of Engineers.

Oversight

External and internal Expert Task Groups (ETGs) were established to provide a rigorous oversight and quality control to the FHWA and the research team on matters relating to LTBP.
program activities. The members of these two groups were appointed by FHWA, based on their technical expertise in bridge design, inspection, maintenance and preservation, management, NDE/nondestructive techniques and structural health monitoring of bridges.

CONTRACTORS

The LTBP Program is designed as a coordinated, collaborative, multiinstitutional, and multidisciplinary manner with the researchers coming from government, academia, and industry. The prime contractor of the LTBP program is Rutgers University's Center for Advanced Transportation and Infrastructure, in partnership with Parsons Brinckerhoff, the Utah and Virginia Transportation Research Centers, the Institute for Transportation Studies at the University of California Berkeley, and the technology providers Siemens and Advitam and Bridge Diagnostics, Inc. These organizations were awarded a contract worth up to $25.5M to conduct the work through 2012.

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The Institution for Transportation at UC Berkeley

Siemens America

Advitam

Bridge Diagnostics, Inc.

LTPP FACTS
What is bridge performance?
Understanding bridge performance will be the key to creating "the bridge of the future."

Bridge performance encompasses how bridges function and behave under the complex and interrelated factors and stresses they are subject to day in and day out—traffic volumes, loads, and environmental assaults like de-icing chemicals, freeze-thaw cycles, rains, or high winds. Age, design, materials, and maintenance history also play huge roles in performance. A bridge that is performing well is doing the job it is intended to do safely, efficiently, and reliably.

Evaluating and measuring performance is the most critical attribute in addressing bridge deficiencies; it will provide the knowledge needed to design and build bridges that last longer, perform better, and are less costly to operate and maintain.

**Why study bridge performance?**

The U.S. highway system is immense, aging rapidly, and being used more frequently and heavily every day.

Highway bridges are vital components of the roadway transportation network that the Nation relies on. Bridges do more than help citizens to more from here to there: they are critical links that make mobility and commerce possible. The entire transportation system is so integrated in the daily lives of Americans that it is possible to take bridges for granted, like tap water and electricity—that is until a bridge used every day is closed.

**What is asset management?**

Decision making tools and models that help the transportation community spend budgets more wisely.

Infrastructure asset management is a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their life cycles. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decisionmaking based on quality information and well-defined objectives. In simpler terms, it is about operating, maintaining, and preserving the transportation system in the most cost-effective manner to achieve desired service objectives. In the case of bridges and bridge management, it provides a decisionmaking framework and tools for bridge owners to better plan maintenance, preservation, and repair actions, the times these actions should be taken, and prioritization to get the most “bang for the buck.” It is important to know where to make the best investments and why those decisions are made.

**CURRENT PROGRAM RESEARCH**

The research team will conduct the work in two phases for achieving the objectives of the LTBP Program—the Developmental Phase and the Execution Phase.

**Developmental Phase**

*Task 1.1: Road Map*

A roadmap was developed to guide the LTBP Program over the life of the program. It is the basis for many of the early communication and marketing products that will be used to garner
support and champions for the program. The road map is expected to evolve as the program advances beyond the pilot study.

Primary Responsibility: Parsons Brinkerhoff

Task 1.2: Specific Data to be Collected

The objective of this task is to identify the data elements that are most relevant to support the objectives of the LTBP Program. These would include examination of the feasibility and economics of collecting reliable and quantitative data; evaluation of the potential for practical use of this data in evaluation of bridge performance; and recommendation of data to be collected.

To meet these objectives, the research team is holding a series of focus groups across at least 12 States, and will send a survey to other States to gather information related to specific modes of deterioration for bridge decks, superstructures, substructures, and ancillary systems, as well as functional and operational aspects of bridge management. Accordingly, the contractor intends to discuss the following five areas:

1. The most common forms of deterioration and damage on bridges, what information is needed to evaluate condition(s) and what information is used to develop feasible solutions.
2. The most common maintenance activities being performed and what information is available on which to base a particular maintenance decision.
3. The information and sources required for program level decision support.
4. The information required for specific project decision support.
5. The performance measures used to gauge the success of the agency's bridge management system.

Primary Responsibility: Virginia Transportation Research Council

Task 1.3: Development of a Data Infrastructure

The objective of this task is to develop an appropriate data infrastructure for storing, describing, updating, and accessing multiple data models (for primary data and associated metadata) with appropriate considerations of security. The data infrastructure will be open, extensible, and scalable to meet goals and objectives of the LTBP Program. Due consideration is given to future needs of the LTBP Program as well as new and upcoming IT Technologies. It is being designed to serve both as a robust and comprehensive repository of scientific data and for ease of use and utility to a broad array of potential users. It shall support the implementation of automated data mining tools and standard queries.

Primary Responsibility: Siemens America

Task 1.4: Protocols for Data Sampling and Collection, and Quality Assurance

The contractor is developing protocols for data sampling, data collection using inspection techniques and instrumentation, and data quality assurance to carry out these functions. Protocols will be compatible with the data infrastructure developed for the LTBP Program. These protocols are being developed and documented sufficiently so that various contractors or agencies understand and implement the process in the same way. These protocols are being designed to accommodate
visual inspection, a variety of sensors and associated instrumentation, and nondestructive (NDE) and destructive test methods.

This task will be finalized once Tasks 1.2 and 1.5 are complete.

Primary Responsibility: Advitam

Task 1.5: Bridge Sampling (quantity, type, location, etc.)

The contractor has developed a methodology and rationale for sampling bridges from the National Bridge Inventory (NBI) database. The sample for the pilot study was identified. The sample for the LTBP Program Data Collection (Tasks 2.2 and 2.3) will be finalized during the pilot study. Culverts, tunnels, and complex (suspension, cable-stay, and movable) bridges were excluded from the sample.

The sample bridges in the pilot study will be selected based on many factors such as the information obtained from task 1.2, geographic location (climate and environmental conditions), traffic volume, bridge type, geometry, span length, maintenance practice, substructure, and age.

Primary Responsibility: Center for Advanced Infrastructure and Transportation

Task 1.6: A Synthesis of Bridge Monitoring and Bridge Autopsy Methods

The contractor is preparing a draft report synthesizing past bridge monitoring and bridge autopsy activities of the State Highway Agencies (SHAs) and others from research and industry. The synthesis will include information on the benefits realized from the application of NDE and structural health monitoring (SHM) for decisionmaking and the knowledge gained from the autopsy efforts. Synthesis of the available information could reveal gaps in data and facilitate streamlining the processes and will be useful in establishment of uniform procedures and guidelines.

Primary Responsibility: Utah Transportation Center

Task 1.7: Protocols for Bridge Monitoring and Bridge Autopsy

The contractor will be developing protocols and standards for bridge monitoring and for autopsies of decommissioned bridges based on findings of Task 1.6. These protocols will be developed and documented sufficiently so that various contractors or SHAs understand and implement the process in the same way. These protocols will be designed to accommodate monitoring and autopsy approaches, a variety of sensors and associated instrumentation, and NDE and destructive test methods.

Primary Responsibility: Utah Transportation Center

Execution Phase

Task 2.1: Project Coordination

The contractor will make all necessary arrangements, in a professional and timely manner, with the SHAs for accessing bridges and traffic control prior to inspection, testing, and evaluation of bridges. The contractor will maintain a log of all verbal and written communications with the appropriate agencies prior to any fieldwork.
Task 2.2: Pilot Study

Task 2.2.1: Draft Pilot Study Plan

The contractor is developing a draft pilot study plan to implement Task 2.2.2. The plan will include the technical approach to implementing the pilot study, and the choice and rationale for equipment for bridge inspection and/or monitoring methodology.

The purpose of the pilot study is to validate protocols for data collection and management and to ensure that all of the components needed to achieve the long-term objectives of the LTBP Program are known before embarking on Task 2.3.

Primary Responsibility: Parsons Brinkerhoff and Center for Advanced Infrastructure and Transportation

Task 2.2.2: Pilot Study Execution

Upon the Federal Highway Administration's (FHWA's) approval of the draft plan delineated in Task 2.2.1, the contractor will execute a pilot study on bridges specified in Task 1.5 prior to inspection, monitoring, testing, and evaluation of all sample bridges. Execution of the pilot study will provide the vehicle through which the various contractors and subcontractors can interact, including identification of all the necessary steps and processes that need to be followed by each team, and provision of all the necessary information so that the respective development and implementation efforts can proceed in a timely and efficient manner. The execution of the pilot study also will help to verify protocols for instrumentation and inspection developed in Task 1.4, as well as the architecture for the data infrastructure, including data models, security protocols, and data/metadata to be collected and developed in Tasks 1.2 and 1.3.

At the end of this pilot study, the LTBP Program will have a working prototype for each aspect of the project that has been verified and can be demonstrated to stakeholders.

Primary Responsibility: Parsons Brinkerhoff and Center for Advanced Infrastructure and Transportation

Task 2.3: LTBP Program Data Collection

Upon the completion of the pilot study, the contractor will commence collecting data identified in Task 1.2 on sample bridges throughout the United States as specified in Task 1.5. The contractor will take advantage of information and knowledge gained during Task 2.2.

Primary Responsibility: Parsons Brinkerhoff and Center for Advanced Infrastructure and Transportation

Task 2.4: A Communication and Marketing Plan and Products

A marketing and communications plan and products will be developed, and executed throughout the duration of the project.

Primary Responsibility: Center for Advanced Infrastructure and Transportation
Task 2.5: Technology Transfer

A technology transfer plan and products will be developed, and deployed throughout the duration of the project.

Primary Responsibility: Center for Advanced Infrastructure and Transportation

UPCOMING EVENTS/WORKSHOPS

- January 15, 2009, LTBP Workshop, Transportation Research Board's (TRB) 88th Annual Meeting (Washington, DC)
- April 30–May 02, 2009, 2009 Structures Congress (Austin, TX)
- June 14–17, 2009, International Bridge Conference (Pittsburgh, PA)

COORDINATION

As the Long-Term Bridge Performance Program evolves, the team will partner and coordinate with State departments of transportation, other federal agencies, and the transportation community, including academia, industry, international organizations, and others.

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