Performance Based Integrated Asset Management (PBIAM)

FINAL REPORT
December 2008

Submitted by

Dr. Ali Maher*
Director

*Center for Advanced Infrastructure & Transportation (CAIT)
Rutgers, The State University
100 Brett Road
Piscataway, NJ 08854-8014

Dr. Emin Aktan
Intelligent Infrastructure Systems (IIS)
50 Belmont Avenue Apt 1010, Bala Cynwyd, PA 19004

In cooperation with

U.S. Department of Transportation
Federal Highway Administration

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TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
PBIAM-RU4474		

4. Title and Subtitle	5. Report Date
Performance Based Integrated Asset Management (PBIAM)	December 2009
	6. Performing Organization Code: CAIT/Rutgers
7. Author(s): Dr. Ali Maher and Dr. Emin Aktan	8. Performing Organization Report No.: PBIAM-RU4474
9. Performing Organization Name and Address: Rutgers University, 100 Brett Road, Piscataway, NJ 08854	10. Work Unit No.
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address: Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.	13. Type of Report and Period Covered: Final Report 2009
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

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- The state-of-the-art in asset management of highway infrastructure in the US and abroad;
- Research needs for demonstrating a network-level implementation of asset management to a regional highway infrastructure system.

The investigation and the resulting report will serve as a foundation for a proposal to establish a multi-disciplinary and multi-institutional research center on infrastructure asset management. This proposal will be submitted by CAIT and its partners to agencies including the National Science Foundation and the Federal Highway Administration.

17. Key Words	18. Distribution Statement
Highway, asset management, infrastructure	

19. Security Classif (of this report)	20. Security Classif. (of this page)	21. No of Pages	22. Price
Unclassified	Unclassified	8	

Form DOT F 1700.7 (8-69)

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Introduction
The research approach was unconventional, it was decided to host a workshop which focused on the paradigm of “performance-based infrastructure asset management (PBIAM)” for infrastructures such as transportation, water, power, etc. in general and the highway transportation in particular. The workshop served as a forum for discussing innovative paradigms and concepts that may be integrated and leveraged to advance the engineering and management of infrastructures. The presentations and panel discussions were designed to explore the inter-relations and synergies between systems identification, health and performance monitoring, lifecycle engineering, integrated asset management, performance-based engineering and multihazard risks, in addition to interdependence, resilience and sustainability of multi-domain systems.

The objectives of the research were:
(1) To bring an international, multi-disciplinary group of engineers and scientists from academe, government and industry together.
(2) To initiate the construction of an Ontology of PBIAM. This was expected as a means for overcoming the fragmentation in civil engineering education, agencies and organizations, and, practice that is a barrier against effective integration and leveraging of concepts and paradigms with potential to innovate the engineering and management of infrastructures. Ontology is envisioned as a mechanism for creating a unified worldview and language in highly complex emerging fields of study that face integration challenges.
(3) To initiate the development of an “International Collaborative Research Agenda” on PBIAM. This Workshop provided sharing of recent experiences and advances towards PBIAM in Europe, the Middle and Far East, and North America. It permitted an understanding of how different social and cultural institutions and related human systems in different regions of the world impact PBIAM applications.

The Agenda of the workshop was:

Infrastructures and Sustainability: Where are we today?

1. Overview: Infrastructure Systems and Integrated Asset Management (F. Moon)
2. Policy, Planning, Financing and Revenue (M. Meyer)
3. Lifecycle Engineering (D. Frangopol)
4. Multi-hazards Considerations for Asset Management (P. Yen)
5. Societal Institutions, Organizational Systems and Individuals (L. Comfort)
6. Sustainability and Infrastructures (F. Montalto)
7. Is there really a need for asset management research? (P. Gurian)

Infrastructures and Sustainability: Vision for the Future

8. Resilience and Sustainability of Infrastructure Assets through Risk-Based Adaptive Incremental Revolution (Y. Haimes)
9. European Research on Sustainability and PBIM (H. Wenzel)
10. Japanese Research on Health Monitoring of Infrastructures (Fujino)
11. How to Ensure 100 Years Lifetime for Concrete in Marine Environment (S. Lykke)

July 8, 2008:

PBIAM: Current State of Applications and Research Needs

12. Asset Management Practice in the USA (Ghasemi)
13. Asset Management Practice in the Netherlands (Klatter)
14. Asset Management Practice in Japan (Kaneuji)
15. The Canadian perspective on Asset Management (Wade)
16. PBIAM Experience on Alpine Motorways in Italy (Mordini)
17. ITS applications in Istanbul (N. Ertas)
18. ITU's Experiences and Lab Support for the Marmaray Project (Y. Akkaya and M. A. Tasdemir)

In addition to the above 30-minute presentations, there were panel discussions on:

1. Infrastructure Performance Measures:
   - System-Wide Performance Measures
   - Societal Domain Performance Measures
   - Natural Domain Performance Measures
   - Engineered Domain Performance Measures
2. PBIAM Ontology:
   - What is Ontology in general, and for infrastructures in particular?
   - How many ways are there for constructing Ontology?
   - How can we best leverage the construction and future applications of Ontology to integrate fragmented expertise areas and asset groups, and improve the engineering and management of infrastructures as multi-domain systems?
3. International Research Agenda on PBIAM:
   - Domain knowledge needs;
   - Corresponding data and information needs;

Tools and research infrastructure needs for data and information collection;
How to leverage existing data/information?
Research needs for data interpretation for knowledge;
Research needs for preserving and leveraging legacy heuristic knowledge and experience;
Country/Culture-specific issues in education and preserving wisdom/experience;
Future activities needed for completing a research agenda and launching international PBIAM research;

July 9, 2008:
An information Session on the Long Term Bridge Performance Program (LTBPP) that has been initiated by the FHWA was held. This was followed by a Panel meeting to discuss the opportunities for international collaborations.

The participants of the Workshop, with their affiliations and expertise areas are listed in the following.

US Delegation Affiliation Expertise Area

1. Dr. Emin Aktan Drexel University Structural and Systems Engineering
2. Dr. Hamid Ghasemi FHWA LTBPP Research Manager
3. Dr. Phil Yen FHWA Seismic Performance Research Manager
4. Dr. Ali Maher Rutgers University Operations, Pavements and Geosystems
5. Dr. Nenad Gucunski Rutgers University NDE Technologies, Geosystems
6. Dr. Bala Balaguru Rutgers University Materials and Durability
7. Dr. Yacov Haimes Univ of Virginia Systems Engineer, Risk and Uncertainty
8. Dr. Michael Meyer Georgia Tech Transportation Planning and Policy
9. Louise Comfort Univ of Pittsburgh Social Scientist: Government Policy
10. Dan Frangopol Lehigh Reliability and Lifecycle Engineering
11. Kevin Womack Utah State University Politics and Engineering Management
12. Mehdi Saiidi Univ of Nevada, Reno Earthquake Structural Engineering
13. Haluk Aktan Western Michigan U Materials and Durability
14. David Lowdermilk Pennoni Transportation Consultant
15. M Mollaghasemi Productivity Apex Int. Industrial Engineer, Ontology
16. Sohila Bemanian Parsons Pavement and Geo-systems consultant
17. Celik Ozyildirim VTRC Concrete Materials
18. Marv Halling USU Structural Engineering
19. Franklin Moon Drexel University Structural Engineering
20. Patrick Gurian Drexel University Systems Engineering, Policy Analysis
21. Franco Montalto Drexel University Environmental Systems, Sustainability
22. Necati Catbas Univ of Central Florida Structural Engineering
23. Masoud Ghandehari Brooklyn Poly Materials and Sensing
24. Sam Fayez Productivity Apex Int. Industrial Engineer, Ontology

Canadian Delegation

25. Roger Chen University of Alberta Civil Engineering Department Head
26. Chris Wade City of Calgary Director, Infrastructure Services, City of Calgary

27. Gamil Tadros SPECO and ISIS Bridge Design Consultant

European Delegation

28. Helmut Wenzel Austria and EC Consulting engineer, Vienna
29. Leo Klatter The Netherlands Asset Management Center for Public Works
30. Andrea Mordini Italy Transportation Consultant
31. Glauco Feltrin Switzerland EMPA Research Scientist

Japanese Delegation

32. Yozo Fujino Tokyo University Structural Engineering
33. M. Kaneuji Kajima Corp. Asset Management Consultant

Turkish Delegation

34. Mehmet Ali Tasdemir ITU, Dean of Engineering Construction Materials
35. Ugur Ersoy BU, Professor Structures and Reinforced Concrete
36. Nadir Yayla ITU, Professor Transportation Engineering
37. Yilmaz Akkaya ITU, Assoc Professor Construction Materials
38. Tugrul Tankut METU, Professor Structures and Reinforced Concrete
39. Ozgur Yaman METU, Assoc Professor Construction Materials
40. Azmi Tiras KGM, Assoc. Director Highways Agency Administrator
41. David Arditi IIT, Professor Construction Engineering
42. Steen Lykke MarmaRay Project General Director of Construction

Preliminary Conclusions and Recommendations:

1. Bringing an International and multi-disciplinary group together, and discussing cross-cutting topics related to infrastructures in general and highways and bridges in particular, proved to be a highly rewarding experience. The fact that the Workshop actually helped transform how they conceptualized various topics related to infrastructure management was articulated by many of the US researchers.
2. The presentations and discussions at the workshop revealed that infrastructures may be viewed in significantly different perspectives by researchers in various disciplines. There was agreement between participants from different fields that performance criteria for infrastructures may be articulated at the global, regional and local levels; and, in terms of different asset groups such as roadways, bridges, operations; and, the human, natural and engineered systems that make up each of the asset groups. It was also possible to reach consensus on the broader global level performance of infrastructures such as safety, choice, efficiency, transparency, etc.
3. However, performance measures for individual asset groups, or, each of the human, natural and engineered domain making up various asset groups was difficult to identify. The intersections, interactions and interdependencies between asset groups and different infrastructures made it very difficult to identify performance measures at asset group levels. It was also recognized that there is no direct correlation between performance criteria at the local level and at the global level, since the make-up of the system is largely unknown, and that the system is highly dynamic and nonstationary.
4. Researchers from industrial, structural, environmental and organizational systems areas who had developed a preliminary Ontology on Infrastructure Asset Management for the workshop recognized the need to considerably change their approach following the experiences and input during the workshop. Ontology remains as a most valuable and promising mechanism for arriving at a common terminology and world-view by a

diverse group of stakeholders on the challenges and opportunities we face today for prudently managing our existing infrastructures. However, the information and knowledge elicitation, and its hierarchical structuring as needed to construct the Ontology was discovered to be far more challenging than initially envisioned. The Ontology Committee will be continuing their efforts.

5. The Committee for developing an International Research Agenda made significant progress. Their draft will be ready by the end of August 2008. The most critical element of the research Agenda emerged as:

5.1 There are limits of theoretical research on “generic” infrastructures. Given that an important characteristic of infrastructures is their non-stationary and highly dynamic behavior, many intersections, interactions and interconnections may emerge during the time-window of a limit-event and then disappear. It follows that identifying infrastructures together with the interactions at their intersections of various domains, different asset groups and between different infrastructures is not possible unless research involves observations of actual operating infrastructures.

5.2 It is therefore highly desirable and in fact necessary to establish field laboratories where researchers may observe, measure and identify the behavior and performance of each of the human, natural and engineered elements and systems that make up infrastructures. The dynamic interactions and interdependencies between different domains, asset groups and entire infrastructures should be identified and characterized based on concrete examples. Only after such an exercise that we may be able to formulate meaningful performance measures for each element, domain or asset group and understand how these local-level performances will in fact contribute to the regional and global performances of the entire system.

5.3 The research agenda will discuss how infrastructure systems such as highway transportation and water may be transformed into field laboratories with their human, natural and engineered domains, and the scientific standards of observation, measurement and modeling of all critical elements with their interrelationships for the characterization and identification of integrated systems.

5.4 Given that infrastructure performance is a highly culture dependent concept, due to the human elements and systems making up the multi-domain system, it is desirable to have field laboratories at different areas of the world such as the European Union, the Middle East and the Far East.

6. The Workshop organizers envision that the Ontology and the Research Agenda will be drafted for presentation by September 2008. These products would be ready for discussion by various stakeholders, including NSF, FHWA, NIST, EPA and US Army Corps, in addition to academe and industry. The Organizers are interested in holding a smaller meeting at Washington DC during October or November 2008 to receive feedback before they finalize and submit their Final report to NSF and other interested Agencies.