CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

Project Summary Report 0-4186-S
Project 0-4186: Cradle-to-Grave Monitoring of Pavements and
PMIS Functionality Enhancement Planning
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August 2004

PROJECT SUMMARY REPORT

Cradle-to-Grave Pavement Monitoring of Pavements and Pavement Management Information System (PMIS) Functionality Enhancement Planning: A Summary

Background

Pavements are an important part of the highway transportation infrastructure, accounting for the single largest share of the overall investment. A tremendous amount of time and money is spent each year on the construction of new pavements, as well as on the maintenance and rehabilitation of existing pavements. To maximize benefits and minimize overall costs, a systematic and scientific approach is needed to manage pavements.

The objective of pavement management is to maintain or improve the condition of the pavement network and to maximize the performance of the network while keeping the costs to a minimum. In short, it encompasses all the activities associated with a pavement from "the cradle to the grave." Pavement management is a complex set of processes that need to be dealt with in a scientific and efficient manner so that accurate results are achieved.

The goal of Project 0-4186 was to develop a comprehensive plan to guide the cradle-to-grave monitoring and management of pavements, so that adequate, accurate data can be made available to enhance pavement management and engineering in Texas. Cradle-to-grave pavement monitoring involves systematically collecting, efficiently maintaining, and effectively utilizing data and information critical to pavement performance throughput its lifespan.

Project 0-4186 involved many steps, including reviewing the pavement-related database and information systems used by the Texas Department of Transportation (TxDOT), analyzing needed improvements, and developing plans for a new generation of pavement information system for the lifecycle monitoring and management of pavement infrastructure. This process involves three important aspects—data collection, data management, and data usage—making this project a mix of both engineering research and information technology (IT). The scope of Project 0-4186 is limited to engineering research with emphasis on the development of pavement management procedures and protocols. The research was conducted as a joint effort between the Center for Transportation Research (CTR) at The University of Texas at Austin and the Texas Transportation Institute.

What We Did...

1) Analysis of User Requirements: To fulfill the objectives of the project, a simple yet reliable process was used to determine the important user requirements of a comprehensive pavement management information systems (PMIS), thus making the PMIS easy to understand and use.The Delphi technique was applied to statistically analyze a set of responses to a survey that was given to each of the twenty-five TxDOT district pavement engineers. This technique brings about a convergence of expert opinions and aims to avoid the direct confrontation of the experts by means of an iterative questioning scheme. This analysis process yielded the rated user requirements for the PMIS.

2) Cost-Benefit Analysis of PMIS Enhancements: While any enhancements to the current PMIS would yield benefits, carrying out the enhancements requires resources. An estimate of the costs and benefits was conducted to develop the appropriate cost-benefit information through the five life stages of a pavement. Costs are defined in terms of the following criteria: activities and resources, cost categories, personnel burdened costs, depreciation, and/or social subsystem costs. The benefits of information systems can be viewed as the return on an investment. An eight-step cost-effectiveness framework was applied to the proposed PMIS for TxDOT and is detailed in Report 0-4186-2.

The eight steps taken (including important results) were as follows: (1) document the assumptions; (2) establish the alternatives; (3) select analysis period; (4) select the discount factor and discount rate; (5) determine costs; (6) determine benefits; (7) evaluate costs and benefits; and (8) conduct sensitivity analysis.

3) Definition of Cradle-to-Grave Pavement Management: One of the tasks under Project 0-4186 required a comprehensive definition of the cradle-to-grave management process for pavements. The definition of cradle-to-grave pavement management is detailed in Product 0-4186-P1. In this document, the primary objectives of each of the five life stages of a pavement are covered, with emphasis on necessary data pavement management requirements within each stage to help ensure the entire pavement management process is a success.

4) Summary of Previous Research Efforts: A clear understanding of previous research efforts involved with cradle-to-grave pavement management activities at TxDOT and their potential contribution to the proposed research plan is important for avoiding redundancies in research efforts. Information from previous research can contribute to the ongoing research. Based on the review work conducted, Report 0-4186-4 summarizes the previous research efforts undertaken at TxDOT between 1997 and 2002 that are relevant to Project 0-4186.

5) Review of Existing Pavement-Related Databases at TxDOT: To support the development of a comprehensive plan for enhancing PMIS functionalities, it is important that existing pavement-related databases at TxDOT be reviewed. Primarily, TxDOT utilizes five different databases to maintain data that is related to pavements. Report 0-4186-3 discusses the background, data elements and structure, uses and applications, and updating and maintenance procedures, as well as hardware/software components, of the five pavement-related databases.

6) Prioritization of Pavement Management Data: Adequate data is imperative for quantifying present and future network conditions and to identify pavement needs. Data collection is expensive, and it is often not known exactly what type of or how much data to collect. Moreover, misguided or haphazard data collection can actually create more problems than it solves. Report 0-4186-8 presents a need-driven, multi-objective data prioritization protocol to aid in efficient and cost-effective pavement management for the proposed TxDOT PMIS. To prioritize data needs, the Analytic Hierarchy Process (AHP) technique was used, in which a panel of TxDOT officials was asked to complete a survey indicating their preference for data requirements across the five stages of pavement life.

7) Traffic Data Provision: Report 0-4186-5 focuses on the acquisition of traffic data from existing pavement sections in order to provide the adequacy and accuracy needed to enhance the current TxDOT PMIS. To fulfill this objective, the needs of PMIS were assessed, and then an evaluation of the current state of TxDOT traffic data collection was made, both through literature research and interviews of key TxDOT personnel. By comparing the needs and the current PMIS provision, the shortcomings of the traffic data collection procedure were identified. These shortcomings were then converted into a set of recommendations for updating the PMIS. The recommendations were validated by examining their potential impact on traffic data accuracy, pavement design, and management processes. Finally, the recommendations were summarized and assessed for applicability and practicality in terms of providing complete, accurate, and up-to-date pavement data for the improved PMIS.

8) Network-Level Optimization for Budget Planning: Efficient and effective network-level optimization of pavement procedures is a major challenge faced by state department of transportations (DOTs). PMIS is used by TxDOT to help perform decision making for network-level pavement management. The PMIS employs a hierarchical decision process using rules established from the experience of TxDOT pavement experts to help guide the decision making. The aim of network level optimization is to minimize the total maintenance cost of the pavement over the entire planning horizon, such that a minimum specified pavement condition exists at the network level and at the individual pavement section level. Ideally, network level optimization modules should provide decision support information along three dimensions: which M&R treatments should be used and where and when they should be applied to maximize the available resources. Report 0-4186-7 details the use of two heuristic procedures for optimizing network conditions with the intent of developing a better budget planning approach for network pavement management within TxDOT.

What We Found...

1) As a result of the analysis of user requirements, the three highest-rated user requirements for the PMIS are as follows:

- Provide map-based display for PMIS data in a GIS format
- Provide user-friendly functions for report generation
- Collect repeatable and consistent visual pavement condition data

2) Bases on the cost-benefit analysis conducted under project 0-4186, the proposed PMIS appears to be a justified investment for TxDOT.

3) The five life stages of a pavement are planning, design, construction, in-service (operational), and maintenance and rehabilitation (M&R), as illustrated in Figure 1. The concept of cradle-to-grave monitoring and

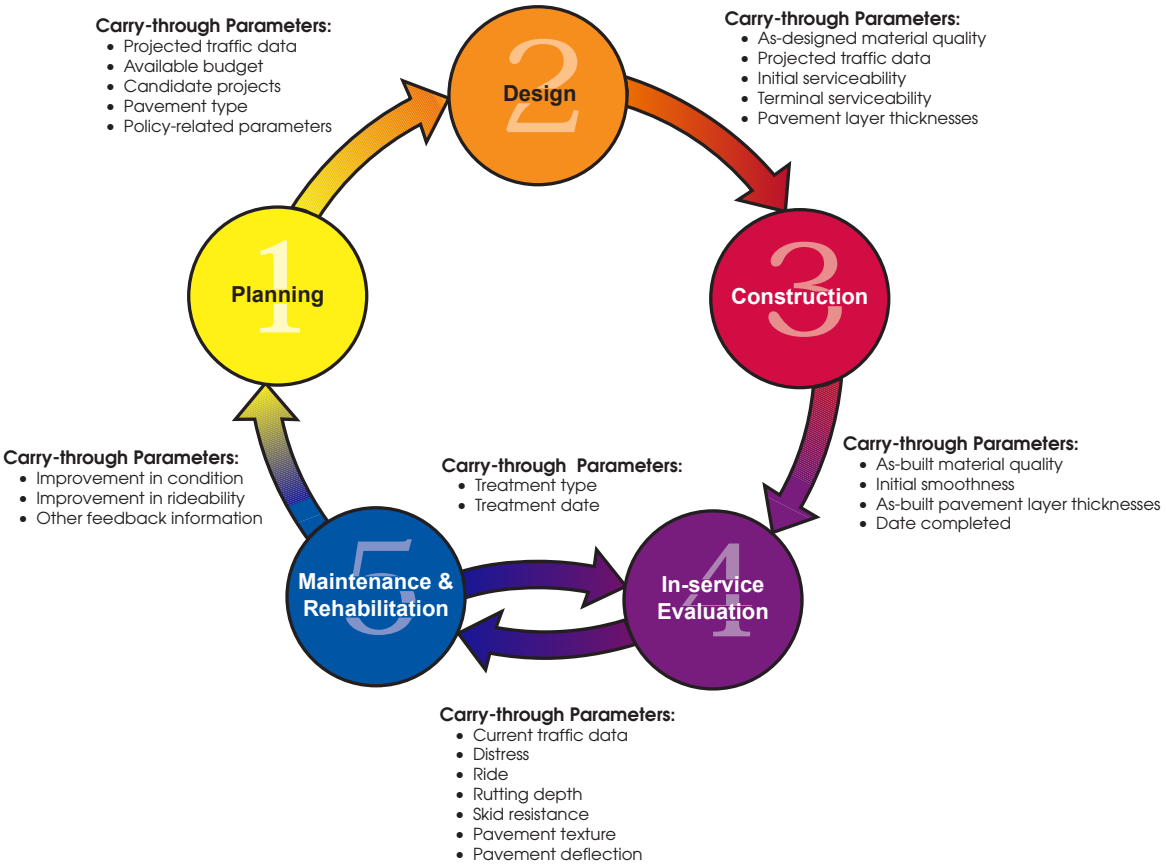

Figure 1. Conceptual Framework of the "Cradle-to-Grave" Pavement Monitoring Process

management refers not only to the life-cycle stages that every pavement experiences, but also to the data and information flow associated with the overall life-cycle process.

4) The review of the existing pavement-related databases indicated that a majority of the pavement-related data resides in TxDOT's legacy databases with mainframe computers. There is an immediate need to develop an information architecture that allows TxDOT Districts and Divisions to access pavement data from a user-friendly Web-based environment.

5) The ranking of the pavement data items was as follows (most important first), with reference information ranked the highest:

   1. Section Reference Data
   2. Pavement Performance Data
   3. Inventory Data
   4. Construction/Maintenance History Data
   5. Traffic History Data
   6. Policy-Related Data
   7. Site- & Climate-Related Data
   8. Cost-Related Data

6) Traffic data for pavement design and management requires more detailed information than traffic data for planning. Careful considerations in this regard should be given to the traffic data collection through close coordination between TxDOT's Transportation Planning and Programming Division and Construction Division.

7) With appropriate simplifications, a heuristic approach to network level optimization is possible for solving problems of budget planning and budget allocation for pavement management at TxDOT, as long as reasonable errors with the theoretical optimum are acceptable.

The Researchers Recommend...

The results of Project 0-4186 provide an opportunity to increase the quality of transportation for the taxpayers of Texas by enabling TxDOT engineers to significantly improve pavement management in an efficient and cost-effective manner while retaining corporate knowledge that is otherwise being lost. It is also paving the way for TxDOT to move into an era of asset management by developing IT tools for information management. What works for pavements will work for all the assets that TxDOT must manage. The recommended enhancements to the current PMIS promote better use of the limited funding to maintain the pavement infrastructure in Texas more effectively. Even though IT development was not in the scope of project 0-4186, it is recommended that findings of this research be evaluated and implemented through an IT development process.

For More Details...

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The research is documented in the following reports:

0-4186-1, *A Workplan for the Enhancement of the TxDOT PMIS*

0-4186-2, *Cost-Effectiveness Analysis of Enhancing the Pavement-Related Information Systems at the Texas Department of Transportation*

0-4186-3, *A Comprehensive Plan for PMIS Functionality Enhancement and Pavement-Related Databases in TxDOT*

To obtain copies of a report: CTR Library, Center for Transportation Research, (512) 232-3126, email: ctrlib@uts.cc.utexas.edu

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