

Technical Report Documentation Page

1. Report No. FHWA/TX-03/4186-1	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle A WORK PLAN FOR THE ENHANCEMENT OF THE TXDOT PMIS		5. Report Date October 2001	
7. Author(s) Zhanmin Zhang Randy B. Machemehl Roger Smith		6. Performing Organization Code	
		8. Performing Organization Report No. Research Report 4186-1	
9. Performing Organization Name and Address Center for Transportation Research The University of Texas at Austin 3208 Red River, Suite 200 Austin, TX 78705-2650		10. Work Unit No. (TRAIS)	
		11. Contract or Grant No. Research Project 0-4186	
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P.O. Box 5080 Austin, TX 78763-5080		13. Type of Report and Period Covered Research	
		14. Sponsoring Agency Code	
15. Supplementary Notes Project conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration, and the Texas Department of Transportation.			
16. Abstract The current pavement-related database and information systems used by the Texas Department of Transportation (TxDOT) were developed decades ago. Although these systems serve their original purposes, significant improvements have to be made to meet the increasing needs for more user-friendly and cost-effective information access not only at the Department level, but also at the District level. Recent advances in technologies have made such improvements possible. The objective of Project 0-4186 is to develop strategic plans and comprehensive protocols for a new generation of information systems and decision support systems for the life-cycle monitoring and management of pavement infrastructure systems using state-of-the-art technologies. This report documents a comprehensive plan of tasks for the enhancement of the TxDOT PMIS.			
17. Key Words databases, information systems, decision support systems, pavement management, infrastructure management		18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.	
19. Security Classif. (of report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of pages. 32 pages	22. Price

A WORK PLAN FOR THE ENHANCEMENT OF THE TXDOT PMIS

Zhanmin Zhang
Randy B. Machemehl
Roger Smith

Research Report Number 4186-1

Research Project 0-4186

Cradle-to-Grave Monitoring of Pavements and PMIS Functionality Enhancement Planning

Conducted for the

TEXAS DEPARTMENT OF TRANSPORTATION

in cooperation with the

**U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration**

by the

CENTER FOR TRANSPORTATION RESEARCH

Bureau of Engineering Research

THE UNIVERSITY OF TEXAS AT AUSTIN

and

**TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM**

October 2001

DISCLAIMERS

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration or the Texas Department of Transportation. This report does not constitute a standard, specification, or regulation.

There was no invention or discovery conceived or first actually reduced to practice in the course of or under this contract, including any art, method, process, machine, manufacture, design or composition of matter, or any new and useful improvement thereof, or any variety of plant, which is or may be patented under the patent laws of the United States of America or any foreign country.

**NOT INTENDED FOR CONSTRUCTION,
BIDDING, OR PERMIT PURPOSES**

Zhanmin Zhang, Ph.D.
Research Supervisor

ACKNOWLEDGMENTS

This project and report has been conducted under the guidance of and has been directly assisted by Stephen G. Smith, Project Director, Odessa District Construction and Laboratory of the Texas Department of Transportation and members of the Project Monitoring Committee whose names are give as follows: Jim Freeman (Program Coordinator), Pat Henry, Gerald Freytag, John T. Jennings, Michael R. Murphy, Elias Rmeili, Andrew Wimsatt, and Bryan Stampley. Without their generous help and guidance, this final product would be severely diminished.

Research performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

TABLE OF CONTENTS

BACKGROUND	1
PHASE I.....	2
Task 1. Review State-of-the Art Development of Pavement Monitoring and PMS.....	2
Task 2. Analyze User Needs.....	2
Task 3. Develop A Work Plan to Guide the Research	2
Task 4. Define the Cradle-to-Grave Process	2
Task 5. Review of Other Research Efforts at TxDOT that Are Related to This Research.....	3
Task 6. Conduct a Cost/Benefit Analysis of the Recommended Changes and Enhancements	4
Task 7. Provide Support for Project Management Plan (PMP) Document Development.....	4
Task 8. Review Current Practice of Pavement-Related Data Collection at TxDOT	5
Task 9. Review Existing Pavement Related Databases at TxDOT	6
Task 10. Review Current PMIS and Available PMS Software.....	7
Task 11. Develop Functional PMIS and Database Support Requirements	8
Task 12. Develop A Practical Approach to Traffic Data Provision	9
Task 13. Provide Support for Interaction with the TxDOT IT Project Process	10
Task 14. Provide Support for Interactions with Database Owners/Stakeholders	10
Task 15. Prepare the Information Management Plan	11
Task 16. Prepare the PMIS Decision Support Enhancement Plan	11
Task 17. Prepare the System Integration Plan	12
PHASE II	13
Task 18. Develop A Pilot Study to Prove the Concepts Under The Information Management Plan	13

Task 19.	Develop A Pilot Study to Prove the Concepts Under the Decision Support Plan.....	14
Task 20.	Develop Pilot Study to Prove the Concept of System Integration.....	15
Task 21.	Revise User Requirements.....	16
Task 22.	Revise Cost Effectiveness Study	16
Task 23.	Revise the Information Management Plan.....	16
Task 24.	Revise the Decision Support Plan.....	16
Task 25.	Prepare Research Reports	17

LIST OF FIGURE AND TABLES

Figure 1.	Schedule of the Work.....	19
Table 1.	Technical Memorandum	20
Table 2.	Deliverables	21

BACKGROUND

The objective of the research is closely connected to the meaning of “Cradle-to-Grave” (C2G) monitoring and management of pavements. A concise definition of “cradle-to-grave” monitoring and management of pavements is given as follows:

“Cradle-to-Grave pavement monitoring and management is the process of systematically collecting, efficiently maintaining, and effectively utilizing data and information that are critical to improving the performance of pavements for the life-span duration encompassing planning, design, construction, in-service evaluation, and maintenance and rehabilitation.”

The objective of the research is defined as:

“To develop a comprehensive plan to guide the cradle-to-grave monitoring and management of pavements so that adequate and accurate data can be made available to enhance PMIS and other activities related to the better engineering and management of pavements in Texas.”

This section presents the background of the project and discusses the needs for developing a work plan to guide the activities of the research and the transition from research to operational development that are essential to the enhancement of pavement management at the Texas Department of Transportation (TxDOT). Some specific issues to be addressed under this work plan include:

- 1) It should be noted that there are three important aspects involved with a project of this kind: data collection, data management, and data usage. While data management is in the domain of IT, data collection and data usage are indeed engineering research. In other words, this project is not simply an IT project, but rather it is a mix of IT and engineering research.
- 2) As a result, such a project is different from a traditional research project with regard to both its nature and scope. While it is appropriate for TxDOT’s research program to address engineering research, the appropriate office should address the operational development of IT. The key to success will be to make maximum use of the research while moving forward, without redundant effort, to the preparation and operational development of IT.
- 3) A detailed work plan is therefore needed to guide the research and the transition from research to operational development activities.

The work plan is arranged in two phases, where Phase I is for development of procedures and protocols and Phase II is for proof of concepts that are developed under Phase I. It is worth noting that as this project has evolved a decision was made to complete activities traditionally considered to be more related to IT development in a separate IT project. For the purposes of completeness and clarity of the scope of all work to be completed to realize improvements in TxDOT’s pavement management process, all activities are logically synthesized into this plan, which will be provided to the operational development project team for further consideration.

PHASE I

TASK 1. REVIEW STATE-OF-THE-ART DEVELOPMENT OF PAVEMENT MONITORING AND PMS

It is important to evaluate work done by others in developing plans for pavement data collection, information management, and PMS functionality enhancement. Although considerable literature on this subject has been reviewed, a further review of recent efforts will help the research proposed. It is noteworthy that related research efforts in information management systems and PMS improvements have been conducted by various agencies in the past, including the Center for Transportation Research at The University of Texas at Austin and the Texas Transportation Institute (TTI). In particular, Project 0-1731 on developing a database and information system was conducted by CTR, and Project 0-1727 on integrating project level and network level PMIS was jointly conducted by CTR and TTI. Efforts undergoing in other countries will also be reviewed under this task. All the information obtained from the literature review will be carefully categorized, systematically analyzed, and thoroughly documented with technical memorandums.

TASK 2. ANALYZE USER NEEDS

The pavement monitoring procedure and recommended enhancements to PMIS should be based on a clear understanding of the needs. The objective of Task 2 is to determine the user needs for the pavement data and PMIS. The research team will not conduct this research in a vacuum. The Delphi approach will be the methodology to ensure quality of the defined user requirements. It should be realized that, the user, depending on their position within the organization, will have different needs. The agency-wide needs should be recognized, agreed to, supported, and maintained across the administrations.

TASK 3. DEVELOP A WORK PLAN TO GUIDE THE RESEARCH

Because of the broad scope of the project and diversified information sources to be dealt with under this project, it is necessary to develop a detailed work plan to guide the research. The plan will layout in detail all the work to be done and the order for carrying out the work. The research team will work closely with the PD and PMC members to ensure that the work plan will be consistent with the objective of the project and the long-term goals of TxDOT for PMIS.

Once the draft work plan is completed, it will be presented to the PD and PMC members for review. Based on the review comments, the plan will be revised and finalized. The final plan will be completed by the end of the first year of the research.

TASK 4. DEFINE THE CRADLE-TO-GRAVE PROCESS

This task is intended to provide a clear definition for the “Cradle-to-Grave” pavement management process and identify the advantages associated with having such a process

implemented at TxDOT. The definition will include both general description and specific examples to reflect the scientific process of pavement management in the TxDOT division and district offices. More specifically, attention will be given to:

- 1) The engineering meaning of the “Cradle-to-Grave” process; and
- 2) The value of the “Cradle-to-Grave” process.

TASK 5. REVIEW OF OTHER RESEARCH EFFORTS AT TxDOT THAT ARE RELATED TO THIS RESEARCH

This task is intended to develop a clear understanding about all the possible research efforts that were undertaken or are undergoing at TxDOT. The primary benefits of this task are three-fold: 1) the results from these other projects can be used to achieve the goals of this project; 2) this process can help prevent any redundant research efforts; and 3) such an effort can also help TxDOT coordinate all the pavement management related research initiatives. The scope of this task will include research projects conducted at TxDOT over the years in pavements and areas related to this project. Of course, support from the TxDOT’s Research and Technology Implementation (RTI) office will be required to complete this task. The subtasks for this task are listed as follows.

Subtask 5.1 Work with RTI to establish a list of research projects selected for review

With cooperation of TxDOT’s Research and Technology Implementation (RTI), the pavement management related research projects should be selected for review. As the first step of this review process and working with the PD and the PMC, the scope of the projects to be included for the review will be defined.

Subtask 5.2 Review selected projects

The research reports produced from the selected projects will be carefully reviewed, clearly documented, and systematically categorized. Because a huge amount of literature review work is expected, a concise review summary for each of the selected projects will be prepared to keep the review process logged.

Subtask 5.3 Establish a cross-reference table or matrix between the tasks/subtasks of this project and the reviewed projects

The tasks/subtasks of the project and the reviewed projects will be cross-referenced to each other using a table or matrix. If a subtask of the project was already done in a previous research, the appropriate “cell” of the matrix will be properly marked. Based on this cross-reference table or matrix, redundant work can be avoided under this research.

Subtask 5.4 Develop conclusions and recommendations

Based on the work done under the previous subtasks, conclusions regarding what had been done and what needs to be done will be drawn; and recommendations on what research efforts should be made in this project will be presented.

Subtask 5.5 Prepare a technical memorandum to document the findings

TASK 6. CONDUCT A COST/BENEFIT ANALYSIS OF THE RECOMMENDED CHANGES AND ENHANCEMENTS

The objective of this task is to assess the various benefits and/or cost-savings that TxDOT would be receiving through the recommended changes and enhancements to the PMIS. Various available cost/benefit analysis approaches will be evaluated. In particular, the “cost effectiveness” concept will be examined for this purpose. Based on the evaluation, the best method will be selected and used to conduct the analysis. This task will include the following subtasks.

Subtask 6.1 Select methodologies for the Project Management Committee (PMC) to approve

Different methodologies that were used by other state DOTs or organizations regarding cost/effectiveness of PMS and information system development will be examined. The appropriate methodologies will be selected and presented to the PMC for approval.

Subtask 6.2 Develop required information for the selected methodologies

After agreement has been reached regarding which methodologies to be used, required information and data for those methodologies will be gathered.

Subtask 6.3 Conduct preliminary analyses to support the development of the Project Management Plan (PMP)

Using the data and information prepared and gathered under Subtask 6.2, preliminary analysis will be conducted. The result from the preliminary analysis will be used to support the PMP preparation.

Subtask 6.4 Conduct more extensive analyses

When additional data are obtained, more extensive analyses will be conducted to obtain the more accurate cost and benefit of the recommended changes to the system.

Subtask 6.5 Prepare the report(s)

Cost/benefit analysis of the recommended changes and enhancements and the result from the preliminary analysis will be documented.

TASK 7. PROVIDE SUPPORT FOR PROJECT MANAGEMENT PLAN (PMP) DOCUMENT DEVELOPMENT

An important part of this project is to coordinate with the TxDOT in the operational development at various stages. The Project Management Plan (PMP) document is the first step to move the operational development forward. It is part of the TxDOT’s standard operation procedure for any IT related projects. The research team will assist the Project Director in preparing the PMP document through the following subtasks.

Subtask 7.1 Provide support for gathering information

All project activities can be divided into the research phase and the operational development phase. To start the transition from the research phase to the operational development phase, the PMP document(s) should be prepared. Supporting information, such as the objectives, critical user needs, cost-benefit analysis, research plan and methodologies, and other important issues of the project will be used to provide the necessary information for preparing the PMP document(s).

Subtask 7.2 Provide support for coordinating efforts

Considering the broad scope of the project, it may be expected that many TxDOT divisions and offices will be involved in this project. There is no doubt that the success of the project will be based on effective cooperation and coordination of all the involved offices and divisions. The research team will provide all the needed support to such coordination efforts.

Subtask 7.3 Provide support for preparing the PMP document(s)

The research team will provide the needed support for preparing the PMS documents.

TASK 8. REVIEW CURRENT PRACTICE OF PAVEMENT-RELATED DATA COLLECTION AT TxDOT

After the needs and user requirements for pavement data and PMIS are established, it is necessary to conduct a thorough review of the current practice of pavement data collection in TxDOT in terms of time, ease of use, reliability, validity, and ease of access. This pavement data collection includes both pavement evaluation and other pavement-related data collected throughout the life of the pavement. A great deal of information, available in TxDOT and in other research reports, will be reviewed in terms of its benefit to the development of the pavement monitoring procedures. It is important to note that the evaluation will be given not only to data collection practice currently being performed, but also to those that may be performed infrequently and any new data collection initiatives that may be developed.

The Long-Term Pavement Performance (LTPP) data collection activity being carried out by the FHWA, in which Texas is a major participant, will provide a great deal of background information on lessons learned from both failures and successes. In addition, the AASHTO and other data standards for pavements will be used during this process.

Subtask 8.1 Evaluate the current pavement evaluation procedures with AASHTO and other standards

Pavement evaluation procedures used by TxDOT, AASHTO, and others will be carefully studied. Special attention will be given to comparisons of current practice of pavement data

collection at TxDOT against the procedures set by these standard guidelines, in terms of data type, data collection technology, data quality, data format, and other issues.

Subtask 8.2 Evaluate current data collection procedures for pavement-related data, including both pavement evaluation data and other pavement-related data as part of the cradle-to-grave process

Pavement data collection includes pavement evaluation data and other pavement-related data. The evaluation of the data collection procedure for the cradle-to-grave process will cover both pavement evaluation data and other pavement-related data that is critical to the cradle-to-grave management of pavements.

Subtask 8.3 Develop recommendations based on the evaluations

Based on the comparison studies conducted in Subtasks 8.1 and 8.2, comprehensive, practical, cost-effective pavement data acquisition procedures over the whole life cycle of the pavement will be recommended.

TASK 9. REVIEW EXISTING PAVEMENT RELATED DATABASES AT TxDOT

TxDOT currently has several large or small databases associated with pavement design and performance information. The five major databases being used by TxDOT include the Pavement Management Information System (PMIS), the Road Life Database (RL), the Maintenance Management Information System (MMIS), the Texas Reference Marker Database (TRM), and SiteManager (SM). While these five databases certainly do not represent the only bodies of electronically stored materials data within the Department, they do represent the bulk of systematic, reliable electronic data storage reservoirs within TxDOT; that is, they are the only dependable, department-wide sources of such data. Other databases that stored such data are not likely available at the department level, making it more difficult for the proposed database to access them. In addition, the linkage between the PMIS and SiteManager as well as laboratory data must be well considered. A very important issue for achieving data integration is the development of a referencing system that is compatible across all database systems to be integrated.

An in-depth review of the existing databases will be performed during the course of the proposed research. In the review, the databases will be compared regarding data elements and data structure, uses and applications, updating and maintenance procedure, computer software and hardware and the future evolution. The task will be completed through the following subtasks.

Subtask 9.1 Analyze data items in the databases (including identifying issues such as missing fields, field existing but not populated, populated but not reliable)

For each pavement-related database, data items will be examined regarding various issues such as normalization, reliability, missing items, blank fields, etc.

Subtask 9.2 Research roadbed vs. centerline issues

Locating the lateral position of a roadway using a roadbed-based location reference system (LRS) needs additional data in comparing with the centerline-based LRS. Research will be conducted to analyze the pros and cons of each. If it is concluded that the roadbed system should be used, the additional data required to implement such a system will be identified.

Subtask 9.3 Conduct analysis of location reference systems

Since several different location reference systems are used for the databases at TxDOT, it is difficult to integrate the databases without using a common location reference system. These location reference systems will be evaluated. An integrated location reference system will be recommended for the pavement-related databases at TxDOT.

Subtask 9.4 Identify issues, develop priority and options

Different issues regarding database integration will be explicitly identified, put into the priority order. Different options for resolving the issues will be discussed.

Subtask 9.5 Develop preliminary recommendations

Preliminary recommendations for addressing various issues that are related to the development of an integrated location reference system will be prepared based on the results of the studies conducted under the previous subtasks.

TASK 10. REVIEW CURRENT PMIS AND AVAILABLE PMS SOFTWARE

The current PMIS has been in use in TxDOT since its development to provide support for various pavement management needs in Texas. The objective of this task is to thoroughly review the current PMIS regarding its functionality, computing environment, user-friendliness, accessibility, etc. The purpose of the review is to determine what changes and enhancements need to be made to realize the maximum benefit of the additional information that is to be provided. In addition, available PMS software will be reviewed so that appropriate recommendations can be made with regard to the PMIS enhancements. Subtasks for this task are listed as follows.

Subtask 10.1 Compare user needs to PMIS capabilities

The current PMIS capabilities will be compared to the interpreted user needs established in Task 11. The needs that can and cannot currently be met will be identified; this will include identifying those that can be met but which are difficult to complete by district personnel. Changes that would be needed to meet the currently unmet needs will be identified. These will include identifying additional data needs.

Subtask 10.2 Review available PMS software

Software vendors who are interested in offering their software for potential use will be requested to provide an evaluation copy of their software to TTI for evaluation. The software will need to be a fully operational software set and it must be provided with a dataset that can

be used in the evaluation. Vendors will also be required to provide TTI with at least three references from state DOTs that use their software.

TTI will compare the capabilities of the vendor provided software to the interpreted user needs established in Task 11. The needs that can and cannot currently be met will be identified; this will include identifying those that can be met but which are difficult to complete by district personnel. Changes that would be needed to meet the currently unmet needs will be identified. These will include identifying additional data needs.

Subtask 10.3 Prepare preliminary recommendations

Based on Subtask 10.1 and 10.2, a set of recommendations will be prepared for TxDOT about how to proceed. The project committee, or other appropriate authority, will need to decide at that point on how to proceed. If the decision is made to use a vendor supplied software, then many of the subsequent tasks will probably need to be modified to accommodate that decision.

TASK 11. DEVELOP FUNCTIONAL PMIS AND DATABASE SUPPORT REQUIREMENTS

User needs are the desired features from the engineers as users without considering how the features will be materialized. Functional requirements are the technical interpretation of the user needs with proper techniques to implement them. This task is intended to convert the user needs analysis conducted under Task 2 into functional PMIS and database functional requirements. The subtasks are given as follows.

Subtask 11.1 Interpret user needs

The user needs identified in Task 2 will be interpreted to first identify which ones will affect the information management efforts and which will affect the decision support efforts; it is understood that many will affect both. They will be grouped into logical groupings so that similar needs can be addressed as simply as possible in Subtask 11.2. For instance, several of the needs may affect the needs analysis portion of the decision support tools, and these may in turn affect the information management needs by requiring additional data or sets of data above what is currently stored.

These groups of needs and individual needs within the groups will be prioritized. We expect that the Project Committee will provide input to this prioritization.

Subtask 11.2 Identify options to satisfy the needs

There may be more than one option that can satisfy the needs. Those options will be identified. Based on the interpretation completed in Subtask 11.1, each interpreted user and derived need will be analyzed to identify the possible options for satisfying these needs. We expect to identify critical needs not explicitly identified by the users but which must be completed on the information management or decision support tools in order to meet the user defined needs. Those which must be completed in order to meet the critical user defined

needs will also be given the highest priority. There will often be a number of alternative approaches that could be used. These alternatives will be identified, and those that are not considered feasible will be discarded from future consideration.

Subtask 11.3 Prepare conceptual documents to illustrate the relationship between user needs and functional requirements

Based on the work completed in Subtasks 11.1 & 11.2, preliminary conceptual documents will be prepared for the information management and decisions support elements. These will identify the overall business processes that must be used for the viable approaches.

Subtask 11.4 Prepare preliminary recommendations

The preliminary recommendations for functional PMIS and database support requirements will be established. A set of recommendations for both information management and decision support will be prepared. These will include recommendations of the approaches to follow based on the work in Subtasks 11.1 through 11.3.

TASK 12. DEVELOP A PRACTICAL APPROACH TO TRAFFIC DATA PROVISION (6 months in Year 2 and 6 months in Year 3)

Accurate traffic data is critical to pavement engineering and management. This task is intended to develop an approach that can be practically implemented to provide more reliable traffic data for the PMIS. Earlier research efforts, such as TxDOT Project 1801, “Evaluation of TxDOT’s Traffic Data Collection and Load Forecasting Process” and the STARS initiative, will be reviewed. The task consists of the following subtasks.

Subtask 12.1 Establish minimum requirements

Traffic data are critical for making sound and optimal pavement management decisions for pavement engineering practice. In order to develop the optimal solution to the provision of adequate traffic data, the minimum requirements for traffic data must be established first.

Subtask 12.2 Compare current data to the minimum requirements

Once the minimum requirements are established, they should be compared with the current traffic data acquisition and usage in the TxDOT pavement management system, so that the necessary procedure(s) can be taken to improve the quality of the traffic data used at TxDOT.

Subtask 12.3 Identify potential constraints

Various potential constraints and limitations may exist in acquiring more and quality traffic data. These constraints will be identified so that the best solutions can be developed within the constraints.

Subtask 12.4 Develop recommended traffic data system

Using the established minimum requirements and the identified constraints, comprehensive recommendations will be developed to ensure the quality and adequacy of traffic data.

TASK 13. PROVIDE SUPPORT FOR INTERACTION WITH THE TxDOT IT PROJECT PROCESS

It is anticipated that there will be intensive interactions between the research team and the TxDOT process for an IT project. This task is intended that such interactions be well maintained throughout the duration of the project. The most intensive period would be from the beginning of Year 3 until the end of the project.

Subtask 13.1 Provide coordination with the Project Board

As part of the TxDOT IT project process, consensus from the Project Board is needed before an IT project can proceed to the substantial programming and coding stage. The research team will provide necessary coordination between the research phase and the IT development phase throughout the duration of this project to make sure that the research results are properly communicated to the Project Board in a timely fashion.

Subtask 13.2 Provide support for Project Board activities

The research team will provide support to the Project Board activities to make sure that sufficient information be provided to them whenever such a need occurs.

Subtask 13.3 Provide support for operational development team

Close cooperation and coordination between the operational development team and the research team is critical to the successful implementation of the findings from the research. Considering the high costs associated with the IT process, an efficient procedure will be developed to guide such coordination so that the overall development costs can be minimized.

TASK 14. PROVIDE SUPPORT FOR INTERACTIONS WITH DATABASE OWNERS/STAKEHOLDERS

Due to the scope of the project and the nature of multiple divisions and offices involved. It is important to coordinate with stakeholders throughout the process to meet the overall needs. In addition, various meetings will be conducted with the current database owners so that general agreement can be reached with regard to the ownership of the databases once they are improved.

Subtask 14.1 Coordinate with stakeholders

Various TxDOT divisions and/or offices managing various pavement-related databases have to be involved in this project. Efforts will be made for the various divisions/offices to work together in defining their common interests as well as separate and local interests, so that every stakeholder will benefit from this process.

Subtask 14.2 Conduct agreement negotiations with the database owners

A standard protocol and a commitment to the protocol guaranteeing the coordination among the TxDOT data/database owners will be established through an agreement negotiation process that involves each individual data/database stakeholder.

TASK 15. PREPARE THE INFORMATION MANAGEMENT PLAN

Based on the research results from the previous tasks, a detailed plan for pavement data collection and information management will be prepared. The plan will document in detail the procedures and programs needed to collect, manage, and utilize cradle-to-grave pavement data. The draft of the Information Management Plan should be available by the end of Phase I.

Subtask 15.1 Develop the conceptual framework

The conceptual framework is critical to the development of the information management plan. The conceptual framework will help define the relationships among the three major parts of the information system—data collection, data management, and data usage. It will also outline the integration framework of all the pavement-related databases.

Subtask 15.2 Develop integration strategies

There are various strategies that can be used to integrate database and information systems. The best strategy will be developed to ensure the continuity of the existing databases while the integration is underway, so that the interruption to TxDOT's daily business operation will be minimized.

Subtask 15.3 Identify potential issues

Considering the magnitude and scope of the database and information systems involved, there is no doubt that there will be issues that have to be resolved in order for a successful development and implementation of the new information systems. These issues will be carefully identified; then the corresponding strategies for addressing these issues will be developed.

Subtask 15.4 Prepare the plan

A detailed plan will be developed to document the framework, strategies, and potential issues for the enhanced information system(s).

TASK 16. PREPARE THE PMIS DECISION SUPPORT ENHANCEMENT PLAN

Based on the research results from the previous tasks, a detailed plan with recommended changes and enhancements to PMIS will be prepared. The plan will document in detail the procedures and programs needed to change and/or enhance PMIS. To allow the early employment and testing of the pilot programs, the individual components of the enhanced PMIS decision support software will be developed incrementally. In the initial phase, the software will be designed to work using the currently available data and the PMIS database

structure in ACCESSTM or similar software. The material for the needs module will be developed first. This will be followed by the prioritization module. The impact analysis module will then follow. Finally the feedback element will be developed. Data needs for each which will affect the information management plan will also be identified. The cost/benefit analysis of these recommended changes and enhancements will also be addressed under this plan. The draft of the PMIS Enhancement Plan should be available by the end of Phase I.

Subtask 16.1 Develop conceptual framework

An overall conceptual framework will be postulated based on work completed in Task 11. It will be object oriented and event based. Each major module will be a large object that receives data and returns data. Within each module, submodules will also be designed as objects that receive and pass data as much as possible.

Subtask 16.2 Prepare flow charts/diagrams

Flow charts and diagrams will be prepared that are conceptual in nature based on the conceptual framework developed in Subtask 16.1. They will provide programmers in task 19 with guidance needed to program the pilot software.

Subtask 16.3 Prepare data flow diagrams

This set of data flow diagrams will be based on using the currently available data and the PMIS database structure in ACCESSTM or similar software. They will identify the source of the data, the flow of the data, the output of data, and the destination of that data. They will provide programmers in Task 19 with guidance needed to program the pilot software.

Subtask 16.4 Prepare the plan

A plan will be prepared which sequences the development of the individual modules to allow sequential programming to occur concurrently in Task 19 as each module is developed. It is projected that the preliminary database will be the first module since it will take the least development. This will be followed by the needs analysis module. The prioritization module will then follow. The impact analysis module will be prepared. The feedback module will then be prepared.

As the documents, flow diagrams, data flow diagrams for each module are completed, they will be incorporated into an overall plan. At the end of this task, the individual module documents will be evaluated for any needed changes in earlier modules to support requirements in later modules. An overall plan will then be provided.

TASK 17. PREPARE THE SYSTEM INTEGRATION PLAN

Integration of the information systems with the PMIS decision support system is a critical step for achieving the ultimate goal of the project. This task is to facilitate this function, with the subtasks being listed as follows.

Subtask 17.1 Develop conceptual framework

The information system proposed in Task 15 and the decision support system proposed in Task 16 should be integrated properly to each other. Fine adjustments in either of the two composing subsystems may be made for seamless integration. As the decision support plan and information management plans are developed, the interactions will be identified. It is expected that the database needed and desired changes will at least affect the data flow diagrams, but may affect other elements as well. As the decisions support system enhancements are designed, they will likely identify additional data management needs. These may include the requirement to collect, store, and/or manage additional data.

Subtask 17.2 Prepare data flow diagrams

Data flow diagrams developed in Task 16 will be modified to reflect expected changes in the database structure. The data flow diagrams are needed to demonstrate the working function of the new pavement management system, help describe the components of the whole system, and exhibit the coordination mechanism of every composing element.

Subtask 17.3 Prepare the plan

The plans developed in Tasks 15 and 16 will be modified to better integrate the expected changes to the database and the decision support system. An integral development plan and work schedule covering both of the two composing subsystems will be proposed for a pilot development study in phase II.

PHASE II**TASK 18. DEVELOP A PILOT STUDY TO PROVE THE CONCEPTS UNDER THE INFORMATION MANAGEMENT PLAN**

With the approval of the PD and upon completion of the first version of the Information Management Plan, the procedures and/or programs defined in the plans will be implemented and tested in a limited number of selected TxDOT Districts. The purpose of this pilot implementation is to test the procedures/programs for their validity and to obtain feedback information from those participating.

Subtask 18.1 Develop the conceptual framework of the pilot software

The conceptual framework of the pilot software will help illustrate the software structure that can accommodate all the procedures and programs defined in the information system plan. A conceptual database model along with the protocols will be developed to demonstrate the relationships among various components of the system.

Subtask 18.2 Program the software

Once the framework is defined, the development tool(s) will be selected for the development of the software. The programming will proceed upon the approval of the PD.

Subtask 18.3 Prepare data for the pilot system

Sample data will be prepared as input for the developed pilot system. Efforts will be made to ensure that the sample data will represent the real-world conditions.

Subtask 18.4 Prepare the user's manual for the pilot system

The user's manual for the pilot will be developed so that the users in the pilot districts can refer to it if needed. The user's manual should be written in plain language that is good for training purposes and easy for regular users to follow.

Subtask 18.5 Deliver the pilot program(s) to pilot district(s)

The pilot information system will be tested through practical use in selected TxDOT districts. Coordination with these districts will be done prior to the delivery of the pilot system.

Subtask 18.6 Collect feedback information

Feedback information from the pilot districts will be collected during and after the pilot study, including potential problems in the pilot system as well as other related design and implementation issues. The feedback information will be used to fine-tune the pilot system and revise the plan if needed.

TASK 19. DEVELOP A PILOT STUDY TO PROVE THE CONCEPTS UNDER THE DECISION SUPPORT PLAN

With the approval of the PD and upon completion of the first version of each major module of the PMIS Enhancement Plan, the procedures and/or programs defined in the plans will be implemented and tested in a limited number of selected TxDOT Districts. The purpose of this pilot implementation is to test the procedures/programs for their validity and to obtain feedback information from those participating. To facilitate the timely completion of this phase, the initial phases of the task will occur concurrently with Task 16.

Subtask 19.1 Program modified PMIS

This subtask will be conducted concurrently with Task 16. After the document for each module is prepared in Task 16, they will be coded in a relatively simple program, such as VisualBasicTM. The modules will be programmed in an object-oriented approach with major sub-modules also programmed as objects. It is expected to have the entire program completed by the end of FY 2003.

Subtask 19.2 Debug the program

Testing data sets and methodologies will be prepared and used to test each module as it is programmed. A second set of data and testing methodologies will be prepared to test the entire program when fully assembled. This testing and programming will be conducted prior to installing the software in pilot districts.

Subtask 19.3 Install the program to the pilot district(s)

At the beginning of FY 2004, the program will be installed in 2 districts selected by the PD that have adequate layer data to use the capabilities of the new modules. In addition, it will be provided to the Pavement Division at Central Headquarters. Each of these 2 districts will be trained in the use of the software and management concepts employed. These 2 districts will be required to test the software and provide feedback within 6 months. We also expect to receive feedback from the Pavement Division. At the end of FY 2004, the program will be installed in 2 additional districts. Each of these 2 districts will be trained in the use of the software and management concepts employed. These 2 districts will be required to test the software and provide feedback within 6 months.

Subtask 19.4 Document results of implementation

Results of the trial implementations in the first 2 districts and the Pavement Division will be documented. Needed changes and desired improvements will be identified. If possible, these will be designed and incorporated into the version placed in the second set of 2 districts. The overall needed changes, desired improvements, and trial results will be documented at the end of the task.

TASK 20. DEVELOP PILOT STUDY TO PROVE THE CONCEPT OF SYSTEM INTEGRATION

With the approval of the PD and upon completion of the first version of the System Integration Plan, the procedures and/or programs defined in the plans will be implemented and tested in a limited number of selected TxDOT Districts. The purpose of this pilot implementation is to test the procedures/programs for their validity and to obtain feedback information from those participating.

Subtask 20.1 Identify decision support changes needed to accommodate changed data structure

As the database needed and desired changes in the information management element are developed, these will be evaluated to identify changes that would be needed in the decision support system. It is expected that this will at least affect the data flow diagrams, but may affect other elements as well.

Subtask 20.2 Identify database change to accommodate the decision support system (DSS)

As the decision support system enhancements are designed, they will likely identify additional data management needs. These may include the requirement to collect, store, and/or manage additional data.

Subtask 20.3 Update conceptual documents

The conceptual documents prepared in Tasks 15 and 16 will be updated to reflect the lessons learned in the pilot implementations. Also based on the work done jointly by CTR and TTI

in Subtasks 20.1 and 20.2, necessary modifications to any part of the original conceptual design plans should be conducted accordingly.

Subtask 20.4 Program identified modifications

Identified modifications will be incorporated into the pilot programs and tested. Based on the work done in Subtasks 20.1 and 20.2, necessary modifications to any part of the programs in the pilot software will be carried out accordingly.

Subtask 20.5 Test in district(s)

Another iteration of pilot implementation of the modified information system and modified decision support system will be conducted in the pilot districts. Modified programs will be installed in the selected pilot districts and the Materials and Pavement Section. These districts will be required to test the software and provide feedback within 6 months.

Subtask 20.6 Document the results and feedback

Another iteration of feedbacks from district users will be collected during and after the pilot implementation. Results of the pilot implementations in the districts and the Materials and Pavement Section will be documented. Needed changes and desired improvements will be identified.

TASK 21. REVISE USER REQUIREMENTS

Under this task, feedback information from the pilot studies will be used to update the user requirements.

TASK 22. REVISE COST EFFECTIVENESS STUDY

Under this task, feedback information from the pilot studies will be used to update the cost effectiveness analysis.

TASK 23. REVISE THE INFORMATION MANAGEMENT PLAN

Using the feedback information from the pilot implementation conducted under Task 18, necessary revisions will be made to the Information Management Plan. The revised plan will then be presented to the PD and PMC members for review. Once approved by the PD, the plan will be finalized.

TASK 24. REVISE THE DECISION SUPPORT PLAN

Using the feedback information from the pilot implementation conducted under Task 19, necessary revisions will be made to the PMIS Decision Support Enhancement Plan. The revised plan will then be presented to the PD and PMC members for review. Once approved by the PD, the plan will be finalized.

TASK 25. PREPARE RESEARCH REPORTS

The research team will make every effort to document progress of the work throughout the project in technical memoranda and in interim reports. A Research Report which completely documents the research performed, method used, and results achieved will be prepared at the end of the project. As required by TxDOT, a Project Summary Report will also be developed to provide a complete summary of project results, with detailed recommendations for implementation and for any future research.

SCHEDULE OF THE WORK

The schedule of the work is provided in Figure 1.

TECHNICAL MEMORANDUM

The technical memorandums that will be produced are summarized in Table 1.

DELIVERABLES

The deliverables of the project are summarized in Table 2.

Figure 1. Schedule of Research Activities for Project 0-4186

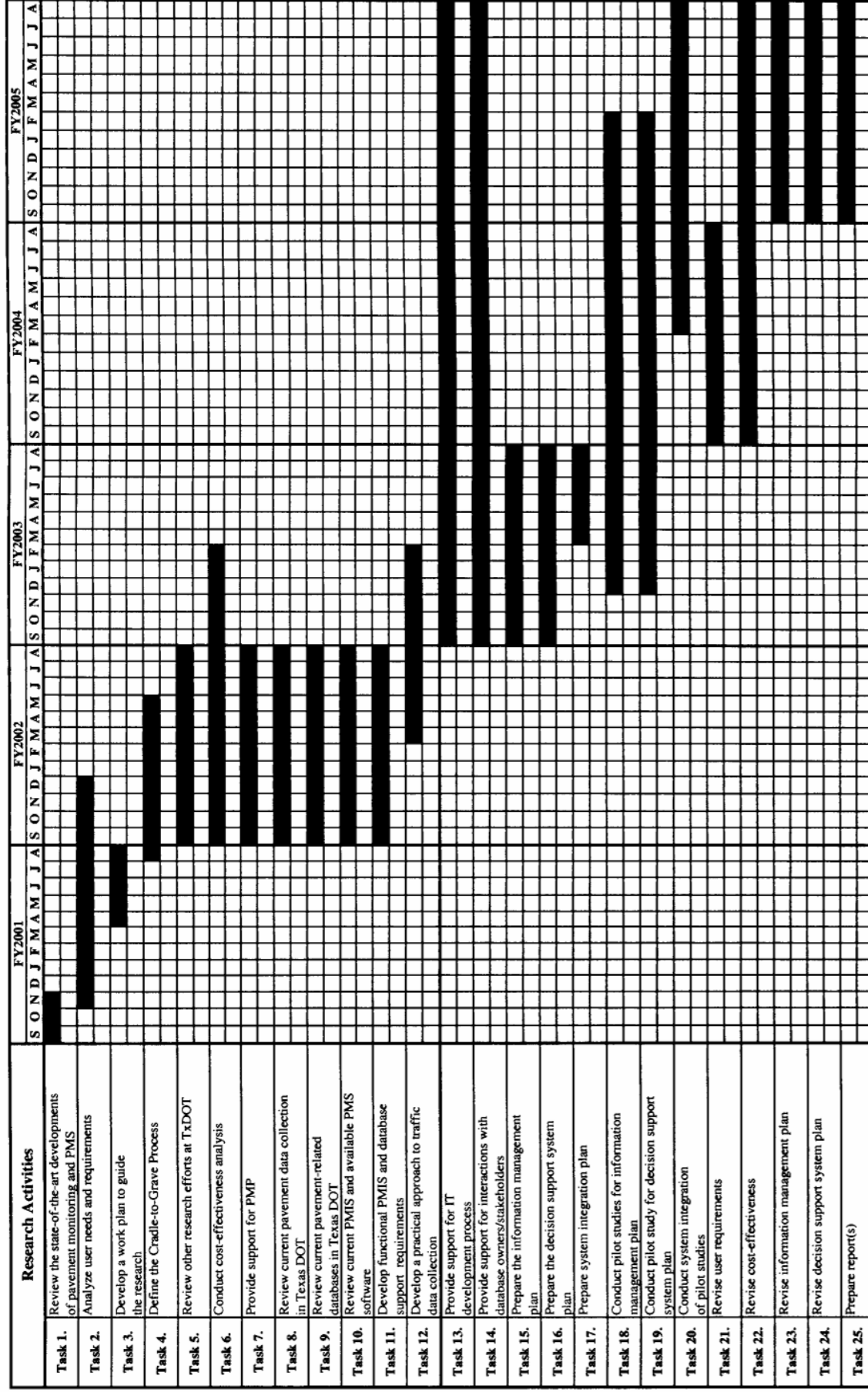


TABLE 1. TECHNICAL MEMORANDUM

Technical Memo	Description	Task	Comments
TM4186-1	Technologies for Pavement Data Collection	1	
TM4186-2	Database and Information Technology	1	
TM4186-3	Pavement-Related Databases at TxDOT	1	
TM4186-4	Current Status of PMIS	1	
TM4186-5	The Cradle-to-Grave Process	4	
TM4186-6	Review Summary of the Pavement-Related Research Project at TxDOT	5	
TM4186-7	Cost Effectiveness Analysis	6	
TM4186-8	Review of Pavement-Related Data Collection Practice at TxDOT	8	
TM4186-9	Review of Pavement-Related Database at TxDOT	9	
TM4186-10	Review of Current PMIS and Available PMS Software	10	
TM4186-11	Functional Requirements for PMIS and Information System	11	
TM4186-12	A Practical Approach to Traffic Data Provision	12	

TABLE 2. PROJECT DELIVERABLES

Products (e.g., specifications, guidelines, design procedures, devices, software, resulting from the project)				
Product Description	Required Submittal Date*	Responsible Party for Multi-Agency Agreement	Comments	
Definition of the Cradle-to-Grave Process	May 31, 2002	CTR		
Cost Effectiveness Analysis of Enhanced PMIS	March 30, 2003	CTR		
Pavement Information Management Plan	October 31, 2005	CTR		
PMIS Decision Support Enhancement Plan	October 31, 2005	TTI		
Computer Program(s) Used for the Pilot Studies of the Pavement Information Management Plan	October 31, 2005	CTR		
Computer Program(s) Used for the Pilot Studies of the PMIS Decision Support Enhancement Plan	October 31, 2005	TTI		
Reports (This table will include a minimum of one Research Report which comprehensively documents the project and one Project Summary Report of maximum 6 pages. The requirements for reports in this table may be revised at a later date by mutual agreement of the Research Supervisor, the Project Director, and the Director of the Research and Technology Transfer Section of the Construction Division.)				
No.	Report Description	Required Submittal Date*	Responsible Party for Multi-Agency Agreement	Comments
1	Research Plan with Detailed Information to Guide the Research Project	August 31, 2001	CTR	
2	Final Research Report Documenting in Detail the Research Conducted and Results Achieved.	October 31, 2005	CTR	
3.	Project Summary Report Summarizing the Key Research Findings	October 31, 2005	CTR	
* If no required submittal date is indicated, it defaults to 60 days after project termination.				

