

Summary of the GIS Implementation Plan for the TxDOT PMIS

What We Did..

Pavements are one of the critical elements of the highway transportation infrastructure in the United States. Billions of dollars are spent annually on maintaining and rehabilitating pavements. However, deteriorating pavement conditions, increasing traffic loads, and limited funds present a complex challenge for pavement maintenance and rehabilitation activities. Pavement management systems (PMS) have been developed to cope with these challenges in almost every state during the last two decades. A PMS is developed to identify

maintenance needs, help allocate funds, support decision-making, and maintain good pavement conditions with the constraint of limited funds. The pavement management information system (PMIS) is the PMS used by the Texas Department of Transportation (TxDOT).

PMIS is an automated system for storing, retrieving, analyzing, and reporting information needed to support pavement-related decision-making within TxDOT (Ref 1). Although it has worked well in serving its original objectives, the TxDOT PMIS is faced with

new challenges arising from diverse data, technologies, and systems that together result in inefficient information exchange within the Department. The adoption of geographic information systems (GIS) can help overcome these challenges if it is carefully planned and implemented.

Successful GIS implementation involves not only the information technologies themselves, but also the personnel and skills needed. The organization and institutional arrangements that govern the patterns of management and information

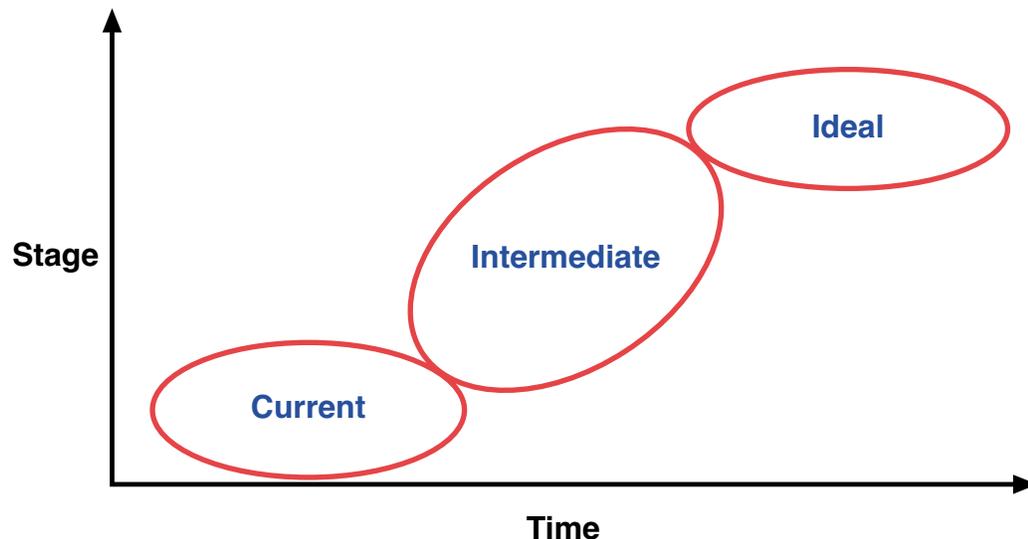


Figure 1. Illustration of the Intermediate Solution Concept



flow are also critical and must be managed interactively. Since GIS-related information technologies are updated rapidly, it can be difficult to predict the future. Thus, a GIS implementation plan is needed to improve the chances of successful implementation. The plan presented here can help reduce mistakes and integrate management of various aspects of data issues, personnel, and GIS skills needed, creating a solid basis for dealing with the unexpected. This report summarizes the completed tasks, major findings, and key recommendations for GIS implementation actions.

What We Found...

1. There are two interacting stages for implementing a GIS for the PMIS. The first is the planning and design stage in which the existing PMIS resources and limitations are examined and then the potential GIS activities identified and selected. The second stage is to manage and operate the recommended GIS activities according to the implementation plan.
2. Four issues are critical for successful GIS implementation. The first is the involvement of both management-level and technical personnel. The second is multiple technologies related to the successful implementation of GIS. The third is related to ongoing technology advances. The fourth is data and system integration.
3. Generally, for each PMIS activity at both network level and project level, there are certain GIS operations that can greatly increase the benefits of PMIS. The primary benefits of integrating GIS with PMIS come from two major categories of GIS functions: 1) to provide a user-friendly basis so that a wide variety of data can

be accessed easily, manipulated visually, analyzed spatially, and presented graphically; and 2) to serve as a logical, coherent, and consistent platform with a common location reference system so that diverse databases can be integrated and shared among different divisions of a department.

4. TxDOT is now ready to actively use GIS, apart from supporting the development of the base map and some ad hoc applications. PMIS is a main-frame application system, and the PMIS data is stored as a non-relational database in ADABAS that cannot be used in GIS directly. Data transfer from ADABAS to PC or Unix is accomplished through ASCII files.
5. A base map contains geographic features used for referencing location. The quality of a base map to a large extent determines the success of a GIS project. The accuracy level required for PMIS, both absolute accuracy and relative accuracy, is determined from the perspective of specific applications. The absolute accuracy level of an existing TxDOT digital base map (about 15 meters) is satisfactory for TxDOT PMIS's main purpose of planning. The relative accuracy level of the digital base map needs to be further examined.
6. The Global Positioning System (GPS) is a three-dimensional measurement system. Integrated with GIS, GPS has enormous potential for engineering surveys and PMIS. For base map development and for the collection and updating of highway inventory data, GPS can be more accurate and more efficient than conventional

instruments.

7. Digital Orthophoto Quadrangle Quarter (DOQQ) is a geographically accurate digital image of the earth produced from aerial photography using photogrammetric techniques. DOQQs offer a complete, accurate base map for many GIS applications. However, DOQQs are expensive to acquire and manage.

The Researchers Recommend...

Based on this research, the following recommendations should be carefully observed in the implementation of a GIS:

1. Different applications require spatial data at different scales. No one scale can support all pavement-related applications satisfactorily. It is recommended that several scale themes be fixed for frequent uses.
2. All GIS data, spatial data and associated attribute data, suffer from inaccuracy, imprecision, and error to some extent. Data quality assurance and quality control (QA/QC) rules must be established to ensure the delivery of high-quality data.
3. Maintenance of GIS data should be assumed by an appropriate "data steward" who is responsible for collecting and disseminating data.
4. Both internal and external data sources should be examined for potential use. Internal sources can include any department, division, or specific office, whereas external sources may include federal and state agencies, universities, and private entities, etc.
5. Products from Environmental Systems Research Institute, Inc.



(ESRI), are recommended as the standard GIS software for PMIS. They are: high-end GIS software (ARC/INFO), desktop software (ArcView), and software for adding GIS functions to non-GIS applications (MapObjects).

6. Mixed database management systems (DBMSs) are recommended to support GIS applications for PMIS. Sybase SQL Server is recommended for enterprise-wide and workgroup applications. Sybase SQL Anywhere is recommended for PC workstation applications that have the potential for expansion beyond a single workstation and for small workgroup applications. Microsoft Access is recommended for individual workstation database applications. INFO is recommended for prototype GIS database applications on an as-needed basis.
7. Based on the level of GIS knowledge needed, there are three levels of GIS staff and users associated with PMIS: core staff, master users, and other users. Based on the organizational level where they are positioned, there are three levels of GIS staff associated with PMIS: local GIS users, local GIS specialists, and a GIS application/data steward.
8. Training for the GIS support personnel is extremely important to the success of GIS. TxDOT's early implementation of GIS is dependent on vendor-supplied training. However, the GIS support group in the Information Systems Division (ISD) should develop training specifications for in-house training.
9. The introduction of new information technologies is accompanied by a change in organizational structures and institutional arrangements.
10. A top-down, then bottom-up GIS management strategy should be adopted for GIS planning and implementation.
11. To integrate GIS with TxDOT PMIS, a database linkage approach should be used so that various kinds of databases can be accommodated.
12. The current data collection procedures should be modified so that the PMIS data can be more effectively integrated with GIS.
13. The potentials of Internet and intranet should be fully examined as a platform to improve the efficiency and effectiveness of GIS-oriented PMIS.

The "three-stage implementation" concept is useful for implementing a GIS. The three stages include current, intermediate, and ideal stage. Assessing resources at the current stage is important because it is the point from which everything starts. The ideal stage is the visionary system for the future. It represents the ideal system and procedure for the agency without being compromised by constraints or limitations. In other words, the ideal system is the technically optimal one, although it may not be politically feasible in every aspect. It is the goal to strive for. However, there are always trade-offs between the ideal systems and the actual resources available in making recommendations for each GIS component. Therefore, it is critical that the implementation plan cover not only the current status analysis and the ideal future directions, but also how to effectively and efficiently conduct the transition from the current stage to the ideal stage. The

intermediate stage is the bridge between the current stage and the ideal stage as illustrated in Figure 1. The bridge has to be smooth at both ends. The research findings and recommendations are all based on this concept of the three-stage implementation.

In order to make the research results and recommendation known to TxDOT district and division engineers and administrators, it is recommended that the following actions be taken as early as possible:

1. A meeting should be held with the program coordinators, the project director (PD), ISD, the Pavements Section of TxDOT's Construction Division, and the CTR researcher to exchange and discuss the research findings and recommendations.
2. A comprehensive GIS for PMIS demonstration package should be put together to include the GIS demonstration developed by ISD, the GIS for pavement applications developed by the Pavements Section, and the demonstration developed by the Center for Transportation Research (CTR) as part of this research.
3. Using the comprehensive demonstration package, workshops should be scheduled in various TxDOT districts and division offices to explain the practical applications of GIS for pavement management and to train the potential users in these offices.



For More Details ...

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The research is documented in the following reports:
Report 1747-1, *Review of Current Geographic Information Systems Technology for TxDOT Pavement Management Information System*. Published August 2000.
Report 1747-2, *Geographical Information Systems (GIS) Needs Assessment for TxDOT Pavement Management Information Systems*. Pending publication.
Report 1747-3, *GIS Implementation Plan for PMIS*. Pending publication.

To obtain copies of a report, contact: CTR Library, Center for Transportation Research, phone: (512) 232-3138, email: ctrlib@uts.cc.utexas.edu.

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The Pavements Section is implementing GIS application in some of the districts at this time. This implementation includes a package of GIS applications to display pavement data (from the PMIS database) using available maps. If your district is interested in GIS applications for pavements, please contact Bryan Stampley or Craig Cox at the Pavements Section, PMIS Branch, in Austin. The need for a GIS training course is being evaluated.

For more information, please contact Dr. German Claros, P.E., Research and Technology Implementation Office (512) 467-3881 or email at gclaros@dot.state.tx.us.

Your Involvement Is Welcome!

Disclaimer

This research was performed in cooperation with the Texas Department of Transportation and the U. S. Department of Transportation, Federal Highway Administration. The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TXDOT. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. Trade names were used solely for information and not for product endorsement. The engineer in charge was Dr. Michael T. McNerney, P.E. (Texas No. 70176).