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16. Abstract
This report summarizes cooperative efforts to gather and make available in a knowledge management system both tacit and currently documented knowledge of rigid pavement forensic methods, tools, and the valuable insights into rigid pavement performance principles and practices gained during forensic studies over several decades. Tacit knowledge was gathered using a structured interview process involving current and retired department personnel, as well as selected academia. A method of storing and efficiently retrieving valued information from i-Way, Texas Department of Transportation's learning content management system, was also developed. A glossary of rigid pavement forensic-related terms was developed and used in a systematic manner to properly and consistently associate key words with the information documents being stored.

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DEVELOPMENT OF A RIGID PAVEMENT FORENSICS KNOWLEDGE MANAGEMENT SYSTEM TO RETAIN TXDOT CORPORATE KNOWLEDGE

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DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). 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 view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation. This report is not intended for construction, bidding, or permitting purposes. The engineer in charge of the project was Paul E. Krugler, P.E. #43317. The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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CHAPTER 1:
INTRODUCTION

ORGANIZATION OF THE REPORT

Included in this introductory chapter is a discussion of the motivations for creating a TxDOT rigid pavement forensics knowledge management system. This introductory chapter also provides a brief description of i-Way, TxDOT's existing learning content management system in which the knowledge management system will reside.

Chapter 2 provides a state-of-the-art overview of knowledge management. It summarizes information located in the literature and on the web. In addition, information learned about knowledge management from two other state departments of transportation is presented.

Chapter 3 describes the components of i-Way which compose the knowledge management system and their roles in supporting TxDOT's rigid pavement forensics community of practice.

Chapter 4 contains a summary of research team and department efforts to identify desired rigid pavement forensics knowledge content to be placed within the knowledge management system. The content items to be placed in the knowledge management system are presented.

Chapter 5 discusses a marketing strategy to overcome obstacles and to take advantage of opportunities for the agency to benefit from the rigid pavement forensics knowledge management system being created.

Chapter 6 summarizes the findings and recommendations from phase one of this project.

The report also includes four appendixes. Appendix A presents the key word glossary used in Rigid Pavement Forensics Knowledge Management System. Appendix B shows an example of Legacy Knowledge Interview questions. Appendix C includes an example of the interview invitation letter. Appendix D shows an example of a Legacy Knowledge Interview Segment. The content of each appendix is explained in the corresponding section of this report.

KNOWLEDGE MANAGEMENT – VALUE AND CHALLENGES

Knowledge can be classified into two broad categories: tacit and explicit. Tacit knowledge resides in the minds of people. The acquisition of tacit knowledge is usually

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developed through a process of trial and error during practical experience. Explicit knowledge is formal knowledge or information. The acquisition of explicit knowledge is usually achieved through a formal educational process.

What distinguishes one organization from another is usually not the explicit knowledge of its employees. The key to its competitiveness resides in tacit knowledge, and one of the core objectives of knowledge management is to expand the understanding and application of tacit knowledge throughout an organization. To turn personal knowledge possessed by individuals into corporate knowledge possessed by the organization, subjective tacit knowledge must be externalized into an explicit form of representation. Once the knowledge is externalized, it is easier to move across communication networks.

Several challenges face an organization in this process. The first challenge is to capture and formulate tacit knowledge into a communicable form. The second challenge is to make the knowledge easily available to the entire organization. The third major challenge is to develop an organizational culture for seeking and using tacit knowledge. The fourth challenge for practitioners is periodic maintenance to preserve this knowledge and maintain security checks through the transferring process.

ORGANIZATIONAL COMMITMENT

The creation of organizational uniqueness based on its knowledge is not a static concept. Indeed, knowledge growth must be a steady, ongoing process. The dynamic perspective of knowledge sustainability implies a great level of commitment across the entire organization, although the amount of information collected and the amount of time spent to sustain the system must be kept practical.

Similarly, the alignment of an organization's knowledge culture and approach with its organizational strategy is essential. This alignment is critical for successful implementation of a knowledge management system. It is also important that the knowledge management system is balanced between human-oriented knowledge management and technology-oriented knowledge management. To achieve this balance, there is a need to develop a strategy to integrate organizational knowledge into knowledge management tools.

Considering these requirements for success in knowledge management, a high level of support and encouragement from upper organizational management is essential. This commitment must be visible and compelling throughout the organization.

VALUE OF PAVEMENT-RELATED KNOWLEDGE MANAGEMENT TO TXDOT

The development of a pavement-related knowledge management system will be particularly beneficial to an organization like TxDOT. This agency has a history of developing nationally recognized experts among its career employees. So there is a wealth of knowledge to capture. Another factor making the forensic pavement area ideal for a knowledge management system is that TxDOT already has a strong pavements community of practice among district pavement engineers and the Construction Division's Materials and Pavements Branch staff. A knowledge management system works best within a well-defined community of practice.

Forensic pavement analysis is a core function of every department of transportation. Excellence in this technical area allows selection of proper and most cost-effective rehabilitation options, with potential monetary benefits to the department of millions of dollars annually. Capturing and disseminating corporate forensic pavement knowledge will help assure exceptional performance in this area in the future.

The Texas Department of Transportation experienced a serious loss of expertise on October 1, 1993, and again on September 1, 2003. In 1993, close to 10 percent of the department retired on October 1. Approximately 5 percent of the department retired on September 1, 2003. A total of almost 2,000 of TxDOT's most experienced employees left between these two occasions. While these two dates were particularly devastating to corporate knowledge, TxDOT loses considerable numbers of career employees each and every year. A method of capturing the corporate knowledge that currently exists only in the minds of well-experienced employees will greatly benefit TxDOT.

A knowledge management plan has been developed for TxDOT considering several goals that are common to most agencies creating a formal knowledge management system. These goals include strengthening communities of practice within the agency, providing users easy and quick access to the best information available, and providing ongoing capture of valuable knowledge.

PLATFORM FOR THE TXDOT KNOWLEDGE MANAGEMENT SYSTEM

TxDOT has selected Knowledge Centre™, a product of Meridian Knowledge Solutions, Inc. as the base software for its learning content management system. TxDOT has named its system i-Way. The home page of i-Way, as developed by TxDOT, is shown in Figure 1. The selected software product is designed to store and manage an agency's training program as well as its information and corporate knowledge to support both training and agency operations. For this reason, the knowledge management system being developed in this project will reside within i-Way.

TxDOT has elected to place i-Way on its intranet system. In that manner, access to i-Way and the information it contains become readily available to all TxDOT employees. Conversely, external TxDOT customers do not currently have access.

The Training Section of the TxDOT Human Resources Division is responsible for administering i-Way. The section is well underway in developing a multipurpose vehicle for communicating, storing, and sharing learning and knowledge information. The Training Section has developed an excellent i-Way User's Manual to assist individuals in navigating i-Way *(1)*.

Figure 1. TxDOT i-Way Home Page.

i-Way consists of six major functional areas. Five of these areas will be heavily involved in the knowledge management system being developed. All i-Way areas may be accessed from the i-Way home page (Figure 1) by clicking on the sign representing the desired type of information or knowledge. The six areas of i-Way are:

- Library,
- Conference Center,
- Communication Center,
- Teaming Center,
- Learning Center, and
- Course & Student Management,

Users can perform searches system-wide or restrict searches to a specific area of the system.

CHAPTER 2:
STATE-OF-THE-ART OF KNOWLEDGE MANAGEMENT

The initial task of this project was to assess knowledge management state-of-the-art. This assessment included a review of books, technical papers, articles, web sites, and software products. In addition, the research team interviewed knowledge management program planners from the Pennsylvania Department of Transportation (PennDOT) and the Virginia Department of Transportation (VDOT).

The purpose of this review was to assure that the Texas Department of Transportation and the research team benefit from earlier knowledge management concept developments as well as from the experiences of others.

KNOWLEDGE MANAGEMENT LITERATURE REVIEW

Several methods and techniques related to knowledge management are discussed in books, technical papers, and articles. In this review, the research team has looked closely at the development of knowledge management systems as well as conceptual approaches and experiences that have occurred in this field of expertise. The following sections present the most relevant information in order to build a solid base for the next tasks of this research.

Historical Background

The growing importance of managing organizational or corporate knowledge was emphasized in Massachusetts Institute of Technology (MIT) and Carnegie Mellon research in the 1970s. However, these efforts were oriented toward the development of automated machine processes and artificial intelligence rather than toward integrating human resources as a unifying corporate goal. In the 1990s, the idea of better utilizing human resource knowledge began to be considered as a new organizational approach. Only now, in the 2000s, has the ability to deploy and exploit knowledge been recognized as being crucial to corporate survival.

What is defined as knowledge management today has emerged from diverse disciplines over at least three decades. Some of the disciplines having the most profound effect on the development of knowledge management concepts are organizational science and human resource management, computer science and management information systems, management science,

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psychology, and sociology. This diverse legacy has resulted in various approaches to knowledge management, but there is no unique, universally accepted method of implementing knowledge management. The historical development of knowledge management from isolated data applications before the 1970s through the late-1990s is shown in Figure 2 *(2)*.

Before the 1970s, at the beginning of information technology (IT) development, no special attention was given to data management. The first step in the historical development of knowledge management started with technical integration of isolated data with the implementation of database management systems (DBMS) in the mid-1970s. The second stage, in the mid-1980s, involved conceptual data integration, data modeling, and data handling. The need for enterprise-wide horizontal integration led to very large database systems (DBS) in the late 1980s. This step is considered the third stage in the historical development of knowledge management. In the 1990s, information was considered as a production factor and object oriented database management systems (OODBMS) were implemented for data warehousing, data mining, and document management. This advance is considered the fourth stage in the evolution. Finally, knowledge management emerged as a business approach in the late-1990s with new technological tools including information and communication technology (ICT), knowledge management systems (KMS), customer relation management (CRM), web portals supported by "intelligent technologies," and a new model to structure data called extensible markup language (XML).

Step 0	Step 1	Step 2	Step 3	Step 4	Step 5
isolation	*technical data integration*	*conceptual data integration*	*enterprise-wide horizontal data integration*	*information life cycle/ vertical data integration*	*knowledge organization*
Step 0	**Step 1**	**Step 2**	**Step 3**	**Step 4**	**Step 5**
isolated applications	use of DBMS	data modeling/ data standardization	separate responsibility for data	information resource	knowledge/ organizational memory
no special attention to data	**database administration**	**data administration**	**data management**	**information management**	**knowledge management**
● *beginning of IT*	● *mid-1970s*	● *mid-1980s*	● *late-1980s*	●*1990s*	● *Late-1990s/2000s*
	relational DBMS	repositories enterprise data modeling	*data warehousing* *data mining* *document management*	new ICT:KMS, CRM, portals application development "intelligent" technologies	
		very large DBS	*reference models* *enterprise resource planning* *OODBMS* *multidimensional DBMS* *active DBMS*	content management metadata management semi-structured data	
				XML semi-structured data/ knowledge modeling	
				DBMS and the web content management systems	

Figure 2. Historical Development of Knowledge Management *(after 2).*

The complexity of knowledge management is compounded because optimal mechanisms for acquiring knowledge are related to the type of knowledge. Tacit and explicit knowledge are the two primary categories of knowledge, as identified or supported by Polanyi in 1967 *(3)*, Nonaka in 1991 *(4)*, Koulopoulos and Frappaolo in 1999 *(5)*, Tiwana in 2000 *(6)*, and Gamble and Blackwell in 2001 *(7)*.

The Nature of Knowledge

The nature of knowledge itself must be considered as a knowledge management system is developed. Knowledge can be classified into two broad categories: tacit and explicit *(4)*. Tacit and explicit knowledge are different in nature, and only by understanding their nature, components, and differences is it possible to select or develop the right tools to capture and transfer knowledge efficiently.

Tacit Knowledge

Tacit knowledge resides in the minds of people. The acquisition of tacit knowledge is usually developed through a process of trial and error during practical experience. This is the reason tacit knowledge is so difficult to articulate, formalize, and encode. If knowledge gained from practice remains only in the minds of people who had the experiences, then this knowledge is lost when the experienced employees retire or change employment. To turn personal knowledge into corporate knowledge, subjective tacit knowledge must be externalized to an explicit form of representation. Once the knowledge is externalized, it is easier to move across communication networks.

Knowledge that comes from experiences accumulated by a field engineer over the years is an example of tacit knowledge. The lessons learned by this engineer are not written in any book or manual and will usually be transferred to other engineers by mentoring.

Explicit Knowledge

Explicit knowledge is formal knowledge or information. The acquisition of explicit knowledge is usually achieved by formal study through some type of educational process. Since explicit knowledge can be articulated in formal language, it is much easier to convey and capture than tacit knowledge. An example of explicit knowledge is knowledge that is found in manuals, books, articles, and any other written documents.

Knowledge Transfer

To transfer knowledge through codification, tacit knowledge has to be made explicit. However, as shown in Figure 3, tacit knowledge cannot be fully transformed into explicit form. Further, explicit knowledge can only rarely be fully personalized or internalized by an individual. Thorough transfer and personalization of knowledge is the goal of knowledge management, and personalization allows a more thorough transfer of both types of knowledge *(8)*.
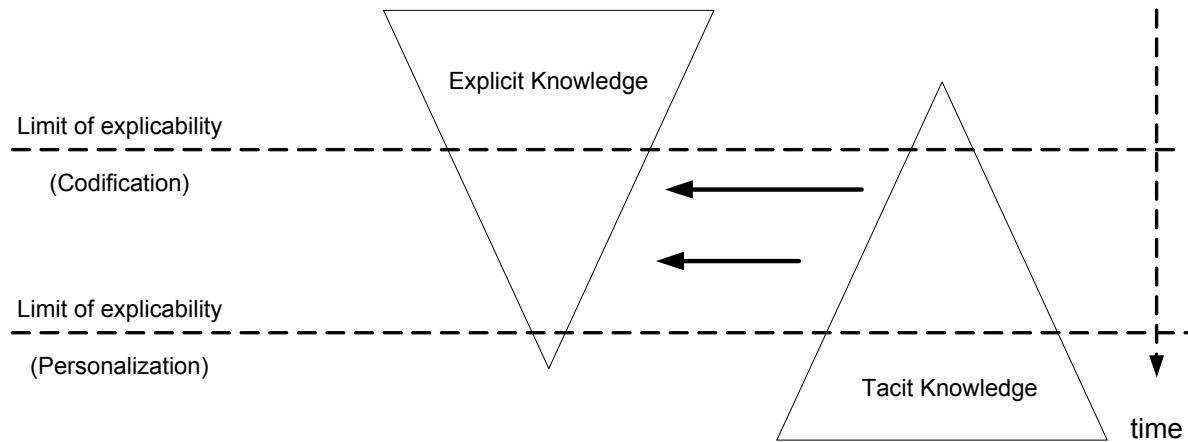
Figure 3. Limits of Knowledge Explicability *(after 8).*

The limits of knowledge explicability or externalization are difficult to establish in a practical sense. There are usually trade-offs between explicit and tacit knowledge that make establishing limits difficult. Codification of explicit knowledge usually involves less cost than personalization of tacit knowledge. On the other hand, an effort to convert tacit knowledge into explicit knowledge through codification, without losing personalization, is a real challenge. The goal is to move the limit of explicability from explicit knowledge toward tacit knowledge, finding a point of equilibrium between codification and personalization. Accomplishing this reduces the gap between explicit and tacit knowledge.

The Role of Information Technology

Information technology tools and database management systems have been used by organizations in the last decades to manage explicit knowledge. Due to its nature, explicit knowledge can be handled in a tangible way. Documents, databases, and web sites are some of the means used to communicate explicit knowledge.

A balance between human-oriented knowledge management and technology-oriented knowledge management is critical for successful implementation of a knowledge management system. The relationship between these forms of knowledge management is shown in Figure 4. This figure shows the two extremes of knowledge management philosophy and how they need to be balanced for successful deployment. To achieve this balance there is a need to develop a strategy to integrate organizational knowledge into knowledge management tools.

strategy

organizational
knowledge

Knowledge
Management
Tools

knowledge
life cycle

human-oriented
knowledge management

←————————————————————————→

technology-oriented
knowledge management

business and
knowledge
processes

individual
knowledge

platforms

integrating
instruments
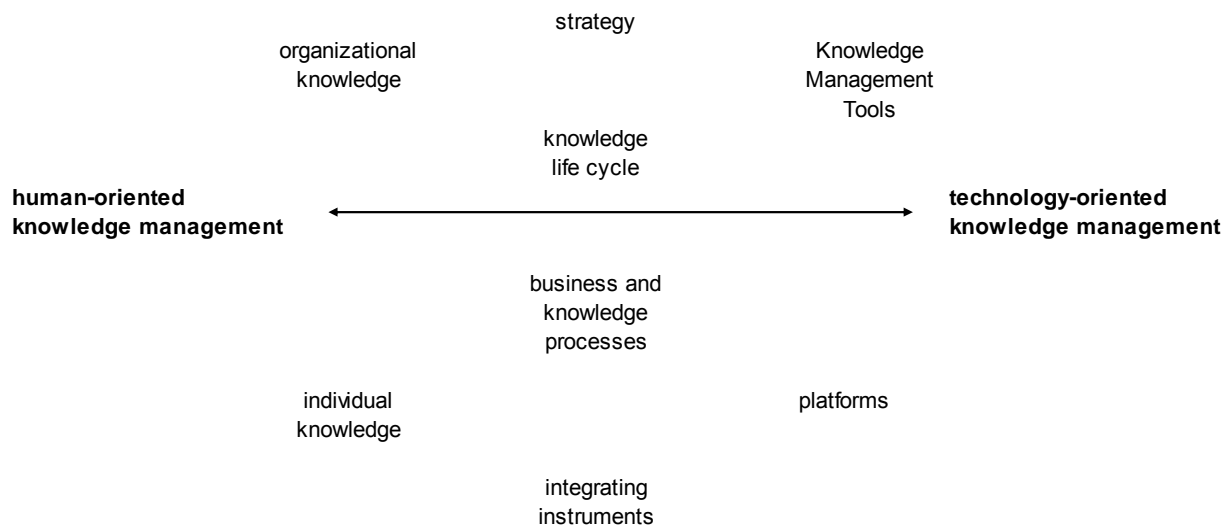
Figure 4. Human-Oriented versus Technology-Oriented Knowledge Management and Approaches to Integration *(after 2).*

From the human perspective, individual knowledge must be integrated into organizational knowledge. From the technology perspective, a platform for deployment must be chosen. Usually, a web-site platform is preferred to support the implementation of a knowledge management approach. Instruments to integrate technology and human assets, such as peer networks and bulletin boards, are also needed.

The challenge faced concerning explicit knowledge is not its capture and formulation. The challenge is to handle the *volume* of knowledge and to ensure the *relevance* of that knowledge to the organization. But, even though explicit knowledge is abundant and can become overwhelming, it can be managed with modern information technology and with the assistance of knowledge management tools.

Knowledge has a life cycle, which means that knowledge contents have a finite life. New techniques may replace old existing methodologies. Lessons learned may change current standards. Therefore, the creation of uniqueness from knowledge is not a static concept; indeed knowledge growth is an ongoing process. This dynamic perspective of knowledge sustainability requires a commitment across the entire organization if the value of the system is to be maintained. Top management support and a practical strategy are essential for success.

Recent Knowledge Management Integrations into Business

At the current time, several approaches are available to integrate a knowledge management system into a business process. These approaches are briefly described below.

PROMOTE Methodology

Hinkelman et al. proposed in 2002 a method and a software tool to model business and knowledge processes *(9)*. This approach distinguishes five phases for the introduction of knowledge management: becoming aware of enterprise knowledge, discovering knowledge processes, modeling knowledge processes and organizational modeling, making knowledge processes and organizational modeling operational, and evaluating enterprise knowledge. The objective of this approach is to identify the kind of knowledge and knowledge flow between the business processes. As a result, knowledge-intensive tasks within the business processes are clearly identified.

Business Process-Oriented Knowledge Management Method

This approach was proposed by the Fraunhofer Institute for Production Systems and Design Technology in 2002. Their aim was to integrate the activities of the people involved in the processes with supporting information tools *(2)*. The method consists of a knowledge management implementation model, a knowledge management audit, a knowledge management analysis of the business process, and knowledge management best practices organized in building blocks.

Ten-Step Knowledge Management Roadmap

In 2000, Amrit Tiwana presented a methodology to develop a knowledge management strategy and a companion knowledge management system to support this approach. The ten steps are organized in four phases *(6)*. The first phase corresponds to an infrastructural evaluation. The second phase of knowledge management implementation involves analysis, design, and development of the system. The third phase involves the deployment. Finally, the fourth phase is the implementation of methods to measure the business value of knowledge management.

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The first phase, infrastructural evaluation, is composed of two steps. First, an analysis of existing infrastructure is conducted. The purpose of this first step is to identify critical gaps to correct them and to be able to build on what already exists. Second, knowledge management is aligned to the business strategy by connecting the knowledge management system platform to strategic plans.

The second phase, knowledge management implementation, is composed of five steps. First, the knowledge management architecture design and component design is selected. Second, a knowledge audit analysis is conducted to identify strengths and weaknesses. Third, the knowledge management team that will design, build, implement, and deploy the system is formed. Fourth, the knowledge management team develops the blueprint that provides a plan for building and improving the knowledge management system. Fifth, the working management system is developed.

The third phase, deployment, is composed of two steps. The first step is testing and deployment using a results-driven incremental technique. The second step involves leadership and the implementation of a reward structure to encourage employees to use the system.

The fourth phase, metrics for evaluation, is a one-step phase that involves the selection of a set of metrics to monitor the knowledge management process. Figure 5 shows the ten-step roadmap and phases proposed by Tiwana.

Turning Knowledge into Action: Stages in the Development of Knowledge Management Cultures

The development of a knowledge management culture begins with a search for bodies of valuable tacit knowledge within the organization. Once these bodies have been identified, a mechanism to transfer this tacit knowledge into corporate knowledge can be determined. But, since tacit knowledge cannot be easily codified for transfer, much tacit knowledge is kept alive

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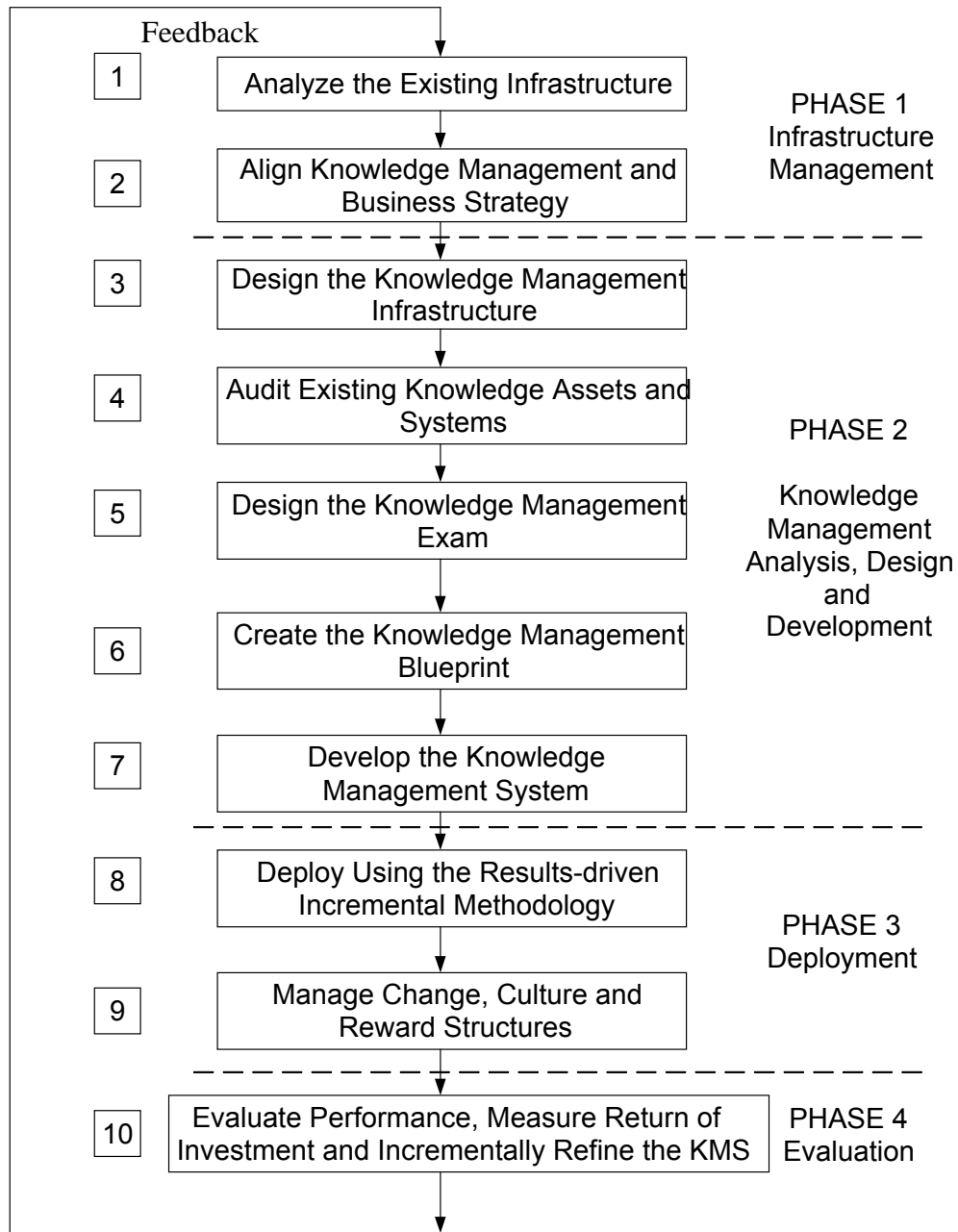
Figure 5. Knowledge Management Roadmap *(6)*.

through the existence of communities of practice in which practitioners who need knowledge can reach other practitioners who possess the knowledge. Hence, knowledge management strategies should not be focused only on technologies to collect, store, and disseminate information, but also on mechanisms to sustain communities of practice wherein uncaptured tacit knowledge may be shared *(10)*.

There are four stages in the evolution of a knowledge management culture within the organization. Quinn, Anderson, and Finkelstein suggested in 1996 that the four stages in the evolution of knowledge management are: know what, know how, know why, and care why, as shown in Figure 6 *(11)*.

Know What

At this first stage, formal knowledge management procedures are available to help capture, catalog, and make accessible the knowledge required to achieve certain corporate goals. However, the procedures are isolated, and they do not work within the framework of an integrated knowledge management approach.

Know How

At the second stage, the employees have acquired the ability to retrieve and use the knowledge at the right time and at the right place. The procedures now are connected and function within the framework of an integrated knowledge management system.

Know Why

At this stage, beyond the skills developed at the "Know How" stage to solve problems, a deeper sense of knowledge and understanding of the complex relationships between cause and effect in routine processes is achieved. By mastering the principles that explain the inner nature of the processes, this level of knowledge management enables employees to deal with unknown interactions and unseen situations. At this point of advancement, the culture, beliefs, and attitudes of the employees have changed to create leverage within the corporation through the use of knowledge.

Care Why

At the final stage, self-motivated creativity is enhanced and channeled into results. Employees at this level of knowledge are highly motivated to share knowledge to face challenges. Communities of practice are well established and sustain themselves without the need of a formal structure. Natural chains of knowledge are formed. At this stage, individual knowledge is embedded within the framework of an integrated corporate knowledge culture.
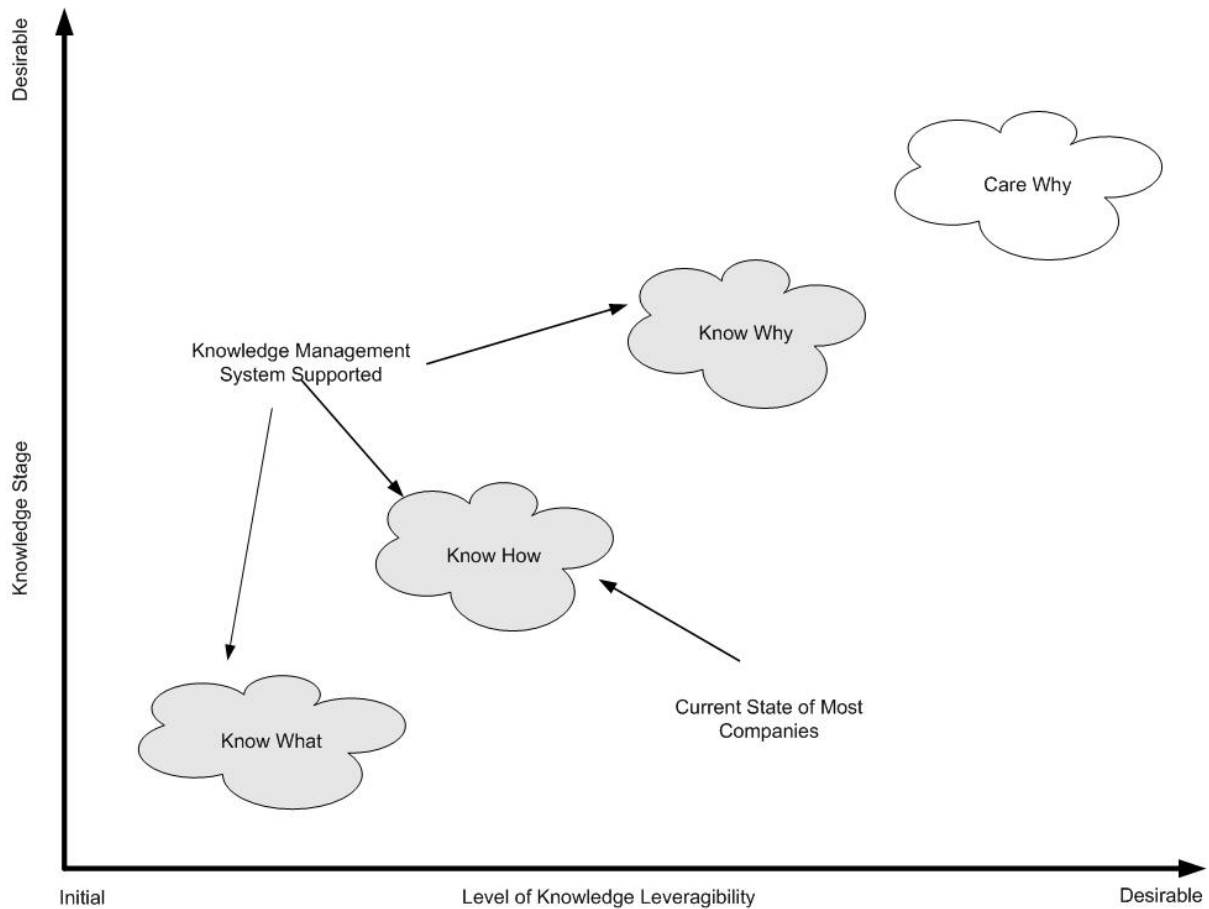
Figure 6. Stages in the Evolution of Knowledge *(after 11).*

The research team envisions that a TxDOT knowledge management system will foster growth in technology, personal expertise, and corporate knowledge, enabling the agency to reach the "Care Why" level of knowledge. At this stage, self-motivated creativity is enhanced in the organization, thereby considerably improving performance and results.

The importance of the alignment of an organization's knowledge culture and approach with its organizational strategy is emphasized by the literature, as shown in Figure 7. This alignment is critical for successful implementation of a knowledge management system *(12)*. This figure also illustrates the need for a link between strategy and knowledge. On the strategic side, there may be a gap between "what the organization must do" and "what the organization can do." To assess what your company can do, there is a need for a knowledge-strategy link based on "what your organization knows." However, there may be a gap between "what your organization knows" and "what your organization must know" to fulfill the organization's goals.

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Therefore, there must also be a strategy-knowledge link between "what your company must do" and "what your company must know." This is the strategy-knowledge cycle shown in Figure 7.

```
┌────────────────────────┐                              ┌────────────────────────┐
│   What  your organization │  ◄──────────────────────── │   What your organization  │
│       must know           │       Strategy-            │        must do            │
└────────────────────────┘      knowledge link          └────────────────────────┘
           ▲                                                         ▲
           │                                                         │
           │  Knowledge gap                           Strategic gap  │
           │                                                         │
           ▼                          Knowledge-                     ▼
┌────────────────────────┐           strategy link        ┌────────────────────────┐
│   What your organization  │  ──────────────────────────►  │   What your organization  │
│         knows             │                               │         can do            │
└────────────────────────┘                              └────────────────────────┘
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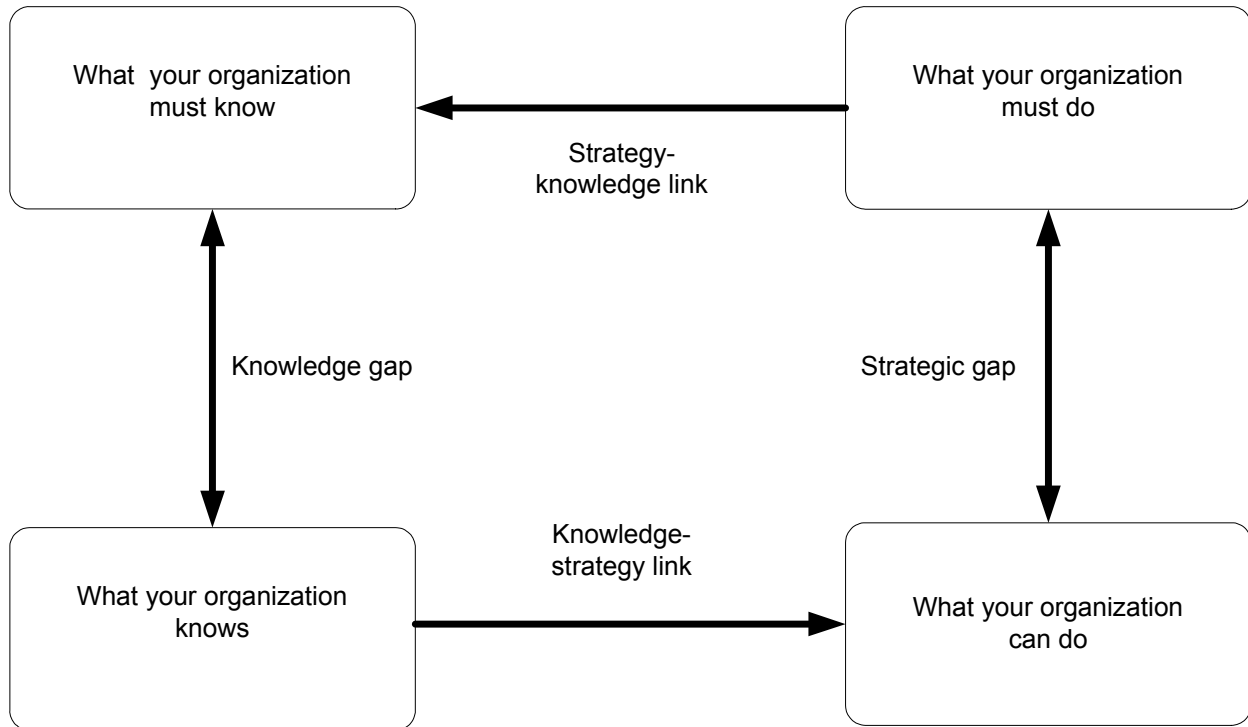
Figure 7. High-Level Framework-Based Strategic Knowledge Gap Analysis *(after 12).*

The involvement of knowledge management and its integration into the business process is illustrated in Figure 8. A balance among technology, personnel expertise, and culture organization during the development and implementation of the knowledge management system is very important. This balance is important because, otherwise, deployment of the system is subject to failure or slow down, retarding the organization's knowledge growth. To achieve this proper balance, a strategic-knowledge approach to fit the organization's needs must be developed.

TxDOT Research Projects Developing Forensic Investigation Methods

In an effort to develop formal procedures for conducting forensic investigations, TxDOT supported research projects in previous years, including Project 0-1731, "Development of a Formal Forensic Investigation Procedure for Pavements" *(13)*. Another published report, SWUTC/02/167203-1, was prepared by the Southwest Region University Transportation Center and related to the implementation of a database and information system for forensic investigation of pavements in TxDOT *(14)*. Among the objectives of these projects was to provide methods for assisting in determining the cause of the failures, for selecting appropriate repair strategies, for prioritizing distressed pavement sections, for improving design practices, and for updating construction techniques.
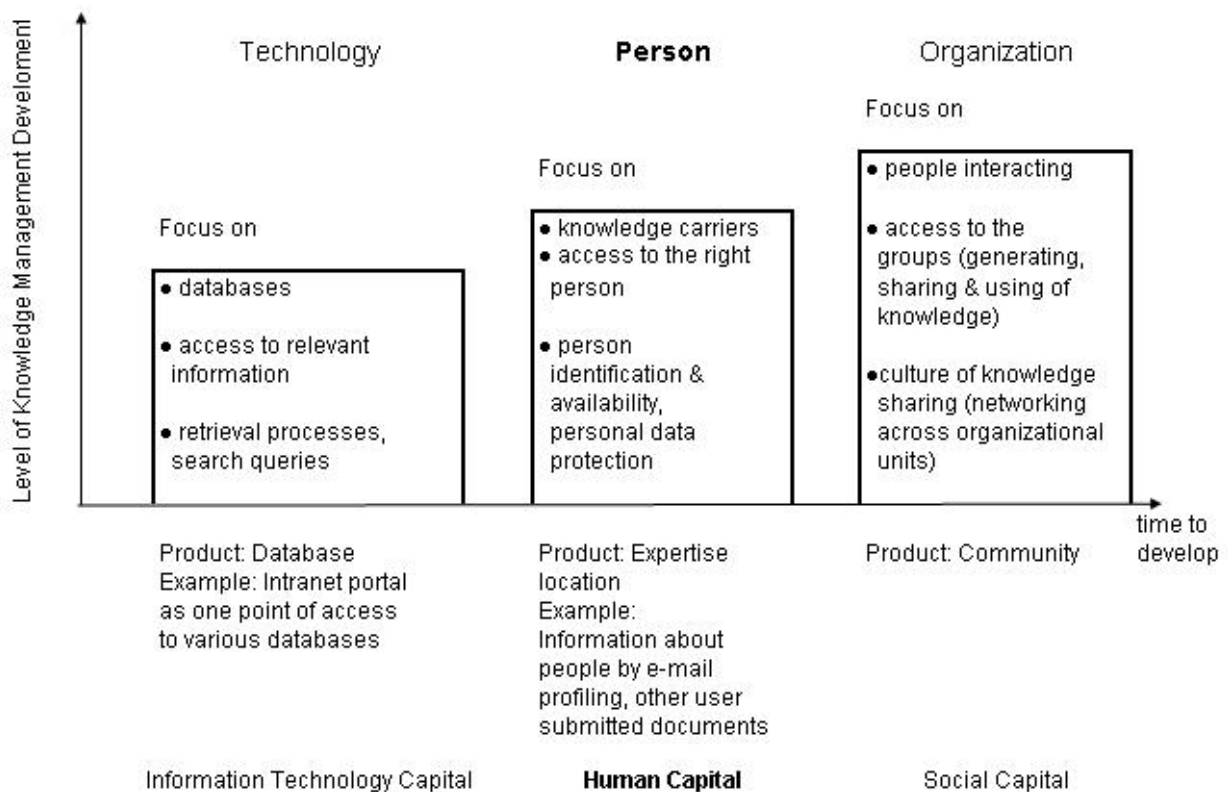
Figure 8. The Involvement of Knowledge Management in Business Processes *(after 8)*.

These research projects emphasize the need for an integrated forensic information and analysis system. The integration of forensic information would eliminate the storage of forensic

documents in different locations, thereby providing a valuable resource center to support forensic activities. Making analysis capabilities centrally available would minimize the time required for forensics engineers to determine causes of distress and possible solutions. The core component of the system was envisioned to be the ForenSys database software that was proposed and developed under earlier research projects. ForenSys was conceived as a means to obtain background information and to enter conclusions from forensic reports. In addition, ForenSys was to be able to perform system analyses and enhance report-writing functionalities. As a result, ForenSys was expected to generate multiple document interfaces, such as views, tables, charts, and layouts. However, ForenSys has not been deployed to date and implementation in the future is uncertain.

Project 0-1731 concluded that "the primary purpose of forensic investigations is to determine the mechanism, or mechanisms, of the observed pavement distresses." *(13)* The identification of the causes of pavement distresses through forensic investigations will allow selecting a repair strategy with a greater likelihood of success. An improvement on future design and construction practices is also expected by taking into consideration the results of pavement investigations. A formal procedure is recommended to conduct forensic investigations. This procedure consists of six steps: gather background information, conduct field observations and form probable causes, perform testing of hypothesis, analyze collected data and information, formulate conclusions and failure history, and prepare forensic reports. Case studies are presented in a project report to illustrate the application of a formal procedure for conducting forensic investigations.

Report SWUTC/02/167203-1 describes the methodology for implementing a database and information system for forensic investigations using the ForenSys database as a center component *(14)*. The concept of the system design for the database, guidelines for using the ForenSys database system software, and the methodology to import data into the ForenSys database are presented in the research report.

The recommendations of earlier research projects also mention the need for creating a knowledge-based expert system (KBES). This expert system would be linked to the ForenSys database, and its functions would include reducing the amount of data to be analyzed, evaluating the data, and determining if the data are relevant to any of the distress mechanisms. The end result of the knowledge-based engine activity would be a conclusion on the causes of distress or

failure based on the available facts. The research team is aware that even though data management is an issue of concern in the development of the overall approach of the knowledge management system, the scope of this project is broader and goes beyond a data management system. Indeed, crude data are of little value. However, when the data are relevant to the decision to be made or problem being addressed, they become information of value. This information becomes a fact when there are enough data to firmly support it. When facts are interpreted and used in the solution of a problem, these facts become applied knowledge. The level of value increases as data evolve to knowledge as shown in Figure 9 *(15)*.

Level of exactness of
statistical model

Knowledge

Facts

Information

Data

Level of improvements on
decision making
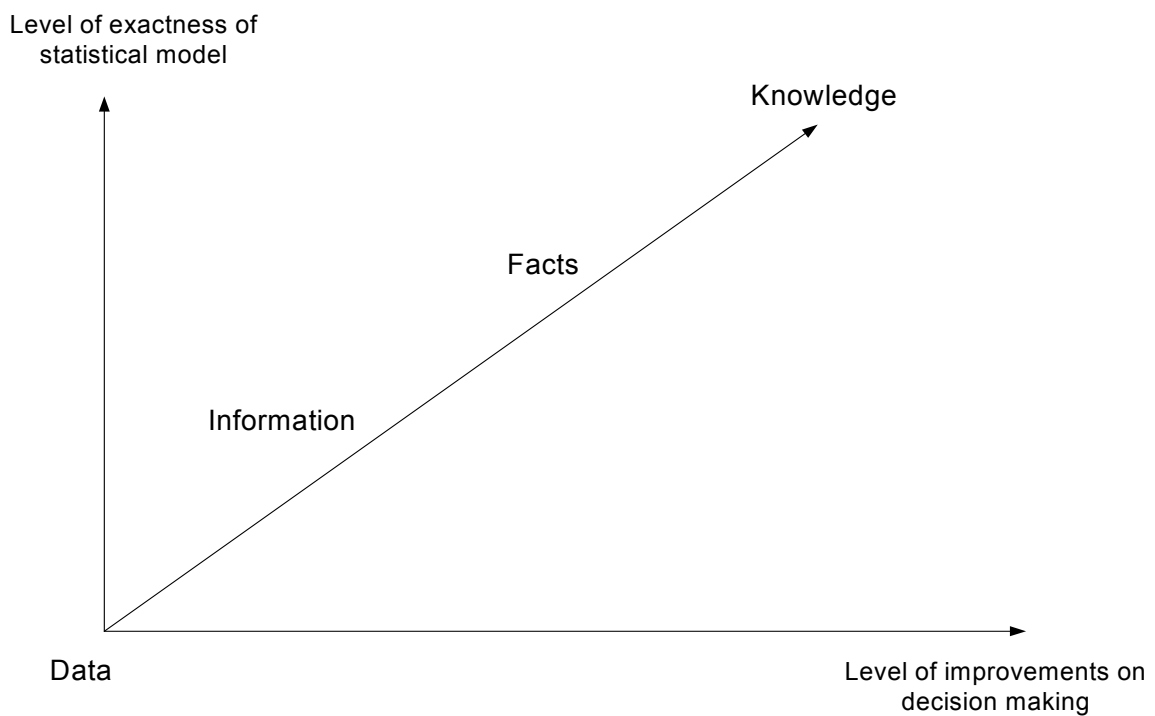
Figure 9. Knowledge Evolution Process from Data *(15)*.

The research team is also aware of another recent research project on pavement forensics. The final report of Project 0-1867, "Develop Comprehensive Failure Diagnostic Manual for Flexible and Rigid Projects," is currently under review by TxDOT and has not been released for publication. As soon as the research project report becomes available to the research team, its contents will be reviewed. Findings valuable to this project will be incorporated where they fit the work plan scope.

TxDOT has made other efforts to capture and share knowledge about forensic investigation techniques. A project under the supervision of Tom Scullion of the Texas Transportation Institute (TTI) is developing flexible pavement rehabilitation training courses. In these courses, techniques for non-destructive testing such as ground-penetrating radar, falling weight deflectometer, and back-calculation analysis are explained using media sources. The aim of the courses is to increase understanding of the processes of selecting rehabilitation strategies for flexible pavements. Without doubt, efforts to provide technical training to TxDOT employees are part of the overall knowledge management approach.

Many of the products from earlier TxDOT research projects and training development projects are still in the review process and are therefore unavailable at this time for study by the research team on this project. As these products from earlier projects become available, their roles in conjunction with the products of this project will be evaluated.

Federal Highway Administration Research Project: Repair and Rehabilitation of Concrete Pavements

The Federal Highway Administration sponsored Project FHWA-010-C00080 *(16)* in an effort to cover all the complex issues related to repair and rehabilitation of concrete pavements. The project was conducted by the Texas Transportation Institute, and the research reports were published in 2003.

The primary objective of this research was to develop guidelines for pavement evaluation and treatment selection, including materials and techniques for optimizing the service life of the pavement. These guidelines can be used during forensic investigations to assist in evaluating pavements and identifying possible maintenance and rehabilitation strategies prior to selection of the most appropriate treatment, considering costs and expected performances.

Utility theory accounted for the variety of factors that play a role in the decision-making process of selecting a rehabilitation strategy. It is a tool designed to provide a more reliable estimate and analysis. Information on different areas of expertise is needed to feed the model. With this purpose, a comprehensive review of the types and causes of concrete pavement distresses, non-destructive and destructive methods of evaluating existing pavements, recommended laboratory tests to identify causes of failure, and an extensive description of maintenance and repair strategies currently available are included in this report *(16)*.

A risk analysis approach was proposed in the research to deal with the inherent uncertainty involved in life-cycle cost analysis. The aim of this approach was to decrease the exposure to risk by making uncertainty explicit. In addition, sensitivity analysis was used to identify what factors had a major impact on the results.

A systematic methodology illustrated through flow diagrams was presented in the research to describe the entire process of selecting the most appropriate treatment for a concrete pavement. This methodology was the heart of a software product called SAPER (Strategic Analysis of Pavement Evaluation and Repair) that was developed to assist decision makers to implement the conceptual approach in practice.

Implementation of Knowledge Management in the Oil Industry

Experiences in implementing knowledge management systems in the oil industry have shown the benefits of a knowledge management approach aligned with business practices. Knowledge management systems already in practice by Shell International Exploration and Production (SIEP), Texaco, and BP Amoco are some of the examples.

SIEP has established global-knowledge communities supported by a web-based platform that enables employees to broadcast their problems. These communities start with a "seed group" of about 25 people who are willing to exchange ideas. The seed community generates an initial flow of traffic transferring knowledge. Then, the existing members of the seed group invite other people that are interested to join the group, and the community grows as a global network. Some communities have 3000 to 4000 members. The advantage of larger communities is that a great amount of information is possessed by this community. The network is also geared to acknowledge team expertise through the concept of centers of excellence. SIEP has quantified their savings due to knowledge sharing at $200 million over a period of four years *(17)*.

Texaco's knowledge management approach gives more emphasis to the importance of human connections. Texaco management believes that any technology solution will fail if it does not recognize the importance of human connections. Texaco encourages face-to-face meetings at least once a year because in its knowledge management approach, technology is the core factor and it provides the means to connect people. Texaco considers that organizations are

living organisms, not engineering artifacts. Texaco's system is based on creating applications that capture expertise as it is created *(18)*.

BP Amoco has a different knowledge management approach. Its approach is focused on the implementation of visualization technologies and common work processes integrated by a network system. Computer-backed visualization environments are fostering teamwork, innovation, and creativity, while common work processes are forming the basis for shared culture and experience. Together, it is a platform for allowing individuals to improve performance *(19)*.

KNOWLEDGE MANAGEMENT WEB SITE REVIEW

Descriptions of knowledge management sites explored during this review are included below. The web sites were evaluated and rated based on content and functionality. The content review involved articles, newsletters, and other resources available at the web site. The functionality review focused on ease of web site navigation and ease of retrieving information. Efforts to promote forums and user discussions were considered strengths in this review. The degree to which the web site served as a portal to other web sites was also considered.

For the purpose of rating, a scale of one to five was used to express perceived quality. Five points is the highest rating, and it is given to a web site that meets the following 10 requirements: rich in content, easy to navigate, includes open forums for discussions, portals to get access to other websites, information about software products, a case-based library, newsletters, expert network, training services, and content that is periodically updated. For each requirement that was not fulfilled, 0.5 points were deducted from the maximum score of five.

It should be noted that this scale was used as a reference to rate the web sites, but that there is great subjectivity inherent in this rating process, and web sites are frequently updated and improved. Therefore, the ratings provided in this section should be considered only a single point-in-time evaluation. Other users may find the web site of considerably different value.

Even though the value of a web site can be determined only through the user's own experience level and need for information, some of the web site characteristics considered and rated by the research team are applicable to any user. Some of these are:

- the need for data organized in section categories to facilitate knowledge storage and easy access to the content;

- the availability of a search engine capable of delivering knowledge quickly; and
- the importance of providing a common platform that serves as an instrument to keep the members of the community of practice connected by the implementation of a peer-network, open forums, and discussions.

Most of the content in the web sites are articles, books, and recommendations in some area of knowledge management. This is considered explicit knowledge. Some of the web sites present case-based experiences applied to business practice, thereby becoming a means of explicitly capturing and sharing tacit knowledge. There can be risk involved with sharing tacit knowledge, as tacit knowledge is the core component that brings a competitive edge to an organization. Therefore, this type of information sharing is more suitable for an intranet platform than an internet platform.

Table 1 shows a summary of the ratings given to 11 web sites, which are briefly described in this section.

Table 1. Summary of Web Site Ratings.

	Name	Rich in Content	Easy to Navigate	Forums	Portals	Software Products	Case-Based Library	Newsletters	Expert Network	Training Services/Events	Updated Content	RATING
1	CIO Knowledge Management Research Center	Y	Y	N	Y	N	Y	Y	N	Y	Y	3.5
2	EKnowledgeCenter	N	Y	N	Y	N	N	Y	N	Y	Y	2.5
3	KM Network	Y	Y	Y	N	Y	N	N	N	Y	Y	3
4	KMPro	Y	Y	Y	N	N	N	N	Y	Y	Y	3
5	KMWorld	Y	Y	N	Y	Y	N	Y	N	Y	Y	3.5
6	Knowledge Board / The European Community	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	4.5
7	Knowledge Management Destination	Y	Y	N	N	N	Y	Y	N	Y	Y	3
8	KM.Gov	Y	Y	Y	Y	Y	N	N	Y	Y	Y	4
9	The Gurteen Knowledge Website	Y	Y	Y	Y	Y	Y	Y	N	N	Y	4
10	The Knowledge Management Resource Center	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	4.5
11	Knowledge Management News	Y	Y	N	Y	Y	N	Y	N	Y	Y	3.5

A brief description of the web sites that showed interesting functions follows.

1. Chief Information Officer (CIO) Knowledge Management Research Center

    URL address: http://www.cio.com/research/knowledge/

    Description: This knowledge management web site contains articles, newsletters, and portals. Topics available on the Knowledge Management Research Center website are related to strategy, process, measurement, technology, portals and collaboration, case studies, books, events, and newsletters. Newsletters are free, but there is a need for a subscription. There are case studies from business practice that provide good examples of how to apply knowledge management in the real world. Access to a database of experts for consulting services is also provided. One of the main strengths of this web site is the question and answer records in several categories such as best practices, career, chief information officer (CIO) role, collaboration, customer relation management (CRM), cyber behavior, e-business, education/training, enterprise resource planning (ERP), global business, human resources, infrastructure, Internet, intranet, knowledge management, leadership, legislation, outsourcing, partnerships, security, staffing, value, and wireless/mobile.

    Rating: 3.5

2. EKnowledgeCenter

    URL address: http://www.eknowledgecenter.com/

    Description: This knowledge management web site offers a knowledge management certification program. The program is designed to provide education and support to knowledge-based practitioners. Course descriptions are available.   There is also a newsletter and announcements section available.

    Rating: 2.5

3. Knowledge Management Network (KM Network)

    URL address: http://brint.com/km/

    Description: This web site of the Brint Institute has tools for knowledge management and promotes a business-oriented approach. Discussion forums, executive job positions, and technology for knowledge management are some of the main sections. Channels of cooperation offered by this web site include

general business, business technology, e-business, and knowledge management. While a subscription is necessary to obtain access to the contents and full functionalities of this web site, the subscription is free.

Rating: 3

4.   KMPro

URL address: http://kmpro.org/

Description: This web site is maintained by the Knowledge and Innovation Management Professional Society. This knowledge management site includes sections dedicated to collaborative tools, a career center, chapters, and a knowledge management events calendar. A knowledge management certification program is also offered. To get access to the contents of this web site, there is a need for a subscription. Subscription to this web site is not free. A user name and a password will be provided to members. Limited access to the web site as a guest is possible.

Rating: 3

5.   KMWorld

URL address: http://kmworld.com/

Description: This knowledge management web site is also operated by the Knowledge and Innovation Management Professional Society. It contains sections dedicated to news, publications, online resources, solutions, conferences, and event information. The major strength of this web site is the articles database offered from experts who are using knowledge management practices in business. A search engine is also provided to facilitate knowledge mining within the web site database. There is no need for a subscription to get access to this web site.

Rating: 3.5

6.   Knowledge Board/The European Community

URL address: http://www.knowledgeboard.com/

Description: This knowledge management web site promotes events and provides access to a group of experts. The web site includes sections dedicated to news, library, and environments for the interaction of communities of practice. The main purpose of this web site is to sustain an online community of practice to foster a European exchange of knowledge management expertise. The main strength of this web site is the knowledge bank section,

which provides access to a knowledge network and a library. The library contains academic papers, case studies, and interviews. Articles can also be submitted for publication. A directory of peer experts in the different areas of knowledge management is also provided in this web site. Access to this web site is free.

Rating: 4.5

7.   Knowledge Management Destination

URL address: http://www.destinationkm.com/

Description: This knowledge management web site has magazines, an events calendar, and a research center. An e-mail subscription to access the newsletters is needed. The main strength of this web site is the research center facility where research reports are posted and organized by topics. Topics are classified by analytic applications software, business communications, business intelligence, content delivery, content management, content management software, corporate portals, data collection, data marts, data mining software, data storage, data warehouse software, decision support systems, document management software, profiling, portal application software, records management, and taxonomies. A search engine helps the user to find a specific report. The online monthly magazine also provides a rich source of articles on knowledge management conceptual approaches and practice. Access to this web site is free.

Rating: 3

8.   KM.Gov

URL address: http://www.km.gov/

Description: This knowledge management web site contains a variety of documents and a calendar of events. Several resources regarding knowledge management organizations and gateways, glossaries, publications and articles, online learning, web search tools, and vendors are provided at this web site. Special interest groups supported by this web site include private communities of practice, content management, and government communities of practice. Information on knowledge management education, learning and development, knowledge management technology, case stories, taxonomies, and semantics is available. Documents produced by and for the working group are classified by categories. The categories are charter, speeches, position descriptions, and presentations. There is no need to register to access this web site.

Rating: 4

9.   The Gurteen Knowledge Website

        URL address: http://www.gurteen.com/gurteen/gurteen.nsf

        Description: This knowledge management web site was developed by David Gurteen and
                      contains articles, books, forums, stories, and downloads. The site acts as a
                      gateway to a wide variety of topics enhanced by knowledge management.
                      The aim is to assist organizations in meeting their business objectives by
                      providing them with conceptual and technology-based tools. The main
                      strength of this web site is the way the content is organized. There are links
                      to knowledge management contents organized by categories, and a broad
                      database of articles is available.

        Rating: 4

10.   The Knowledge Management Resource Center

        URL address: http://www.kmresource.com

        Description: This knowledge management web site has a bookstore and searching tools.
                      The content of this web site is organized in departments that offer a
                      selection of reviewed sites and/or resources. The departments cover
                      knowledge management sites, knowledge markets, knowledge links, case
                      studies, periodicals, professional organizations, products and services,
                      search engines and portals, conferences and events, community of practices,
                      university sites or department centers, and a knowledge management
                      bookstore. The main strength of this web site is the richness of links
                      available for access to a variety of knowledge management resources.

        Rating: 4.5

11.   Knowledge Management News

        URL address: http://www.kmnews.com/

        Description: This knowledge management web site contains newsletters, technology
                     resources, links to other knowledge management web sites, and knowledge
                     management job position postings. The content is classified in sections
                     including newsletters, recommended reading, knowledge management jobs,
                     events, technologies, links, and perspectives. The newsletter of this web
                     site covers topics on knowledge content, information technology, and
                     identity management. Access to this web site is free.

        Rating: 3.5

KNOWLEDGE MANAGEMENT SOFTWARE REVIEW

TxDOT conducted a comprehensive software review in 2002 to select a collaborative tool for supporting knowledge sharing. As a result of this review, the Human Resources Division of TxDOT selected Meridian KSI Knowledge Centre™, a product of Meridian Knowledge Solutions, Inc., in January 2003. One of the primary strengths of Meridian KSI Knowledge Centre™ is its capability to combine the functionality of a robust knowledge management system, a learning content management system, and a competency management system (CMS) *(20)*. The selected software system includes capabilities for knowledge capture, knowledge repository, and knowledge dissemination among members of a community of practice. TxDOT has initiated the implementation of Meridian KSI through development of i-Way, a customized TxDOT portal.

As part of the software product review, a brief description of alternative knowledge management systems available on the market follows. The intention of this software product review is to document alternative technologies with similar functionalities to Meridian KSI. It is not the purpose of this review to formally evaluate or rate the alternative software products. This work was done in great detail by TxDOT during its software selection process, and a comprehensive re-evaluation is beyond the scope of this project.

A description of these knowledge management software products follows. A web site address is provided should more details about software functionalities be desired.

1.   Meridian KSI Knowledge Centre™

Description: This knowledge management system was designed with a centralized knowledge repository system. The system allows access to a personal knowledge portal, supports peer ratings and reviews of knowledge items, and provides for peer networking. The system also includes expert locator tools assisted by threaded and discussion functions. The system has great flexibility. The user may search and work in a general environment, or the user may choose to create functional team locations for each of his/her communities of practice. The teaming center function is considered the cornerstone of Knowledge Centre functionality since it provides dedicated locations for public, moderated, and/or private team discussions, collaboration, and scheduling, and makes lists of selected references available only to team members.

URL address: http://www.meridianksi.com/homepage/

Vendor: Meridian Knowledge Solutions, Inc.

2.   Confluence

Description: This knowledge management tool supports a system to share information among team members. The knowledge management site is divided into discrete spaces in which users can create, edit, and link pages using a special notation. Intelligent editing features are provided to automatically maintain and organize the content. Full text searching across content and attachments is one of the main strengths of this system. The system can run on a variety of operating systems including Windows and Unix. A demonstration version of this software can be downloaded from the vendor's web site.

URL address: http://www.atlassian.com/software/confluence/default.jsp

Vendor: Atlassian

3.   Lotus Notes

Description: This software product provides users with a single, unified access point to tools, tasks, and people, giving a common platform for collaborative applications with a customized selection of applications such as e-mail, instant messaging, team-project workspaces, group scheduling, web conferencing, and on-line learning. Among the benefits provided by Lotus Notes is the capability to integrate messaging, as well as collaborative and personal management resources available to the users, while connected to or disconnected from the network.

URL address: http://www.lotus.com/products/product4.nsf/wdocs/noteshomepage

Vendor: IBM

4.   OneNote 2003®

Description: OneNote 2003® provides a single place to electronically capture and organize typed and handwritten notes, audio recordings, graphics, and other rich media. Great flexibility to organize the content is given by this tool. Several effective methods to retrieve information from the notes are available. Notes can be reused for different purposes such as presentations, memos, papers, or speeches. A trial version of this software product can be downloaded from the vendor's web site.

URL address: http://www.microsoft.com/office/onenote/prodinfo/guide.mspx

Vendor: Microsoft®

5.   MS SharePoint®

Description: SharePoint® is a tool used to create team-oriented web sites for sharing information and fostering collaboration among team users. The concept of a "smart organization" is enhanced by this software, providing sites that connect places to people, teams, knowledge, and applications. Emphasis is given to support users' navigation, content topics, personalized sites, searching functions, and enterprise application integration. Many kinds of information can also be stored using this tool, such as calendars, contact information, web links, discussions, issue lists, and announcements. A demonstration of this software can be downloaded from the vendor's web site.

URL address: http://www.microsoft.com/sharepoint/

Vendor: Microsoft®

OTHER STATE DEPARTMENT OF TRANSPORTATION EXPERIENCES WITH KNOWLEDGE MANAGEMENT

Pennsylvania Department of Transportation Knowledge Management System

The Pennsylvania Department of Transportation implemented a knowledge management system to assist its employees in sharing expertise. The program was initiated three years ago and was deployed through an intranet system using Lotus Notes with templates. The first community of practice involved with this initiative was PennDOT's equipment managers. This group was already an active community of practice when the program was launched.

The core of the system is found in the specialized communities of practice in which knowledge is gathered and disseminated. PennDOT visualizes the knowledge management process developed within these communities of practice as a model in which the "know how" gained through experience is shared and applied to various situations. The model also encourages knowledge capture of best practices. Once the knowledge is captured, it is classified for effective retrieval and then stored for safekeeping. There is a moderator in each community of practice who monitors the progress and oversees knowledge sharing. The knowledge division also supervises the process and provides advice to the community of practice through the

moderators. The knowledge cycle is repeated through more sharing and constant re-evaluations of the knowledge, which leads to knowledge growth.

The PennDOT Knowledge Management System gives special emphasis to the conversion of tacit knowledge into an explicit medium for wide dissemination and effective reuse. With this objective, PennDOT initiated several pilot projects for knowledge management. Some of PennDOT's projects are:

- Institutional Memory for Foremen: Every project foreman gains valuable experience and know-how regarding specific applications that can be shared. The purpose of this project is to capture this know-how in the words of the foremen themselves through audio and videotapes. Storytelling was the technique used.

- The Agile Collaboratory Pilot: The intention of this project is to learn and demonstrate the application of agile collaboratories to PennDOT operations using line painting processes as an example.

- Fleet Ideas Exchange and Information Technology (FIXIT): The objective of this project is to extend a communication bridge between equipment managers and technicians. The aim is to create value by transferring best practices, innovations, tips and techniques, policies, and procedures. The FIXIT process uses an Internet-based system to locate, store, and disseminate centralized data through a user-friendly interface.

Lessons Learned from PennDOT Experience

Review of PennDOT experience provided the following information and lessons learned:

- Implementation of a knowledge management system is best begun in a community of practice that already actively shares knowledge among members.

- It is important to have someone responsible for each community of practice within the knowledge management system. This person acts as a knowledge management moderator for that community of practice. The moderator is responsible for monitoring the progress of the community of practice and oversees knowledge sharing among its members. More specific details of responsibilities will be included in product 0-4505-P4, which will describe functioning of the knowledge management system being proposed.

- The best way to market the program is through "word of mouth."   A reward system may also be used to encourage participation.

- Structured interviews can be framed as case scenarios of "what happens if," using a story-telling technique.

- Contributions from members should not be limited to successes, but should include cases in which problems were encountered. Sharing both types of experiences is considered important. PennDOT did not report that they had encountered major resistance to sharing problems objectively.

- Limitations in software functionality will slow implementation of the program. PennDOT personnel faced problems in populating knowledge into repository software systems during development of the program.

- It is desirable to monitor work progress and allow face-to-face communication in addition to electronic knowledge transfer opportunities. Quarterly or semiannual meetings are recommended.

- Strong and continued support from agency administration is necessary to sustain the development and implementation of a knowledge management system.

This information was provided by Marleen Steele of the Center for Performance Excellence, Pennsylvania Department of Transportation.

Virginia Department of Transportation Knowledge Management System

The Virginia Department of Transportation has two projects underway to help capture and retain tacit knowledge before it "walks out the door." The first project is the development of a community of practice for project managers of major construction projects. This project was partnered with the project management office, which uses Microsoft Windows® SharePoint™ as a portal to share the knowledge. This system was supported by an interim technology based on public folders managed by Outlook®. The second VDOT project involves knowledge mapping at a district office. Since a large part of the work force will be retiring in the next few years, the purpose of this project is to assess what individuals know and to discover with whom they share information. The process begins with district leadership being asked to decide what information is most important. Next, meetings with resident engineers and department representatives are arranged to set priorities and to interview experts. One of the first questions to be asked is, "If

you were to leave tomorrow, what would be essential for your successor to know?" The final product is a map of who possesses what types of knowledge.

Lessons Learned from VDOT Experience

The research team's review of VDOT experience provided the following information and lessons learned:

- It is essential to identify the experts within the community of practice at the outset of the program. These experts will be able to highlight what lessons have been learned in that field of expertise and what legacy documents are most important for that community of practice.

- The organization of communities of practice within an agency can facilitate the management of knowledge. To be successful, each community of practice must have leadership in place that will encourage use of the system among its members.

- To achieve a better rapport among members, it is important that the community of practice be composed of people tied by similar interests and, to the extent possible, having similar levels of expertise. This environment increases the willingness and ability to share knowledge among members.

- Knowledge management planners should be specific in laying out the essential issues related to the community of practice. Critical problems that affect the daily activities of the members should be central. While VDOT noted the value of having a similar level of expertise within a community of practice, the research team believes that there are at least two levels of expertise within TxDOT's pavement community of practice, each with some differing needs but with considerable overlap in needs. The knowledge management system to be proposed to TxDOT in product 0-4505-P4 will be designed to cover the needs of all within the TxDOT pavement community of practice.

- Integrating retirees who are recognized as experts by the community of practice provides valuable insights to the program.

- A VDOT commissioner provides support to foster the knowledge management system through a policy statement concerning use of best practices by the agency. The commissioner also meets with communities of practice to encourage them to share

knowledge. This policy has helped in the development of communities of practices and the implementation of the program.

- VDOT has a full-time staff dedicated to provide support to the knowledge management program. Work progress of the communities of practice within the organization is monitored. The knowledge management division is composed of about seven members. Due to the nature of the program, the background of the division's staff is very broad. The knowledge management division assists the communities of practice in sharing knowledge and keeping themselves current on new technology. Each community of practice is composed of about 20 members, having one moderator per group who interacts with the knowledge management division.

- The Meridian staging site is one of the repository systems used by VDOT to share knowledge. This staging site is supported by a customized database system located outside of the staging site. This database is used to organize the information based on a standard taxonomy. Key words are used to locate documents based on this taxonomy.

- Currently, VDOT is working on a methodology to quantify the benefits of the program. The methodology will be based in metrics methods. These methods will identify the top contributors in each community of practice. This will also serve to reward the top contributors for sharing knowledge in the community and encourage other members to be active. An e-magazine is another means considered in the program to share knowledge among members. It is also a way to recognize contributors.

More information about the VDOT Knowledge Management System can be found at http://www.virginiadot.org/vtrc/main/index_main.htm (under staff, team, and then knowledge management).

This information was provided by Maureen Hammer, director of the Knowledge Management and Technology Transfer Office at the Virginia Department of Transportation.

CHAPTER 3:
KNOWLEDGE MANAGEMENT SYSTEM STRUCTURE

OVERVIEW OF TXDOT KNOWLEDGE MANAGEMENT PLAN

An objective of this project was to develop a plan to house the new TxDOT knowledge management system within i-Way. This plan was developed and presented to TxDOT as a separate product in April 2005. A prototype of the plan was demonstrated to TxDOT in August 2005. This chapter documents the content of the knowledge management system plan at the end of phase one of this project.

This plan is designed to make optimal use of the variety of functions and capabilities available within i-Way. Implementation of this plan will not require customization of the proprietary software supporting i-Way. Table 2 displays how various functions within i-Way have capability to contribute to the agency's successful achievement of desired knowledge management goals.

While this plan focuses primarily on forensic pavement knowledge management, the methodology was developed to function in a mature knowledge management system containing information on numerous and widely varying subjects.

I-WAY FUNCTIONALITIES USED IN PURSUIT OF GOALS

The Library, the Conference Center, the Communication Center, and the Teaming Center of i-Way are central to the KMS being developed within i-Way. The Library, the Conference Center, and the Communication Center will all support knowledge storage. The Teaming Center and the item-rating capabilities will provide primary support for ongoing knowledge and information capture. The team rooms, the global and team room search capabilities, PeerNet, a key word glossary, and an acronym key word list developed by the research team will support knowledge location and retrieval.

Moderated and private team rooms will play several key roles in the rigid pavement forensics KMS being created. A moderated team room named Rigid Pavement Forensics Public Forum will provide department-wide access to selected information and a forum for anyone in TxDOT to post questions related to rigid pavement forensics. Similarly, a private team room named Rigid Pavement Forensics Work Room will offer district pavement engineers and

Table 2. Address of Agency KMS Goals.

Agency Goal for KMS	Contribution of i-Way Toward Agency Goal	Primary i-Way Functionality Involved
Strengthened Community of Practice	KMS encourages the community to function as a team when unique challenges occur.	Private team room (for exclusive use of community) Private team room logo
	KMS increases recognition of the community of practice as a functioning team.	
	KMS facilitates improved communications among team members and throughout agency.	Team room bulletin boards
		Team room member e-mail
		Team room calendar
	KMS offers improved procedure for review of draft documents.	Private team room contents & bulletin board
	KMS facilitates locating technical expertise.	PeerNet
	KMS promotes mentoring by senior members.	Private team room contents & bulletin board
	KMS expedites learning of junior members.	Private team room contents & bulletin board
Improved Information Accessibility	KMS key-word glossary and acronym taxonomy assembled by research team facilitate precise information retrieval.	Team room and global search tools
		Key word fields
	Specific location provides for any agency employee to seek highly technical assistance.	Moderated team room contents & bulletin board
	Analysis Tool Box assembled by research team provides ready access to best tools.	Moderated & private team room links & contents
	Top Reference Collection assembled by research team provides ready access to best information resources available.	Moderated & private team room links & contents
	KMS facilitates locating technical expertise.	PeerNet
Ongoing Capture of New Knowledge and Resources	Specific locations provides for new knowledge capture and unique experience documentation.	Private team room contents & bulletin board
	User evaluation of information is basis for retaining it within the KMS.	Item rating system
	Specific locations provides for supporting active forensic study teams.	Private team rooms (for exclusive use of each forensic study team)
	Periodic review and update of Analysis Tool Box and Top Reference Collection maintain information currency.	System administrator capabilities
	Plan for annual interview selections for ongoing capture of tacit knowledge.	Most areas of i-Way

selected division pavement engineering staff members a location to access information as well as a place to share new ideas and recent lessons learned and to request peer assistance in an environment conducive to mentoring and developing knowledge.

Besides facilitating communications, team rooms will make frequently needed and highly valued forensic rigid pavement knowledge and resources readily available to KMS team room users. The contents sections of these two team rooms will offer two categories of valuable resources, the "Top Reference Collection" and the "Analysis Tools and Databases." Team room members may also post their own documents for peer viewing in the contents section of the team room.

A graphical description of the functional plan is shown in Figure 10.
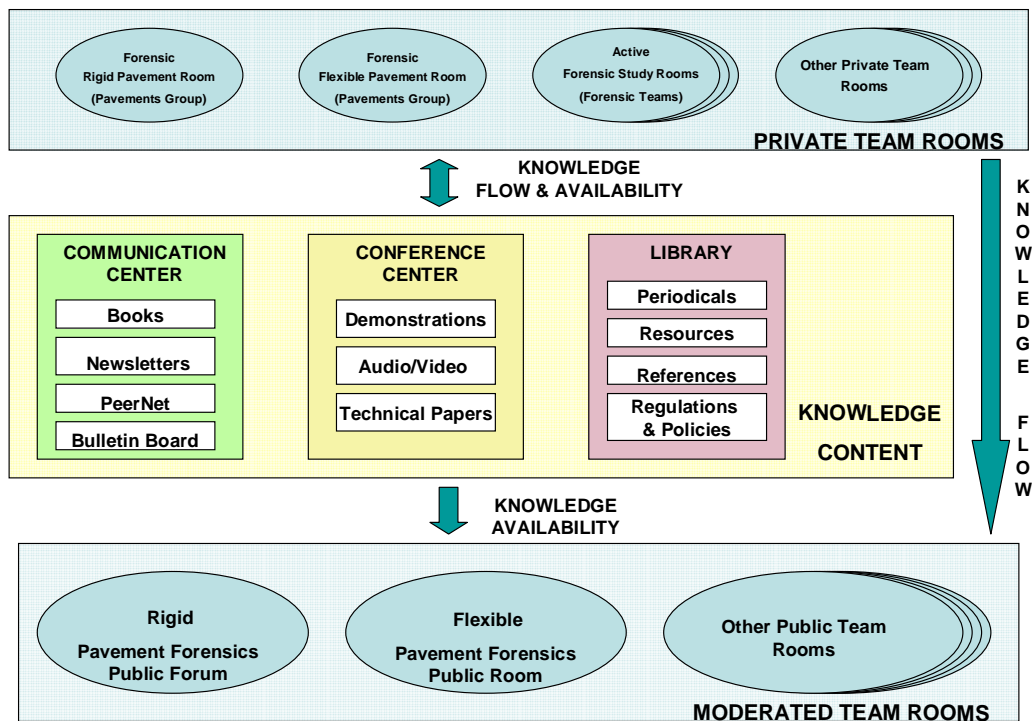
Figure 10. Knowledge Management System General Functional Approach Diagram.

As seen in Figure 10, the private team rooms will serve as incubation sites for new knowledge. New ideas and experiences can be shared and discussed, merits of procedure or

specification changes can be debated, and requests for assistance in unique situations can be made. New knowledge and information developed in the private community of practice team rooms can be migrated to the Library, Conference Center, or other portion of formal KMS item storage. When deemed appropriate by management, the new knowledge will also be made available as a content item within the moderated team room, highlighting it as a particularly valuable resource to the broader community of practice.

Users of the KMS in i-Way will have several new tools to facilitate interaction. Interaction among users is essential for sustaining system currency and value. This interaction will promote knowledge elicitation and knowledge sharing. Three main features of the KMS will support this interaction. These features are the PeerNet function, the discussion board section of team rooms, and other Teaming Center functionality. The private team room e-mail function is also available to users.

The PeerNet function builds a communication network of coworkers with similar interests. This feature will be used in the KMS to enhance communication among TxDOT employees. Among the main applications of PeerNet is its capability to find experts in a specific topic area for consulting on problems and for sharing valuable experiences. Mentoring of less-experienced members of the community is facilitated, resulting in growth in the expert network.

The discussion boards in team rooms provide a discussion-based forum environment to post, read, and comment on messages posted by other users. The team room discussion board has a key word search capability to assist users in locating information.

The private team room content section, discussion board section, and e-mail capabilities combine to provide an efficient and effective method of gathering feedback from reviewers of draft documents. Any private team room contributing member may place draft documents in the team room as content items. A message thread would then be initiated in the team room bulletin board to harbor all team member review comments. Finally, an e-mail would be sent to select or all team room members requesting document review and comment through reply to the message thread initiated for this purpose. In this manner, any reviewer has the opportunity to read earlier reviews, if desired, without the earlier reviewer having to reply-to-all in an e-mail, thereby cluttering everyone's e-mail inbox. Another advantage is that the individual requesting the review will find all review responses in one location instead of spread throughout an e-mail inbox.

Private team rooms will also be the location for any members to share unique experiences, lessons learned, and what they believe to be new insights or knowledge about pavement forensic investigation. A template called Knowledge Note, as shown in Figure 11, has been provided for users to document personal insights, ideas, and observations. Knowledge Notes should be posted in the content section of the private team room to make the information available to the community of practice for peer consumption. The means of coding Knowledge Notes and other types of documents will be provided so that content contributions may be accessed efficiently by other team room members. These private rooms are intended to facilitate a much increased communication level within these communities of practice, hence they are called work rooms.

The rigid pavement forensic community of practice will have two bulletin boards to support its activities, one in each of the team rooms. In phase two, if approved, the flexible pavement forensic community of practice will be provided with two similar team rooms with bulletin boards. While all district pavement engineers and a number of individuals from TxDOT divisions will hold membership in both of these private team rooms, there will also be uniqueness in each membership list.

The bulletin boards in the private team rooms, accessible only to district pavement engineers and selected other pavement experts, will provide a venue for seeking advice from peer subject matter experts, presenting new knowledge, and sharing lessons learned with peers. The bulletin board in the moderated team room concerning forensic rigid pavement information, which is accessible to all TxDOT personnel, will offer the means for anyone in TxDOT to seek advice from knowledgeable department technical personnel. Any individual may also publicly share information and ideas concerning that subject area on the moderated team room bulletin board. Bulletin board moderators will regulate and oversee activity on each bulletin board. Management aspects of this plan will be discussed in the System Management section of this chapter.

The moderated forensic rigid pavement team room will allow any i-Way user to quickly access carefully selected, best-available technical resources and forensic rigid pavement knowledge. Some of the primary users of the moderated team are envisioned to be area engineers, maintenance foremen, and construction inspectors, to name a few.

KNOWLEDGE MANAGEMENT SYSTEM CONTENT AND STORAGE LOCATIONS

Information items will be stored in various subsections of the Communication Center, Conference Center, and Library. Items are stored in subsections depending on the media or type of information. A list of the categories for information content items considered for this

Knowledge Note

Texas Department of Transportation

Sharing Knowledge to Achieve our Mission

Name:
Date of Note:

District/Division/Office:
Position Title *(optional)*:

This note may be described as: *(check all that apply)*

- ☐ Just something of value I learned over the years
- ☐ Description of a field observation of possible value to others
- ☐ Theory I think may be true
- ☐ Description of a somewhat unique experience or event
- ☐ Idea for possible specification, procedure or equipment change
- ☐ Simply advice for others
- ☐ Other:

Add notes here. Tips: Include location information such as highway number and county when a field observation or unique application is described. Include pictures in this section to help communicate whenever possible.

Knowledge Notes may be used or distributed in any manner desired. Its purpose is solely to promote the documentation of information that is often only observed and noted but never shared with others. It is recommended that Knowledge Notes be placed as Content information items in appropriate community of practice team rooms in i-Way.

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Figure 11. Knowledge Note Template.

project is presented in Table 3. The item categories listed in Table 3 constitute the core of information to be included in the knowledge management system.

Stored information items that are highly recommended and/or are frequently needed for forensic studies will also be made available within rigid pavement forensic team rooms to be created in the Teaming Center. These selected database items will be made available in the team rooms through links to the item storage locations in the Communication Center, Conference Center, and Library.

Table 3. Content Items for the Knowledge Management System.

Content Items	i-Way Room	i-Way Room Subsection
Books	Communication Center	Books
TxDOT Newsletters	Communication Center	Newsletters
Experts Network	Communication Center	PeerNet
Bulletin Board	Communication Center & Teaming Center	Bulletin Boards
Videos	Conference Center	Audio/Video
Presentations	Conference Center	Demonstrations
Forensic Reports	Conference Center	Technical Papers
Legacy Interview Documents	Conference Center	Technical Papers
Technical Journals	Library	Periodicals
Diagrams/Work Instructions	Library	References
Glossary & Acronym Taxonomy	Library	References
TxDOT Manuals	Library	Regulations & Policies
TxDOT Databases	Library	Resources
Web Links	Library	Resources

The TxDOT staging site provided by Meridian KSI was the initial repository location for considerable rigid pavement forensic knowledge content. In addition to temporarily storing information items, this site has been used to exercise i-Way capabilities and to gain better understanding of i-Way options during the development of this plan. As mentioned in Chapter 1, TxDOT's functional KMS will reside on the TxDOT intranet at http://crossroads/lcms/iway.htm. After initial use of the staging site, both the required prototype and the final Rigid Pavement Forensics KMS were already placed in i-Way on TxDOT's intranet.

Information items that are currently located on TxDOT servers will not require content loading into the knowledge storage areas of i-Way. These items will be accessed within i-Way by link. TxDOT databases that are of value during forensic investigations and that are available to i-Way will also be linked to i-Way.

As briefly described above, three main navigation sections of i-Way available from the home page will be used to store various types of information content. These sections are the Communication Center, the Conference Center, and the Library.

In the Communication Center, there are two subsections in which items will be stored. These are Books and Newsletters subsections. The Books subsection will include a collection of publications relevant to the pavement communities of practice. The Newsletter subsection will link to the TxDOT newsletter, which contains news or publications important to the members of the team rooms. There may be more than one newsletter if a specific community of practice desires to promote more expert-oriented newsletters.

In the Conference Center, there are three subsections to be used for information storage. These are Audio/Video, Demonstrations, and Technical Papers subsections. The Audio/Video subsection will store presentations and other information that may be found relevant to forensic pavement investigations. The Demonstrations subsection will include PowerPoint presentations useful for learning or training regarding forensic pavement investigation. The Technical Papers subsection will be used to store forensic reports, research reports, and legacy knowledge documents pertinent to forensic pavement investigation.

In the Library, there are four subsections relevant to the KMS. These are the Periodicals, Resources, References, and Regulations and Policies subsections. The Periodicals subsection will include technical journals related to the field of expertise. The Resources subsection will contain information related to TxDOT databases and links to the forensic-pavement-related databases available to i-Way users. The References subsection will store the glossary, acronym taxonomy, and diagrams useful for work instruction. The glossary and acronym taxonomy will be described in more detail later in this report. The Regulations and Policies subsection is designed to include specific standards and guidelines and will contain TxDOT manuals related to pavements.

KNOWLEDGE MANAGEMENT SYSTEM INFORMATION ENTRY AND RETRIEVAL METHODS

Entry of Information Items into i-Way Database

The software platform provided by Meridian KSI includes several dozen electronic worksheets to assist the system administrator in loading various types of information items. An example i-Way electronic entry format is shown in Figure 12. A corresponding worksheet was developed by the research team to transmit necessary information to TxDOT for loading on the TxDOT intranet server. An example of a corresponding data entry worksheet is shown in Figure 13.

Figure 12. i-Way Content Entry Screen — Standard Fields *(2)*.

Knowledge Management System

REGULATIONS AND POLICY CONTENT FORM

Name	Welcome to TxDOT's Knowledge Management System (KMS)
Description	Introductory information about TxDOT's Knowledge Management System (KMS) located within i-Way. It briefly answers the questions: What is the KMS? What is the purpose of the KMS?
Key Words	KMSID-00001 , core documents , i-Way , KMS , knowledge management , introduction , Top Reference Collection – All Categories , Top Reference Collection – All Rigid Pavement Categories Acronyms: trc, trcrp
Topic	X Administration/Staff Development __ Public Relations __ Engineering __ Safety/Health/Environment __ Information Systems __ Transportation __ Property – Equipment & Purchasing
File	KMSID-00001-INTRODUCTION.pdf
Source	Texas Transportation Institute (TTI)

Figure 13. Data Entry Worksheet Example.

An important element of each entry screen is the key words field. The key words field allows the creator of the database item to associate the item with key words that are not already contained in the title or the description boxes. This additional opportunity to associate a database item with certain words improves user success in locating desired information when using the search function. A search requiring one or more words will retrieve only database items that contain the required word or words in the Title, Description, and/or key words fields.

Another opportunity provided by the key words field is the use of unique, non-English code words. In this manner, a user may exclusively retrieve selected categories of items, avoiding retrieval of extraneous database items which happen to include the English-language search word in the description or title.

As quick and accurate retrieval of only desired database items is of utmost value to users, this plan proposes a simplified use of both of the above coding methods in the rigid pavement forensics KMS to be delivered in phase one of this project. Two key word tools will be provided, a key word glossary of terms related to rigid pavement forensic study and a non-English taxonomy based on acronyms and abbreviations of descriptive terms. Continued use of both of the coding methods in phase two will be based upon user evaluation and feedback from phase one use. The key word tools to be provided will be brief lists of terms, logically organized from a technical user's perspective. It is understood that the majority of future users will have little formal training in database search and library crafts.

Key Word Glossary

The glossary of key terms related to forensic rigid pavement investigations will assist users in consistently describing information content. The glossary will contain categories of descriptors. The user creating an information item will be asked to select applicable key words from each of the categories. Table 4 further describes these categories. The intent is to provide a very basic, easily understood, yet sound key word structure to facilitate the most common types of information searches. It is anticipated that key words describing distress modes will be the most frequently used in searches. The glossary will be made available as a content item in team rooms to guide those preparing entry information for new knowledge items and to assist those preparing to do a search for database information. The Key Word Glossary used in describing rigid pavement forensics is provided in Appendix A.

The development of this glossary began with rigid pavement forensic-related terms from the Transportation Research Thesaurus (TRT), which is used by the Transportation Research Board. In addition, the research team has reviewed research reports and other publications concerning concrete pavement distress for additional terms to be included. Forensic reports were also reviewed for terms that needed to be added. This list of terms will then be augmented as necessary to include common TxDOT terminology not already included. The research team

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was assisted by Mike Kleiber, an expert that worked in the development of the TRT, in preparing the rigid pavement forensics glossary.

Table 4. Categories of Key Words and Examples.

Category	Key Words
Geographic Area	statewide, Abilene District, coastal, panhandle, north Texas, south Texas, west Texas, east Texas
Information Type	legacy knowledge, reference material, analysis tool/database, observation/new knowledge, unique application/innovation
Legacy Knowledge Source	James A. Brown, Larry W. Buttler, etc.
Analyses Involved	pavement tests, laboratory tests, traffic analysis, design analysis
Rigid Pavement Distress Involved	spalling, debonding, punch-outs, joint failure, pumping, wide cracks, transverse cracks, longitudinal cracks, micro-cracking, corrosion, poor skid, poor ride, faulting, blowup, aggregate chemical reaction, etc.

Acronym Taxonomy

In addition to the use of common key words from the glossary of forensic rigid pavement terms, the research team proposes the use of acronym taxonomy in the key words field. The acronyms will be selected to avoid English words. To maintain simplicity and ease of use, this taxonomy will contain only a limited number of acronyms which correspond to the most frequent rigid pavement forensic search needs. The value of using this acronym taxonomy is that use of subject codes will exclusively retrieve only information purposefully selected for this key word search. For instance, if a user wishes to retrieve all legacy knowledge documents pertaining to rigid pavement forensics, a search using the acronym of "lkrpf" would retrieve those items exclusively and completely. Other methods of searching may retrieve extraneous documents or could omit some desired documents. If a smaller subset of information is desired, this information can be obtained by adding one or more additional acronyms or glossary key words to the search. An example would be a search using "lkrpf" and "D-cracking." Only rigid pavement forensic legacy knowledge documents which involve D-cracking would be retrieved.

The acronym taxonomy recommended for rigid pavement forensic items is found in Tables 5 through 8. Five knowledge and information categories were selected to be applicable to

a broad range of future TxDOT communities of practice as well as the pavements community. These knowledge and information categories are:

- Legacy Knowledge,
- Top Reference Collection,
- Analysis Tools and Databases (Analysis Tool Box),
- Observations and New Knowledge, and
- Unique Applications and Innovations.

While search acronyms are proposed to expedite locating specific types of KMS content, users may instead use only traditional key words for searching and retrieving database items. The research team believes that with the expected rapid growth in quantity of knowledge items in i-Way, the usefulness and value of providing these search acronyms will grow.

Table 5 shows the acronym taxonomy to uniquely identify the legacy knowledge documents to be prepared from interview information. Note that the table has three levels of information description. The first and most general level is all legacy knowledge. The second level is a subset of the first, rigid pavement legacy knowledge. The third level has multiple options, with forensic rigid pavement legacy knowledge being the one to be used most frequently in phase one project work. The additional third level options are provided since there will undoubtedly be knowledge captured during interviews that would be desired for other uses than forensic study applications. The research team proposes applying these other acronyms, as applicable, to each item of legacy knowledge to be included in the i-Way database during phase one of this project.

Table 6 shows the acronym taxonomy to identify knowledge management system items that have been selected as Top Reference Collection materials. These items will be selected by the research team and TxDOT rigid pavement forensic experts. A three-level category structure is also proposed in this taxonomy. More levels and item-content acronyms may be added if needed, but taxonomy brevity and simplicity are believed to be imperative.

Performing a search within a team room using Table 6 acronyms will retrieve only Top Reference Collection materials that have been added as content items in that team room. In this manner, a user in a team room can quickly retrieve, browse, and then select from a pre-selected group of i-Way database items that are believed to be the best sources of information currently available. If the search is done globally from the i-Way home page Search function, as described

earlier, all items in that area of i-Way that contain that specific acronym in the key word field will be retrieved for the user.

Table 5. Acronym Taxonomy for Legacy Knowledge.

Information To Be Retrieved	Acronym Used in Key Word Field
Legacy Knowledge – All Categories	lk
Legacy Knowledge – All Rigid Pavement Categories	lkrp
Legacy Knowledge – Rigid Pavement – Forensic	lkrpf
Legacy Knowledge – Rigid Pavement – Design	lkrpd
Legacy Knowledge – Rigid Pavement – Maintenance	lkrpm
Legacy Knowledge – Rigid Pavement – Construction	lkrpc
Legacy Knowledge – Rigid Pavement – Inspection	lkrpi
Legacy Knowledge – Rigid Pavement – Rehabilitation & Reconstruction	lkrpr
Legacy Knowledge – Rigid Pavement – Pavement Testing & Data Analysis	lkrppt
Legacy Knowledge – Rigid Pavement – Laboratory Testing & Data Analysis	lkrplt
Legacy Knowledge – Rigid Pavement – Specifications	lkrps
Legacy Knowledge – Rigid Pavement – Traffic Data & Data Analysis	lkrpt
Legacy Knowledge – Rigid Pavement – Unique Application & Innovation	lkrpu

Table 6. Acronym Taxonomy for Items Selected as Top Reference Collection Materials.

Information To Be Retrieved	Acronym Used in Key Word Field
Top Reference Collection – All Categories	trc
Top Reference Collection – All Rigid Pavement Categories	trcrp
Top Reference Collection – All Rigid Pavement Forensic Categories	trcrpf

Table 7 shows the acronym taxonomy for knowledge management system content selected as frequently used, valuable, forensic-related tools or databases. This group of content items will provide an Analysis Tool Box for forensic rigid pavement i-Way users. Together with the Top Reference Collection, the Analysis Tool Box will provide the user with quick access to best available, frequently needed standard formats, tools, and database information sources. As for legacy knowledge documents, three levels of content acronyms are provided.

Table 7. Acronym Taxonomy for Analysis Tools and Databases.

Information to Be Retrieved	Acronym Used in Key Word Field
Analysis Tools & Databases – All Categories	atd
Analysis Tools & Databases – All Rigid Pavement Categories	atdrp
Analysis Tools & Databases – All Rigid Pavement Forensic Categories	atdrpf

Table 8 shows the acronym taxonomy to identify knowledge management system content items created by community of practice members to describe recent observations or thoughts that may represent new knowledge to the community at large. It is likely that this type of document would first be entered as a Knowledge Note content item in the private team room of the applicable community of practice. This type of information is a very important part of ongoing knowledge capture in the proposed i-Way KMS. Convenient retrieval of the items in this category will also be important, as it is envisioned that knowledgeable team members will utilize this means of sharing new and old knowledge about rigid pavement forensics, or any other pavement subject. These items will be of high interest to the rest of the community, and these items will be reviewed under this plan at least semi-annually and considered for migration to become highlighted as a Top Reference Collection material. It may also be that a set of interview questions will be provided to the individual to more completely capture the new knowledge for legacy knowledge capture and coding into i-Way.

As in Table 5, a number of third-level acronym options are offered so that these database items may be retrieved by technical area.

Table 8 shows the acronym taxonomy for knowledge management content describing unique applications and innovations. For example, a document about precast concrete pavement would carry one or more of the acronyms from this table. This document could be a Knowledge Note, a published research report, or it could be an MSWord® document for the sole purpose of capturing and sharing information about a trial project.

Table 8. Acronym Taxonomy for Items Describing Unique Applications and Innovations.

Information to Be Retrieved	Acronym Used in Key Word Field
Unique Applications & Innovations – All Categories	uai
Unique Applications & Innovations – All Rigid Pavement Categories	uairp
Unique Applications & Innovations – Rigid Pavement – Forensic Investigation	uairpf
Unique Applications & Innovations – Rigid Pavement – Design	uairpd
Unique Applications & Innovations – Rigid Pavement – Maintenance	uairpm
Unique Applications & Innovations – Rigid Pavement – Construction	uairpc
Unique Applications & Innovations – Rigid Pavement – Inspection	uairpi
Unique Applications & Innovations – Rigid Pavement – Rehabilitation & Reconstruction	uairpr
Unique Applications & Innovations – Rigid Pavement – Pavement Testing & Data Analysis	uairppt
Unique Applications & Innovations – Rigid Pavement – Laboratory Testing & Data Analysis	uairplt
Unique Applications & Innovations – Rigid Pavement – Specifications	uairps
Unique Applications & Innovations – Rigid Pavement – Traffic Data & Data Analysis	uairpt

Retrieval of Information Items

There are a number of options for users to access database items from i-Way. Each has certain advantages. One of the major strengths of i-Way is its searching capabilities. The user does not need to know where a document is located to find and retrieve it if the global search function is used from the homepage. Therefore, the key to easily finding documents will depend heavily upon associating each document with the right key words. Great care will be given to selection of key words when items are prepared by the research team for uploading into the system. Figure 14 shows the global search function provided by i-Way.

If a user does know the storage location for desired information, a more refined search can be conducted by entering the specific room through the "Select a Function" drop-down box in the upper right of this screen. It is also possible to limit a search by topic, as also can be seen in Figure 14. However, as the topics offered by the i-Way drop-down box are necessarily broad, it is recommended that users of the rigid pavement forensic KMS leave the topic selection as "All" during searches. Detailed information about these functionalities can be found in the Meridian KSI Knowledge Centre™ manuals (20, 21) and the i-Way user guide prepared by TxDOT (1).

Searchers are advised to take advantage of the glossary and acronym taxonomies when selecting key words, particularly when first becoming familiar with the i-Way KMS. The glossary and acronym taxonomies provide multiple means for searching, giving the user a powerful searching capability exceeding that which would otherwise be available. Less experienced users who are unfamiliar with the glossary and acronym taxonomies can still search using common words. But they may need to spend more time browsing retrieved documents which are not as relevant as desired.

Figure 14. Global Searching Function from i-Way Home Page.

Table 9 shows some additional key words and acronyms that the user can enter to retrieve information about knowledge management processes and philosophy. These items can be retrieved by entering the appropriate key words or acronyms either through a global search of the entire i-Way or a localized search within the Knowledge Management System – Central team room where the item is stored. The knowledge management items are grouped as knowledge management books, knowledge management software, and knowledge management web sites.

Table 9. Key Words and Acronyms to Retrieve Knowledge Management Item Types.

Room	Key Word	Abbreviated Key Term
COMMUNICATION CENTER Books	Knowledge Management Book	KMB
LIBRARY Resources	Knowledge Management Software Knowledge Management Web Site	KMSOFT KMWS

Table 10 shows the corresponding key words and acronyms to retrieve rigid pavement items stored at this site. The rigid pavement items are grouped in rigid pavement books, rigid pavement newsletters, rigid pavement video, rigid pavement demonstrations, rigid pavement technical papers, periodicals, rigid pavement software, rigid pavement web sites, pavement-related databases, and pavement manuals and specifications.

Table 10. Key Words and Acronyms to Retrieve Rigid Pavement Item Types.

Room	Key Word	Abbreviated Key Term
COMMUNICATION CENTER Books Newsletters	 Rigid Pavement Book Rigid Pavement Newsletter	 RPB RPN
CONFERENCE CENTER Audio Video Demonstrations Technical Papers	 Rigid Pavement Video Rigid Pavement Demonstration Rigid Pavement Technical Paper	 RPV RPD RPTP
LIBRARY Periodicals Resources References Regulations & Policies	 -- Rigid Pavement Software Rigid Pavement Web Site Pavement Database Manual	 RPS RPWS PDB RPM

Table 11 shows the corresponding key words and acronyms to retrieve rigid pavement forensic reports and rigid pavement interviews.

Table 11. Key Words and Acronyms to Retrieve Rigid Pavement Forensic Reports and Rigid Pavement Interviews.

Room	Key Word	Abbreviated Key Term
LIBRARY Resources	Rigid Pavement Forensics Reports	RPFR
LIBRARY Resources	Rigid Pavement Interviews	RPI

Examples of Information Retrieval

The following examples show some methods of retrieving information from the rigid pavement forensics knowledge management system within i-Way.

Global Search Function

Click on the Search sign or the Search option on the i-Way home page navigation tool bar.

Enter the following search topics as words in the "Keywords" field. Select the type of search shown in parentheses from the drop-down list to the right of the Keywords field. A list of documents will appear corresponding to each search topic. Click on the desired document title to view it. Figure 15 to Figure 21 show seven examples of a global search by entering the following words as Keywords.

a.   Core Documents (All Words)
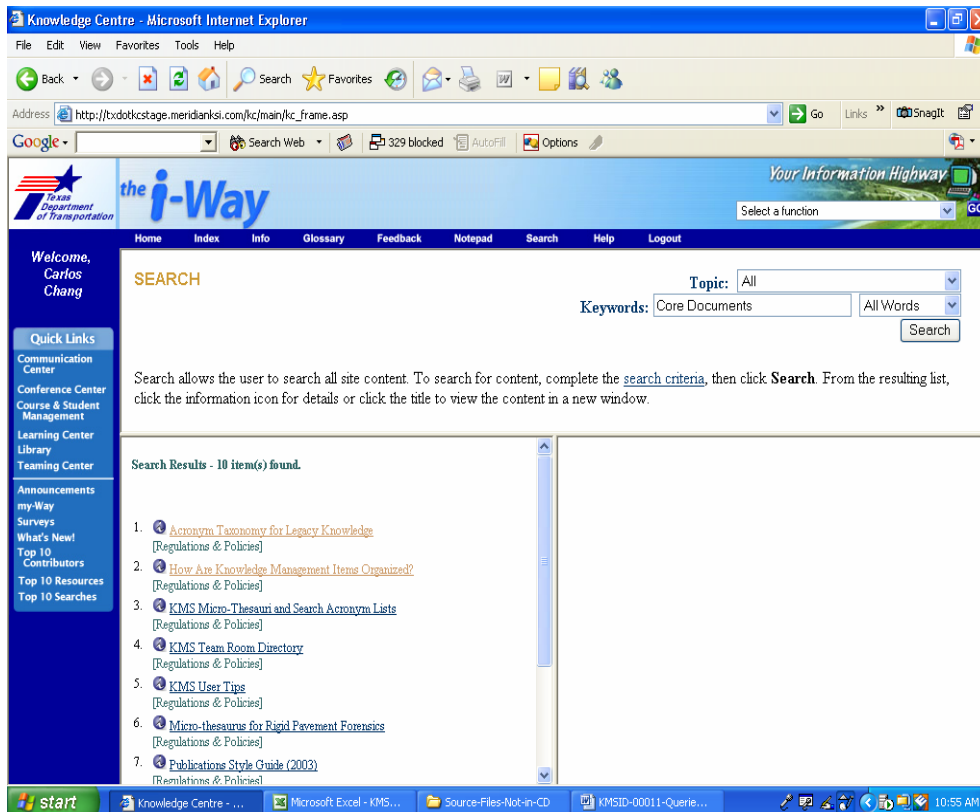
Figure 15. List of Core Documents in i-Way.

b. Interview Segment (All Words) or Rigid Pavement Interview (All Words)
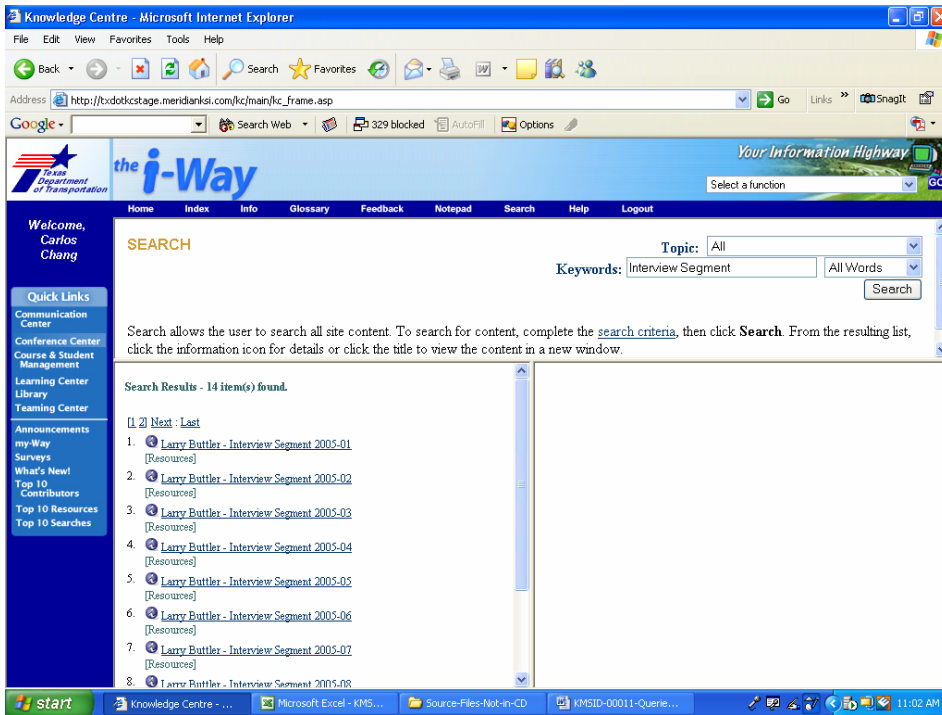
Figure 16. Interview Segments in i-Way.

c. Pavement Design Manual (Exact Phrase)
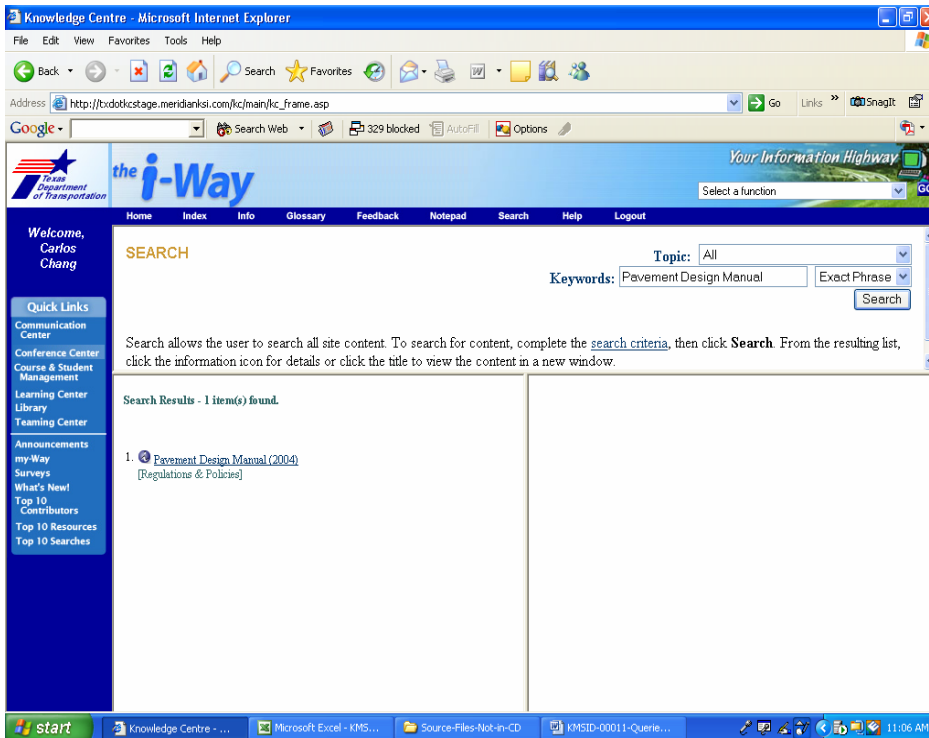
Figure 17. Finding Pavement Design Manual (exact phrase).

d.   Pavement Design Manual (All Words)

Figure 18. Finding Pavement Design Manual (all words).

e.   Visual Pavement Evaluation (All Words)

Figure 19. Visual Pavement Evaluation Documents.

f.   Pavement Book (All Words)

Figure 20. Pavement Books.

g.   PMIS Reports (All Words)

Figure 21. Finding PMIS Reports.

Local Search

From the i-Way homepage, click on the Library sign. In the next screen, click on the Resources door sign. Use the "Keywords" field as described below and shown in Figure 22 and Figure 23.

Enter in Keywords: Pavement Forensics Reports (All Words)

Figure 22. Pavement Forensics Reports.

Go to the i-Way Library and then to Regulations and Policies.

Keywords: distress manual

Figure 23. Finding Distress Manuals within Regulations & Policies.

Acronyms to Search by Content Categories

Use global search and the acronyms in Table 10 and Table 11 to search by content categories. Each key word should be searched separately, each causing display of different types of information contained in the i-Way database. Library / Resources

Example: Go to Library/Resources and type in Keywords: RPFR as shown in Figure 24

Figure 24. Finding Rigid Pavement Forensic Reports (RPFR).

Advanced Searching

Search for Rigid Pavement Software that is considered an analysis tool for pavement forensics which is also a top reference collection item.

Enter in Keywords: RPS and atdrpf and trc (Boolean) as shown in Figure 25.

Figure 25. Using Advance Search Capabilities.

SYSTEM MANAGEMENT

A recommended plan for management and administration of the knowledge management system is provided in this section. This plan is prepared for immediate use with the initial knowledge management system being created under this research project. The plan is also applicable for a mature knowledge management system containing technical content from a wide range of technical areas.

Knowledge Management System (KMS) Central Team Room

KMS Central has been created in an i-Way team room to serve as a hub for TxDOT's knowledge management system. Information available in KMS Central is KMS User Tips, a directory of KMS subject-specific team rooms, a directory of available key word glossaries and acronym lists, and a Welcome page. KMS Central is envisioned as a portal for the entire future TxDOT KMS.

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Site Administration

The Human Resources Division of TxDOT is the current owner and site administrator of i-Way. It is recommended that this division retain these functions. Site administration roles include the following:

- providing maintenance contracts and department interface with the software vendor,
- determining potential customizations of the software,
- providing training for bulletin board moderators,
- providing second-level oversight of bulletin board use,
- assigning and managing user access, and
- loading content.

Technical Content Administration

It is recommended that technical content administration of each technical subject area to be created within the knowledge management system be provided by the TxDOT division having responsibility for the technology involved. For the pavement forensics knowledge management system, the pavement branch manager of the Construction Division of TxDOT is recommended to have technical content administration responsibility. It is envisioned that the individual roles described below be delegated by the branch manager, as appropriate:

- selecting moderators for team room bulletin boards in the moderated team room and the private team rooms created for the forensic pavement communities of practice,
- approving all Analysis Tool Box items and Top Reference Collection materials for entry into the content sections of the moderated and private forensic pavement team rooms,
- determining appropriate use of a disclaimer statement on items related to this technical area, and
- semiannually reviewing and updating, adding, or deleting Analysis Tool Box and Top Reference Collection content.

Bulletin Board Moderators

Based on experience from other DOTs such as VDOT, it is recommended that moderators be assigned for each team room bulletin board of the knowledge management system. At least two assigned moderators for each bulletin board will lighten the workload and provide closer to continuous moderator availability. The moderators must be proficient in the technical subject area involved. Duties of the bulletin board moderators include the following:

- monitoring bulletin board use to limit discussions to topics pertaining to the technical subject matter of the team room;

- encouraging professional etiquette and tact in bulletin board threads;

- reporting inappropriate use of the bulletin board to the technical content administrator and the site administrator; and

- recommending to the technical content administrator bulletin board thread information, new knowledge documents, or unique observation descriptions for migration into individually loaded information items, or also possibly including in the Analysis Tool Box or Top Reference Collection list.

A graphical view of the system management structure is shown in Figure 26.
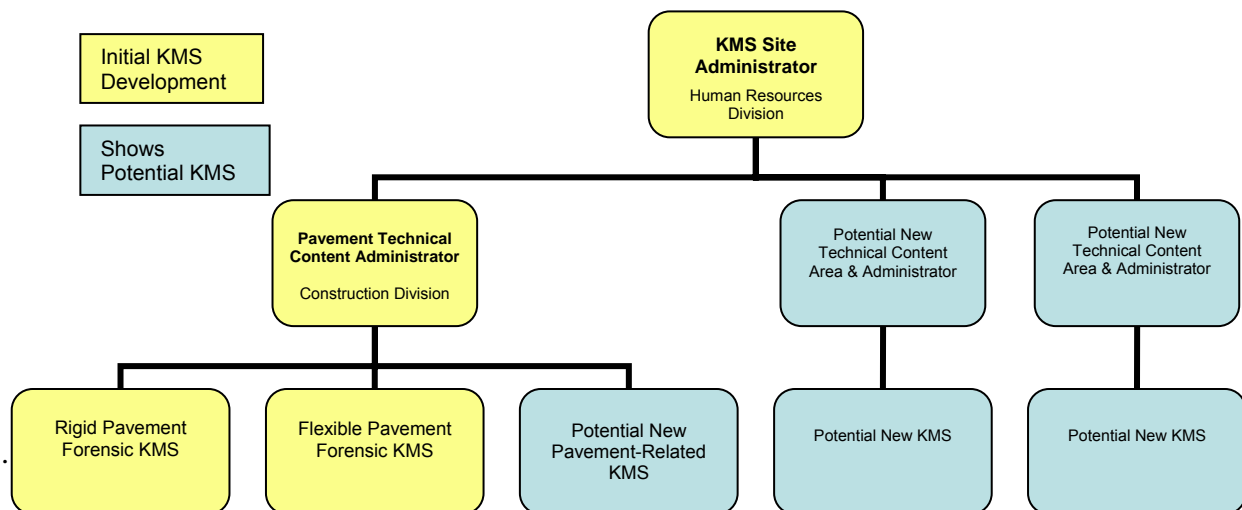
Figure 26. Knowledge Management Structure.

Potential Software Enhancements

While the plan presented in this chapter utilizes only existing i-Way functionalities, the research team noted potential opportunities to enhance software capabilities and improve KMS functions. Table 12 shows these suggestions, along with the desired outcomes from the enhancements.

Table 12. Potential Opportunities for Software Enhancement.

Potential Enhancement Opportunity	Desired Capability
Provide Team Room owners the option to create multiple discussion boards, similar to the flexibility currently found in the Communication Center's Bulletin Board.	Allow separation of discussions into topic areas logical to the specific community of practice using the team room.
Allow objects, files and pictures to be inserted into discussion board threads.	Greatly improved communication capability.
Allow search by author field.	Improved knowledge retrieval.
Provide moderator tools for Team Room discussion boards.	Ability to delete, modify, or move threads and replies.
Place the Books section in the Library.	Improve intuitiveness of i-Way.
Auto-e-mail functionality to notify the Team Room discussion board thread originator when replies are posted.	Improve usefulness and efficiency in use of Team Room discussion boards to request assistance.
Display "# Times Accessed" next to each Team Room owner, contributor, and member name on the team room home page.	Assist owner management of team room.

It is anticipated that a prototype system will be deployed in 2006, allowing the gathering of feedback from practitioners across the state. This feedback will supplement the ideas listed in Table 12.

CHAPTER 4:
IDENTIFICATION AND CAPTURE OF RIGID PAVEMENT
FORENSICS KNOWLEDGE

INITIAL AND ONGOING KNOWLEDGE CAPTURE

Knowledge capture was a major element of this research project. However, a significant additional challenge was to provide TxDOT with a means of ongoing knowledge capture after the project is completed. Outdated information should be removed from the knowledge repository as well.

The greatest challenge in initially creating the knowledge management system was the development of an efficient and effective process for capturing valuable tacit knowledge, that knowledge only learned through experience and that exists only in the minds of community of practice members. A structured interview process was developed and used to capture tacit knowledge.

Ongoing capture of knowledge by the TxDOT knowledge management system will rely heavily upon sustained and active use of the Teaming Center by the community of practice. Team rooms created for the rigid pavement forensics community of practice will serve as incubators for new knowledge. It is envisioned that experts from the community of practice will debate technical issues on the discussion boards, will share unique observations and personal theories on discussion boards and in Knowledge Notes, and will mentor less-experienced personnel within the team rooms being established. These discussions and sharing opportunities are designed to provide a constant flow of new knowledge into the knowledge management system over time.

Not only can members of the community post documents and participate in discussions, but peer members of the community may also rate the value of documents being posted by others, and provide additional commentary as well. These ratings and comments will assist in the selection of new knowledge to be migrated into legacy knowledge, or perhaps become a new Top Reference Content material or Analysis Tool Box item.

The process of ongoing knowledge capture is envisioned to include periodic identification of additional individuals for knowledge capture interviews.

KNOWLEDGE SCOPING MEETING

Efforts to gather rigid pavement forensics knowledge and information began with the research team hosting a knowledge scoping meeting. This meeting was held October 21, 2004, at the J. J. Jake Pickle Research Center in Austin, Texas. A cross-section of individuals was invited. Those attending the meeting are shown in Table 13.

Table 13. Knowledge Scoping Meeting Attendees.

Last Name	First Name	Organization	Experience
Cumby	Tracy	Lubbock District	Maintenance Foreman
Eltahan	Ahmed	Construction Division	Pavement Engineer
Fults	Ken	Center for Transportation Research	Research Engineer and Retired TxDOT State Pavements Engineer
Graff	Joe	Maintenance Division	Engineer of Maintenance
Krugler	Paul	Texas Transportation Institute	Research Engineer and Retired Pavement Materials Engineer
Lukefahr	Lisa	Construction Division	Concrete Materials Engineer
McDaniel	Mark	Construction Division	Rigid Pavement Design Engineer
Pigg	Billy	Waco District	District Pavement Engineer
Saenz	Tomas	El Paso District	District Pavement Engineer
Torres	Walter	Houston District	Construction Engineer
Warren	Dennis	Texas Concrete Pavement Association (TCPA)	TCPA Executive Director and Retired Houston District Construction Engineer
Won	Moon	Center for Transportation Research	Research Engineer and Retired Concrete Materials Engineer
Woodruff	Mykol	Paris District	District Pavement Engineer

Input received from this group included:

- anticipated users of the rigid pavement forensics knowledge management system;
- events and circumstances likely to trigger users to seek information on the rigid pavement forensics knowledge management system;
- specific information that would be valuable to anticipated users;
- sources or locations of the identified valuable information;

- initial list of candidates to be interviewed to capture tacit knowledge; and
- keys to creating a successful rigid pavement forensics knowledge management system.

After knowledge content items related to rigid pavement forensics were suggested by the participants, the individuals were each asked to assist in prioritizing the value of the various information items. Each participant was given a number of "votes" to allot among the information items that the group had previously listed in a brainstorming session. The information items receiving votes are shown in Table 14.

Table 14. Knowledge Items Suggested for Consideration.

Information Knowledge Item	Relative Value to Include Item in KMS (Number of Votes by Meeting Attendees)
Format Forensic Reports (with photos)	13
Applicable Technical Advisories	11
Information Gathering Guides for Individual Pavement Distress Types	11
Pavement Management Information System Rater's Manuals	11
Analytical Procedures, Modeling Programs, etc.	7
As-Built Plans	7
Applicable Research Reports, Particularly Project 0-1700 and all Project Summary Reports (PSRs)	6
Maintenance Manual	6
Project 0-1867 Forensic Manual	6
Internal Forensic Reports	4
Soil Conservation and Geological Maps	4
Construction Manual	3
Superior Highway Research Program (SHRP) Manual	3
Site Manager Information – Construction Inspection Notes	3
Trade Association Links and Guidance: Portland Cement Association (PCA), American Concrete Institute (ACI), Concrete Reinforcing Steel Institute (CRSI), Others	2
Department Materials Specifications	1
Pavement Designs	1
Rigid Pavement Database / Programs	1
Texas Sampling and Testing Procedures	1

The vote tallies shown in Table 14 were considered when types of information were selected to be included in the KMS. Additional item types were later identified as well, and final decisions on including information were made considering many factors. Additional discussion about selection of information items is provided in Chapter 3.

TXDOT DATABASES SUPPORTING THE RIGID PAVEMENT FORENSICS KMS

TxDOT annually collects detailed pavement performance information from its highway system that can be useful during rigid pavement forensic studies. In addition, construction-related records that are saved for a period of time after construction can prove invaluable to some forensics investigations. The following databases were identified to be of value.

Pavement Management Information System (PMIS)

The Pavement Management Information System (PMIS) is an automated system used by TxDOT for storing, retrieving, analyzing and reporting information to assist in pavement-related decision-making. It contains information from 1993 to present. PMIS is stored in the TxDOT mainframe in eleven ADABAS-type files. PMIS may be accessed remotely through either the "Customer Information and Control System" (CICS) or the "Remote Operating System Conversational On-Line Environment" (ROSCOE) software.

Data are downloadable using the PMIS MapZapper program. The main uses of the PMIS database are to:

- describe pavement condition (current and trends),
- help districts with project selection, and
- estimate total pavement needs (lane miles, dollars, broad type of work).

It is estimated that there are approximately 220 district users of PMIS. These users include district pavement engineers, design engineers, laboratory engineers and supervisors, maintenance engineers, and construction engineers. Additionally, PMIS is used by various personnel in area offices and maintenance sections.

PMIS contains useful information, including pavement type, distress information, average daily traffic (ADT), 18-kip equivalent single axle loads (ESALs), ride quality, skid resistance, surface age, and falling weight deflectometer (FWD) test results if this test has been

performed. Access to selected databases such as PMIS is an important element of the knowledge management system being created.

Roughness is one of the distress types that can be obtained from PMIS. This information is collected every year. Information stored in PMIS can provide initial insights for forensics studies, but it does not contain all information desired during forensic investigations, as its primary role is to serve as a tool for pavement management. Users of PMIS information during forensic studies also need to be aware that PMIS data types and methods of collection have changed over the years. For example, in 1996 rut measurements changed from visual rut ratings to automated rut measurements, and since 1999, International Roughness Index (IRI) measurements are used.   A major advantage of this database is that it contains information for the entire TxDOT pavement network. Data for one hundred percent of the network have been collected by contract raters since 2001. But from 1993 to 2000, only a portion of the network had data collected each year.

Maintenance Management Information System (MMIS)

The Maintenance Management Information System (MMIS) stores maintenance data on the TxDOT mainframe. It is a well-populated database. Only maintenance activities are recorded. MMIS is mainly used to store maintenance data (location, type of work, and cost) and as a tool to produce state reports containing this information. MMIS is stored in Audit, Transaction, FIMS-ENC41 and Master files on TxDOT's mainframe computer. MMIS is the source for year-end pavement maintenance expenditure data in PMIS.

Texas Reference Marker Database (TRM)

The Texas Reference Marker Database (TRM) is designed to be a control-location inventory of current roadway conditions within the TxDOT road network.

Useful information includes the name, location, and inventory of current highways on the TxDOT road network as well as the mileage and other characteristics of Texas highways. TRM is the source for PMIS basic inventory data.

SiteManager

SiteManager is a comprehensive construction management system sponsored by the American Association of State Highway and Transportation Officials (AASHTO), departments of transportation (DOTs), one Canadian Province, and FHWA. SiteManager automates administrative functions currently handled manually for construction projects. SiteManager is not only a network database, but it is also a relational and an object-oriented database. SiteManager is capable of running on Microsoft Windows 95, Microsoft Windows for Workgroups, Microsoft Windows NT and IBM's OS/2 platform. Laboratory and construction personnel are the main TxDOT users of SiteManager.

PMIS MapZapper

PMIS MapZapper is a tool to make maps of PMIS data, to create some basic PMIS data reports, and to plan strategies for meeting statewide pavement condition goals. The program can be downloaded from an internal Materials and Pavements Section web site, although it is not available on TxDOT's agency-wide intranet site, Crossroads. It is estimated that there are approximately 50 users of PMIS MapZapper in TxDOT. The majority are district office personnel.

Design and Construction Information System (DCIS)

The Design and Construction Information System (DCIS) is the Texas Department of Transportation's automated information system used for planning, programming, and developing projects. Project information such as work descriptors, funding requirements, and dates for proposed activities can be found in DCIS.

TxDOT Rigid Pavement Database

The Center for Transportation Research at the University of Texas at Austin maintains a rigid pavement database for TxDOT, which is another possible source of information during a forensic investigation. However, this database stores information for a limited number of control sections, and the data are used mainly for research.

Rigid Pavement Construction Records

During the interviews it was expressed that pavement construction records are kept for reference for a period of seven to ten years, after which they are destroyed. This policy makes it difficult to rely on construction records for forensics investigations. Inspection notes are also considered important, even though there is no standard format and each inspector uses his/her own system.

LITERATURE AND TECHNICAL REPORTS

Rigid Pavement Forensic Study Reports

Three rigid pavement forensic study reports were obtained from TxDOT as shown in Table 15. An electronic copy of each report was obtained and placed in the knowledge management system database.

Not many rigid pavement formal forensics reports were found during the research because, in most of the cases, rigid pavement distresses are repaired as part of maintenance activities. Only major problems are usually considered for formal forensics investigation. However, it is highly desirable to make these formal forensics reports available for future reference.

Table 15. Rigid Pavement Forensic Reports.

ID_Number	Name	Year
RPFR-00001	IH-30 Forensic Investigation in the Paris District, Hopkins County	2002
RPFR-00002	A Detailed Forensic Investigation and Rehabilitation Recommendation on IH-30	2005
RPFR-00003	Performance Report on Jointed Concrete Pavement (JCP) Rehab Strategies in Texas	2005

Research Reports

An extensive research report review was conducted during phase one of this project. Over two dozen rigid pavement forensic-related research reports were identified during the

literature search. A partial list of the research reports is shown in Table 16. The reports selected for the Rigid Pavement Forensics Knowledge Management System constitute the current state-of-the-art in modeling techniques for analysis, pavement performance, maintenance and rehabilitation techniques, and life-cycle cost analysis. Reports with background information regarding prior attempts to develop a pavement forensics system are also included.

LEGACY KNOWLEDGE CAPTURE INTERVIEWS

Selection of Individuals for Interview

A list of over 60 interview candidates was developed during the knowledge scoping meeting. The 20 individuals who were selected and interviewed were chosen from this list in an attempt to obtain a broad range of experiences as well as to capture information perceived to be the most valuable. Table 17 contains the names, affiliations, and backgrounds of those individuals who provided legacy knowledge capture interviews to the research team. This group includes five retired individuals.

Table 16. Rigid Pavement Forensic-Related Research Reports (Partial List).

ID_Number	Name
RPTP-00001	Advanced Pavement Design: Finite Element Modeling for Rigid Pavement Joints. Report II: Model Development
RPTP-00002	Project 10-50: Strategies for Rehabilitating Rigid Pavements Subjected to High-Traffic Volumes
RPTP-00003	Advanced Pavement Design: Finite Element Modeling for Rigid Pavement Joints, Report 1: Background Investigation
RPTP-00004	A Process for Selecting Strategies for Rehabilitation of Rigid Pavements
RPTP-00005	Project 20-50 (10): LTPP Data Analysis: Factors Affecting the Performance of Flexible and Rigid Pavements
RPTP-00006	LTPP Data Analysis: Effectivenesss of Maintenance and Rehabilitation Options
RPTP-00007	Life Cycle Cost Analysis of Portland Cement Concrete Pavements
RPTP-00008	Pavement Forensics: Investigating Failures
RPTP-00009	Basic Concepts, Current Practices, and Available Resources for Forensic Investigations on Pavements
RPTP-00010	Repair and Rehabilitation of Concrete Pavements – Volume I - Executive Summary and Key Rehabilitation Considerations
RPTP-00011	Repair and Rehabilitation of Concrete Pavements – Volume II – Guidelines for Pavement Condition Assessment and Evaluation
RPTP-00012	Repair and Rehabilitation of Concrete Pavements – Volume III – Summary of Pavement Rehabilitation Techniques and Strategy Development
RPTP-00013	Repair and Rehabilitation of Concrete Pavements – Volume IV – Strategic Analysis of Pavement Evaluation and Repair
RPTP-00014	Development of a Formal Forensic Investigation Procedure for Pavements
RPTP-00015	Implementation of a Database and Information System for Forensic Investigation of Pavements
RPTP-00016	Evaluation of Concrete Characteristics for Rigid Pavements
RPTP-00017	A Life Cycle Cost Analysis of Rigid Pavements
RPTP-00018	Mechanistic Analysis of Continuously Reinforced Concrete Pavements
RPTP-00019	Acceptable Concrete Pavement Thickness Tolerance
RPTP-00020	Sensitivity Analysis of CRCP Computer Programs
RPTP-00021	Estimating In Situ Strength of Concrete Pavement Under Various Field Conditions

Table 17. Legacy Knowledge Capture Interview List.

Last Name	First Name	Primary Experience	Experience Location	Status
Alford	Mike	Maintenance	Houston	TxDOT
Buttler	Larry	Maintenance	Statewide	TxDOT
Buzalsky	Ray	Construction	Fort Worth	TxDOT
Chen	Dar-Hao	Pavement Design	Statewide	TxDOT
Elliott	Glenn	Maintenance	Fort Worth	TxDOT
Fults	Ken	Pavement Materials and Design	Statewide	Retired
Gaskin	Charles	Construction	Houston	TxDOT
Graham	Gary	Pavement Design	Statewide	TxDOT
Henry	Pat	Pavement Design	Houston	TxDOT
Hunt	Jim	Construction	Dallas	Retired
Julian	Bob	Construction	Fort Worth	TxDOT
McCullough	Frank	Pavement and Materials Research	Statewide	Retired
Murphy	Mike	Pavement Design	Statewide	TxDOT
Scullion	Tom	Pavement and Materials Research	Statewide	TTI
Selman	Kelly	Area Engineer	Dallas	TxDOT
Warren	Dennis	Construction	Houston	Retired
Whitehead	James	Construction	Fort Worth	TxDOT
Wimsatt	Andrew	Pavement Design	Fort Worth	TxDOT
Won	Moon	Pavement Materials	Statewide	Retired
Zollinger	Dan	Pavement and Materials Research	Statewide	TTI

Legacy Knowledge Interviews

The interview process was designed to capture tacit knowledge, information contained only in the minds of experts. To elicit this knowledge, a set of questions to retrieve targeted knowledge was prepared based on the expertise area of the individual to be interviewed. Individuals being interviewed were asked to provide references to existing sources of explicit knowledge that they have found particularly valuable.

There were a number of questions common to all interviews. A typical set of interview questions is shown in Appendix B. The questions were developed to focus memory on unique experiences and observations which often are not documented in written form.

Before the list of questions could be developed, an information framework or matrix of subject categories was prepared. The interview task of this project will attempt to populate each category and subcategory of the matrix with knowledge from those interviewed. This matrix is shown in Table 18.

Prior to contacting TxDOT employees, the research team first obtained permission of a supervisor, usually the district engineer in the case of district personnel.

Individuals selected for interview were contacted initially by telephone whenever possible. Virtually all of those contacted were quite willing to provide an interview even though no compensation was offered to retired employees. A letter of invitation for the interview was then forwarded to each individual, with the question list attached. The three-fold purposes of the letter were to document the individual's willingness to be interviewed, to provide the list of interview questions in advance of the interview, and to thank them for their spirit of cooperation in sharing their knowledge. A copy of the letter was also mailed to the individual's supervisor. A typical letter is included in Appendix C.

The interviews were audio-taped so that they could be accurately transcribed for later processing. It was typically noted that those being interviewed appeared a little uneasy for the first few minutes of the interview, and this may have been in part due to the audio-recording of comments. Within minutes, however, those interviewed appeared to relax and freely conversed with the interviewer. The interviewers made an effort to approach the interviews in a conversational manner, which seemed to ease apprehensiveness. Interviews typically lasted an hour and fifteen minutes to two hours.

Interview Knowledge Capture Process

Each audiotape was transcribed after the interview. Each transcription was then analyzed for portions deemed to be the most valuable pieces of information. These portions were placed into a Legacy Knowledge document format, and the information was edited to improve clarity of communication, where needed.

The legacy knowledge documents were then sent to the interviewed individual for approval to assure that no meaning was lost or changed in editing. These legacy documents are generally one page or less in length. Photographs were added, where available. An example legacy knowledge document may be seen in Appendix D.

The research team used both in-house and contract transcribers. The contract transcribers were generally more efficient due to their considerable experience and specialized equipment. The time required to perform the transcriptions ranged from 4 hours to 12 hours, depending on the length of the interview and the clarity of enunciation and the recording.

Evaluation of the Legacy Knowledge Capture Interview Process

Individuals enjoyed the interview process. It is believed that most employees welcome the opportunity to share what they have learned over the years. The use of a structured set of questions for the interview was useful to capture knowledge from the experts. The selection of experts with different backgrounds allows covering all areas involved in forensic investigations and the techniques to repair pavement failures. Interviews were not restricted to the questions prepared in advance. Topics and questions were expanded to capture unique knowledge. This valuable knowledge would have not been able to be captured without conducting a face-to-face interview. The knowledge of the interviewer also contributed to the success in obtaining valuable knowledge by reformulating questions or providing comments to elicit additional information.

Table 18. Information Framework Category Matrix.

Objectives	Categories of Information	Sub-Categories of Information	Information Sources
To Assist KMS User in Performing a Forensic Pavement Study for the Purpose of Determining the Best Option for Repair/Rehabilitation	Pavement Forensic Study Methodology	First Steps. Determining Data/Records to Be Gathered. Determining Tests to Be Performed. Methods of Data and Information Analysis. Communication and Reports.	Interviews. TxDOT Forensic Manual. Earlier Forensic Study Reports. Standard Forensic Study Report Format. Transportation Research Information Services (TRIS) Search. Trade Association Manuals and Publications. Specific Scoping Meeting Suggestions.
	Pavement Test Tools	Descriptions of Pavement Tests. Primary Use (Value to Forensic Studies) of Each Test. Special Things to Know about Pavement Testing Tools.	TxDOT Manuals. TRIS Search. Research Reports. Specific Scoping Meeting Suggestions. Interviews.
	Laboratory Test Tools	Descriptions of Laboratory Tests. Primary Use (Value to Forensic Studies) of Each Test. Special Things to Know about Laboratory Testing Tools.	TxDOT Test Procedures Manual. TRIS Search. Research Reports. Interviews.
	Traffic Data Tools	Descriptions of Traffic Data Tools. Primary Use (Value to Forensic Studies) of Traffic Data. Special Things to Know about Each Traffic Data Tool.	Interviews. TxDOT Mainframe. TxDOT Servers. CDs.
	Pavement Data Tools	Descriptions of Databases. Uses of Databases. Special Things to Know about Each Database.	Interviews. Meeting with TxDOT Personnel. TxDOT Mainframe. TxDOT Servers. CDs.
	Types of Distress	Descriptions of Distresses. Primary Causes Often Associated with Each Distress Mode. Special Things to Know about Each Distress Mode.	Interviews. TxDOT Forensic Manual. Earlier Forensic Study Reports. TRIS Search. Trade Association Manuals and Publications. Specific Scoping Meeting Suggestions.
	Methods of Repair/Rehabilitation	Description of Each. Best Places to Use Each Method. Reasons Not to Choose Each Method.	Interviews. TxDOT Forensic Manual. Earlier Forensic Study Reports. TRIS Search. Trade Association Manuals and Publications. Specific Scoping Meeting Suggestions.
	Assistance Available	Pavement Section. Materials Section. Division Pavement Engineer (DPE) Group. Trade Associations. Academia.	Organization Charts. Web Sites. Interview(s).
	Historical Forensic Studies	By Type of Distress Mode. By District or Area of Texas.	TxDOT Electronic Records. Perhaps TxDOT Hard Copy Records.

Table 18. Information Framework Category Matrix. (Continued).

Objectives	Categories of Information	Sub-Categories of Information	Information Sources
To Assist KMS User in Understanding Relationship between Pavement Distress Modes and Design, Construction, Traffic Loading, and Maintenance Factors	Types of Distress	Descriptions of Distresses.	Interviews. TxDOT Forensic Manual. Earlier Forensic Study Reports. TRIS Search. Trade Association Manuals and Publications. Specific Scoping Meeting Suggestions.
	Design Requirements Associated with Distress Types		Interviews. TRIS Search. Scoping Meeting.
	Specifications & Construction Requirements Associated with Distress Types		Interviews. TRIS Search. Scoping Meeting.

CHAPTER 5:
MARKETING STRATEGY FOR THE RIGID PAVEMENT FORENSICS KNOWLEDGE MANAGEMENT SYSTEM

INTRODUCTION TO MARKETING STRATEGY

Certain key questions must be addressed in developing a marketing strategy for the Rigid Pavement Forensics Knowledge Management System (RPFKMS):

- What are TxDOT's goals for the RPFKMS?
- Who are the target markets (audiences) for the RPFKMS?
- What are the obstacles to achieving TxDOT's goals?
- How can TxDOT overcome these obstacles?
- What marketing principles and strategies can be employed at TxDOT to help overcome these obstacles?

These questions and others were discussed in several meetings with TxDOT personnel as well as during a number of telephone and email exchanges. The marketing strategies discussed in this document were developed based upon the information learned during those interviews and discussions, coupling that information with proven marketing principles that can be applied to TxDOT's unique position. The interviews were an important aspect not only in gaining a situational awareness of TxDOT's current position in the application of its new knowledge management system (KMS), but where TxDOT staff wish to be in the near future as well. The marketing strategies discussed in this document are prepared for the RPFKMS, as this is the initial KMS knowledge area to be developed and implemented.

The analysis of marketing strategies contained herein achieves the marketing objectives of this project – to analyze both the constraints involved with marketing this product and the marketing methodologies that can be used to overcome these constraints and successfully promote the RPFKMS to the specifically targeted market. Detailed action plans – including task assignments to specific personnel, timelines, task budget limits, and other action plan details – may be developed from the information provided as TxDOT finalizes implementation planning.

MARKETING BACKGROUND

In May 2004, TxDOT undertook development of a Pavement Forensics Knowledge Management System (PFKMS). As planning proceeded, this undertaking advantageously

merged with concurrent department efforts to establish a new Learning Content Management System (LCMS). The PFKMS will serve the needs of TxDOT's pavement community and, as the first KMS in TxDOT, begin setting the stage for acceptance and use of knowledge management principles throughout the organization. The scope of the PFKMS project includes identifying sources of valuable forensic pavement knowledge; capturing that knowledge; transferring that knowledge to the LCMS; developing methods for maintaining and updating KMS content; and assisting in marketing the PFKMS throughout TxDOT's pavement community.

Marketing the PFKMS should accomplish three major objectives:

- increase awareness of the availability of the PFKMS throughout the TxDOT pavement community and beyond,

- promote proactive sharing of forensic pavement knowledge by recognized experts, and

- achieve a more rapid gain of pavement forensics knowledge and experience in the less-experienced portion of the community of practice.

MARKETING GOALS

There are four primary goals for marketing:

- Promote the availability and uses of the PFKMS forum to the TxDOT pavement community to create a shift in culture toward acknowledgement and use of KMS tools and principles.

- Promote the need for and responsibility of acknowledged subject matter experts (SMEs) to share pavement forensic knowledge with the broader TxDOT community.

- Promote the availability, benefits, and consistent use of the PFKMS within the TxDOT pavement community.

- Promote the application of KMS principles throughout TxDOT.

TARGET AUDIENCES

Development of a successful KMS will be particularly beneficial to an organization such as TxDOT. The department has a long history of developing nationally recognized experts

among career employees, and has created a wealth of knowledge that can benefit TxDOT long after those who created the knowledge have left the department. A knowledge management system will work best within a well-defined community of practice, such as TxDOT's strong pavements community among the district pavement engineers and the Materials and Pavements Branch. The PFKMS should also have the effect of supporting and nurturing the close working relationships within that community of practice.

Capturing, integrating, and creating a forum for knowledge exchange from across the pavement community in the LCMS will serve to enhance the forensic pavement area of TxDOT. In order to accomplish this, certain target populations within the pavement community must be convinced of the validity of the principles of KMS and the usefulness of the PFKMS in particular. The target audiences we wish to influence through promotion of the PFKMS can be extrapolated from the marketing goals above, and include:

- acknowledged forensic pavement subject matter experts who can share critical pavement forensics knowledge with the TxDOT pavement community, such as district pavement engineers; Construction Division pavement engineering staff; and other recognized subject matter experts;
- TxDOT employees involved with pavement construction or maintenance;
- district engineering staff; and
- all TxDOT employees.

Including the rather broad market segment of *all TxDOT employees* is necessary in order to move KMS principles into the mainstream of TxDOT business activities. Although the PFKMS may not be a primary concern or interest to a large portion of this broad audience, there exists the need for all employees to recognize the principles and benefits of knowledge management. Therefore, the TxDOT community as a whole becomes a key market segment in the long-term goal of the department for adopting deliberate knowledge management as a business strategy. This marketing analysis may be considered a prototype for implementing KMS practices into other department areas of operation.

OBSTACLES TO IMPLEMENTATION

In every analysis of marketing and promotion, there comes a time to look at particular strengths and weaknesses of the organization and how they will affect marketing strategies.

Individuals, communities of practice, and organizations as a whole each have unique ways of approaching new practices and new ways of doing business. The adoption and utilization of the PFKMS within the TxDOT pavement forensics community is no exception.

The success of the PFKMS primarily hinges on the value the target audiences find in using the system for locating, assimilating, and applying the information found there. Once the value of the system is realized among the target populations, its use and benefit will increase significantly over time. However, certain obstacles must be overcome in order to initially gain the confidence of the target audiences. These audiences must find that the PFKMS contains useful information, that this information can be located without difficulty, and that the information will benefit the user in a tangible way. Looking at some of the obstacles to PFKMS implementation gives insight in selecting marketing strategies that will successfully overcome some of the initial reservations TxDOT employees may have with the system.

Lack of Understanding

The most critical element of implementing a new business method such as this KMS is overcoming a lack of understanding of the new system and its benefits. Many times this lack of understanding takes form in the following complaints:

- It won't save time.
- It's too hard to use.
- It's too hard to maintain.
- It takes too much time to use.
- It doesn't have the information I need.
- The old methods work better.

To overcome these obstacles, the marketing approach must make the benefits of the system abundantly clear. Positive words, phrases, and visuals used in marketing a new concept can have a significant impact on its acceptance. A commitment to usability and customer service – making sure the system is maintained, periodically upgraded, and addressing user feedback – will also serve to enhance the user's experience and positively influence the user's impression of value.

Unrealistic Expectations

The next major obstacle and one harder to overcome is an audience's unrealistic expectations of the new system. One of the problems created if the Rigid Pavement Forensics KMS is visited by individuals outside of the technical community of practice is that they will likely be looking for information outside of the forensics specialty. Once they discover that the information they need is unavailable, it is less likely they will perceive the value of overall KMS principles as they are applied to different areas of TxDOT over time. The marketing of the RPFKMS, therefore, should be directed in steps and limited at the outset to the community of practice that includes pavement forensics and associated pavement construction and maintenance staff.

Sharing Information

In addition to overcoming lack of understanding and unrealistic expectations for the system, there is a third obstacle that may be overcome with the proper marketing and implementation strategy. Within a particular community of practice, where the members share some basic level of knowledge, prestige is often gauged on knowledge and experience. To share one's knowledge with the community at large may be perceived as having a negative effect on that prestige and even as limiting a person's chances for advancement. The perception is that if people give up their knowledge, they will be less valuable to the organization or that someone else may become more valuable because of the information shared.

Sharing knowledge with the community could also be viewed by some as embarrassing if the information they are sharing describes trials of methods or materials which did not work. It is important for the community to understand that sharing what does not work is just as valuable as sharing things that do work.

To help overcome obstacles to sharing information, it is appropriate to develop recognition of the benefits of the new system within a small and highly respected portion of the community of practice. In this case, acknowledged forensic pavement subject matter experts who can share unique pavement forensics knowledge are critical to the success of the PFKMS and comprise a select target market. If this select group accepts the principles of KMS and applies them by sharing and distributing its wealth of knowledge, the greater community will then:

- benefit from SME knowledge and shortened learning curves,

- identify the PFKMS as a key component in improving each individual's knowledge,

- adopt regular use of the PFKMS as a valuable tool and KMS in general as a valuable TxDOT business principle, and

- realize the benefit of others' experiences and the value of learning what works or even what *does not* work.

There are numerous ways to recognize acknowledged experts for their time and effort in making the KMS a success. Public accolades, prizes, or awards can be very successful in creating motivation for improving the use of KMS principles. A specially designed baseball cap, a hat or lapel pin, or a wall plaque are options to provide a "badge of expertise" in a specific field. When presented in a public forum, especially among peers, it creates an opportunity to reinforce the KMS principles while fostering pride in the ability and willingness to share knowledge and experience.

MARKETING STRATEGIES FOR IMPLEMENTATION

Use a limited, small group of acknowledged forensic pavement SMEs to develop and drive understanding of the value and benefits of the PFKMS.

1. Invest in education forums for SMEs about PFKMS, its use and benefits.
2. Encourage mentoring on use of PFKMS and setting up team rooms.
3. Promote success stories among target populations.
4. Start discussion threads of great interest, designed to introduce target audiences to the benefits of shared knowledge on the PFKMS.
5. Capture and use testimonials from people that have had success in finding valuable information within the new KMS. Success stories from less-experienced personnel would be the most effective.

Develop high-level management "champions" that will lead the effort to encourage use of the PFKMS. This strategy will not work alone, but must be used in conjunction with other strategies that prove to the community the viability of KMS.

1. Direct target populations directly to the PFKMS area in order to access critical information and updates from management.

2. Generate directives and/or recommendations concerning the use of PFKMS directly from management champions.

3. Transition to using only the PFKMS for regular dissemination of information traditionally sent out by other means (email, memoranda, etc.).

Use regular, direct opportunities for education and promotion of the PFKMS throughout TxDOT.

1. Send regular promotional and informational email concerning updates to the PFKMS, such as new team rooms, new discussion threads, etc.

2. Present the PFKMS at appropriate forums and in publications where the target audiences will be attending or will read the information.

    a. Research Management Committee (RMC) meetings

    b. Transportation short courses

    c. Construction engineering personnel meetings

    d. Maintenance engineering personnel meetings

    e. District engineers, division and office director meetings

    f. Articles in *Transportation News*, *Research Quarterly*, *CST Newsletter*, and other internal publications

3. Develop and distribute promotional materials to aid in the recognition and use of the PFKMS such as flyers, posters, brochures, mouse pads, table tents, etc. for use in offices, break rooms, and work areas of the target populations.

    a. Create and institutionalize a theme or identity (brand) for the PFKMS for use on printed and electronic materials

    b. List the benefits of KMS on every marketing piece

    c. Provide contact for assistance or further information

4. Develop and promote staff incentives as a reward for using the PFKMS. This could take the form of a reward for setting up a discussion thread or creating a new team room, etc.

    a. Tee-shirts

    b. Coffee mugs

    c. Tape measures, or other tools useful in their work

> d. Baseball caps, hat or lapel pins, or wall plaques and/or appreciation certificates

5. List the newly developed PFKMS on the *What's New* page of the *TxDOT i-Way!* as well as making links available on the home page and other high-profile pages of *Crossroads*.

NOTEPAD MARKETING TOOL

The marketing strategy recommended to promote use of the newly created KMS includes initial focus on the core group of experts, early development of upper-level management champions, and finally the use of a variety of tools and methods of promotion. One of the tools for promotion within the core group will be a notepad in the form of a mouse pad. The graphic design for this promotion item is shown in Figure 27.

MEASURING MARKETING SUCCESS

Successful marketing will result in a more rapid technical maturation throughout the community of practice than had been occurring prior to the initiation of the KMS. While this desired outcome cannot be directly measured, several indicators of success may be monitored easily. These include the number of hits that the KMS receives and the number of discussion board posts being made on a monthly basis. These numbers should increase steadily until a saturation level of use is achieved within the community.

Figure 27. Promotion Document Graphic Design.

CHAPTER 6:
FINDINGS AND RECOMMENDATIONS

FINDINGS

The following findings have been provided from phase one of this project:

- The pavement forensics community of practice is well-suited to be the initial group to utilize a formalized TxDOT knowledge management system.

- Current i-Way functionality provides a solid platform for technical knowledge management.

- Almost all current and former TxDOT employees are willing and, in fact, have a desire to share the knowledge gained during their transportation-related careers.

- The structured interview method used in phase one was successful in capturing considerable quantities of knowledge.

- There is a great need for sharing knowledge acquired by experience that is not explicitly expressed in current manuals.

- Capturing the knowledge of TxDOT experts allows understanding many of the bases for existing construction specifications and laboratory testing procedures.

- Many times forensics investigators face the challenge of not having construction records available for the road segment that failed. Talking to people who participated during construction is also a potential great source of information while doing a forensic study.

- Some forensics investigations are not documented with a written report. When this happens, there may be no written records describing specific problems, sectors, causes and solutions.

- More information is needed on how existing information from TxDOT pavement databases can be useful to forensics studies. Knowledge of the content and usefulness of existing databases by personnel performing forensics investigations needs to be encouraged.

RECOMMENDATIONS

The authors have the following recommendations:

- Phase two of this project should utilize similarly formatted structured interviews to capture tacit knowledge for flexible pavement forensics.

- TxDOT should consider applying the methods of knowledge management developed during phase one to additional communities of practice within the agency.

- The potential enhancements to i-Way functionality which could facilitate knowledge capture and retrieval should be explored by TxDOT.

- Initial marketing for the newly created KMS should be directed toward the department's acknowledged subject matter experts, which form the core portion of the pavement community of practice.

- The use of Knowledge Notes to capture knowledge on pavement forensics will facilitate sharing of valuable information that otherwise may be lost. These Knowledge Notes will also be useful to identify candidates for additional interviews.

- The bulletin board can play a major role in the Rigid Pavement Knowledge Management System to keep TxDOT employees that work in pavement forensics updated on new techniques, methodologies, or potential problems.

- The sustainability of the peer network in pavement forensics must be encouraged to keep the Rigid Pavement Knowledge Management System updated.

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Appendix A:
Key Word Glossary for
Rigid Pavement Forensics KMS

Key Word Glossary for Rigid Pavement Forensics

A. Rigid Pavement Types

Continuously Reinforced Concrete Pavement (CRCP)
Jointed Concrete Pavement (JCP)

B. Material Sampling and Testing Terms

Air Content
Compressive Strength
Core
Density
Dynamic Cone Penetrometer (DCP)
Falling Weight Deflectometer (FWD)
Flexural Strength
Ground Penetrating Radar (GPR)
Indirect Tensile Strength
Modified Texas Triaxial
Modulus of Elasticity
Sawed Sample
Slump
Thermal Coefficient of Expansion (TCE)
Thickness
Unit Weight

C. Rigid Pavement Distress Terms

I. General Conditions

Aging (Materials)
Construction Defects
Deterioration
Fatigue (Mechanics)

Joint Failure
Materials-Related Distress
Premature Concrete Distress
Structural Defects
Structural Deterioration

II. Cracking

Average Crack Spacing
Corner Breaks
Cracking
Cracking in Overlay
Crazing
D-Cracking
Durability Cracking
Joint Reflective Cracking
Longitudinal Cracking
Map Cracking
Microcracking (and micro-cracking)
Spalled Cracks
Stress Cracking
Surface Cracking
Transverse Cracking
Transverse Shrinkage Cracking

III. Layer Interface and Surface Issues

Blistering
Debonding
Delamination
Scaling
Shattered Slabs
Slaking
Spalling

IV. Deformation

Bending
Buckling
Deformation
Distortion (Structures)
Reduction in Bending Stiffness
Warping

V. Surface Course Irregularities

Asphalt Patches
Concrete Patches
Divided Slab
Eroded Area
Low Skid Resistance
Map Cracking and Scaling
Patch/Patch Deterioration
Popouts
Potholes
Punchouts
Ride Quality
Roughness
Scaling
Slabs with Longitudinal Cracks
Skid resistance
Smoothness
Surface Course Irregularities

VI. Corrosion

Corrosion
Electrochemical Corrosion
Fretting Corrosion
Galvanic Corrosion
Stray Current Corrosion
Pitting
Stress Corrosion

VII. Subgrade Swelling, Movement and Conditions

Blowups (Pavements)
Delayed Ettringite Formation (DEF)
Differential Settlement
Ettringite [formation]
Expansive Heave of Black Pyritic Shale
Faulting
Faulting of Transverse Joints and Cracks
Heaving [same as blowup, a TRT term]
Lane-to-Shoulder Dropoff
Lane-to-Shoulder Separation
Pumping
Pumping Index
Voids
Water Bleeding

VIII. Aggregate Issues

Alkali-Silica Reaction (ASR)
Polished Aggregate
Segregation (Aggregates)

IX. Joint Issues

Debris in Joints
Joint Failure
Joint Seal Damage
Joint Spacing Issues
Longitudinal Joint Seal Damage
Spalling of Longitudinal Joints
Spalling of Transverse Joints
Transverse Joint Seal Damage

D. Distress Causes and Manifestations

Accidental Loadings:
    Spalling, Cracking
Acid Attack:
    Disintegration, Rust Staining, Cracking, Spalling
Aggressive-Water Attack:
    Holes, Rough surface, Sand present
Alkali-Carbonate Rock Reaction:
    Map or Pattern Cracking, Swelling
Alkali-Silica Reaction:
    Map or Pattern Cracking, Swelling
Cavitation:
    Pitting, Roughness
Construction Errors:
    Scaling, Crazing, Dusting, Discontinuities, Cavitation Erosion, Bug Holes, Honeycombing,
    Cold Joints, Structural Cracking, Failure, Separations, Freezing, Flaking Off
Corrosion of Embedded Metals:
    Corrosion of Embedded Metals, Staining, Parallel Cracks
Drying Shrinkage:
    Fine, Shallow Cracks
Externally Generated Temperature Changes:
    Pattern Cracking, Spalling
Freezing and Thawing:
    Surface Scaling, Parallel Cracks

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Inadequate Structural Design:
  Spalling, Cracking
Internally Generated Temperature Changes:
  Regularly Spaced Cracks Perpendicular to Larger Dimension of Concrete
Miscellaneous Chemical Attack:
  Surface Disintegration, Spalling, Opening of Joints/Cracks, Protruding Aggregates
Plastic Shrinkage:
  Wide, Shallow and Isolated Cracks
Poor Design Details:
  Cracking, Ponding, Saturated Concrete, Encrustations
Settlement and Movement:
  Faulty Alignment of Structural Members
Sulfate Attack:
  Map and Pattern Cracking, General Disintegration

Appendix B:
Example of
Legacy Knowledge Interview Questions

EXAMPLE
Legacy Knowledge Interview Questions

1. Tell me about one or more rigid pavement forensic investigations that taught you something important about rigid pavement design, construction, materials, or maintenance. (This can be a formal forensic investigation situation, which also involved Austin division employees, or it can be a time that only you or you and other district personnel were asked to look at a distressed rigid pavement.) What did each teach you?

2. Have any of your experiences looking at distressed rigid pavements led to changes in the specifications used by your district? If so, please explain the situation and what changes were made.

3. Are there any district or statewide TxDOT databases that you have consulted and found to provide helpful information when investigating a distressed rigid pavement? If so, how were they helpful?

4. Has traffic data ever been an important consideration as you investigated a distressed rigid pavement investigation? If so, what were those situations?

5. Have construction inspection and/or test records provided you valuable insights during a past investigation of a distressed rigid pavement? If so, how so?

6. If there are things that you particularly look for in the construction inspection records and test data, which things may indicate possible causes for –

> Spalling
> Cracking around joints
> Punch outs
> Poor skid properties
> Poorly spaced and wide cracks
> Pumping at joints or cracks
> Other performance problems

7. Please describe the steps you take after you are asked to investigate a rigid pavement performance problem (i.e., what do you do or look at first, second, third, etc.).

8. What are situations, in your experience, when taking cores or other samples from a rigid pavement was helpful or even necessary in diagnosing the problem and determining optimal rehabilitation action?

9. What would you like to pass on to others about the selection of repair materials and methods when repairing or rehabilitating premature rigid pavement with:

> Spalling

Cracking around joints
Punch outs
Poor skid properties
Poorly spaced and wide cracks
Pumping at joints or cracks
Other performance problems

10. Are there specific types of pavement testing equipment that you have found particularly useful when conducting a rigid pavement forensic investigation? If so, what type(s) of pavement testing equipment and data did you find most useful?   Also, what type(s) of premature pavement distress was involved when this test equipment proved particularly useful in the investigation?

11. Are there specific laboratory tests you have found particularly useful in conducting a rigid pavement forensic investigation? If so, what type of laboratory test and data did you find useful?   Also, what type of premature pavement distress was involved when this laboratory test proved particularly useful in the investigation?

12. Have you found it useful to contact paving contractors or materials industry personnel to discuss a pavement performance problem during a forensic investigation? If so, who do you typically contact and for which types of performance problems?

13. Are there any manuals, research reports, websites, or other sources of information about performing rigid pavement forensic investigations that you would recommend as excellent resources for a new district pavement engineer?

14. Are there any aspects of this interview where photographs and/or video would be essential in conveying the information that you have provided? If so, are these visual aides already available?

15. Are there individuals (your district, Austin divisions, universities) that you typically contact when you have a rigid pavement performance problem to investigate? Do you typically ask them to accompany you during the investigation or do you usually only consult with them by phone or by email?

16. In your experience, in what situations should a district consider requesting a formal forensic pavement investigation?

17. Do you have any other input/advice for TxDOT personnel in the districts or divisions about rigid pavement forensic investigations or processes?

Appendix C:
Example of
Interview Invitation Letter

June 3, 2005

Mr./Ms.
Texas Department of Transportation
Fort Worth District
P.O. Box 6868
Fort Worth, Texas 76115-0868

Dear Mr./Ms.   :

Thank you so much for your willingness to provide "legacy knowledge" for the benefit of
TxDOT personnel in the years ahead.

As described to you in our phone conversation today, you have been identified as
someone possessing particularly valuable knowledge and insights gained from rigid
pavement forensic investigations. This information may include some unique insights
into how best to perform forensic investigations, what causes certain types of distress,
and how distressed pavements should be rehabilitated. You may also be aware of
revisions made to construction or maintenance specifications based on distresses you
investigated in the field. The valuable information that you provide by interview will be
transcribed by the research team, and after your approval, some or all of the information
provided will be made available to TxDOT personnel across the state. Access to this
information will be via TxDOT's intranet. A new knowledge management system being
created by TxDOT will hold the information and make it available to TxDOT users.

It is our desire to schedule this interview at the time and location most convenient for
you. Someone from our research team will contact you to set up your interview.

It is anticipated that this interview, which will be audio-taped, may last about two hours.
It will be a completely informal interview, and it will be limited to the questions on the
attached list. The interview questions are provided to you in advance so that you may
give a little thought to the experiences that you have had over the years and that may be
of value to share with others in TxDOT. Also, there is certainly no requirement for you
to respond to all of the questions. However, we would appreciate your careful
consideration of each question.

Again, thank you for your willingness to spend some of your valuable time meeting with someone from the research team for this interview. Your desire to provide some of the important things that you have learned so that others in TxDOT may benefit is commendable. Should you have any immediate questions, please call me in Austin at (512) 467-0000 or email me at xxxxxx@ttimail.tamu.edu.

Sincerely yours,

Paul E. Krugler, P.E.
Research Engineer & Manager of
    Research Implementation
Texas Transportation Institute

Enclosure

cc: Ahmed Eltahan, CST, Project Director
      Maribel Chavez, District Engineer, FTW

Appendix D:
Example of a
Legacy Knowledge Interview Segment

Legacy Knowledge

Moon Won's Thoughts on ....

> Faulting failure mechanism
> Value of non-eroding bases
> Value of dowel bars

A forensic investigation was conducted in 2002 on a section of plain, jointed concrete pavement on US 287 in Childress. This section included integral curb and gutter. The pavement was designed according to AASHTO 1986 guidance, constructed in 1991, and it was 13-inch thick with joints at 15-foot intervals. The pavement had joints experiencing ¼-inch to ½-inch of faulting distress. The faulting was typical for this distress type – the upstream traffic side of each joint was elevated in relation to the downstream side of the joint.

Faulting distress is often associated with water beneath the slab, which facilitates base erosion in the vicinity of the joints. For this reason, poorly stabilized bases or non-dowelled joints are frequently a factor in faulting occurrence. Well-stabilized bases meeting the requirements of Items 276 or 292 are needed to

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resist the erosive forces underneath a concrete pavement subjected to pumping action.

We did note some interesting factors when investigating this pavement faulting. We found little evidence that eroded material was being pumped up through the transverse joints. We did, however, see evidence of fine material being pumped through the longitudinal area between the sidewalk and the curb and gutter.

Ground penetrating radar (GPR) testing confirmed that there was erosion beneath the joints and that water was present there. The testing also indicated that the erosion seemed to be worse in the vicinity of a small creek that traversed the alignment of the roadway. This stream may have been an additional source of moisture to facilitate the erosion process.

This pavement study led to several important pavement design conclusions. Most importantly, it was decided to strongly recommend that all future jointed concrete pavements include dowel bars, and that the bases should be more resistant to erosion. The recommendation included that engineers should not hesitate to increase the cement content in the base to insure erosion resistance, even at the risk of creating additional cracking in the subbase layer due to drying shrinkage.

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Repair recommendations stemming from the investigation included fixing the eroded base, installation of retrofitted dowel bars, and restoring the riding surface by diamond grinding. The district opted to go with all three recommendations. The repaired pavement has been performing well after about three years under traffic.

Key Words, by Category:

Geographic Area - Childress district, west Texas, urban, US 287

Information Type - Legacy knowledge

Legacy Knowledge Source - Moon Won, May 2005 interview

Analyses Involved - Strength testing, ground penetrating radar, GPR

Rigid Pavement Distresses Involved - Faulting, transverse joints, slab erosion, pumping, eroded area, voids

Other Descriptors - Cement stabilized base, pavement design, forensic investigation, jointed concrete pavement, JCP, doweled joints, joint spacing, curb and gutter, sidewalk, longitudinal joint, stream, creek

Search Acronyms: Legacy Knowledge – Rigid Pavement – Forensic, lkrpf, Legacy Knowledge – Rigid Pavement – Design, lkrpd, Legacy Knowledge – Rigid Pavement – Standards, lkrpst

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