A SUMMARY OF KNOWLEDGE MANAGEMENT INFORMATION GATHERED FROM LITERATURE, WEB SITES, AND STATE DEPARTMENTS OF TRANSPORTATION

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CHAPTER 1: INTRODUCTION

This product documents the information gathered and reviewed by the research team during the initial task of Project 0-4505, "Develop a Knowledge Management System for TxDOT Pavement-Related Corporate Knowledge." The assessment of knowledge management state-of-the-art 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 (TxDOT) and the research team benefit from earlier knowledge management concept development as well as the experiences of others.

CHAPTER 2:
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 most relevant information is presented 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, 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 to knowledge management in the late-1990s is shown in Figure 1 *(1)*.

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).

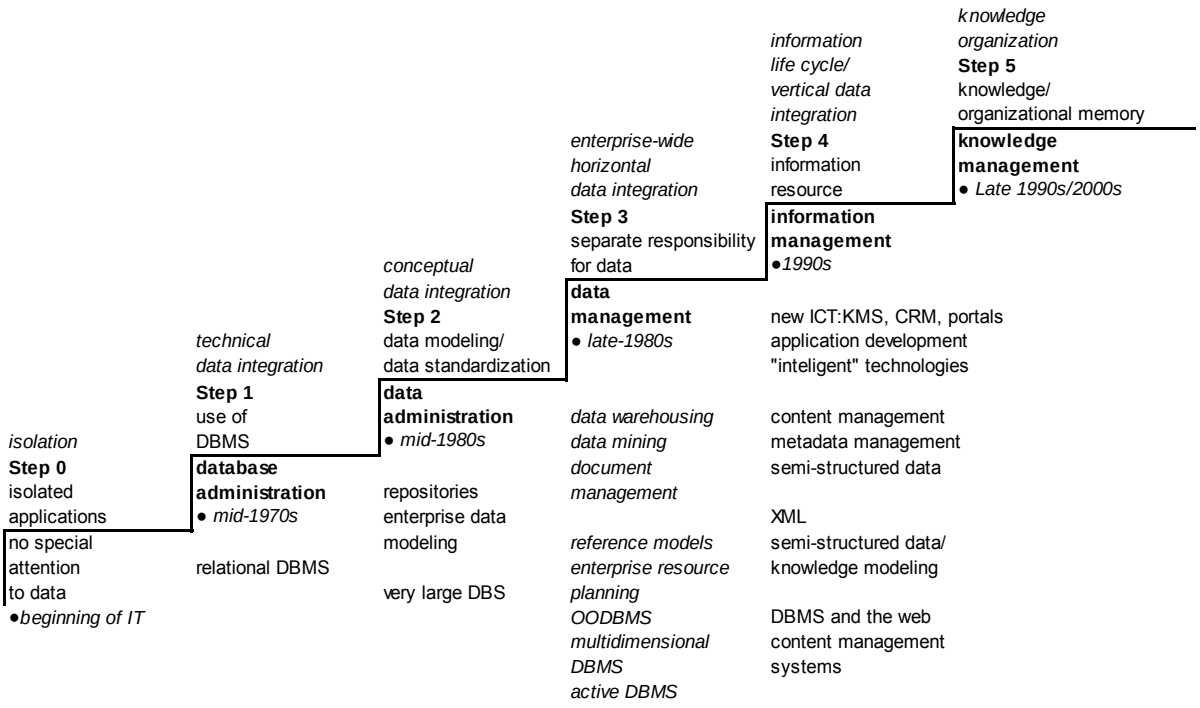

Figure 1. Historical Development of Knowledge Management *(after 1)*.

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 1966 *(2)*, Nonaka in 1991 *(3)*, Koulopoulos and Frappaolo in 1999 *(4)*, Tiwana in 2000 *(5)*, and Gamble and Blackwell in 2001 *(6)*.

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 *(3)*. 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. Three challenges are faced by an organization in this process. The first challenge is to capture and formulate tacit knowledge in a communicable form. The second challenge is to make the knowledge easily available to the entire organization. The third and ultimate challenge is to develop an organizational culture for seeking and using tacit knowledge.

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 be usually 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 education 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 in the manuals, books, and articles, or any other written document.

Knowledge Transfer

What really distinguishes an organization from another is not its explicit knowledge. 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. Preserving this knowledge and maintaining security checks through the transferring process is an additional challenge for practitioners.

To transfer knowledge through codification, tacit knowledge has to be made explicit. However, as shown in Figure 2, 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 *(7)*.

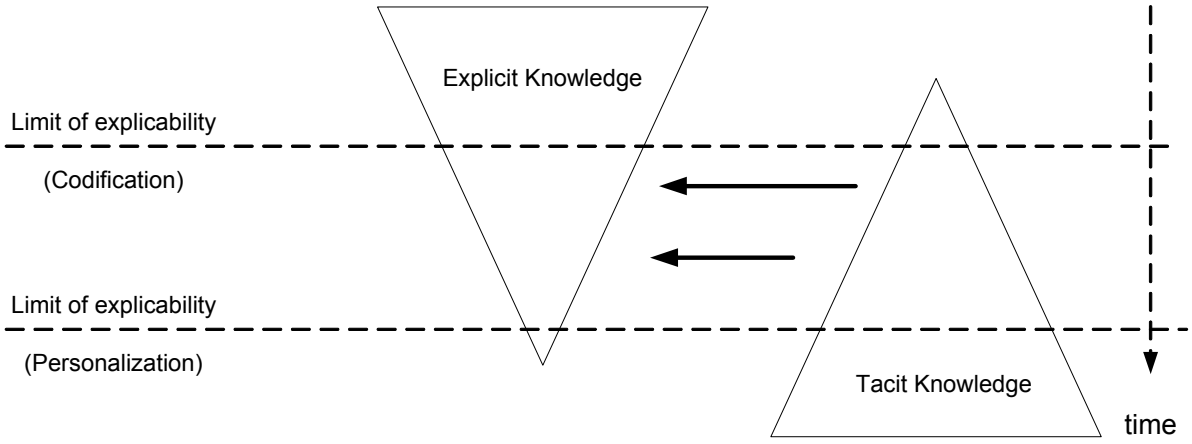

Figure 2. Limits of Knowledge Explicability *(after 7)*.

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 a successful implementation of a knowledge management system. The relationship between these forms of knowledge management is shown in Figure 3. 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.

From the human perspective, individual knowledge must be integrated into the 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-network 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 (KM) 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 implies a great level of commitment across the entire organization.

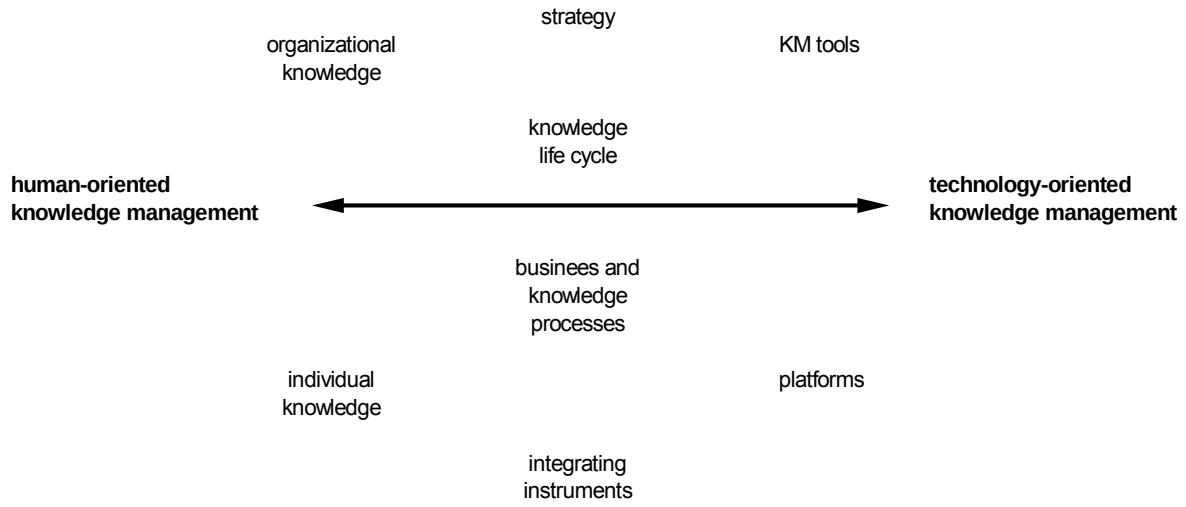

Figure 3. Human-Oriented versus Technology-Oriented Knowledge Management and Approaches to Integration *(1)*.

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. Some of these ideas may be of value during the development of the TxDOT knowledge management system.

- PROMOTE Methodology: Hinkelmann et al. proposed in 2002 a method and a software tool to model business and knowledge processes *(8)*. 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 (KITs) 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 2003. Their aim was to integrate the activities of the people involved in the processes with supporting information tools *(1)*. The method consists of a knowledge management implementation model, a knowledge management audit, an oriented 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 *(5)*. 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.

  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 will develop 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 (RDI). The second step involves leadership and the implementation of a reward structure to encourage employees using 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 4 shows the 10-step roadmap and phases proposed by Tiwana.

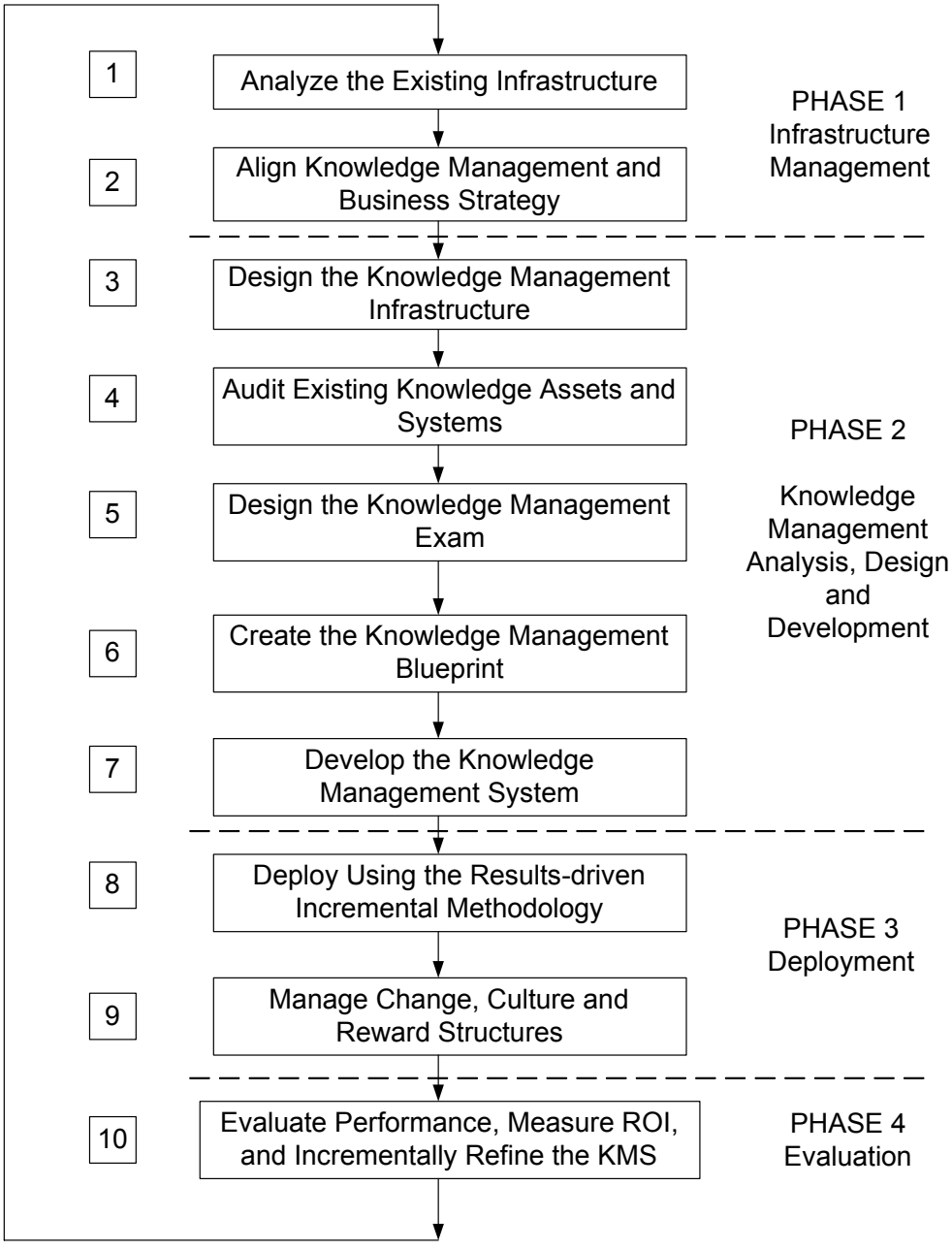

Figure 4. Knowledge Management Roadmap *(5)*.

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 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 only be focused on technologies to collect, store, and disseminate information, but also on mechanisms to sustain communities of practice wherein uncaptured tacit knowledge may be shared *(9)*.

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 5 *(10)*.

- 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.

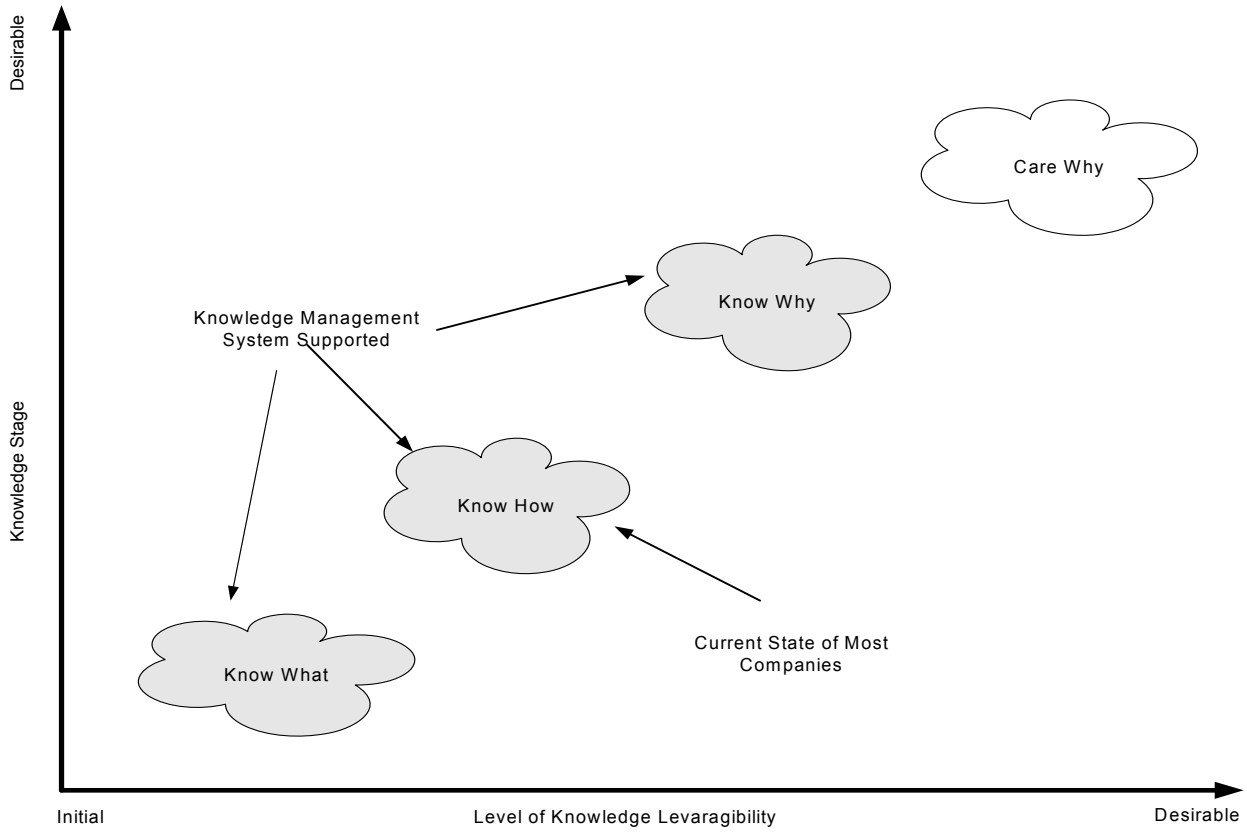

Figure 5. Stages in the Evolution of Knowledge *(after 10).*

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 enhancing 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 6. This alignment is critical for successful implementation of a knowledge management system (*11*).

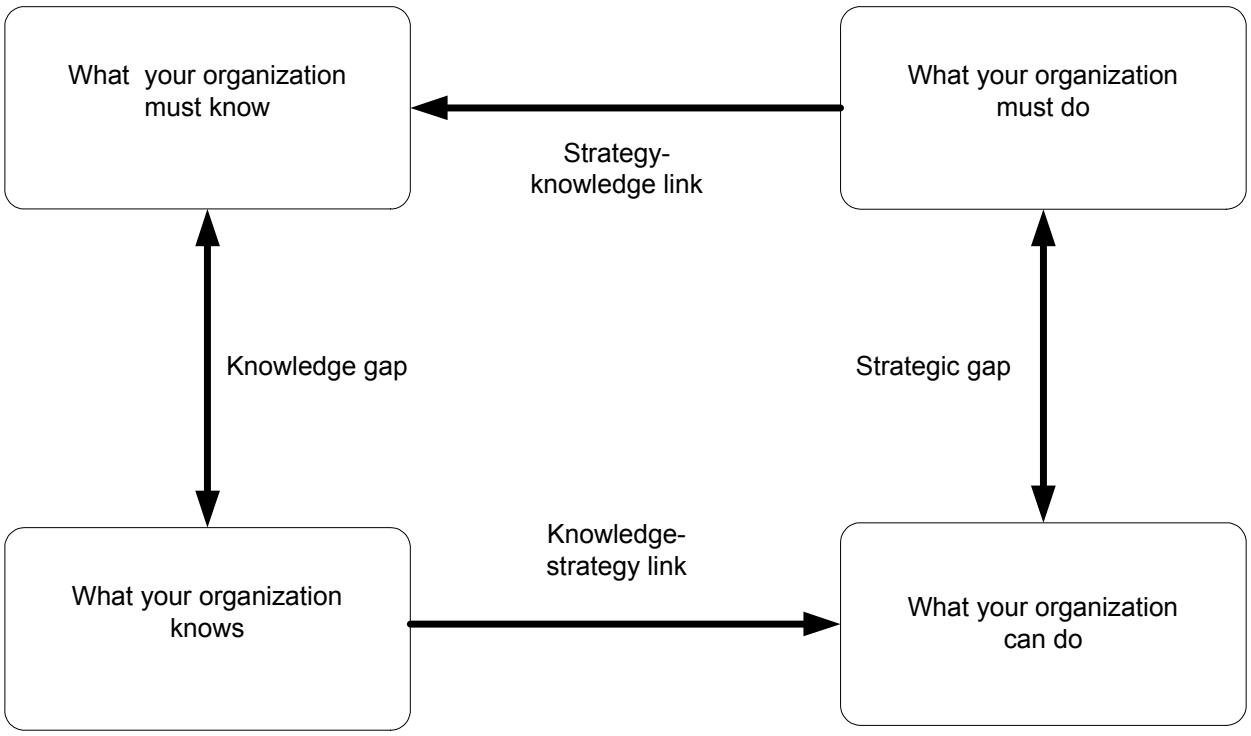

Figure 6. High-Level Framework-Based Strategic Knowledge Gap Analysis *(after 11)*.

Figure 6 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 goals. 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 6.

The involvement of knowledge management and its integration into the business process is illustrated in Figure 7. 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.

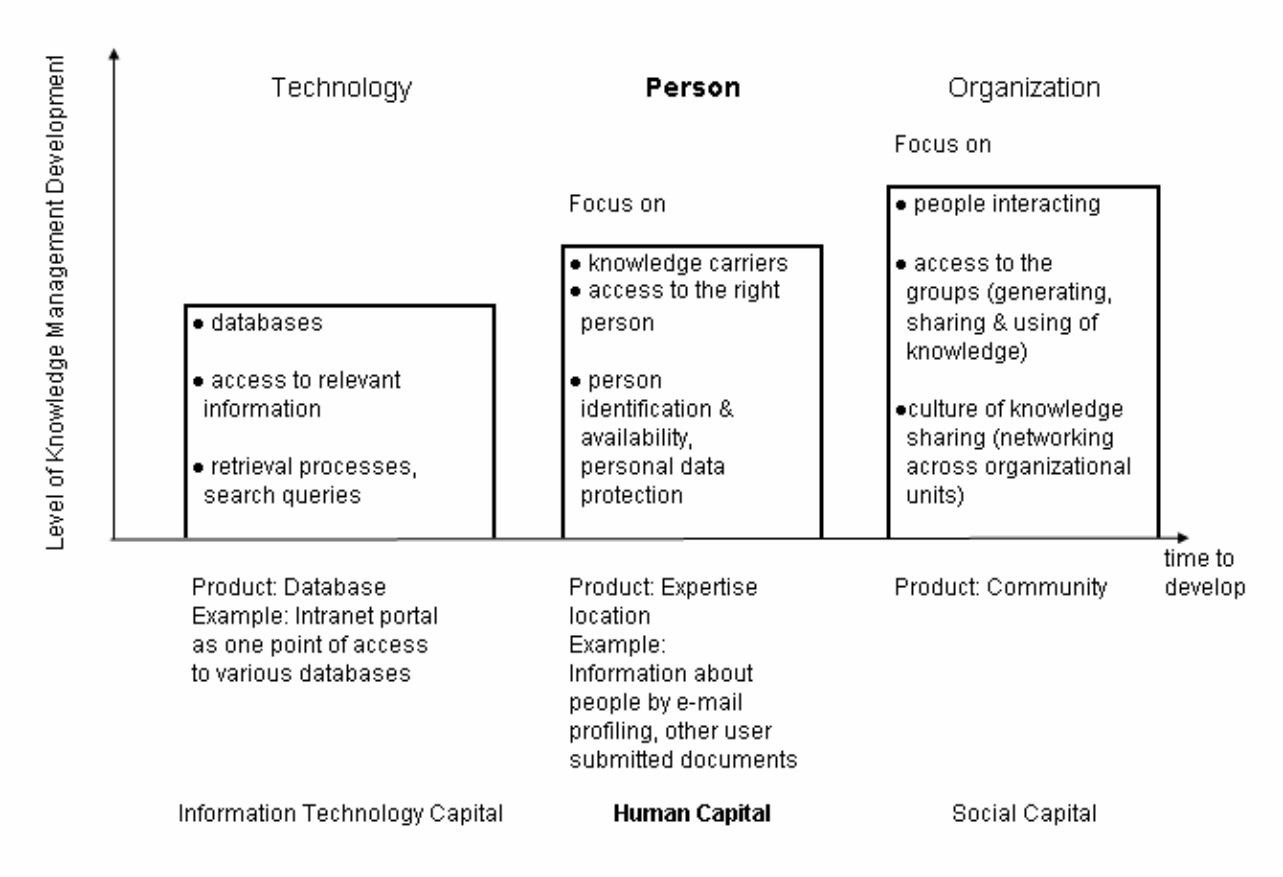

Figure 7. The Involvement of Knowledge Management in Business Processes *(after 7)*.

TXDOT FORENSIC INVESTIGATION RESEARCH PROJECTS

In an effort to develop formal procedures for conducting forensic investigations, TxDOT has supported research projects in previous years, including Project 0-1731, "Development of a Formal Forensic Investigation Procedure for Pavements" *(12)*. 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 (*13*). 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.

These research projects emphasize the need for an integrated forensic information and analysis system. The integration of forensic information would prevent storing documents in different locations and will provide a valuable resource center to support forensic activities. Analysis functional capabilities will allow minimizing time and assist forensics engineers to figure out causes of distress and possible solutions. The core component of that system is 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 should perform system analyses and enhance report-writing functionalities. As a result, ForenSys is expected to generate multiple document interfaces, such as views, tables, charts, and layouts.

Project 0-1731 concluded that "the primary purpose of forensic investigations is to determine the mechanism, or mechanisms, of the observed pavement distresses." 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. 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 study 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 is 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 8 *(14)*.

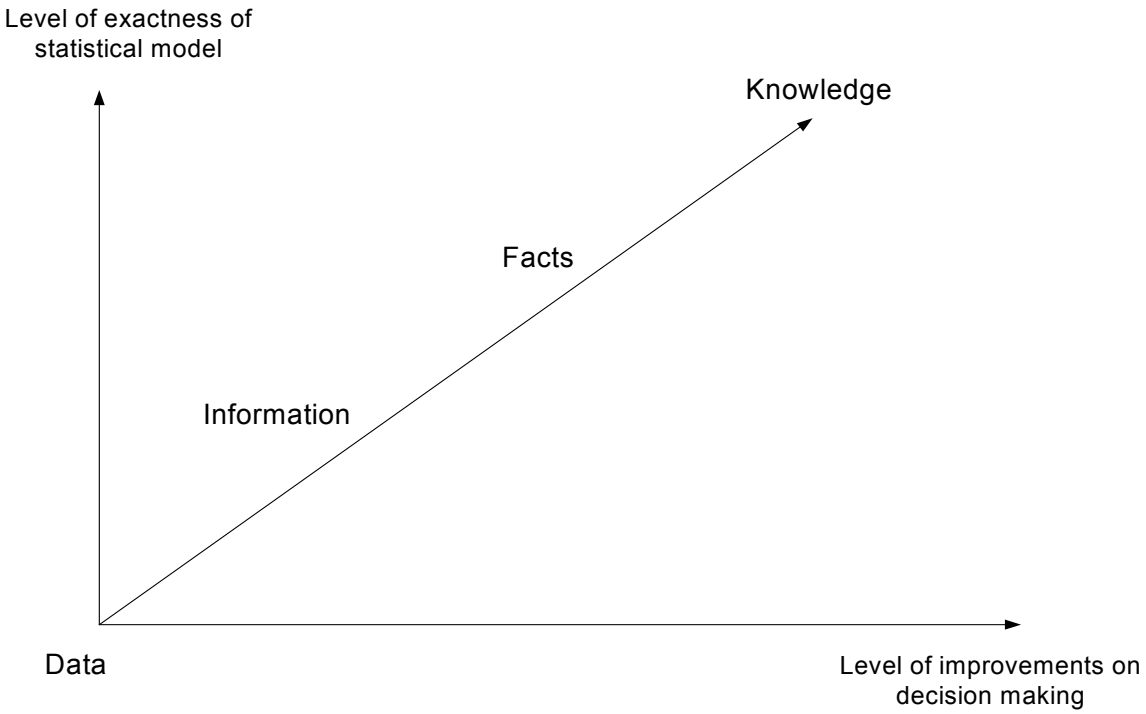

Figure 8. Knowledge Evolution Process from Data *(14)*.

The research team is also aware of another recent research project on pavement forensic. 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.

Some other efforts have been made by TxDOT 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 (FHWA) RESEARCH PROJECT: REPAIR AND REHABILITATION OF CONCRETE PAVEMENTS

The Federal Highway Administration sponsored Project FHWA-010-C00080 (*15*) 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 was used to account 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 the report.

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) which 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 3,000 to 4,000 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 *(16)*.

Texaco's knowledge management approach gives more emphasis to the importance of human connections. They believe 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 their 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. Their system is based in creating applications that capture expertise as it is created *(17)*.

BP Amoco has a different knowledge management approach. Their 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 *(18)*.

CHAPTER 3:
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 the ease of navigating the web site 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 which meets the following 10 requirements: rich in content, easy to navigate, includes open forums for discussions, portals to get access to other web-sites, 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 points.

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 only be determined 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 of having the 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 Rating

	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	KM Pro	Y	Y	Y	N	N	N	N	Y	Y	Y	3
5	KM World	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 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 group 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 (KMNetwork)

   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: 2.5

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

CHAPTER 4:
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). 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. At the current time, the Information Systems Division of TxDOT is in the final stages of interfacing this software with existing departmental e-mail services.

As part of our software product review, a brief description of alternative knowledge management systems available on the market is included. The intention of this software product review is to document alternative technologies with similar functionalities to Meridian KSI. Please note that 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 their 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 or disconnected to the network.

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

Vendor: IBM

4. OneNote®

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®

CHAPTER 5:
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 their 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 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 safe keeping. 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 especial 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 video tapes. Story telling 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 friendly interface.

Lessons Learned from PennDOT Experience

The 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 cases in which problems were encountered should also be included. 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. Problems in populating knowledge into repository software systems were faced during the 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 semi-annual meetings are recommended.

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

The TTI research team appreciates and acknowledges the information provided by Marleen Steele. Ms. Steele works at the Center for Performance Excellence of the 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 of interest 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 LCMS 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. Keywords 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. With these methods the top contributors in each community of practice can be identified. 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).

The TTI research team appreciates and acknowledges the information provided by Maureen Hammer, director of the Knowledge Management and Technology Transfer Office at the Virginia Department of Transportation.

CHAPTER 6:
CONCLUSIONS

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 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 by formal study through some type of education process.

What really distinguishes an organization from another is not its explicit knowledge. 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 into corporate knowledge, 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 are faced by 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 and ultimate challenge is to develop an organizational culture for seeking and using tacit knowledge. Preserving this knowledge and maintaining security checks through the transferring process are additional challenges for practitioners.

ORGANIZATION COMMITMENT

The creation of uniqueness due to knowledge is not a static concept; indeed, knowledge growth is a steady, ongoing process. This dynamic perspective of knowledge sustainability implies a great level of commitment across the entire organization.

The importance of the alignment of an organization's knowledge culture and approach with its organizational strategy is emphasized by the literature. This alignment is critical for successful implementation of a knowledge management system.

A balance between human-oriented knowledge management and technology-oriented knowledge management is also critical for a knowledge management system. To achieve this balance there is a need to develop a strategy to integrate organizational knowledge into knowledge management tools.

TXDOT FORENSIC INVESTIGATION RESEARCH PROJECTS

The objectives of previous research projects for TxDOT forensic investigations highlight the need 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. Research projects emphasize that an integrated forensic information and analysis system is required. The integration of forensic information would prevent storing documents in different locations and will provide a valuable resource center to support forensic activities. Analysis of functional capabilities will allow minimizing time and assist forensics engineers to determine causes of distress and possible solutions.

KNOWLEDGE MANAGEMENT WEB SITE REVIEW

Some of the insights obtained by reviewing the web sites that our research team consider valuable to the project are:

- the need of having the 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.

VISION OF KNOWLEDGE MANAGEMENT IN OTHER STATE DEPARTMENTS OF TRANSPORTATION

The PennDOT knowledge management system relies upon specialized communities of practice in which knowledge is gathered and disseminated. PennDOT visualizes the knowledge management processes 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 safe keeping. From PennDOT's perspective,

implementation of a knowledge management system is best begun in a community of practice that already actively shares knowledge among members. The need for a moderator responsible for each community of practice within the knowledge management system is also emphasized. The moderator is responsible for monitoring the progress of the community of practice and oversees knowledge sharing among its members.

VDOT has a similar model based on communities of practice for its knowledge management system. The LCMS Meridian staging site is the repository system 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. Keywords are used to locate documents based on this taxonomy.

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