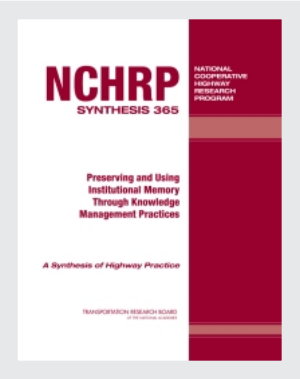

Preserving and Using Institutional Memory Through Knowledge Management Practices

DETAILS

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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Preserving and Using Institutional Memory Through Knowledge Management Practices

A Synthesis of Highway Practice

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SUBJECT AREAS
Planning and Administration

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TRANSPORTATION RESEARCH BOARD

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FOREWORD

By Staff
Transportation
Research Board

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice.*

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

This synthesis report documents practices regarding the preservation and use of institutional memory through the knowledge management (KM) practices of U.S. and Canadian transportation agencies. It identifies the practices for the effective organization, management, and transmission of materials, knowledge, and resources that are in the unique possession of individual offices and employees. Issues covered include: Does the agency have a KM program? Who has overall responsibility for KM practices? Is there an agency library, and sufficient staff or financial resources? Have materials to be retained been identified? Are there written guidelines for the retention of historical materials? and what tools are available for capturing and storing KM resources? Exemplary practices for KM from other professions are included.

Surveys were returned from 38 transportation agencies [34 U.S. state departments of transportation (DOTs), three Canadian provinces, and one Canadian city]. A literature survey was conducted to identify trends and practices within the transportation community. In addition, three case studies are provided as examples of DOTs with KM programs at various stages. Detailed survey responses can be found in the appendices, as well as those sections covering the literature survey.

Maryanne Ward, Consultant, Mount Vernon, Washington, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

PRESERVING AND USING INSTITUTIONAL MEMORY THROUGH KNOWLEDGE MANAGEMENT PRACTICES

SUMMARY

This TRB Synthesis Report documents practices regarding the preservation and use of institutional memory through knowledge management (KM) practices of the 50 U.S. state transportation agencies (STAs) and the Canadian provincial transportation agencies. There are a number of important reasons for STAs to better preserve and manage institutional memory, including:

- Facilitating and expediting training and succession management in light of the unprecedented numbers of long-term STA employees who are retiring or otherwise departing;
- Needing to build on past understandings and improve efficiency when providing the information and knowledge so that managers, professionals, and technicians can deliver agency programs effectively, on time, and within budget;
- Doing more with fewer resources;
- Answering requests from legal staff for information to support agency positions in litigation;
- Integrating historical perspectives and lessons learned into current transportation agency activities and decision making; and
- Striving to respond efficiently and accurately to requests for information from elected officials, media, historians, researchers, and the public.

Because these needs are increasing in magnitude and urgency at a time of diminished agency resources, this synthesis study is both timely and appropriate.

Of the 38 transportation agencies returning questionnaires [34 U.S. state departments of transportation (DOTs), three Canadian provinces, and one Canadian city], seven reported having a successful KM process robust enough to continue through staff and administration changes. Nineteen STAs in all reported having a KM-related program in existence at some organizational level and in varying states of development. Thirty-three STAs reported that they are making efforts to retain the knowledge of retiring employees.

Specifically, this synthesis documents STA practices, at a practical level, for preserving and enabling use of internally generated knowledge resources—that is, on those materials, knowledge, and resources in the unique possession of individual STAs at the program, policy, project, and project detail levels. It also contains an annotated literature survey, interviews, and other resources detailing practices from transportation and other types of organizations.

For this synthesis study, the following definitions of key terms apply throughout:

- Institutional memory—"the body of knowledge, formal as well as informal, that is essential to the continuous and effective functioning of the agency at all levels" (contributed by Dr. Howard Rosen, University of Wisconsin, Madison).
- Knowledge—"the combination of data and information, to which is added expert opinion, skills, and experience, to result in a valuable asset which can be used to aid decision

making. Knowledge may be explicit and/or tacit, individual and/or collective" (*European Guide to Good Practice in Knowledge Management, Part 1,* 2004, p. 6).

- Knowledge management (KM)—"a trans-disciplinary approach to improving organizational outcomes and learning, through maximizing the use of knowledge. It involves the design, implementation, and review of social and technological activities and processes to improve the creating, sharing, and applying or using of knowledge" (*Australian Standard,* 2005, p. 2).

Therefore, throughout this report, the term "knowledge management" or its abbreviation, KM, refers to business management practices that maximize use of knowledge, whether the organizations are government agencies, businesses, or non-profits, and regardless of where the "home office" is located.

Throughout this report references and understandings are drawn from the global community. A literature survey was conducted to identify trends and practices utilized both within and beyond the U.S. transportation community. Indeed, as the annotated literature survey reveals, KM is an international phenomenon. The trend worldwide in the current global economy is to treat knowledge as an asset. Organizations are increasingly integrating knowledge into the overall management of organizations by establishing KM-specific business strategies and processes. Many of the most helpful references came from non-U.S. sources.

The literature survey revealed that KM processes are recognized as the business processes underlying the management of knowledge as an asset, comparable to physical, financial, and human resource assets. The literature survey focused on examples of very current practices from a wide range of organizations, practices, and literature types, as opposed to more theoretical or evaluative literature. An effort was made to include references that are reasonably accessible to STA employees who, although they may have KM responsibilities, may not have easy access to major academic libraries or document repositories. In short, the emphasis is on the practical application of KM practices.

The literature survey focused first on standards or guidance documents issued by internationally recognized standards-developing organizations. These types of documents are useful because they emerge from a broad consensus process and therefore offer a distilled view with input from many quarters. Most documents of this type are "international," in that they were not issued by U.S. standards-developing organizations. Indeed, as our literature survey annotations revealed, KM is an international phenomenon, with excellent references from the International Standards Organization (ISO), The European Committee for Standardization (CEN), Australia, Great Britain, and Denmark.

Probably the most helpful overall treatment of KM as a business process is documented in the five-part *European Guides to Good Practice in Knowledge Management* published by CEN. The framework or context within which KM as a business process, at both the organizational and the personal level, is carefully demonstrated within a strong overall business focus. This is important. As seen from the questionnaire results, there is weak implementation among STAs of KM as an intentional, purposeful business process. Knowledge is generally not seen as an asset of sufficient importance to warrant organization-wide attention.

Gathering some key concepts from these *Guides,* the organization needs to define its mission, vision, and strategy in regards to KM. A culture of motivation is necessary, in which people are respected, feel a sense of trust, belonging, and empowerment. Knowledge activities are seen as an integral part of wider business processes, and should be value adding, clearly communicated, understood, and accepted. Roles and responsibilities must be made clear. Individuals need to be acknowledged and rewarded for their contributions. The environment must be conducive for people meeting, working together, and sharing ideas and experiences.

Many actual day-to-day practices were derived from the literature. There are a wide range of activities from many disciplines documented in the literature. It is this eclectic, trans-disciplinary approach that our literature sources indicate is fundamental to success. Some categories of practical practices, some of which might be termed "technical" and others "human resource," are:

- Content management,
- Knowledge taxonomies,
- Groupware,
- Online communities of practice,
- Enterprise portals,
- Social network analysis and design,
- e-learning,
- Storytelling and narratives,
- Wireless tools for knowledge mobilization, and
- Innovation and idea management systems (*Knowledge Management Tools and Techniques,* 2005, pp. 1–21).

This study indicates that, just as the management of other asset types requires specifically skilled professionals such as in the case of financial assets, accountants, budget experts, forecasters, banking, or financial analysts, and so on, so too do certain professions play lead roles in the management of knowledge assets.

In our definition, KM is described as "trans-disciplinary." This is an important concept that implies that certain facets or functions of historically separate professional disciplines are being intermingled to create something new. Many disciplines may find a home under the KM umbrella; however, the most important are organizational science and human resource management, computer science and management information systems, library science, and information management.

KM acts as an umbrella under which the skills of these historically separate disciplines are integrated in what may be hitherto unknown ways to create a single, increasingly coherent business management process. These disciplines have long histories with disparate philosophies, professional cultures, habits of mind, and skill sets. In some organizations, they may be in direct competition. The challenge of managers is to mesh the various necessary skill sets into a single integrated business process without destroying what is valuable and necessary from each. It is easy for professionals to be dismissive or even unaware of the capabilities of professionals from other disciplines. For example, the librarian may underestimate the skill needed by computer scientists for ensuring robust, reliable, secure handling of large databases with business-critical content. Likewise, the human resource manager may have a simplistic understanding of the complex practices developed over decades by librarians worldwide to properly procure, organize, codify, maintain, and provide access to collections of literally millions of intellectual resources, including books, periodicals (in hardcopy or electronic format or both), CDs, videotapes, websites, virtual collections, content-only databases, etc. In turn, the information technologist may be naïve about or unappreciative of the human resource professional's skill in forming high-performing work teams, managing succession strategies, and establishing cultures conducive to knowledge sharing.

That said, although professionals as described earlier drive the KM business process, all staff must be involved. Just as every employee shares responsibility for taking stewardship of the physical resources of an organization—using facilities wisely, minimizing waste of space or utilities, conserving on electricity, storing hazardous materials properly, maintaining equipment under their care, etc.—so, too, must all employees engage in stewardship over knowledge assets as is appropriate given their individual business responsibilities.

Thirty-three STAs reported specific efforts to capture the knowledge of experienced retiring or exiting employees, which indicates that there is widespread recognition that this area warrants attention. Key findings show that

- The exit interview was the most common effort made.
- Rehiring arrangements on temporary or contract basis are common.
- Seven STAs reported having a succession plan process in place.
- A few STAs assign individuals to document expertise.
- A few STAs assign knowledge-capturing tasks to senior staff.

Overall, the questionnaire data do not show that STAs typically have purposeful, ongoing enterprise-wide programs to deal with leave-taking in a methodical manner, on an ongoing basis, as part of the normal business process.

As shown in the literature survey, many organizations embed KM practices into their normal business processes to ensure that employees stay on the job, retirements are anticipated, and leave-taking is not an unexpected event, but a normal part of the human resource side of the KM business process.

Questionnaire results did not reveal that ongoing, day-to-day purposeful programs and practices for sustaining internal knowledge transfer as a normal business process that engages all employees and provides a smoother path for staff leaving and changes is widespread among STAs.

Nineteen STAs (including New Brunswick, Canada) have adopted elements of KM programs or are trying to do so. The questionnaire defined the practices generically, and made clear that it was the practices themselves that were of interest, regardless of the terminology used in the agency to describe them.

From the questionnaire results, it was determined that most KM efforts are being made by individual work units, are what could be termed "piecemeal" projects, or are pilot programs. Although these may be very useful and effective within their work units, overall agency-wide KM business strategies that permeate the culture and help define how business is done throughout the agency were not commonly found to exist. In addition, few STAs reported procedural or policy documentation that broadly define and support KM business practices.

From the many initiatives and processes reported by STAs, it was found that there is substantial attention paid to institutional memory issues and specifically implementation of KM practices in the individual STAs at some level or by some individuals. However, a commonly acknowledged understanding of KM business processes among agencies was not found in a manner similar to, for example, that of physical or financial assets.

Some STAs stand out. Certainly, Virginia, with its Knowledge Management Office and range of practices is one. Its program is approximately two years old, according to the respondent, but enjoying robustness within the agency. Texas, with its forensic pavement program and other initiatives, is another. The Texas Department of Transportation (DOT) sees the forensic pavement program as a possible model for future initiatives. The California DOT, challenged by a large decentralized agency, has many sharing in the responsibility. It also has a unique History Program established by formal written policy in 1984, which created a History Center in the Library and a statewide History Preservation Committee. The Ohio DOT has a strong KM initiative derived from its library function, with robust attention paid to bringing external knowledge into the organization in a sophisticated, systematic manner, and with strong ties to transportation-rich repositories. Arizona, Kansas, Kentucky, Missouri, and Ohio reported enterprise-wide KM programs, with Idaho, Minnesota, Nebraska, New Brunswick, Pennsylvania, and Virginia indicating that although they had enterprise-wide programs, they were in "roll-out" phase.

When it came to STAs that indicated their KM programs were robust enough to continue through staff and administration changes, the list shortened to eight (see Table H1 in Appendix H). Ten STAs reported that their programs were not evenly supported or well communicated by management, and four indicated that their programs might not survive a new budget cycle or top administration changes. This suggests that even enterprise-wide recognized programs are not well-embedded as a normal, ongoing KM business process, and knowledge itself is not necessarily seen as a strategically important business asset.

This conclusion is supported by the few STAs that reported using metrics to gauge the effectiveness of their KM programs (see Table H3 in Appendix H). In addition, eight STAs have training or mentoring programs to help staff transferred to new jobs, new hires, or those new to leadership understand the agency's KM practices and how to make the best use of KM resources (Table H4, Appendix H).

As to points-of-contact to which individuals may turn when information is needed, the preponderance of responses indicated that there is typically no specified central point of contact or office with coordinating responsibilities, and that employees have to "know where to go." The most common responses were that

- Individuals must go to different work units, depending on what is needed.
- On an informal basis, individuals go to knowledge individuals or supervisors.
- Individuals spend a lot of time figuring out where things are.

This finding may point to inefficiencies in business processes, because searching for internal documents and information can be an important source of non-value-added activity, especially for professionals, who are most likely to need the information to carry out their work, and whose labor costs are relatively high. Note that those STAs that have formal libraries were more likely to indicate them as the central point-of-contact.

Taking these examples of STAs developing KM as a business process together with examples from the literature sources surveyed, one can conclude that the worldwide trend is to develop KM business processes ubiquitously throughout organizations with strong support and recognition from every level of management. The literature survey lists management standards that incorporate and even require that knowledge and document practices be embedded into the management process. Worldwide, countries, international organizations, and individual companies and government agencies are integrating KM practices into their business processes.

Taking into consideration the responses to questions regarding cultural receptivity, authority, leadership, day-to-day responsibilities, and management expectations, management attention in the STAs can be characterized as "passively positive." In other words, there is does not appear to be aggressive or assertive leadership from the executive level; however, neither is there pervasive or persistent negativity. One can conclude from the job titles of those with KM responsibilities that most KM practices occur from bottom-up or middle-out initiatives. The data do not indicate that managing knowledge as a valuable asset is a top priority of top-level STA executives. There is a lack of normal, ongoing established business processes, similar to those for physical, financial, and human assets.

Most STAs with KM programs have at least one professional librarian on staff. There is at least a correlation and there may be a causal connection. Of the original 19, five did not have a professional librarian on staff, and one of those hired a contract librarian to help with certain functions. One—Idaho—has a formal library but no professional librarian on staff. Although librarians traditionally are valuable in managing the interface between the agency and the world of external information, their professional skills are needed in an enabling role in internal KM implementations. It is incumbent on librarians to merge their skills with information technology (IT) and human resource professionals to build organization-wide robust comprehensive KM programs.

There are currently few human resource professionals assigned to KM responsibilities in STAs. A review of the current literature and the practices of two institutions with well-developed KM programs, NASA and the World Bank, revealed that their current KM programs incorporate human resource professional expertise. Indeed, their skills are paramount in helping organizations deal with tacit knowledge, knowledge transfer, incorporating new understandings or lessons learned into training programs, incorporating KM skills and competencies into performance evaluation and award systems, facilitating workshops and communities of practice, establishing mentoring systems, social network analysis, facilitating after-action face-to-face meetings, etc.

The World Bank, and other organizations revealed by the literature survey, have harnessed IT skills to set up sophisticated, transactional web-based databases, and use web portals and other web-based technologies to manage KM resources. NASA, for example, is seeking to harness web technology in a more sophisticated fashion by pulling together "views" of employees, from résumés to project descriptions to project charging systems, to identify expertise. It is apparent that strong IT skills, in a supporting role to core operations, especially in the area of web portal design and integrated transactional databases, are important in organizations where KM pervades the culture. The literature survey revealed that both IT and library science skills play important enabling roles in the KM business process.

Based on the responses to questions regarding specific practices, tools, and techniques employed, STAs use those that can be characterized as more traditional practices, which see knowledge capturing as mostly a by-product of normal work in the form of compiling and keeping normal work documentation by means of a records management system. Some STAs are implementing enterprise-wide electronic document management systems to manage, store, and provide ongoing access to this type of documentation. Most efforts appear to be in the area of documentation, which is very important, especially as organizations move from hardcopy to e-documentation. Indeed, both NASA and World Bank interviews revealed that the first phase of KM implementation involved a conscious and major effort in document management, which became an institutionalized ongoing platform to support other initiatives.

Current understandings of KM, as revealed by the literature survey, however, revealed human-resource-oriented methods as of vital importance. STAs use these methods less frequently. Such approaches include communities of practice, knowledge-generating teams, oral interviews, lessons learned, face-to-face workshops, or social network analysis, all of which specifically target implicit knowledge in people's minds. Also, more complex IT-oriented approaches, such as transactional portals tying multiple databases together for project management, sophisticated staff expertise identification through databases, advanced web-based approaches, such as team-share or "push" technologies, or incorporation of enterprise-wide taxonomies to apply subject tagging to content repositories are less often used by STAs.

When it comes to storing KM resources, the biggest concern is in discrepancies between storage and preservation of hardcopy as opposed to electronic resources. Practices for hardcopy appear to be well ensconced in traditional, well-developed records management programs. Practices for electronic resources, however, are less well defined, and seem to be based mostly on format rather than on the type of document or content. For example, in the hardcopy environment, one could expect very different handling practices for, say, an agenda for a specific meeting as opposed to a formal final project report. There was no clear indication that this kind of differentiation in handling based on type of document or content has been resolved for the electronic environment. This also proved true regarding the question on destroying or making knowledge resources obsolete.

In most STAs, there does not seem to be an overall focused strategy to provide clear access paths to explicit KM resources. The emphasis appears to be on which department "owns" it, rather than on the end-user who needs it. The results show that in most cases the user must "know where to go" depending on the nature of the resource. In the matter of identifying and

finding stored KM resources for application to current work and decision making, the most common responses indicated that overall, it depends on which work unit is handling the resource. Individual STAs reported a variety of finding tools, mixtures of databases and manual (hardcopy) indexes, databases, clearing-house-type websites, and knowledgeable individuals. A few states reported an intranet portal, which presumably offers a "one-stop-shopping" approach by means of some kind of unified display screen with links to various resources. Iowa and Minnesota reported on electronic document/records management systems. The Virginia DOT noted that an effort to create an enterprise-wide taxonomy is underway to allow searching of multiple repositories simultaneously. However, a clear strategy of providing a kind of "one-stop-shopping" approach conceived of from the point of view of the employee looking for and needing the resources rather than from the work unit that "owns" the resource was not apparent.

Once the resources are identified, however, most DOTs reported that physical resources, at least, are stored in reasonably convenient and accessible locations, and that decisions to move or destroy records are done carefully, probably the result of well-established records management programs. Seven DOTs reported a high priority to get KM resources available to the desktop, however; two have a "push" or proactive system. Therefore, perhaps one can conclude that hardcopy resources are more readily available than electronic ones.

Overall, the main conclusion from the questionnaire results is that institutional memory practices exist at some level in at least 19 STAs; however, overall strategic intentionality or conscious effort are not strongly evident in most STAs on an agency-wide basis. Exceptions are documented in the case studies.

In general, the main conclusion is that institutional memory practices exist at some level in at least 19 STAs; however, overall strategic intentionality or well-implemented business processes are not present. As revealed in the literature search and interviews, KM practices are generally not as well defined or measurable as other business processes. In recent years, KM practices have been implemented as an underlying internal process to support organization's evolution into customer-oriented, team-based, highly flexible, global enterprises, where internal knowledge is viewed as a major asset. There is not a set protocol or clear path for implementation such as may exist, for example, in the management of financial assets. Thus, it takes creativity and careful strategizing to implement KM practices that actually deliver benefits and are embedded in day-to-day operations. According to *CEN Workshop Agreement* 14924-1, efforts in many organizations have typically taken an IT approach initially; however, the *Agreements* were written specifically to help organizations align culturally and socially to take advantage of knowledge sharing within and beyond their organizational boundaries. This people-centric approach adds value to technology-focused initiatives. The goal is to put in place the cultural, human, environmental, and technical ecology necessary to take advantage of collective knowledge.

CHAPTER ONE

INTRODUCTION

BACKGROUND

This synthesis report documents how state transportation agencies (STAs) use knowledge management (KM) practices to preserve and enable use of institutional memory. STAs can use this report as a resource for assessing their own institutional memory management practices.

There are a number of important reasons for STAs to preserve and manage institutional memory. These include:

- Facilitating training and succession management in light of the unprecedented numbers of long-term department of transportation (DOT) employees who are retiring or otherwise departing;
- Needing to build on past understandings and improving efficiency when providing the information and knowledge that allow managers, professionals, and technicians to deliver agency programs effectively, on time, and within budget;
- Budget-wise, doing more with less;
- Responding to requests from legal staff for information to support agency positions in litigation;
- Integrating historical perspectives and lessons learned into current transportation agency activities and decision making; and
- Striving to respond efficiently and accurately to requests for information from elected officials, media, historians, researchers, and the general public.

At a time of diminished agency resources, these needs are growing in magnitude and urgency. Therefore, this synthesis study is both timely and appropriate.

STAs have adopted a wide range of approaches in response to these needs for the management and preservation of historically significant material. This study identifies the practices followed by STAs for the effective organization, management, and transmission of documents and other forms of knowledge to current employees and the next generation of leadership at the program, policy, and project detail levels.

SCOPE

Specifically, this synthesis documents the extent and nature of STA practices and approaches to, or lack thereof, at a practical level, for preserving and enabling use of internally generated knowledge resources—that is, on those materials, knowledge, and resources in the unique possession of individual STAs at the program, policy, project, and project detail levels. Also included are an annotated literature survey, interviews, and other resources detailing practices from transportation and other types of organizations.

OVERALL FINDINGS

Of the 38 STAs returning questionnaires, seven reported having a successful KM process robust enough to continue through staff and administration changes. Nineteen STAs reported having a KM-related program at some organizational level and in varying states of development. Thirty-three STAs reported making some efforts to retain the knowledge of retiring employees.

METHODOLOGY AND ORGANIZATION OF REPORT

A brief questionnaire was distributed by e-mail to each state's TRB Research Advisory Committee member, soliciting the name of an individual knowledgeable about the agency's KM practices, and able to respond to a more detailed questionnaire. Drawing on a review of the relevant literature, a questionnaire was prepared to gather information on current practices within each DOT. On January 21, 2006, the questionnaire was sent by e-mail to the designated individuals in all 50 states and Canadian provinces. The questionnaire is in Appendix A.

Thirty-four U.S. state DOTs, three Canadian provinces, and one Canadian city returned completed questionnaires. Organizations that returned the questionnaires are listed in Appendix B. The first question on the questionnaire asked whether specific efforts were being made to capture the knowledge of experienced retiring or exiting employees. Questions 2, 3, and 4 probed whether the STA had knowledge-related programs or elements of such programs in place at some level within the agency. Those STAs that responded affirmatively to any of these three questions were asked to finish the questionnaire, which probed the nature of the STA's knowledge-related activities, specific practices, staffing, etc. Those who responded negatively were asked to return the questionnaire without proceeding further.

Chapter one introduces the report and puts the concept of institutional memory and its relationship to KM in perspective

and provides definitions. Chapter two is a summary of the literature survey. Chapter three analyzes the results of the STA questionnaire and the literature survey regarding leave-taking. Chapters four through eight analyze the results of the questionnaire regarding overall KM practices in STAs. Chapters nine and ten present transportation-related and non-transportation-related case studies. Chapter eleven presents the conclusions.

The appendices (A–L) contain the questionnaire itself, job titles and STA affiliations of the respondents, detailed questionnaire results, and an annotated literature survey.

DEFINITIONS AND TERMINOLOGY

For this synthesis study, the term institutional memory is defined as "The body of knowledge, formal as well as informal, that is essential to the continuous and effective functioning of the agency at all levels."

This heretofore unpublished definition is attributed to Dr. Howard Rosen, University of Wisconsin, Madison, as part of his participation as a panelist for this synthesis topic.

This definition was chosen from among many in the literature because it succinctly states key concepts:

- Both formal and informal knowledge are present and necessary.
- To be worthy of memory (formal remembering in this case), the content in the body of knowledge must be essential, implying thoughtful winnowing and synthesizing.
- The body of knowledge is not preserved for its own sake, but because the agency needs it for continuous functioning; implying long-term, systematic attention over time. Without the body of knowledge functions may become ineffective, broken, or disjointed.
- The body of knowledge is necessary at all levels, implying that all employees have responsibilities regarding the creation and preservation of the body of knowledge, and also can expect to be able to use it as necessary to be effective in their own work.

To further refine our understanding, there is a need to be more precise about what is meant by knowledge. The literature survey revealed that KM as a business process is being applied much more robustly in Europe, including Great Britain, and in Australia than in the United States. These entities have advanced to the stage of standards writing, which implies a certain consensus on the value of the KM business process. Thus, for a specific workable definition of knowledge, the European Committee for Standardization (CEN) was used:

> The combination of data and information, to which is added expert opinion, skills, and experience, to result in a valuable asset, which can be used to aid decision making. Knowledge may be explicit and/or tacit, individual and/or collective (*European Guide to Good Practice in Knowledge Management, Part 1,* 2004, p. 6).

This definition lays out the following key concepts:

- Knowledge is a *combination* not only of data and documents, but of information, expert opinion and judgment, skills, and human experience.
- Knowledge is an *asset,* implying value and necessity for management attention and control.
- Knowledge *has value,* not for itself, but because it is used to aid decision making.
- Knowledge may be *explicit,* captured in a document, DVD, e-mail, chart, book, content database, or similar medium.
- Knowledge may be tacit, held only in the minds of people.
- Knowledge *may be held* by a single individual or may be generally understood by many (collectively).
- KM is a *business management process.*

To clarify further, knowledge differs from information (G.T. Shin, personal communication, May 15, 2006). To summarize this communication, information is organized data and is captured in inorganic systems, perhaps on tape, on digital media, in books, handwritten documents, graphs, charts, tables, etc. Knowledge, on the other hand, is created by an individual internalizing and digesting information. It changes over time in various ways as it evolves and matures with accumulated experience, and it is active—it drives and informs action.

Increasingly, the practices for managing an organization's institutional memory are gathered collectively under the trans-disciplinary business management process known as KM. In organizations, accumulated knowledge can be considered the fourth major asset to be managed as part of typical business processes, comparable to physical assets (buildings and equipment), financial assets, and human resources (HR). Geiger et al. (2005) referred to knowledge as an asset in their report on asset management practices. When discussing the Alberta Infrastructure and Transportation agency, they describe the agency's asset management information system, citing the system's benefits:

- Enables gaining best life-long returns on investments;
- Documents the rationale for investment decisions;
- Provides the tools to achieve excellence in all phases of asset creation and maintenance;
- Enables preservation and optimum use of knowledge assets, such as data, information, and human capital; and
- Provides an effective and efficient learning tool (p. 33).

However, there is a need to define KM more specifically. Some definitions for KM emphasize it as a tool for business competitiveness; others are so vague as to yield little guidance for practical implementation. For this synthesis, the best definition, in our opinion, is formulated in Australian Standard AS 5037-2005:

> Knowledge management—A trans-disciplinary approach to improving organizational outcomes and learning, through max-

> imizing the use of knowledge. It involves the design, implementation, and review of social and technological activities and processes to improve the creating, sharing, and applying or using of knowledge (p. 2).

Note that KM practices, as understood in this report, are directed not only to preserving historical information and institutional memory, but also to facilitating the sharing of current knowledge and practices and enabling application of prior knowledge to current work.

PROFESSIONAL RESPONSIBILITIES

In this synthesis report, the term knowledge management or its abbreviation, KM, refers to business management practices that collectively maximize use of knowledge.

Just as the management of other asset types requires specifically skilled professionals such as, in the case of financial assets, accountants, budget experts, forecasters, bankers, financial analysts, and so on, so too do certain professions playing lead roles in the management of knowledge assets.

In our definition, KM is described as "trans-disciplinary." This is an important concept; it implies that certain facets or functions of previously separate professional disciplines have been intermingled to create something new, and indeed, KM is a relatively new field. According to Chang-Albitres and Krugler (2005), KM emerged in the mid-1970s, beginning with the implementation of database management software, moving into data handling in the mid-1980s, and in the 1990s developing enterprise-wide database systems and document management systems. It emerged as a business process in the late 1990s. The authors list the disciplines having the most profound effect on the development of KM concepts as organizational science and HR management, computer science and management information systems, management science, psychology, and sociology (pp. 3–4).

The Australian standard AS 5037-2005 includes others that should be added to Chang-Albitres and Krugler's list. AS 5037 includes the related disciplines of competitive intelligence, customer relationship management, human computer interaction, information management, intellectual property management, market research, project management, quality management, records management, and risk management (*Australian Standard . . .* 2005, pp. 66–70).

Over the years, the field of library science and information management is perhaps the discipline most closely associated with KM in its generic sense. Practitioners in this field historically and currently contribute important techniques, standards, practices, and habits of mind for content and document management, especially for organizing, preserving, indexing, and codifying, and for researching and retrieving large quantities of information and documents. Even a cursory review of current trade publications aimed at librarians in specialized business or government environments reveals articles on KM. Additionally, it is certain that the skills of archivists, technical writers and editors, web content designers, historians, instructors, and similar professionals regardless of job title, should also find a home under the general umbrella of KM, depending on the needs of the organization. NASA at one time used the services of a cultural anthropologist.

KM acts as an umbrella under which the skills of these historically separate disciplines are integrated in what may be hitherto unknown ways to create a single, increasingly coherent business management process. These disciplines have long histories with disparate philosophies, professional cultures, habits of mind, and skill sets. In some organizations they may be in direct competition. The challenge of managers is to mesh the various necessary skill sets into a single integrated business process without destroying what is valuable and necessary from each. It is easy for professionals to be dismissive or even ignorant about the capabilities of professionals from other disciplines. For example, the librarian may underestimate the skill needed by computer scientists for ensuring robust, reliable, secure handling of large databases with business-critical content. Similarly, the HR manager may have a simplistic understanding of the complex practices developed over decades by librarians worldwide to properly procure, organize, codify, maintain, and provide access to collections of literally millions of intellectual resources, including books, periodicals (in hardcopy or electronic format or both), CDs, videotapes, websites, virtual collections, content databases, etc. In turn, the information technologist may be unaware or unappreciative of the HR professional's skill in forming high-performance work teams, managing succession strategies, and establishing cultures conducive to knowledge sharing. Moreover, to make matters even more complicated, each discipline's long-established practices must evolve as they are pressed into service in new challenges and relationships.

That said, although the professionals described earlier lead and drive the KM business process, all staff must be involved. Just as every employee shares responsibility for taking stewardship of the physical resources of an organization—using facilities wisely, minimizing waste of space or utilities, conserving on electricity, storing hazardous materials properly, maintaining equipment under their care, etc.—so too must all employees engage in stewardship over knowledge assets as is appropriate given their individual business responsibilities.

KNOWLEDGE MANAGEMENT AS BUSINESS MANAGEMENT PROCESS

History of Knowledge Management as Business Process

KM has a relatively short history as a recognized business management process. Conceptually, it has been discussed and written about, especially in the business literature, since the early 1970s. The Library of Congress (http://www.loc.gov) apparently did not use the term "knowledge management" as

an authorized subject heading in its catalog until about 1997. As of this writing, the Library has applied the term to only 95 titles published before 2000. It has applied the term to 519 post-2000 works, including, as of January 2006, 38 with 2006 publication dates. Two 2006 publications are encyclopedias, which may signal a certain maturation of the field: *Encyclopedia of Communities of Practice in Information and Knowledge Management* and *Encyclopedia of Knowledge Management.*

Categories of Knowledge Management Activities

This report focuses on specific practices for preserving and using institutional memory—that is, an organization's body of knowledge. Typically, these specific practices fall into the following broad categories of activity:

- *Creating* or *developing* knowledge;
- *Transferring* knowledge from one human mind to another in "non-tangible" form (often termed "tacit") through, for example, communities of practice, face-to-face discussions, interviews, or roundtable sessions;
- *Capturing* knowledge in explicit form, as in written documents or in media such as videos, training films, photographs, graphics, presentations, and oral history interviews by trained transportation historians;
- *Storing* knowledge in some fashion for future use, as in databases or physical repositories;
- Providing *finding* and *identification tools* such as indexes, codification systems, or search software;
- *Using* by applying prior knowledge to current work; and
- *Reevaluating, validating, modifying, or destroying* knowledge when it becomes obsolete or is found to be erroneous.

CHAPTER TWO

SUMMARY OF FINDINGS FROM LITERATURE SURVEY

In the literature survey for this synthesis study, the focus was primarily on selected recent references that explore specific KM practices. Authors vary in their points of view on KM, depending in part on chronology and in part on their own professional expertise. Earlier writings focused more on technology, more recent writings on HR aspects. The most recent writings emphasize combinations of approaches using technology, human resources, organizational development, and physical and digital document and content-rich repositories (people issues, process issues, and technology).

Chapter two summarizes the findings from the literature survey and puts them into context in light of the findings from the responses given by the STAs to the questionnaire. Note that the literature survey findings regarding leave-taking have been included with the questionnaire results in chapter three.

All references are annotated in the appendices and complete citation data are given in the References. Appendix J is an annotated literature survey of relevant standards and guidance documents issued by internationally recognized standards-developing organizations. These types of documents are useful because they emerge from a broad consensus process and therefore offer a distilled view with input from many quarters. All of the documents referenced in Appendix J are "international," in that they were not issued by U.S. standards-developing organizations. To our knowledge, the U.S. standards-developing community, as coordinated by the American National Standards Institute, has not published standards or recommended guidelines on KM, although the Malcolm Baldrige Award does include "measurement, analysis, and knowledge management" as one of its seven criteria. This award is given by the President of the United States to businesses—manufacturing and service, small and large—and to education and health care organizations that apply and are judged to be outstanding in seven areas: leadership; strategic planning; customer and market focus; measurement, analysis, and KM; HR focus; process management; and results. However, there are excellent references from the International Standards Organization (ISO), CEN, Australia, Great Britain, and Denmark.

Appendix K contains an annotated literature survey from a variety of sources organized around these topics:

- Knowledge as an asset
- KM as a business process
- HR and organizational development in KM
- Trans-disciplinary nature of KM
- Characteristics of successful KM programs
- Specific KM practices
- Measuring KM effectiveness.

Appendix L contains annotated resources of various types, including websites, academic institutions, and other resources.

LITERATURE SURVEY SUMMARY: KNOWLEDGE AS AN ASSET

In a sense, the two references to Peter Drucker's writings in this literature survey can be considered a set of bookends. There may have been others, but Peter Drucker laid out the overall concept of knowledge as a valuable asset that needed management attention in 1969. Thirty years later, he reaffirmed that, in his view, "the most important area for developing new concepts, methods, and practices will be in the management of society's knowledge resources" (Drucker 1997, p. 24). During the ensuing 30 plus years, KM has come of age as a business process.

Leonard-Barton (1995) also saw knowledge as an asset, but her special emphasis was on how cultural climate affects an organization's ability to take full advantage of knowledge as an asset. She moved beyond document management and information technology (IT) as sole key drivers, to include the "human resource" or what might be called the people-centric dimension. In her view, that dimension is needed to maximize our knowledge assets.

Leonard-Barton's view of the importance of knowledge as central to an organization's success was reinforced by business writers Nonaka and Takeuchi (1995) who claimed that KM is not something done simply at the personal level by professionally trained, conscientious employees, but is an organization-wide responsibility, at all levels. Their view was that knowledge creation was the most important factor behind the competitive success of Japanese firms. Indeed, the concept of managing knowledge as an asset, comparable to financial, physical, or human assets, is gaining in importance worldwide.

ISO 9004 *Quality Management Systems—Guidelines for Performance Improvements* (2000) sets the stage for a wide-scale implementation of KM, because it specifically requires (for those organizations seeking certification) that both tacit

and explicit knowledge is continually developed as a necessity to decision making and innovation. As a high-level quality management document, it does not provide specific tools and techniques, leaving that for individual organizations to work out within their own context; however, because these standards are being adopted worldwide means that specific KM business processes are also being implemented by organizations worldwide.

Often, standards such as ISO 9004 are regarded as a requirement. For example, organizations seek certification when they have met the requirements of certain standards. However, standards also can be used as references, especially as a starting point when an organization is developing a new business process or making substantial changes. These documents typically do not detail exactly how to execute management processes or specific practices, but they do specify what types of processes are necessary or recommended. Therefore, it is not suggested, for example, that STAs adopt any single standard or set of standards as a requirement within their own STA. It is not necessary to actually seek ISO 9000 certification, for example, to make use of the ISO quality management standards.

However, in the case of standards issued by the ISO, it is noteworthy that to become certified an organization must implement the specific business processes detailed in the standard. At the end of 2004, 670,399 certificates had been awarded worldwide to business and industry, non-profit, and government organizations. The ISO website also notes that there has been a transition, and as of 2004 the service sectors are by far the biggest users of the standards, as compared with the manufacturing sectors that were formerly the predominant users (see http://www.iso.org/iso/en/commcentre/pressreleases/archives/2005/Ref967.html). This widespread adoption of a standard in which knowledge is spelled out as an important business asset that must be managed is significant and points to a growing understanding of the necessity of developing business processes to accomplish a task.

The Malcolm Baldridge Award is given by the President of the United States to businesses—manufacturing and service, small and large—and to education and health care organizations that apply and are judged to be outstanding in seven areas: leadership; strategic planning; customer and market focus; measurement, analysis, and *knowledge management;* HR; process management; and results. The award process examines the management, effective use, analysis, and improvement of data and information to support key organization processes and the organization's performance management system (see http://www.quality.nist.gov/).

LITERATURE SURVEY SUMMARY: KNOWLEDGE MANAGEMENT AS BUSINESS PROCESS

As seen, ISO 9004 *Quality Management Systems—Guidelines for Performance Improvements* sets the stage for wide-scale implementation of KM. Although it does not describe specific processes, it indicates that to meet the general quality management requirements, organizations must develop business processes for handling knowledge assets.

The five-part *European Guides to Good Practice in Knowledge Management,* published by the European Committee for Standardization, fills a gap between ISO 9004 and an organization's specific implementation of KM. The framework or context within which KM is a business process, at both the organizational and the personal level, is carefully laid out within a strong overall business focus. This is important. As seen from the questionnaire results, there is inadequate implementation of KM among STAs as an intentional, purposeful business process. Questionnaire results show that STAs do not routinely view knowledge as an asset of sufficient importance to warrant agency-wide attention. STAs wanting to understand the KM business process may find these *Guides* useful.

Gleaning some key concepts from these *Guides,* it is noted that the organization needs to define its mission, vision, and strategy with regard to KM. A culture of motivation, in which people are respected, feel a sense of trust, belonging, and empowerment is necessary. Knowledge activities are seen as an integral part of a wider business process, and should be value adding, clearly communicated, understood, and accepted. Roles and responsibilities must be made clear. Individuals need to be acknowledged and rewarded for their contributions. The environment must be conducive for people meeting, working together, and sharing ideas and experiences.

Furthermore, as for any other business process, the *Guides* indicate that there must be measurements of effectiveness. Technology and infrastructure must be in place to support the business process. Nontechnical facilities such as dedicated meeting rooms, help desks, and office spaces arranged to stimulate knowledge-sharing behavior are also needed. Knowledge assets must be captured so that they will remain when the employees depart. The *Guides* discuss change management, because implementation of a KM system will inevitably require changes, perhaps even in the basic beliefs and behaviors of management and employees.

According to Davenport (2005), KM business processes cannot simply be imposed on top of existing processes. de Holan et al. (2004) assert that tacit knowledge must be articulated and made explicit. The whole process must be routizined and codified. Explicit knowledge must be communicated. In other words, the whole process involves systems thinking and institutionalization of processes.

Gordon and Grant (2005) provide us with basic understandings about some of the challenges around the concept knowledge-as-power, which they discard for a better approach: knowledge-as-strategy. Gupta and Govindarajan (2000) warn us that technology infrastructure is not the answer, but the enabler.

Hammer et al. (2004) articulated that the goal is to get more out of the organization's knowledge assets. The need is to improve the performance of the end-to-end business process by eliminating non-value-adding work. Indeed, Kucza (2001) spelled out such a systems approach by defining a KM business process model.

Taken together, this brief summary of the literature survey regarding KM as a business process indicates the necessity of developing an overarching business process, rather than a piece-meal "bottoms up" or even "middle out" approach. The annotated literature survey gives much more supporting evidence.

LITERATURE SURVEY SUMMARY: BARRIERS TO KNOWLEDGE MANAGEMENT

The *European Guide to Good Practice in Knowledge Management, Part 2: Organizational Cultural* reviews the common barriers to the implementation of KM as a business process (p. 7):

- Time and priority;
- Difference between management statements and actions;
- An enduring notion that "knowledge is power";
- Apathy about sharing knowledge;
- "Not invented here" syndrome;
- Reward systems that mitigate again knowledge sharing;
- Differing cultures and subcultures;
- Knowledge travels by means of language, and there may not be a common organizational language;
- Considering the organization to be "machine-like";
- Organizational "amnesia";
- Growth in "virtual" working can hinder as well as help;
- Overemphasis on technology or inadequate supporting technology; and
- Knowledge does not grow forever, and organizations and individuals should unlearn and leave behind old ways of thinking.

In the course of this research, interviews, and personal reflection, other impediments to strong business process implementation were observed, including:

- "Hero" syndromes.
- A system in which individuals believe that they must remain indispensable and therefore do not or will not share knowledge.
- Employees seeing knowledge work as added on to an already over-full plate.
- Lack of balance among disciplines; that is, over-reliance on IT as driver and not as enabler, over-reliance on documentation, or overreliance on people-to-people approaches.
- Insufficient IT skills to develop sophisticated databases that handle textual information as something other than just "data," necessitating applications of taxonomies, superior searching capabilities, etc.
- Development of numerous startups, pilots, small work unit efforts, etc. without a coherent enterprise-wide strategy or a "systems thinking" holistic approach.
- Inability of a small KM work unit to handle the workload required to get KM practices sufficiently developed so that they can be spun off to work units.
- Insufficient effort by KM specialists to spin off practices and develop ownership by affected group, thereby freeing themselves up to develop new initiatives.

LITERATURE SURVEY SUMMARY: HUMAN RESOURCE AND KNOWLEDGE MANAGEMENT

A review of our literature survey annotations reveals that KM has evolved from focusing on IT to a focus on document and content management. Most recently, the people-centric approach has joined these earlier disciplines to create a more coherent holistic process.

Leonard-Barton (1995) relatively early on articulated the importance for KM of the people-centric view, especially for all managers and levels of managers, as opposed to the commonly held view at the time that IT managers were mostly responsible. Gilmour (2003) also recommended a shift from the "publishing" model to the brokering model, based on collaboration management.

Australian Standard AS 5037 focuses on "the continuum of the knowledge ecosystem" (p. 18). It calls for an environment where the organization is "knowledge aware." There is fluidity about the organization and it can adapt readily to external factors. Networks can form, de-form, and re-form, according to their own life cycle (p. 19).

There are barriers to inserting people-centric approaches. According to the *European Guide to Good Practice in Knowledge Management, Part 2: Organizational Culture* (pp. 12–13) these can include:

- Illusion of invulnerability
- Collective rationalization
- Illusion of morality
- Shared stereotypes
- Direct pressure
- Self-censorship
- "Mind guards," where people screen out information from outsiders that challenges the group's assumptions and beliefs
- Illusion of unanimity.

The document goes on to discuss that these barriers can be mitigated by forming communities of interest, practice, or purpose. Values, belief, and trust come into the process. So do leadership styles; the credibility of leaders especially, but

also of individuals; and motivation that surpasses the stress inherent in the change process. Some useful tools for strengthening the people-centric approach are:

- Community building,
- Observing and questioning,
- Coaching and mentoring,
- Narrative, and
- Conversation and dialogue.

LITERATURE SURVEY SUMMARY: TRANS-DISCIPLINARY NATURE OF KNOWLEDGE MANAGEMENT

In chapter eight, "Reflecting" (Australian Standard AS 5037), it states that KM promises deeper insights into an organization's content and culture and its surrounding ecosystem than other business processes. This chapter reviews the emergence of KM as a discipline in the 1990s. Two strategies emerged: the first focused on collection, storage, and reuse of explicit knowledge in documents and IT systems. Much of the data gleaned from the STAs in this synthesis fell into this category. NASA and the World Bank both started at that point in their own KM developments. The NASA interview revealed that its engineers and other technical professionals expressed frustration over the inability to find documents they knew existed; therefore, the first order of business for the KM Office was to correct that. The World Bank did the same thing, institutionalized it as a day-to-day ongoing operational process, and then went on to more people-centric processes.

The second early strategy focused on connecting people to people, where KM was seen as a social communication process with emphasis on tacit (personal) knowledge.

Today, KM is a blending of these alternatives within specific organizational contexts, and concentrates on a balance among the four elements: people, process, technology, and content (Australian Standards AS 5037-2005, p. 60). The Australians have contributed much to our understanding with the publication of this standard, which is not prescriptive, but a guideline.

All organizations require an influx of knowledge from the outside in an organized, systematic manner to refresh them. Librarians and professionally managed libraries can play a key role in the KM business process.

Newer skills involving classification, ontology, thesaurus construction, and information architecture development are important for constructing useful electronic repositories. NASA and the World Bank are both developing integrated, transactional databases that pull together multiple repositories. For example, when searching for potential team members, résumés, project documents, accounting charge records, and other data can be pulled together to create a composite view of an individual's expertise.

LITERATURE SURVEY SUMMARY: SUCCESS FACTORS ASSOCIATED WITH SUCCESSFUL KNOWLEDGE MANAGEMENT PROGRAMS

The following list is derived from many sources given in the literature surveys' toolbox of success factors.

Cross and Baird (2000)

- Managers determine which lessons are worth learning
- Managers deliberately develop organizational memory
- Personal relationships are turned into organizational know-how
- Knowledge rapidly finds its way into a distributed database
- Learning processes are quickly structured to incorporate new knowledge into daily activities
- New knowledge is constantly embedded into databases, work processes, support systems, products, and services
- Leverage the knowledge in databases with technology that enables dialogue.

Davenport and Glaser (2002)

- Specialized knowledge is baked into the jobs of highly skilled workers by embedding it into the technology workers need to do their jobs
- Ensure a measurement-oriented culture
- Ensure IT professionals know the business as well as the technology.

Davenport et al. (1998)

- Money is saved or earned—evidence of financial gain
- Broad infrastructure of both technology and organization
- Balanced structure that is flexible and evolutionary
- Knowledge is easy to access
- People are positive about creating, using, sharing knowledge
- Project contains motivators
- People may use multiple channels to transfer knowledge
- Growth in number of resources
- Growth in volume of content
- There is strong likelihood the project will survive without support of particular individuals
- Pervasive desktop and communications technologies
- Established roles and organizational groups whose members have skills to serve as resources for others
- Structured repository with categories, key terms, indexes, etc.
- Responsibility for controlling decisions about knowledge structure assigned
- "Knowledge-friendly" culture
- "Hero" mentalities are avoided
- Use language common to company culture
- Raw, undistilled data does not get into repository
- Concepts are framed in business terms employees can understand
- Incentives and motivational aids are not trivial and are tied to overall evaluation/compensation system

- Senior managers send message that KM is crucial to organization, provide funding and other resources, clarify what types of knowledge are important.

Zack (2003)
- Attention is paid to application of existing knowledge
- Attention is paid to creation of new knowledge
- Worrying is not about "who works for whom," but on "who needs to work with whom"
- Organization learns from customers
- Information is extracted from outside organization
- KM activities are aligned with the organization's strategy
- Internal and external knowledge gaps are recognized and closed
- Mission and purpose are defined in terms of knowledge
- Position within the industry is defined in terms of knowledge
- Strategies are formulated with knowledge in mind
- Customers are segmented by how much can be learned from them
- Organization is transformed into a learning organization
- Cost of learning is seen as an investment, not a cost
- HR management is taken seriously
- Business model is thought out, taking knowledge into consideration.

European Guide to Good Practice in Knowledge Management, Part 2: Organizational Culture (2004)
- Barriers have been investigated and addressed
- Individuals understand and can respond appropriately to cultural dynamics
- High emotional intelligence
- Actions show recognition of the importance of relationships between individuals, working groups, organizations, and interorganizations
- Policies and behaviors indicate an awareness of and ability to support knowledge
- Use of informal and formal time encourages knowledge sharing
- Organization is seen as dynamic entity with key points of expertise
- Organization is structured in line with knowledge strategies
- Individuals are coached into appropriate behaviors
- Leadership qualities are valued and developed
- Credibility is important
- Recognition is a social benefit of effective communities of practice
- Motivation is strongly linked to personal recognition
- Importance of knowledge in developing competencies understood
- Importance of sharing knowledge is made clear to staff
- Concepts and practices of a learning organization are understood
- Policies and management support developing communities
- Employees use good judgment in deciding between internal and external resources
- Coaching draws competence from the recipient
- Storytelling is encouraged
- Good meeting skills are developed
- IT tools used for collaboration, knowledge capturing
- IT systems have sufficient buy-in for long-term usability.

LITERATURE SURVEY SUMMARY: SPECIFIC KNOWLEDGE MANAGEMENT PRACTICES

This research did not reveal a better compendium of specific tools and techniques for KM than Australian Standard AS 5037-2005 *Knowledge Management* (2005, pp. 35–52). Some are more people-centric, some emphasize people-to-documents or explicit content, and still other are specific technological efforts. This document is probably the single most useful document referenced in this report. It approaches KM as an "ecological" process that integrates a rich, eclectic diversity of people-centric, people-to-documents or content and technological approaches. The document lists, together with descriptions, what are termed "enablers"—specific practices that together underlie the KM business process. Not only is this an excellent list of practices, but it also shows how various professional disciplines underlie the entire KM process.

- After-action reviews
- Business process mapping
- Champions and advocates
- Change management
- Communities of interest
- Communities of practice
- Content management
- Critical incident technique
- Document management
- Environmental scanning
- Information auditing
- Knowledge auditing
- Knowledge literacy
- Knowledge mapping
- Leadership
- Learning and development
- Leveraging information repositories
- Meetings and "share fairs"
- Mentoring and coaching
- Narrative management
- Networks and communities
- Physical environment
- Play theory
- Reflection
- Rewards and recognition
- Social network analysis
- Storytelling
- Strategic conversations
- Taxonomies and thesauri
- Technological integration

- Technologies for communication and knowledge sharing
- Technologies for discovery and creation
- Technologies for managing repositories.

Knowledge Management Tools and Techniques: Practitioners and Experts Evaluate KM Solutions (Rao 2004, pp. 1–21) is also a rich source of tools and ideas. Included are examples and case studies. Rao provides the following tool categories, with some specific examples for each included here:

- *Content management*—codification; authoring templates; multiple content types; sources; corporate libraries; personnel directories; videos; company policies; external and internal websites; presentations; press releases; powerful abstracts; successful practices; innovations; lessons learned; meta-data features including classification, tagging, and validation; and web portals.
- *Knowledge taxonomies*—tools with pre-built taxonomies; tools with dynamically and automatically generated taxonomies; and using these tools with human interventions, context-sensitive taxonomies, manual classification of content, clearly stated meta-data requirements, and terminology standardization.
- *Groupware*—tools for affinity building, knowledge mapping, threading, polling, group/collaborative document creation, e-mail, instant messaging, and meeting–thinking sessions.
- *Online communities of practice*—web-based communities, peer-to-peer sharing of insights, best practice sharing, knowledge sharing, innovation, learning, collaboration, accountability rather than anonymity in knowledge networks, expertise directories, and networked virtual environments.
- *Enterprise portals*—IT platforms of choice, on-demand workplace, single points for interaction and collaboration, transaction capability, management of digital assets, and binding together of various content and collaboration activities.
- *Social network analysis and design*—knowledge flows, identifying gaps, surveys, recommender systems, role development, connectivity of workers, degrees of separation, and exchange of knowledge.
- *e-learning*—interleaving of learning and working, anticipate training needs, and bridge between classroom and on-the-job training.
- *Storytelling and narratives*—art and graphics, theatrical tools, poetry, creating conversations, participatory observation, anecdote circles, organizational metaphors, knowledge blogging, break down silos, and descriptive language.
- *Wireless tools for knowledge mobilization*—mobile technologies, real time, function across boundaries of space and time, and continuous economy.
- *Innovation and idea management systems*—an "idea central," a "hundred-headed brain," responsible transparency, access to experts, serendipity, innovative culture, drawing on past innovations.

Some of Rao's (2004) ideas may seem somewhat "wild" or foreign to many of us—one has to wonder about a serious, sober transportation engineer using "art," "theatrical tools," or "poetry" to share his/her knowledge with others! However, a HR manager was observed using just such an approach to convey just what the company's "return on equity" goals really meant, cutting through obtuse financial jargon to present a memorable lesson.

APQC hosts an excellent website that contains many ideas for tools. Another excellent "idea central" type of website is the "Specialist Library for Knowledge Management" from the UK National Health Services. (Note the URL and other information can be found in the annotated reference in Appendix L.)

Content Management Practices

Content management techniques may be overlooked in the current rush to apply people-centric approaches. Here is where Boiko's book, *Content Management Bible* (2002), comes to the rescue. Not quite a recipe book, but close, he details how one can actually create a content management system.

Nor should the *Transportation Research Thesaurus* be overlooked. It is a well-developed meta-data tool, providing a specialized list of transportation-related terms, organized in hierarchical fashion, for use in taxonomy work, indexing, or as an authoritative source of words and terms for writers and editors. Use of such a thesaurus ensures consistency among multiple indexes and can pull together many different kinds of media into one topical framework.

ANSI/NISO Z39.85-2001 *Dublin Core Metadata Set: An American National Standard* (ISO 2001) provides a method to adequately describe information and knowledge resources for future discovery. Anyone working in a database/Internet environment should be familiar with this standard, which has been adopted at the national level in the United States and is used worldwide.

Perhaps Zack (1999) summarized it best when he listed the four primary resources for *explicit* KM:

- Repositories of explicit knowledge;
- Refineries for accumulating, refining, managing, and distributing the knowledge;
- Organization roles to execute and manage the refining process; and
- Information technologies to support the repository and processes (p. 47).

According to Zack the repository of explicit knowledge:

- Needs structure and content,
- Is a "knowledge platform" from which many views of the knowledge can be derived,

- Uses the repository's structural element as the knowledge unit,
- Is indexed with appropriate concepts and categories,
- Should accommodate date changes, and
- Must accommodate additions to knowledge.

In addition, according to Zack

- The *knowledge platform* may consist of several repositories, each appropriate to particular *content.*
- The *knowledge refinery* represents the process for creating and distributing knowledge contained in the repository. *Roles* must be assigned to ensure *responsibilities* are clear.
- The *IT infrastructure* provides the pipelines for the *flow* of *explicit knowledge* (pp. 47–50). (Emphasis added by the author.)

Communities of Practice

Mike Burk has long been organizing communities of practice (COPs) at FHWA. The reader will find details about these programs elsewhere in this report. Burk (2003) thoroughly described what COPs are and how to make them effective. Snyder and de Souza Briggs (2004) present what is almost a "cookbook" on how to organize COPs on a sustainable basis. Hammer (2005) emphasizes the need for an executive sponsor to ensure that participation in COPs is supported and that the organization will get a return on its investment.

LITERATURE SURVEY SUMMARY: MEASURING KNOWLEDGE MANAGEMENT EFFECTIVENESS

Liebowitz (2005) cites an example of how to measure KM. He chooses a KM initiative, and then defines system measures, output measures, and outcome measures. His methodology can be extended to any KM initiative. For example, for the initiative "communities of practice" he gives a "ratio of number of members to the number of contributors" as one system measure. An output measure example would be the "attrition or turnover rate," and an outcome measure might be "savings and/or improvement in organizational quality and efficiency" (p. 37). This source may not be a cookbook; however, a careful reader can extrapolate from it and develop measures appropriate to his or her environment.

European Guide to Good Practice in Knowledge Management, Part 4: Guidelines for Measuring KM is an excellent source for measurement techniques. The steps for identifying measures are (p. 10):

- Defining your goals,
- Identifying the stakeholders for your measures,
- Defining the measures,
- Deciding what data will be collected and how it will be collected,
- Analyzing and communicating the measures, and
- Reviewing the combination of measures.

The *Guide* contains descriptions of some well-known measurement approaches including:

- The Intangible Assets Monitor (focuses on a few relevant indicators depending on organizational strategy).
- The Skandia Navigator (focuses on a collection of critical measures—financial, customers, processes, long-term sustainability, human focus—that comprise a holistic view of performance and goal achievement).
- The Patton Approach (based on best practices from research, practitioners, experiences, expert opinion, lessons learned, etc.).
- A list of methods and tools for collective knowledge evaluation.

Because this document is readily available, the measurement approaches are not described in detail here. Suffice it to say that Chapter 4 in the *Guide* lists 25 typical measures and key performance indicators. Appendix l is a good example of a diagnostic tool called "the Knowledge Quick Scan." The reader is encouraged consult the actual document for specific details.

The FHWA Knowledge Sharing Initiative, which is the terminology used for FHWA's KM program, uses the balanced scorecard method to assess its progress in improving business results through better knowledge exchange within FHWA and in the larger highway community. It uses four quadrants to organize its results: customer results, business results, initiative growth and processes, and outreach and leadership activities (*FHWA Knowledge Application,* 2005, p. 1).

CHAPTER THREE

SUMMARY AND ANALYSIS OF STATE TRANSPORTATION AGENCY QUESTIONNAIRE RESULTS AND LITERATURE SURVEY REGARDING SPECIFIC EFFORTS TO CAPTURE KNOWLEDGE OF EXPERIENCED RETIRING OR EXITING EMPLOYEES

STATE TRANSPORTATION AGENCY RESPONSES FOR QUESTION 1

The first question on the survey questionnaire ascertained whether specific efforts are being made by STAs to capture the knowledge of experienced retiring or exiting employees. Thirty-three STAs reported making such efforts.

Figure 1 shows the number of respondents who selected one or more of the five choices for Question 1 (see Appendix C for detailed results). The most common practice was the exit interview; however, it may not be as effective as desired, because it may not be able to capture years of experience and it may be conducted by HR employees who cannot be expected to have technical depth in the leave-takers' expertise. Note that seven DOTs reported having a succession plan process in place. Nine reported assigning "knowledge-capturing tasks" to senior staff on an ongoing basis.

STA comments to Question 1 revealed some other STA practices:

- Retaining the retiree as a consultant after a two-year period or as a "retired" state employee with a salary cap.
- Using retired annuitants to transfer information, train new managers, provide ongoing level of expertise.
- Overlapping or double-filling positions for up to several months with incumbent mentoring successor.
- Providing opportunities for employees to perform "acting" roles for vacations or in the course of career management plans.

There are no doubt informal practices being carried out in many STAs at some organizational level or even by conscientious individuals; however, the questionnaire results do not show a focused agency-wide intentionality regarding how to deal with the loss of knowledge as a result of to leave-taking.

SYNTHESIS OF PRACTICES TAKEN FROM LITERATURE SURVEY ON LEAVE-TAKING

The annotated literature survey in Appendix I documents numerous practices for dealing with leave-taking, some short-term, but most long-term. Many ideas were taken from the literature survey and synthesized into the 42 ideas listed here.

1. Establish mentoring programs.
2. Establish ongoing process to determine which employees have the most critical knowledge.
3. Institute succession and career development planning.
4. Build repositories of knowledge that professionals need as they move through the organization.
5. Master practices of knowledge transfer, such as face-to-face skill training programs.
6. Use technology to supplement person-to-person knowledge transfer.
7. Explore phased retirement.
8. Look for new ways to retain key workers.
9. Use retirees' expertise by implementing formal programs to reemploy recent retirees, especially on contract or part-time basis (i.e., an intentional, focused program, as opposed to ad hoc, on-the-fly hiring in time of crisis or in unplanned manner).
10. Build a knowledge-retention culture and make knowledge retention part of the organization's mission.
11. Understand that voluntary reductions, because the most marketable and knowledge individuals leave first, can harm social networks and undermine trust.
12. Spread pay cuts rather than layoffs to maintain underlying social networks.
13. Systematically record knowledge of employees on verge of retirement by using video, interviews, and documentation.
14. Pay bonuses to departing employees willing to share their working knowledge with their replacements.
15. Encourage workers to mingle across department boundaries, etc., to facilitate knowledge transfer.
16. Use social network analysis to map patterns of interaction and identify key individuals.
17. Use knowledge mapping techniques.
18. Investigate in a purposeful manner why individuals leave the organization.
19. Pay close attention to worker demographics and staff positions requiring extensive experience so as to allow junior employees to grow in experience.
20. Allow succession practices in selected critical specialized positions.

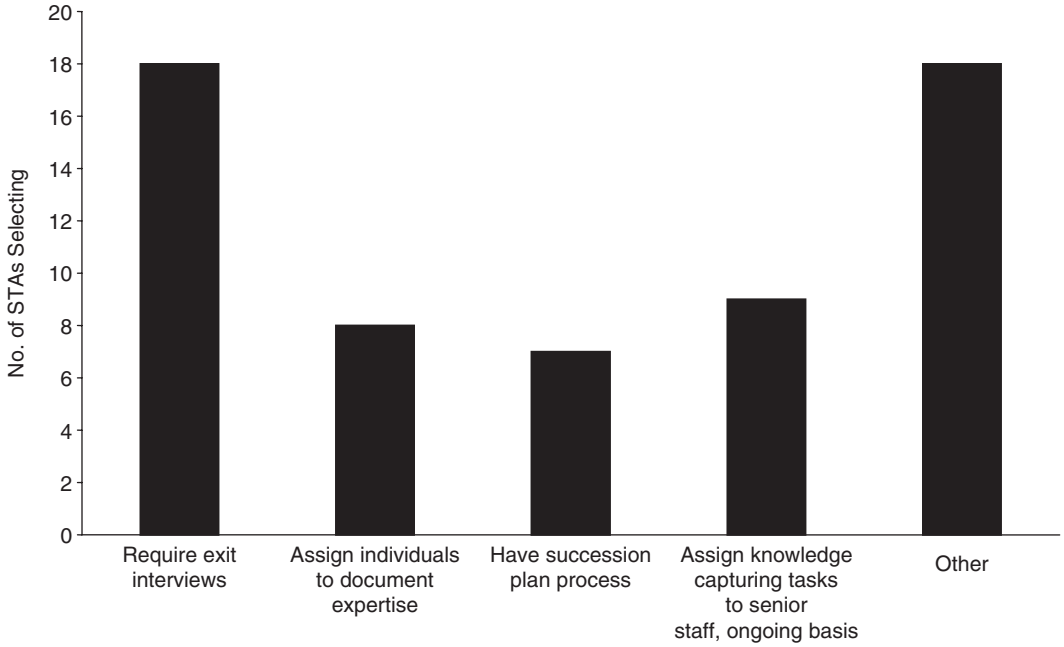

FIGURE 1 Specific efforts to capture knowledge of leave-taking employees ($n = 60$; multiple selections allowed).

21. Shape the organization to meet future demands by understanding whether the organization itself (or department) is in a growth or stewardship cycle.
22. Encourage employees to transfer between disciplines to increase skill sets.
23. Ensure that attention is paid to less glamorous but critical positions.
24. Include social scientists, cultural anthropologists, transportation historians, and other social scientists on consulting teams.
25. Use sophisticated software to analyze make-or-break losses in key competencies.
26. Develop extended "supply chains" of people by creating pools of individuals to train and develop so they are ready to move into positions in about three years.
27. Reduce importance of positions and skills of retiring workers by revamping job or outsourcing.
28. Redesign existing processes to focus on knowledge retention needs.
29. Calculate the cost of lost critical knowledge in terms of how much productivity will be lost.
30. Leverage what is already in place, such as by making exit interviews more knowledge oriented or improving existing communities of practice or focus groups.
31. Hire people with strong knowledge-sharing skills and behaviors.
32. Allow employees to "shadow" senior staff and reward senior staff for that.
33. Give employees just-in-time access to retirees as they need them for current work.
34. Understand it is necessary to gather knowledge from the high performers only, regardless of their level in the organization or job slot.
35. Identify core processes in organization that need protection and identify top performers in those processes.
36. Use specialized interviews called a "naïve new person" interview, led by a coach, and then polishing that knowledge gleaned into a best practice stored in an electronic library.
37. Update knowledge, especially that which is stored in explicit form, regularly through continuous use and feedback.
38. Seek not to retain workers but to constantly "re-recruit" them by engaging and valuing them.
39. Make sure employees do not have to choose between loyalty to their careers and loyalty to their organization.
40. Engage retired workers on a project-consulting basis.
41. Create a retiree job bank.
42. Hold one-day wisdom transfer workshops.

Note that these practices come from a variety of organizations. Some may already be used by STAs and others may not be applicable. Moreover, individual state rules and regulations may make an idea impractical or even illegal. These ideas are offered more in the spirit of brainstorming than as recommendations.

CHAPTER FOUR

SUMMARY AND ANALYSIS OF QUESTIONNAIRE RESULTS REGARDING THE EXISTENCE OF KNOWLEDGE MANAGEMENT PROGRAMS: QUESTIONS 2–5

SUMMARY OF QUESTIONNAIRE RESULTS REGARDING EXISTENCE OF KNOWLEDGE MANAGEMENT PROGRAMS

Questions 2, 3, and 4 on the questionnaire provided an overall assessment of whether or not a KM-related program exists in each STA and, if so, to what extent. Of the 38 responding STAs, 19 reported the existence of some formal KM program at varying levels within the organization. STAs that answered "no" to all of these questions were asked to cease taking the questionnaire and to return it. Figure 2 shows the nature of the existing programs. Note that although the option was not given on the questionnaire, several states reported that some aspects of their programs are enterprise-wide and others are in one of the other phases. For example, Arizona and Kansas reported the existence of both an "enterprise-wide program" and an "enterprise-wide program in rollout phase or unevenly developed among divisions." See Table D1 for detailed results for each individual STA.

It is likely that some practices are carried out within STAs by certain departments or even at the individual employee level. It may be that such activities are not recognized as falling under the KM umbrella or are so informal that they are not generally recognized by the broader organization. Note, however, that the wording in the questionnaire for these questions emphasized that although terminology may differ from STA to STA, the nature of the activities and practices was what was important.

The comments (see Table D2) also show fragmented programs with some work units carrying out specific activities, but showing a general lack of enterprise-wide implementation. There are some exceptions: Virginia, for example, with its Knowledge Management Office, is moving toward a knowledge-oriented organizational culture. Elsewhere in this report is documented an interview with the Virginia Knowledge Management Officer. During the course of this research, it was learned indirectly that Maryland, although not responding to the questionnaire, has launched a startup pilot KM program that is from inception being seen as an enterprise-wide endeavor. Texas has several initiatives that are well enough developed that they may coalesce into an overarching program in time. Ohio also appears to be moving in that direction.

However, the questionnaire results show that although STAs have some local KM activity, most of those reported activity at different levels of development, indicating that some practices within individual STAs have evolved into an enterprise-level business process, whereas others have not. This may indicate that KM activities are carried out in a bottom-up or middle-out manner, or even by individual "champions," but that KM as a business process is not driven from the executive level as a core business process. Considering that 11 STAs reported programs at more than one level, one can conclude that KM programs are not commonly embedded as an enterprise-level business management process (see Table D1). The data show a lack of an overall organizational level of purposefulness or intentionality regarding knowledge as a valuable, strategically important asset requiring a business management process.

WHOM OR WHERE IS YOUR STATE TRANSPORTATION AGENCY INSTITUTIONAL MEMORY POINT OF CONTACT?

As a follow-up to Questions 2–4 regarding the existence of recognized KM programs, Question 5 simply tried to find out who or where is the point of contact to which individual employees turn when they need historical information or documents about previous programs or projects. Table E1 in Appendix E gives detailed results by STA.

Thirty-three STAs responded to this question, with the majority making multiple selections. Figure 3 summarizes the overall results.

Note that in the comments (see Table E2), eight STAs reported the library as the central functional unit. Others indicated records management, archives, or combinations of units. Again, because most STAs made multiple choices, the results probably can be summarized as "it depends." Because the two most-selected choices were "go to different work units depending on what is needed" and "on an informal basis go to knowledgeable individuals or supervisor," the response indicates that when it comes to finding existing information, the individual employee probably has to know where to go in advance for any hope of success. This finding is reinforced by the 13 selections for "spend a lot of time trying to figure out where things are."

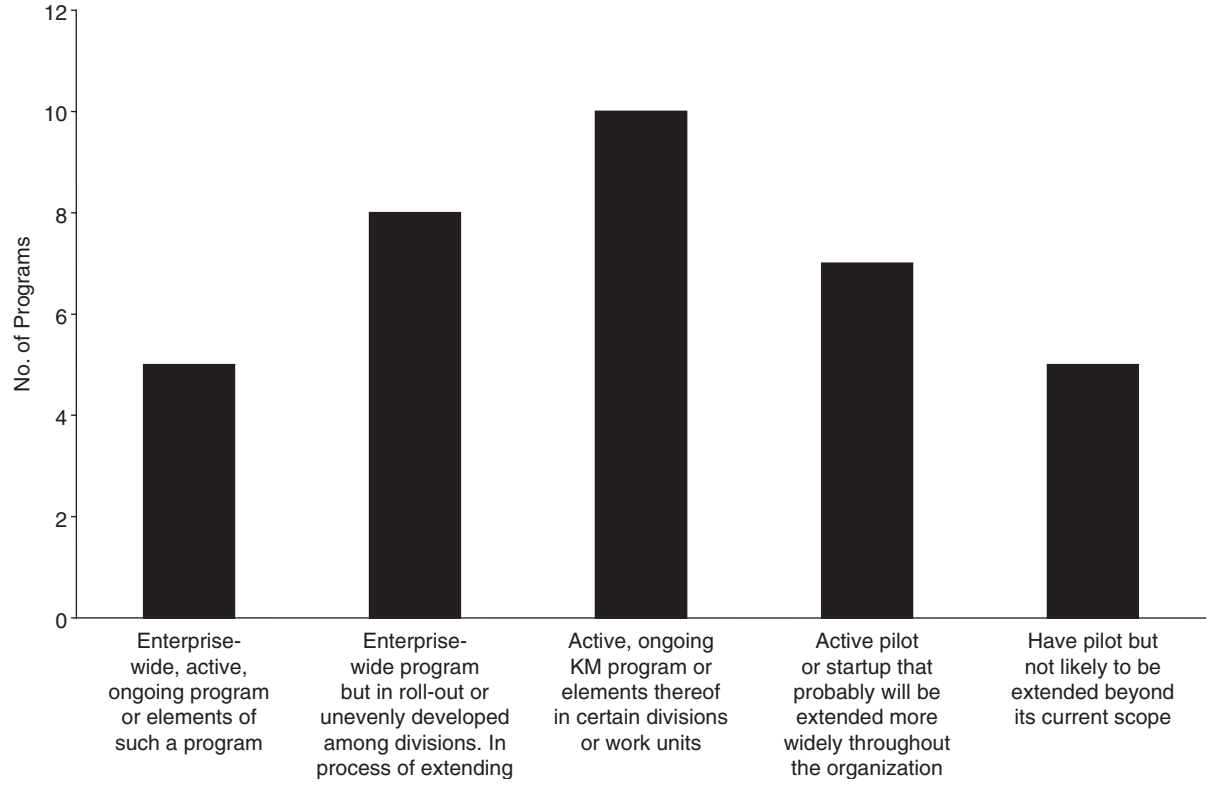

FIGURE 2 Existing knowledge management programs.

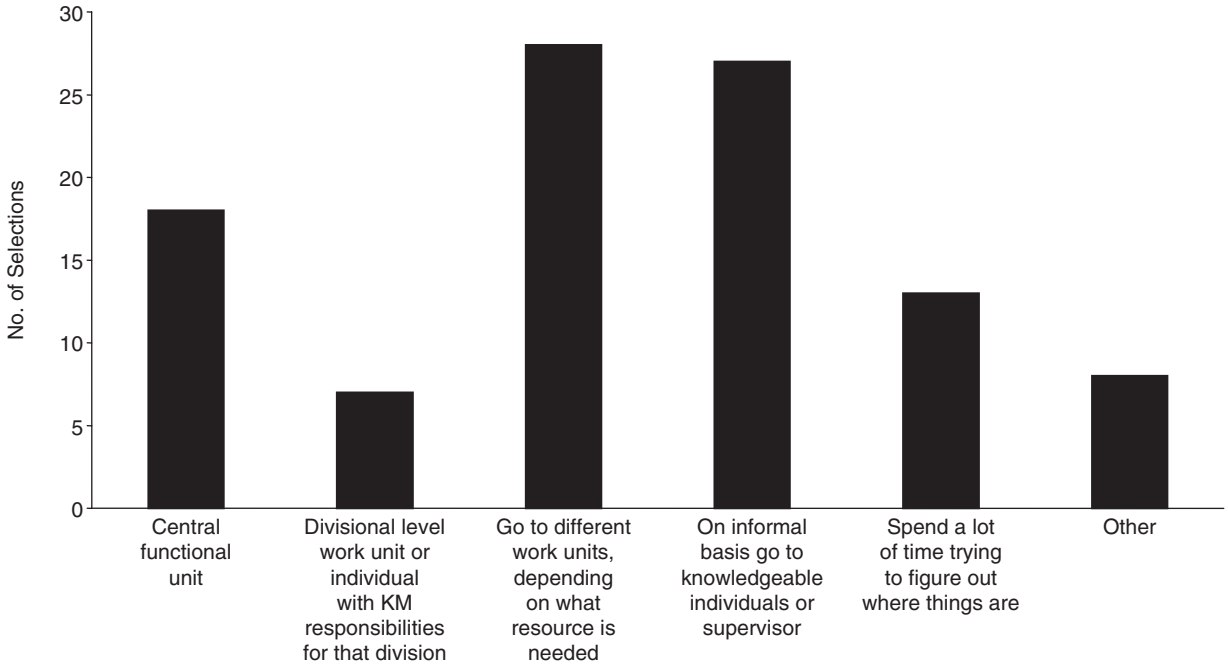

FIGURE 3 Who or where is your organization's institutional memory point of contact (multiple selections allowed).

CHAPTER FIVE

SUMMARY AND ANALYSIS OF QUESTIONNAIRE RESULTS FOR QUESTIONS 6–12 REGARDING CULTURAL RECEPTIVITY, AUTHORITY, AND RESPONSIBILITIES

CULTURAL RECEPTIVITY

Even a casual review of the literature regarding KM reveals that the overall cultural receptivity to sharing knowledge is a key factor in managing knowledge processes. Question 6 asked the STAs to rank their organization's cultural receptivity based on such factors as:

- Is knowledge sharing more common than knowledge hoarding?
- Are KM practices encouraged and supported by management?
- Does staff enter into KM activities willingly?
- Are practices encouraged, including documenting work, sharing lessons learned in after-action sessions, participating in discussions about what went right or wrong, saving project documentation for future reference, building effective information repositories, or accessing information from external sources?

Table F1 in Appendix F gives the results for each STA. Figure 4 summarizes the results.

As Figure 4 shows, the combination of "largely negative" and "neutral" roughly balance that of "largely receptive" and "highly receptive." One can conclude that while there is not outright opposition, neither is there a strong push for better KM implementation. From this, it is inferred that management attention can probably be characterized as "passively positive." In other words, there does not appear to be aggressive or assertive leadership from the executive level, but neither is there pervasive or persistent negativity.

MANAGEMENT EXPECTATION THAT EMPLOYEES CONSULT PRIOR ORGANIZATIONAL EXPERIENCE AS EVIDENCED IN DOCUMENTS, DATABASES, KNOWLEDGEABLE PEOPLE, AND OTHER RESOURCES

Question 7 went beyond cultural receptivity to probe management attitudes regarding application of institutional memory to current work. It is interesting that of the 19 STAs responding to this question, all 19 answered "yes." Comments as documented in Table F3 in Appendix F articulated that whereas there is an expectation, the mechanisms for doing so are not necessarily readily available or known. This reinforces the results shown in Figure 4. Overall, the receptivity can be characterized as neutral to weak positive and, as evidenced by the results for Question 7, management expectation for using institutional memory is there; however, overall there is not a strong enough emphasis to require implementing a formal KM program to ensure that the business process is in place.

WHO EXERCISES OVERALL AUTHORITY FOR KNOWLEDGE MANAGEMENT PRACTICES?

Question 8 sought to determine who in the organization has authority over KM practices. The following list derived from the responses of 18 STAs shows that in most cases overall authority in not specifically designated. A few STAs reported authority residing at the top executive levels. Also, the limited number of STAs responding to this question may indicate that the responder did not know and chose not to guess. Note that Table F3 in Appendix F gives complete comments.

- Motor Vehicle Division program management
- Shared by library and agency-wide records management
- No one/none assigned
- Director of design
- Executive director
- Two division directors
- KM practices are accomplished by each office area
- Director and division heads
- No individual or unit—everyone
- Director, senior staff, plus shared responsibility of district deputy directors
- This is a sometimes in our organization, depending on the project and culture of the unit
- Does not reside with any one person or even just one office, maybe the General Services Division
- Senior leaders
- KM officer.

WHO EXERCISES STRONGEST LEADERSHIP OVER KNOWLEDGE MANAGEMENT PRACTICES?

Question 9 was a follow-up to Question 8. It sought to determine who exercises leadership, as opposed to who actually has authority. Again, the list shows a wide variety of responses

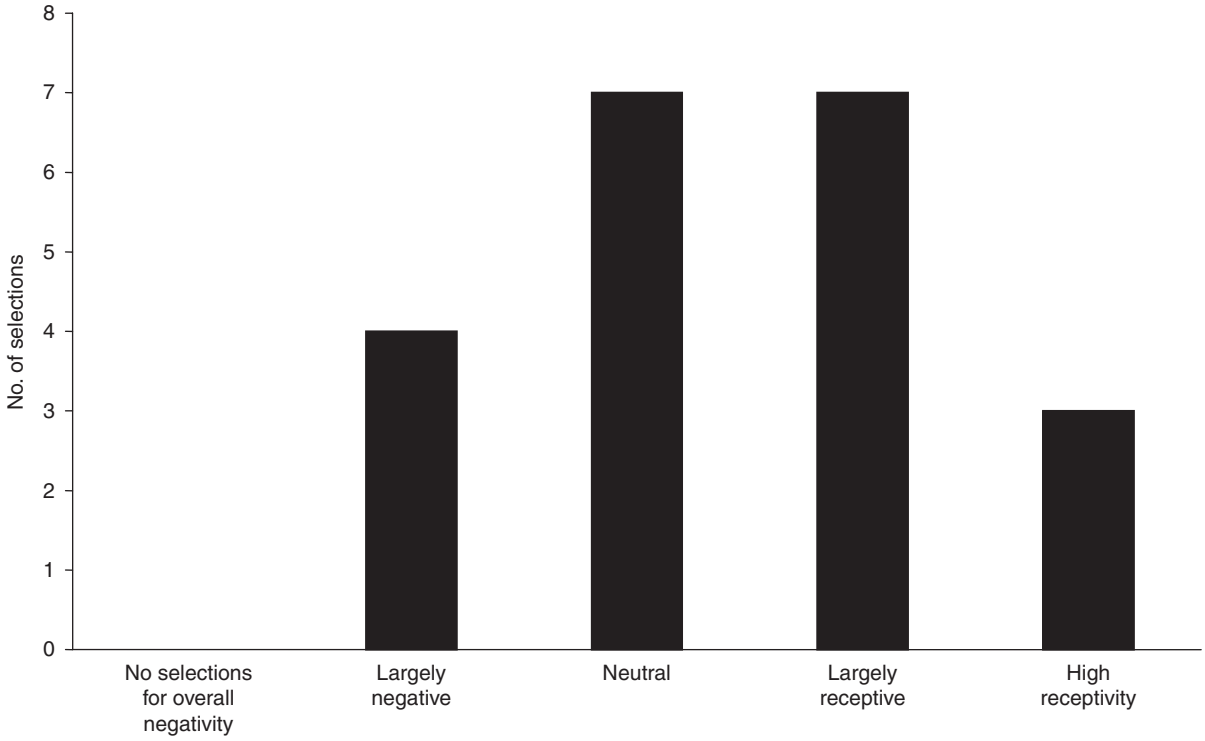

FIGURE 4 Cultural receptivity.

as to the type of training or job position of perceived leaders, as given by the 18 STAs that responded.

- Section leaders in IT department and scattered throughout another division
- Agency-wide records manager and supervising librarian
- Librarian, agency-wide records managers, management professionals
- Bridge engineer and engineer-in-training manager
- Director of design
- Executive director
- Lieutenant governor and staff of division directors
- None assigned
- Research engineer
- Communication division manager
- Adopted as a culture, with leadership from senior management
- Assistant director for planning/production and assistant director for highway management
- Not sure
- Project development director
- Commissioner, chiefs, and district administrators
- Information technology manager
- Executive.

WHO HAS OVERALL DAY-TO-DAY ENTERPRISE-WIDE RESPONSIBILITY FOR KNOWLEDGE MANAGEMENT PRACTICES?

Question 10 was a follow-up to Questions 8 and 9. The responses show a wide variety of skills and job titles. Overall, there does not seem to be a clear-cut assignment of responsibility for KM, nor is there a recognizable pattern of professional or management training that logically leads to such an assignment. Table F6 in Appendix F provides complete comments.

- Statewide records manager
- No one
- Systems software specialist
- Executive secretary
- Electronic document management system director
- None assigned
- Records Management Unit
- Everyone
- HR or Training units
- Division deputy directors and district deputy directors, and related administrators in planning/production, highway management, and HR
- There is none now
- Everyone in the department
- Research Division has most responsibility
- KM officer
- Division directors
- Training and development manager.

ARE AUTHORITY, LEADERSHIP, AND DAY-TO-DAY OVERALL RESPONSIBILITIES THE SAME FOR BOTH PHYSICAL AND ELECTRONIC RESOURCES?

Of the 16 STAs that responded to Question 12, 6 reported that the authority, leadership, and day-to-day overall respon-

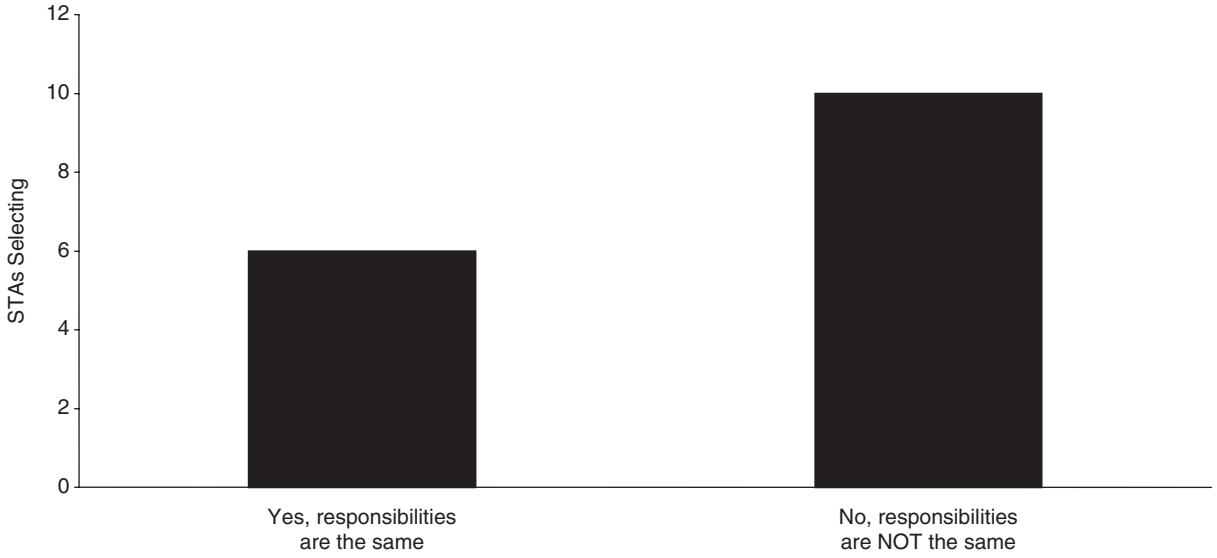

FIGURE 5 Are authority, leadership, and day-to-day overall responsibilities the same for physical and electronic resources.

sibilities for KM practices are essentially the same for both physical and electronic resources and 10 reported they were not. Table F8 in Appendix F provides detailed STA responses.

The implication behind the question has to do with how documents and other explicit KM resources are managed as STAs evolve from hardcopy to e-formats and new technologies and practices are brought under the KM umbrella. Are the same individuals or work units responsible in terms of authority, leadership, and day-to-day responsibility regardless of the technologies used? Are documents and other resources handled based on document type and content rather than simply based on whether they are in hardcopy or in e-format? For example, would a hardcopy project plan and a similar document in e-format be handled the same in terms of length of retention, availability, etc.?

Responses to this question suggest, both as summarized in Figure 5 and in the comments listed in Table F8 in Appendix F, that how documents in differing formats are handled seems to be evolving with no clear consensus on solutions.

CHAPTER SIX

SUMMARY AND ANALYSIS OF QUESTIONNAIRE RESULTS REGARDING KNOWLEDGE MANAGEMENT STAFFING: QUESTIONS 13–19

Question 13 asked responders to specify specific staff by job title assigned to KM responsibilities with full-time equivalents (FTEs). Table F9 in Appendix F shows staffing by individual STA. Figure 6 displays the cumulative results for all 14 responding STAs. The figure shows that STAs rely most on IT professionals and records managers to perform KM tasks. This runs contrary to the trans-discipline approach discussed previously in this report. Additionally, the literature survey contains many examples encouraging IT to play an enabling rather than a driving role. Also, there is no apparent, clear career path for employees who may want to serve their organization in a KM role.

ARE KNOWLEDGE MANAGEMENT RESPONSIBILITIES CLEARLY DEFINED?

Question 14 asked a simple question: are KM responsibilities clearly defined? The possible answers were "yes" or "no, there is overlap or confusion about who is supposed to do what." Figure 7 summarizes the results. These results correspond to the earlier ones regarding authority, leadership, and responsibility, where responsibility was shown to be diffuse. Table F11 in Appendix F provides detailed results by STA and Table F12 contains a few comments from STAs.

DOES YOUR STATE TRANSPORTATION AGENCY HAVE A SINGLE POINT OF CONTACT BY WHICH INDIVIDUALS FROM WITHIN OR WITHOUT THE AGENCY CAN OBTAIN PUBLISHED INFORMATION OR DOCUMENTS, SUCH AS RESEARCH REPORTS?

Question 15 deals with how easily employees can obtain published information, whether emanating their own or from other agencies. The question explores the overall efficiency of obtaining documents in which knowledge has been captured explicitly. This is important because typically these are

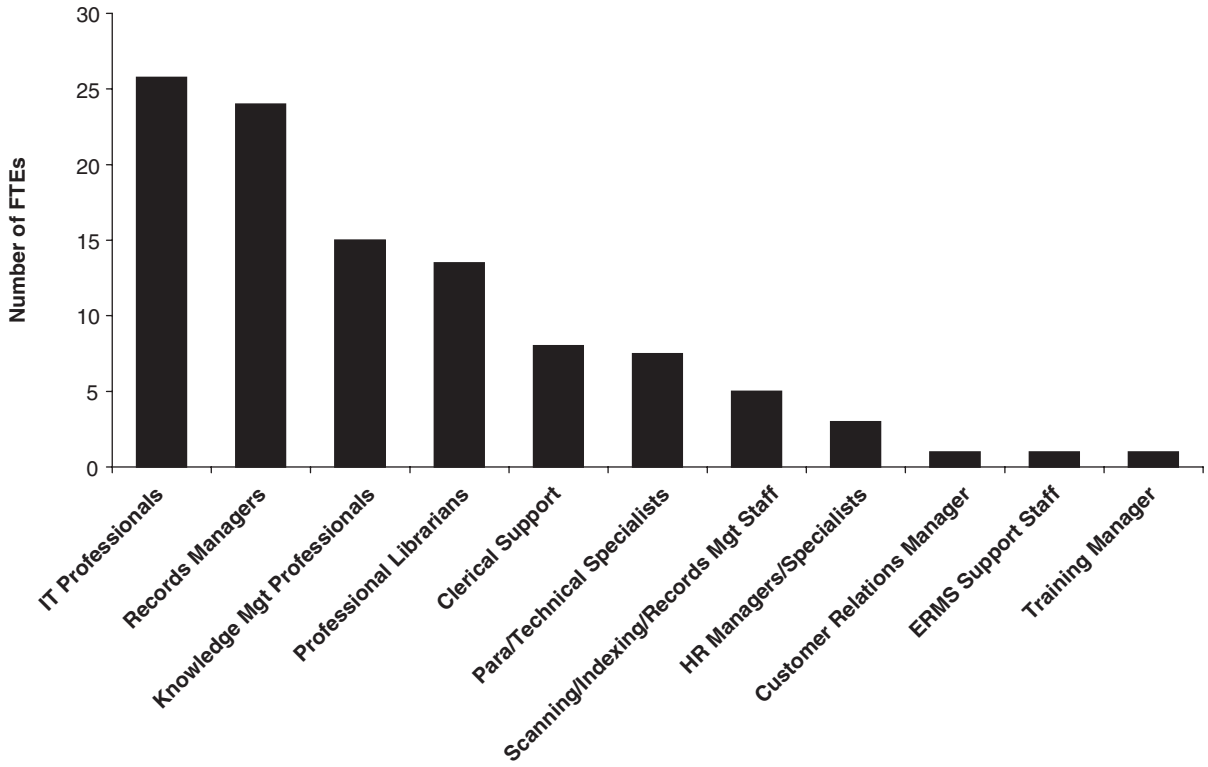

FIGURE 6 Knowledge management staffing in FTEs. ERMS = electronic records management system.

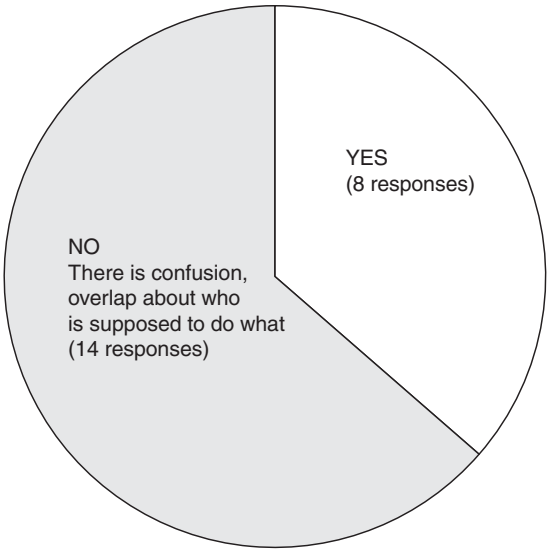

FIGURE 7 Are knowledge management responsibilities clearly defined?

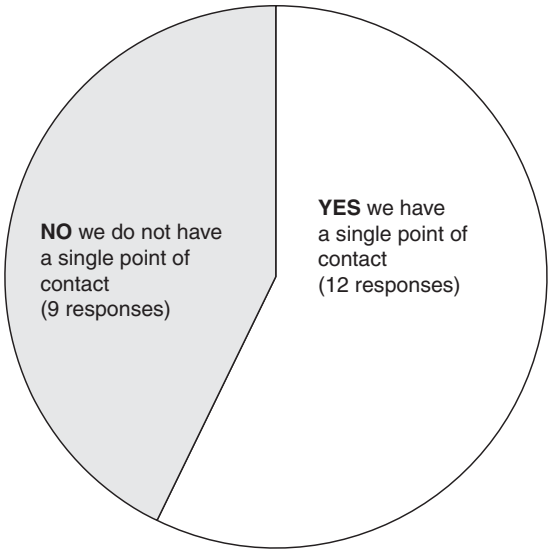

FIGURE 8 Single point of contact for obtaining published documents.

high-level consensus documents containing the results of hard-won, costly research. The ability to obtain efficiently such documents makes professional work easier and can help to avoid repeating research. Figure 8 summarizes the results. Although more STAs had such a point of contact then did not, 21 STAs responded, possibly indicating that in general STAs are weak in this regard and in many cases lack coherent internal practices to make published information readily available.

DOES A LIBRARY FUNCTION EXIST? DOES YOUR STATE TRANSPORTATION AGENCY HAVE AT LEAST ONE PROFESSIONAL LIBRARIAN ON STAFF?

Question 16 determined whether an STA does have a formal library. Of the 18 DOTs responding affirmatively to Question 16 regarding the existence of a library function that deals mostly with external publications and provides formal and informal links and access to published references, etc., 16 also have a professional librarian as lead staff member in the library functional unit. Table 1 shows that most states with an existing KM program do have a formal library function and at least one professional librarian on staff. See Tables 15F and 17F for detailed results by STA and Tables 16F and 18F for comments regarding libraries and librarians.

KNOWLEDGE MANAGEMENT BUDGETS

Questions 18 and 19 dealt with KM budgets. Virginia DOT alone has a line item in the enterprise-wide budget. California, Iowa, Kentucky, and Texas have a line item in a divisional or department budget. Fifteen others reported no specific KM budget allocation. In spite of that, Virginia and Utah were able to approximate total budgets amounts at $850,000 and $1 million, respectively. Note that Utah's budget includes microfilming plus publication and two FTEs. It is apparent that costs for KM practices are dispersed throughout organizations, with no clear definition as to what is or is not included, and virtually no STAs were able to provide even an approximation of actual costs.

TABLE 1
CORRELATION OF FORMAL LIBRARY FUNCTION, LIBRARIAN ON STAFF, AND EXISTENCE OF KNOWLEDGE MANAGEMENT PROGRAM

STA	Formal Library Function	Professional Librarian on Staff	KM Program Exists
Arizona	Yes	Yes	Yes
California	Yes	Yes	Yes
Iowa	Yes	Yes	Yes
Idaho	Yes	**No**[a]	Yes
Kansas	Yes	Yes	Yes
Kentucky	Yes	**No**	Yes
Massachusetts	Yes	Yes	**No**
Michigan	**No**	**No**	Yes
Minnesota	Yes	Yes	Yes
Missouri	Yes	Yes	Yes
Montana	Yes	Yes	Yes
Nebraska	Yes	Yes	Yes
New Brunswick	**No**	**No**	Yes
New Jersey	Yes	Yes	Yes
Nevada	Yes	Yes	**No**
Ohio	Yes	Yes	Yes
Pennsylvania	Yes	Yes	Yes
Texas	Yes	Yes	Yes
Utah	Yes	Yes	Yes
Virginia	Yes	Yes	Yes
Vermont	Yes	**No**[b]	Yes

[a] Library is staffed by Research Program Manager and Research Program Assistant.
[b] Librarian on contract assisted in cataloging function.

CHAPTER SEVEN

SUMMARY AND ANALYSIS OF QUESTIONNAIRE RESULTS REGARDING SPECIFIC KNOWLEDGE MANAGEMENT PRACTICES: QUESTIONS 20–32

WHAT METHODS ARE USED TO CAPTURE KNOWLEDGE?

Question 20 asked what methods are used to capture knowledge. It probed into the techniques used to make individual knowledge available to the organization, whether in explicit or tacit form. Table G1 in Appendix G gives specific detail for each of the 20 STAs that responded, and Table G2 documents the comments. Results are summarized by frequency of type of practice in Table 2. The most frequently used practices tend to cluster around documentation practices. Practices more closely aligned with HR approaches or ways to share tacit knowledge are not as common, with the exception of "enhanced communication practices," which really are an assortment of long-used approaches. Approaches involving HR or sophisticated database or Internet information technologies, many of which are documented in our literature survey, are less commonly used.

STAs added a few methods of their own in their comments:

- Training and orientation programs
- Electronic document management system
- Internal quarterly publication distributed to all employees
- Internal conferences on specific topics held yearly around the state
- Extensive training catalog
- Incorporating "war stories" into instruction materials.

WHAT TOOLS ARE AVAILABLE FOR KNOWLEDGE CAPTURING?

Question 21 asked what tools were available for knowledge capturing. This question was a somewhat redundant follow-up to Question 20. Using the two closely related questions, the attempt was made to harvest as many details about specific tools, techniques, and methods as possible. Table G3 in Appendix G lists the responses for each STA and Table G4 gives a few comments. Table 3 summarizes the responses sorted by frequency of selection. Results show that office technologies and specialized work process types of software are relatively common.

Note that although Table 2 shows documentation practices as the most frequently used method, a few STAs selected tools from the questionnaire that are specifically designed to facilitate the documentation process. For example, a limited number of STAs selected web-building tools; templates, outlines, or content guidelines; or content management applications. This suggests a somewhat weak intentionality or purposefulness in the capturing process concerning documentation.

Note that in the comments given by responders, in response to the choice of "Other" on the questionnaire, there were a few more tools cited, including:

- Video conferencing
- Intranet portals
- Electronic records management system
- Electronic document management system
- Web-based software for writing/developing manuals
- Microsoft Word software templates for manual writing
- Internet conferencing/meeting software.

ARE PRACTICES FOR STORING KNOWLEDGE MANAGEMENT RESOURCES IN PLACE?

When knowledge goes through the cycle from the "in people's heads" stage to explicit forms that can be reused and applied to new work, the explicit resources must be stored. Question 23 attempted to discover whether there are clear strategies for that part of the KM process and whether rank-and-file employees understand them. There was special interest in whether processes prevail across a range of media types and formats. Table G5 in Appendix G documents specific responses by individual STAs and Table G6 contains a few comments.

As summarized in Figure 9, it would appear that processes are well-defined for critical resources such as legal and financial documents. That corresponds with the overall finding that STAs have active records management programs. Most of these types of documents have well-defined legal requirements to retention and are retained in hardcopy, often offsite. For explicit resources in the general sense, the data do not show a clear strategy except in a few cases. Also, as one can see from the data in Table G5 (see Appendix G), most STAs selected more than one option. That would indicate that for some types of documents, or for some departments, or perhaps for conscientious work units, there is a process

TABLE 2
WHAT METHODS ARE USED TO CAPTURE KNOWLEDGE?

Specific Practices	No. of STAs Utilizing
Capturing is essentially achieved as a work by-product, part of the normal routine of project and program work such as project plans, program proposals, write-ups of roundtable sessions, project reports, etc.	18
Close-out reports or final project reports	16
Management expects staff to document experiences and lessons learned and make these accessible to the rest of the organization	14
More experienced staff members are given knowledge-capturing assignments, such as documenting important procedures or writing standards and specifications	14
Enhanced communication practices (e.g., up-to-date e-mail system, internal listservs or electronic bulletin boards, effective meeting management, ad hoc discussions, team rooms, or verbal sharing of expertise among employees is encouraged, etc.)	14
Post-project reviews (also known as after-action reviews or post-mortems)	12
Staff specially trained as meeting facilitators	9
Communities of practice and expertise groups	8
Oral interviews	8
We have explicit strategies for knowledge development and capture	7
Employees spend time and effort to contribute to the organizations store of knowled ge in an ongoing and structured manner	6
Best practices database	5
Staff expertise database	5
Lessons learned database	4
Knowledge development teams (specifically formed to develop new knowledge assets for the organization)	4
Oral histories (more formal than “interview,” perhaps facilitated by trained historian)	3
Other	3
Knowledge fairs	2
Formal storytelling	0

TABLE 3
WHAT TOOLS ARE AVAILABLE FOR CAPTURING INSTITUTIONAL MEMORY RESOURCES?

Knowledge Management Tools	No. of DOTs Utilizing
Reasonably up-to-date personal computer systems and business/office software	20
Meeting rooms well equipped for group interactions (low-tech whiteboards, markers, tablets, etc., or high-tech web access, computer projection, video communication center, etc.)	19
Specialized software tools such as geo-mapping, computer-aided design, statistical analysis, flowcharting, resource utilization, process control and analysis, business process analysis, voice-to-text software, etc.	19
Intranet portals that provide an interface to the organization’s knowledge resources	17
Phone systems equipped for conference calling	17
Project management software with capability to capture important project documents	15
Databases that are reasonably easy to maintain and search	13
Web building tools for shared or team websites (such as may be used by communities of practice, cross-functional teams, internal–external teams, etc.)	13
Templates, outlines, or other specific content/format guidelines to provide guidance on what to include and how to go about writing	12
Content-management or text-base-type software specifically targeted to document/text management applications	8
Other	6
Meeting management software	5
Wiki or blog software	0

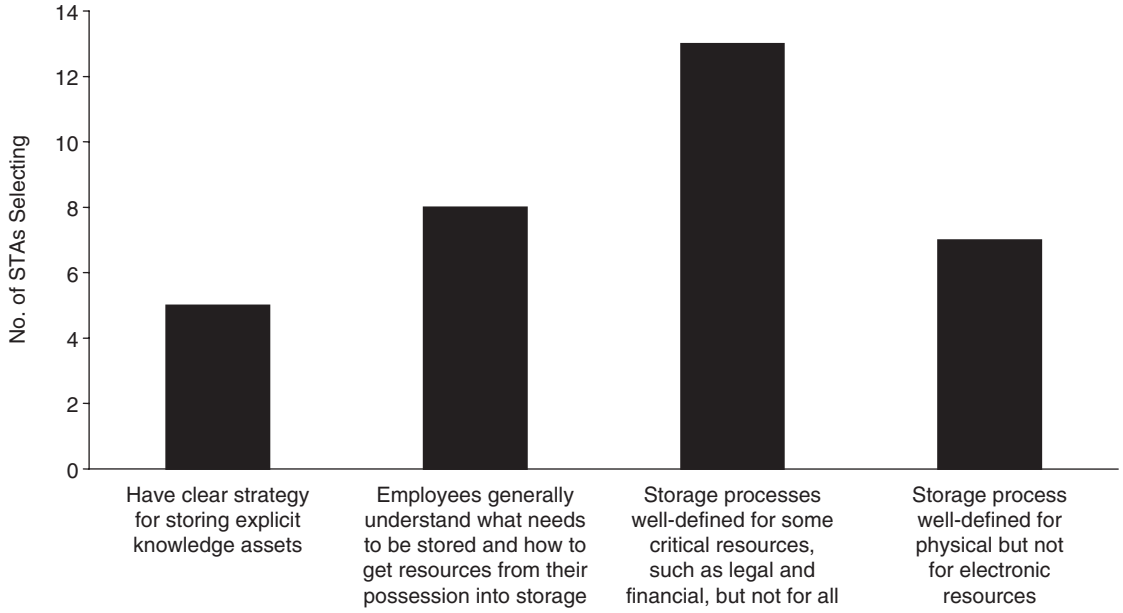

FIGURE 9 Practices for storing knowledge management resources.

in place; however, not found was a pattern of intentionality regarding storing knowledge resources specifically with the idea of reuse and application to new work. In addition, 15 STAs reported written procedures; however, in most cases, they pertained only to retention of hardcopy document storage.

WHERE ARE CAPTURED SOURCES STORED?

Question 24 was a follow-up to Question 23. See Table G7 in Appendix G for specific results by STA and Table G8 for comments. Figure 10 summarizes the results. Most STAs chose multiple selections, indicating that a combination of

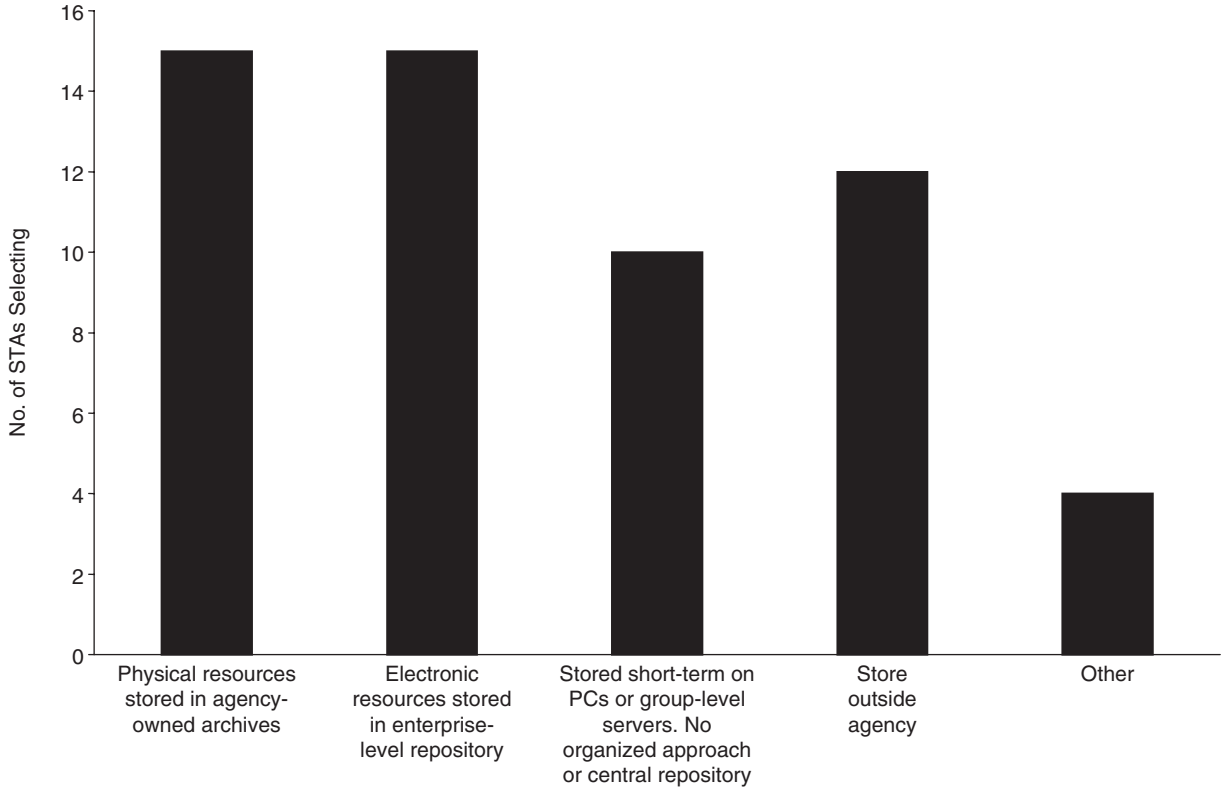

FIGURE 10 Where are explicit knowledge management resources stored?

practices are used, and which one depends on the resource and probably on which division or work unit "owns" it. Also, the comments revealed that state law influences or determines storage practices for some resource types. These practices fall under the records management process rather than overall KM strategy.

HOW ARE RESOURCES PRESERVED OVER TIME FOR DIFFERING RESOURCE TYPES AND FORMATS?

Question 26 sought to determine what processes are used for preserving for future use knowledge that has been made explicit in different media types and format. It asked how resources are preserved over time for differing resource types and formats. This question attempted to discover how essentially the same resource type, in terms of content, is handled in electronic versus physical formats. For example, is a project plan that is stored in a digital repository preserved similarly to one archived in hardcopy, such as in a typical records management facility? Table G9 in Appendix G shows specific results for each STA.

Figure 11 summarized the results given by the 19 DOTs that responded to this question. The chart shows that resources seem highly likely to be handled based on format rather than resource or document type or the nature of content.

Also in response to Question 26, the Iowa DOT commented that it is difficult to track documents or records that are outside of the Records Management program. The Montana DOT commented that their retention schedule defines the retention process for all agency records (hardcopy and electronic).

HOW ADEQUATE IS STORAGE INFRASTRUCTURE?

Question 27 probed the adequacy of the storage infrastructure. Figure 12 gives the results for the 19 STAs that responded to the question. Here, as expected, the long-established records management practices in most STAs are obvious, as is IT implementation of standard procedures for backup and digital storage. Adequacy of digital storage was not reported as a problem, probably owing to decreasing digital storage costs.

HOW DO EMPLOYEES IDENTIFY AND FIND KNOWLEDGE RESOURCES?

As modern KM practices centering on a people-to-people approach grow in importance and effectiveness, there is a cyclical process by which knowledge in people's heads (tacit) is embedded into explicit resources—in documents, operations manuals, training manuals, videos, databases, storyboards, wall charts, web-based team repositories, HR orientation packages, e-learning resources, etc. For KM to be effective these explicit resources must be made available to employees for reuse and for application to new work; the cycle never ends.

Question 28 probes how STAs go about making explicit resources "findable." It has been seen in the previous questions how explicit resources are captured, stored, and preserved over time. Question 28 attempted to discover the irretrievability of these resources.

Table G11 in Appendix G gives results by individual STA. Table 4 summarizes the results, sorted by frequency of selec-

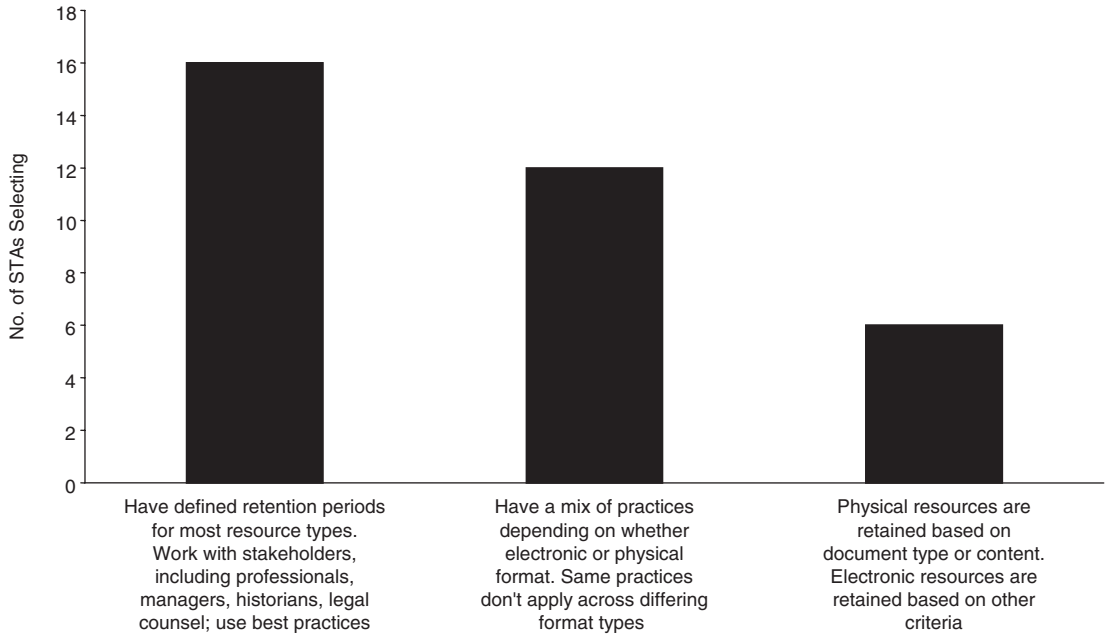

FIGURE 11 How are explicit resources stored over time?

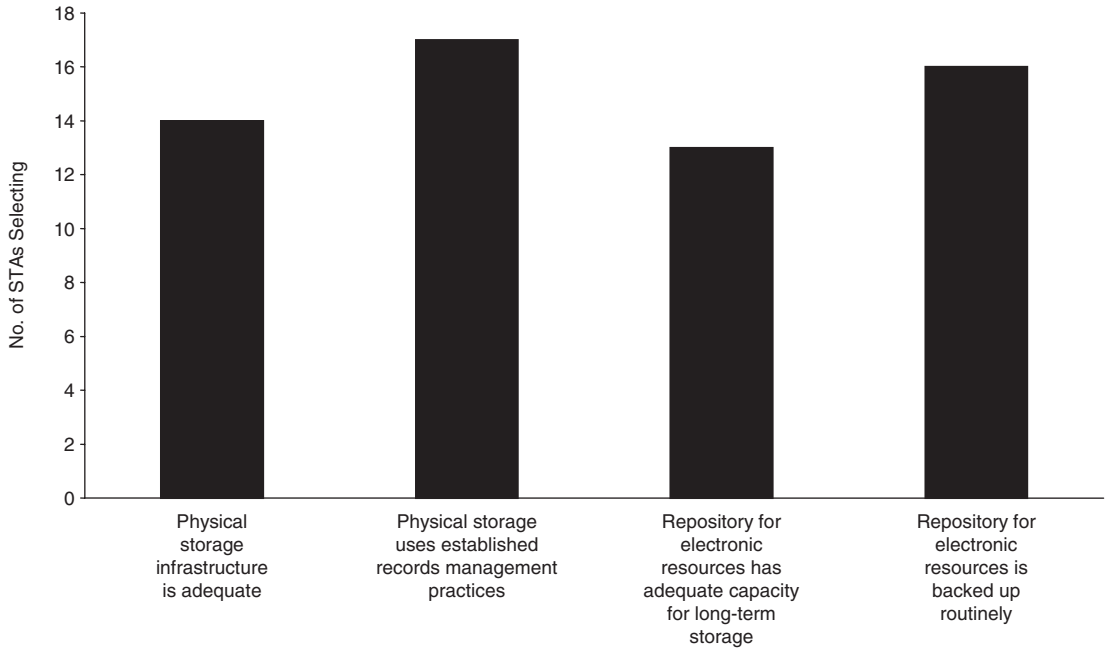

FIGURE 12 Adequacy of storage infrastructure.

tion. Note that multiple selections were allowed. Two DOTs (Iowa and Montana) reported having an enterprise-wide database system. Eight (Arizona, California, Idaho, Kansas, Missouri, Ohio, Utah, and Virginia) reported having an intranet portal. Note that the two most commonly selected responses show lack of an overall unified approach. Focus is on the departments or work units, or the type of resource. The point of view is from that of "who owns the resource," rather than on handling knowledge overall as a single asset, with the focus on facilitating the searcher's need to obtain prior knowledge to apply to current work.

The Virginia DOT commented that an enterprise-wide taxonomy, based on the *Transportation Research Thesaurus,* is under development to allow people to search multiple repositories simultaneously. Four DOTs, Kansas, Kentucky, Missouri, and Nevada, reported having active written procedures in place to guide identifying and finding resources.

ARE STORED KNOWLEDGE MANAGEMENT RESOURCES READILY AVAILABLE FOR USE IN CURRENT WORK AND DECISION MAKING?

Question 30 queried whether KM resources are readily available for current work and decision making. Again, with regard to Question 28, it probed the availability of KM resources as they move from tacit into explicit forms. Multiple selections were allowed. See Table G12 in Appendix G for detailed results for each STA and Table G13 for comments.

Table 5 summarizes availability, sorted by frequency of selection. Note that two STAs—Massachusetts and Ohio—have a "push" or proactive system in place. Seven STAs

TABLE 4
HOW DO EMPLOYEES IDENTIFY AND FIND KNOWLEDGE RESOURCES?

Methods of Identifying and Finding Resources	No. of DOTs Selecting
We have various finding tools, depending on who is managing the resource (e.g., library, records management, KM, archives, IT, division staff, etc.)	17
We have a mix of databases and manual (hardcopy) indexes	17
We have a plethora of databases, clearinghouse-type websites, and portal-type web pages, depending on the division/work group, resource type, or some other criteria. There is no central access point; one has to access each individually	12
We mostly rely on knowledgeable individuals to help us find resources	9
Our intranet portal ties resources together and provides links or keyword-type index data to help find most resources, electronic or physical	8
We search an enterprise-wide database(s), populated with meta-data, to find most resources that have been captured, stored, and preserved	2

TABLE 5
ARE STORED KNOWLEDGE MANAGEMENT RESOURCES READILY AVAILABLE FOR USE IN CURRENT WORK AND DECISION MAKING?

Availability of Knowledge Management Resources	No. of DOTs Selecting
The location of stored resources, physical and electronic, is reasonably convenient and accessible	14
Decisions to move physical materials off-site or destroy them are based on reasonable needs for efficient access by staff for use in current work, as well as on physical space needs	14
There is a system in place that tracks the location of physical resources (check in/checkout)	13
Resources can be delivered to the user within a time frame that fits reasonably well into the current work stream	10
We have a high priority to get as many KM resources as possible available through the personal computer at the desktop	7
We have a "push" or proactive system that delivers new resources as they become available to the user, based on individually defined criteria	2

reported a high priority to get KM resources available at the desktop. Here the responses show that for those STAs responding physical convenience to the staff is important and implemented. That again points to the strength of existing records management programs, especially for resources in physical format.

IS THERE AN ESTABLISHED PRACTICE FOR DESTRUCTION OF OBSOLETE KNOWLEDGE MANAGEMENT RESOURCES?

Question 32 probed how resources are disposed of when they are no longer needed or are in error. It was especially focused on comparing practices for electronic and physical resources.

Table G14 gives results for each STA. Figure 13 summarizes the results, which show that processes are not as well in place for making out-of-date or erroneous electronic resources obsolete as for physical resources. This is important because, as has been seen in previous questions, the whole process for managing explicit electronic resources is not as well defined as for physical resources. As agencies move more and more from physical to e-resources, those processes will affect the quality of the knowledge embedded in explicit resources.

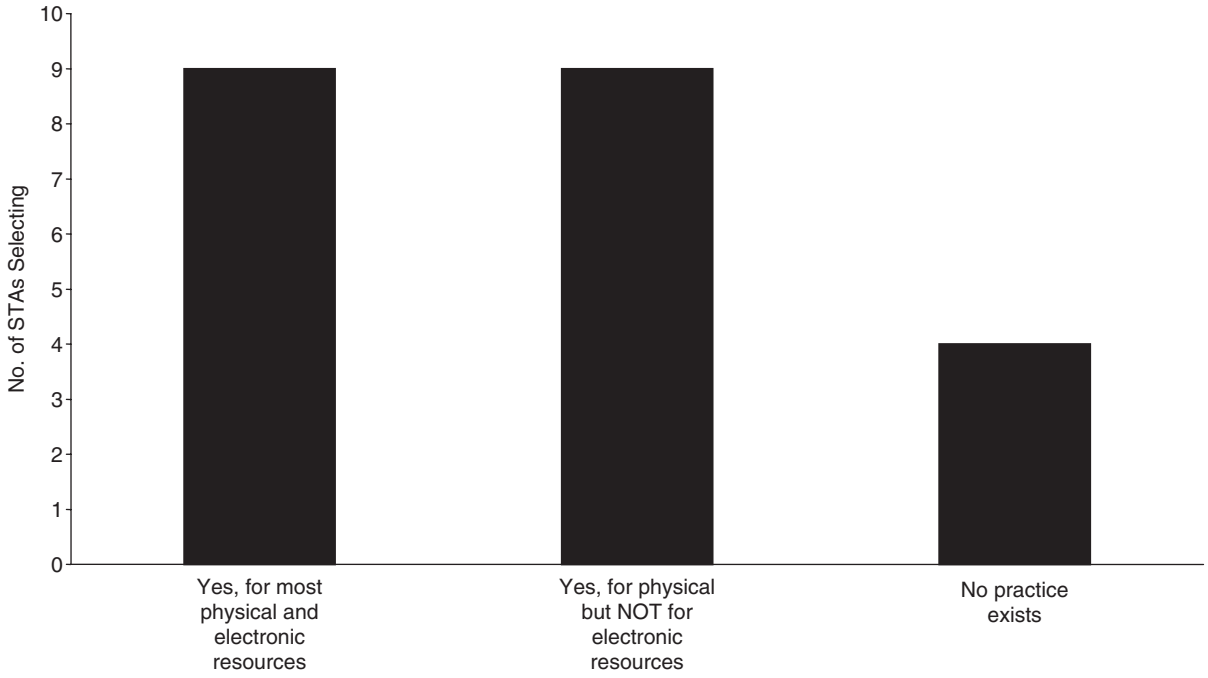

FIGURE 13 Established practices for making obsolete . . .

CHAPTER EIGHT

SUMMARY AND ANALYSIS OF QUESTIONNAIRE RESULTS REGARDING EFFECTIVENESS OF KNOWLEDGE MANAGEMENT PRACTICES AND TRAINING INITIATIVES: QUESTIONS 34–37

DO KNOWLEDGE MANAGEMENT PRACTICES ENJOY CONTINUITY AND PERSISTENCE OVER TIME?

Figure 14 summarizes the results of 19 responses for Question 34 regarding the continuity and persistence of KM practices over time. Several STAs chose multiple selections, although it was not a questionnaire option. This probably demonstrates an unevenness of the KM programs across the enterprise. Some parts of it may enjoy strong continuity; in other parts, it may not. See Table H1 in Appendix H for detailed results for each STA and Table H2 for a few comments.

Figure 14 shows that the continued existence of most KM programs is not necessarily a given and the programs are not part of the normal business-as-usual management process.

DOES YOUR AGENCY USE METRICS (PERFORMANCE MEASURES) TO GAUGE THE VALUE ADDED OR EFFECTIVENESS OF KNOWLEDGE MANAGEMENT PROGRAM OR TO JUSTIFY COSTS?

Results for Question 35 are summarized in Figure 15. Detailed results for each STA are found in Table H3, Appendix H. Results show minimal use of metrics to evaluate KM programs.

DOES AGENCY HAVE KNOWLEDGE MANAGEMENT TRAINING AND/OR MENTORING PROGRAMS FOR STAFF TRANSFERRED TO NEW JOBS, NEW HIRES, OR THOSE NEW TO LEADERSHIP? WHAT INITIATIVES HAVE LED TO SUCCESSFUL PARTICIPATION IN KNOWLEDGE MANAGEMENT PRACTICES?

Figure 16 summarizes how many STAs have or do not have KM training or mentoring programs. The results show that the understanding of KM in the organization is probably not considered vital for full participation as an engaged employee.

There were some useful comments regarding training and mentoring:

- Minnesota reported that this is a work in progress.
- Texas commented that they do not have such programs per se, except within each functional area, depending on what a new employee needs to know.
- Utah noted that it is improving in this area.

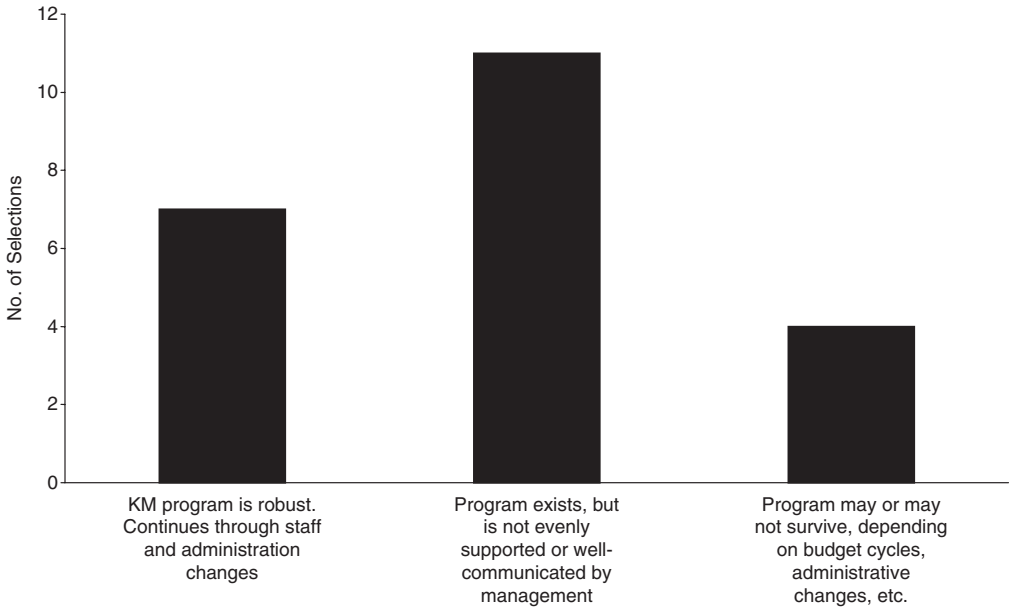

FIGURE 14 Knowledge management continuity and persistence over time.

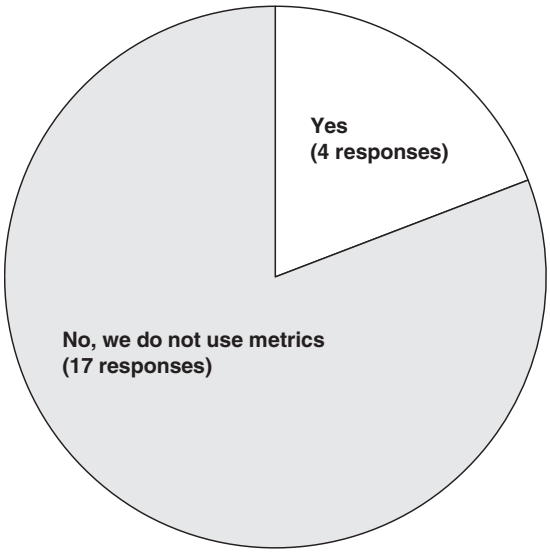

FIGURE 15 Use of metrics.

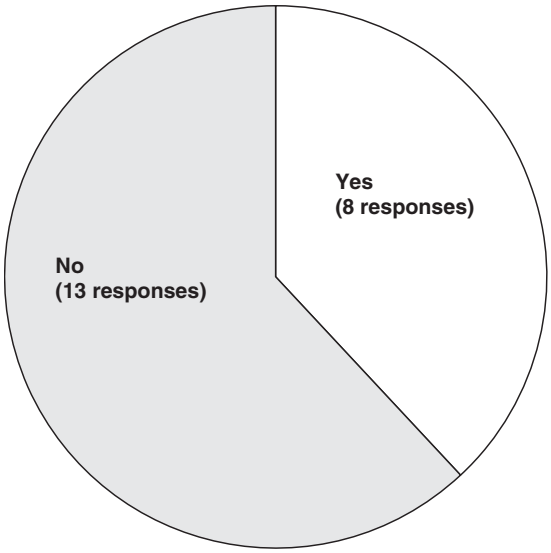

FIGURE 16 Training and mentoring programs.

- Virginia commented that such programs are part of a leadership development program that is evolving/emerging.

The final question, Question 37, asked whether the agency has found any specific initiatives to be especially effective in acceptance of and participation in KM practices within the organization. Three STAs answered affirmatively: Kansas, Minnesota, and Ohio.

- Minnesota commented that their electronic document management system (EDMS) is supported by senior management. Day-to-day work between EDMS staff and employees is fostering a common understanding of the importance of information asset management and the need to share information across the organization.
- Ohio commented that one of their most successful programs for succession planning and knowledge transfer is the Engineer-in-Training program. Texas commented that the Pavement Forensics KMS Project includes a marketing plan for promoting the Pavement Forensics KMS when it gets closer to implementation.

CHAPTER NINE

TRANSPORTATION CASE STUDIES

VIRGINIA DEPARTMENT OF TRANSPORTATION

The Virginia DOT (VDOT) was selected to be interviewed because it was identified by the literature survey as an agency with an active, although fairly new, KM program. Dr. Maureen Hammer, Knowledge Management Officer at VDOT, was interviewed on May 11, 2006. She reported that the formal initiation of the KM Office was in 2003. The chief executive officer (CEO) at the time came from private industry, and although he was not very familiar with KM business processes, he believed in its value and created a new division as an incubator. The office was located in Charlottesville, rather than at the corporate headquarters in Richmond, which was a neutral location. Dr. Hammer was hired in November of 2003. The CEO gave the new office one month to set up a COP of the mega-construction project managers, of which there were 17, all leading very-high-cost projects. The office got underway during January 2004.

Dr. Hammer attempted to form an online community; however, the group had not previously met, and was not in the habit of sharing. By March, it was clear that it was not working. Dr. Hammer took the blame and in doing so believes she won their trust. They changed to a face-to-face style and also enjoyed the support and mandate of the CEO. Since then they have continued to meet quarterly. Two other communities were formed: Quality Assurance and Right-of-Way. One of the important drivers was that 90% of the managers were eligible for retirement.

These three communities each now meet quarterly and share resources across district boundaries. They act as an informal apprenticeship to less-experienced members. They use both online and face-to-face approaches. The HR Department has been pulled into the communities to some extent in the process of working on strategic staffing plans. The communities use Microsoft Sharepoint Technology to facilitate sharing discussions, documents, etc. Lessons learned are stored there until they are moved to a more permanent Lessons Learned site for the entire agency. People use templates or their own styles to format documents.

Currently, the agency has 20 COPs. Some have external members and extranet modules for their team software, whereas some are strictly external and the KM Office plays a coordinating role. In that case, they are using an open source software. Some of these "external" members for which VDOT plays a coordinating role do include agency people. Most meet face-to-face several times a year.

These COPs affect procedures, policies, and contracts. They create new knowledge. The KM officer's role is to take decisions that the individual COPs make to a higher decision-making body for a hearing and possible acceptance agency-wide. That is the basic process by which the "products" of the COPs are embedded into VDOT practices. Dr. Hammer remarked that each COP is different, and each hearing is different as well. All have their own individual outcomes.

The KM Office also does knowledge mapping, which is especially important given the number of eligible retirees. They use interviews, audio tapes, videotapes, and other elicit medium to pass on knowledge to the next generation. The managers identify critical knowledge and what must be captured. They are using social network analysis, mapping how knowledge flows across the organization. This approach is based on networks. It is important not to disturb these networks, which, although they are loose and relatively weak, are extremely important. They use UICNet software to do social analysis, through the University of Virginia, as an online data collection tool. Data are consolidated, there is some graphic display, and people are tagged with identifiers, as well as documents. The intent is that one can go on the intranet and pull together policies, procedures and other documents, as well as people and their expertise.

Dr. Hammer discussed the role of the library in the KM process. As a trained librarian herself, she noted the importance of professional librarian skills in creating and applying taxonomies, indexing, organizing vast amounts of resources ("the huge outflow" as she put it), collecting important documents, pulling external knowledge into the organization in an organized manner, retrieving explicit resources, and creating hardcopy and virtual collections.

The VDOT Knowledge Office is staffed with individuals trained in library science, organizational development, management, and change management. It has 2.5 professional librarians with Master of Library Science degrees, 2 FTE clerical support, and 3 project managers, including an engineer, a former auditor, and a PhD in education with special skill in process mapping. Although there are no IT staff in the office, Dr. Hammer and the IT manager report to the same chief in

the same directorate, and are on the same level, which gives her a good partnership. The VDOT KM program has in its staff a variety of professional skills, all of which are utilized to pull the program together. She believes that she is at a sufficient organizational level to gain entry to decision makers and implement her programs.

Although the CEO who initiated the KM Office has left, the program has been sustained under a new administration. After 2.5 years of operation (as of May 2006), it enjoys the support of senior leadership. As yet, KM practices are not part of the formal VDOT employee performance evaluation; however, she reported that there is not a problem with hoarding or a lack of cooperation. They do have recognition awards, and outstanding performance does win praise from the commissioners.

In the near-term, she hopes to focus more on the promising practice of social network analysis. It offers a snapshot in time and she hopes to get it firmly established. She wants to know: Who is isolated? Who needs help getting integrated? She wants more COPs to spin off and function well on their own, with help from her office. She herself is very aware of what is going on in the organization—she remarked that the office functions as "KM Hub Central." At present, they are revamping the new-hire orientation process to incorporate KM processes. She remarked that Virginia is the third largest DOT, in terms of miles of roads, surpassed only by Texas and California. If Virginia can use KM effectively, she believes that smaller states can as well. She reported that the existing networks among employees broke down in the 1990s, owing to budget cuts reducing travel, and communication technologies were implemented. Therefore, employees did not know their counterparts. Now the value of face-to-face contact is recognized, and more travel money is available as the COPs become more effective. They had to demonstrate real value. The challenges include not enough staff to support all the needs and the need to get the COPs to be self-sufficient. They are training participants in the various techniques and technologies and spinning them off as they become strong enough to function on their own.

MARYLAND STATE HIGHWAY ADMINISTRATION

Jeffrey N. Withee, Soils Aggregate Technology Chief, Office of Materials and Technology, was interviewed on May 16, 2006. The Maryland State Highway Administration was selected because its KM program is in the start-up phase. Mr. Withee reported that he is a participant in a two-year class sponsored by the Maryland State Highway Administration in advanced leadership planning and development. The class of seven was required to do a project together that would benefit the entire agency. They decided to investigate KM as a potential business process for the agency. With retirements looming the need was perceived by the administration, which approved the project. The class surveyed other organizations, including FHWA, VDOT, the World Bank, APQC, and others. They also studied their own organization and found pockets of KM activity; therefore, it was not new, but the class perceived the need for KM to be more formalized and focused.

The class developed a strategic plan and a phased implementation guide, both of which have also been approved.

- Phase 1 includes a KM pilot project lead by the class to support and enhance KM efforts already underway, measure the results, and apply best practices and lessons learned to the roadmap.
- Phase 2 sees the agency starting to build a KM infrastructure, incorporating KM into its business plan, and initiating additional pilots.
- Phase 3 includes conducting audits, incorporating KM needs into the IT strategic plan, continuing to build the KM structure, and deciding whether to commit to a comprehensive KM implementation and knowledge sharing culture.

The strategic planning document discussed the significance of KM on work force planning. KM efforts will need to complement performance excellence initiatives, summarized as having a culture of knowledge sharing to achieve performance excellence. One of the goals is to retain knowledge when people leave and provide a continuity that facilitates transfer of knowledge to replacement employees.

Currently, the class is working on a pilot project with a particular group that has been meeting for a while to convert it into a formal COP. The goal is to maximize the transfer and retention of information. The class is also working with IT to develop a common support platform for KM efforts. Funding is not assured at this time. The issue is scalability; the class would like a framework that will work as KM efforts are expanded.

The class is also involved with discussions of staffing and where the KM effort should be housed, department-wise, on a permanent basis. What skills are needed? Are these skills currently available within the agency? Mr. Withee reported that some senior managers want to jump-start the process, because of the high number of retirements within their departments. There is pressure for rapid implementation; receptiveness is high. The class will start with the quick wins and easy successes to achieve buy in. Mr. Withee speculated that there might be a challenge for front-line supervisors to mid-level managers, because people may be taken out of production to focus on KM tasks. Because these departments are now losing staff, they are at a "pinch-point," and already have to outsource. It is difficult to endure short-term pain for long-term gain.

The class is currently assembling the overall framework. It is considering job descriptions and assignments. The class

will evaluate the pilot project and incorporate findings into the implementation guide. It will be the strong champion for KM.

FEDERAL HIGHWAY ADMINISTRATION

During the course of the research, there were informal conversations and sharing of informal documents with Mike Burk, Chief Knowledge Officer of FHWA. The FHWA KM program focuses on facilitating knowledge exchange both within FHWA and in the highway community. An early project was the "Rumble Strip Initiative," started in 1998. A COP was formed. FHWA partnered with other organizations that assisted in establishing a framework for KM within FHWA's existing culture, and in constructing and hosting a communication tool for peer-to-peer exchange. The exchange capabilities included knowledge regarding rumble strips, community resources such as web links, rumble strips providers, etc., and provided a communication tool. This early initiative evolved into a template for subsequent COP tools for handling discussions, references, works in progress, a directory of community members, and an e-mail subscription service. Other COPs evolved from that early initiative. Both qualitative and quantitative outcomes were measured. One piece of advice is that the communities themselves must "own" their communities; for example, selecting their own leadership, agendas, and goals.

According to Mr. Burk, the FHWA KM initiative uses a balanced scorecard approach to assess progress in improving business results through better knowledge exchange. The balanced scorecard uses a qualitative and quantitative mix of measures.

Other themes that emerged from our informal communications were:

- Focus on critical business areas.
- Create web templates to facilitate fast implementation of new COPs.
- Use technology as an enabler, not in a lead role.
- Promote a culture in which knowledge sharing, as opposed to knowledge hoarding, is encouraged and rewarded.
- Get senior level buy-in.
- Focus on people.
- Tie KM to corporate strategy.
- Use tools to facilitate the capture of explicit knowledge for knowledge reuse.
- Keep management in a supporting but not controlling role.
- Recognize those that demonstrate an exemplary attitude for community and sharing.
- Measure results to determine how KM practices affect business outcomes.
- Move into a sustaining and evolving mode to match COP members' ever-changing needs and business goals.
- Know the "knowledge transfer cycle: Create, Identify, Harvest, Filter & Organize, Share, Adapt, Use."
- Understand that the KM cycle starts with a people-to-people focus during which knowledge is discovered on the job through experiences, insights, and lessons learned. Next, the knowledge is demonstrated in local use, through methodologies, emerging best practices, and success stories. Finally, there must be the people-to-documents phase, in which the knowledge is established and is in widespread use, with a high degree of structure and approval. It is made explicit by being embedded in established policies, procedures, processes, data, and training. The whole cycle is unending because of constant change and new learnings.

According to Mr. Burk, knowledge enables us to take action to produce positive results. He gave informal examples, such as knowing when to use open-graded pavements to help with drainage problems or knowing which option to use when improving visibility—trim trees? Improve signage? Install traffic devices?

Note that the FHWA Knowledge Sharing Initiative has been recognized for its leadership, including receiving the APQC's Best Practice Partner for Communities of Practice award.

TEXAS DEPARTMENT OF TRANSPORTATION

Based on procedural documents forwarded by the Texas DOT (TxDOT) and comments accompanying the returned survey, there is in TxDOT an example of a robust startup or pilot project that may lead to more extensive KM initiatives. A forensic pavement KM system (KMS) has been developed for the TxDOT. The Center for Transportation Research at the University of Texas actually conducted the work. This KMS is the first within TxDOT and is expected to set the stage for applying KM principles throughout the organization. The scope of the project includes identifying sources of valuable forensic pavement knowledge; developing methodology for capturing that knowledge through interviewing, systematic classification, and codification; transferring that content to the TxDOT Learning Content Management Systems; and making related forensic pavement data and information sources. It is expected to be a framework for maintaining and systematically updating KMS content, and for marketing this pilot system throughout TxDOT's pavement community and beyond. The project will be a coordinated effort involving expertise from the fields of forensic pavement analysis, library science, marketing, IT, and training. Although this report has focused for the most part on enterprise-wide KM programs, TxDOT's program is noteworthy because it is a source of lessons learned about KM implementation. Also, it is trans-disciplinary in that a number of professionals have been purposefully brought together to meld their skills into this project. Although a more holistic approach is probably better, this is a good example of units doing KM work on a smaller scale.

CHAPTER TEN

NON-TRANSPORTATION CASE STUDIES

There are many organizations worldwide implementing KM programs. For this research, the World Bank and NASA were chosen for further study because they were identified by the literature survey as organizations that have developed active KM programs over time. KM processes at the World Bank have evolved over approximately 10 years from a central unit providing KM services to a business process that is embedded into the organization. NASA's KM program has a similar history. In addition, the reader will find many references to other organizations in the annotated literature survey.

KNOWLEDGE SHARING AT WORLD BANK

The introductory remark at the main page for knowledge sharing at the World Bank states its philosophy succinctly and shows how it has evolved: http://web.worldbank.org/WBSITE/EXTERNAL/WBI/0,contentMDK:20251495~menuPK:204788~pagePK:209023~piPK:207535~theSitePK:213799,00.html.

> Knowledge sharing at the World Bank has evolved over time. From an early emphasis on capturing and organizing knowledge, its focus now is on adopting, adapting, and applying knowledge in a way that helps World Bank staff, clients, and partners work more effectively to reduce global poverty (World Bank Institute 2006).

Notice how the focus moved from internal emphasis to a sharing of the broader organizational goal of supporting clients in their bid to reduce poverty. Under that umbrella, many different strategies and professional disciplines can work together in one cohesive, all-encompassing approach.

Continuing from the website, the World Bank Institute's (WBI) Knowledge Sharing program includes building networks, including the global learning network, global development network, global knowledge partnership, and world links for development. Tools used include e-discussion groups; a web casting service; a development issues gateway for gaining access to information, tools, and resources; and electronic newsletters. There is also an oral history project, which is in the main collection of the Bank Archives, comprising interviews conducted with almost 120 World Bank staff. There are more than 80 internal COPs called "Thematic Groups" made up of bank employees, plus another set of communities made up of bank clients, but facilitated by the WBI.

Another WBI initiative is the Advisory Services Group, which acts as the central hub of networks and other groupings, serving as the human interface for learning and knowledge sharing. One of their main functions is to provide a "one-stop shop" to respond to information needs on various development topics. These groups ensure that responses are given, usually within 24 to 48 h, to internal and external queries. In addition to human networks, there are multiple libraries, catalogs, document repositories, and web portals. Readers are urged to visit the website for a wealth of practical ideas on the World Bank's formalization of KM efforts, implementation, communities of practice, partnerships, leadership, training, technology, and measurement. The site offers exceptionally useful and informative videos of presentations by actual WBI KM leaders discussing their strategies over a period of approximately 8 to 10 years to develop knowledge sharing within their organization. Indeed, this historical approach is so helpful because one can see the progression of ideas and strategies over time. Also, the World Bank has published a number of useful reports, which are available either for free or at reasonable cost by means of download from the website.

In 2004, for the fifth consecutive year, the WBI Group has been named as one of the world's top 20 Most Admired Knowledge Enterprises. Teleos, an independent KM and intellectual capital research company, which was discussed earlier in this report, made the award. WBI was the only non-private-sector company to have made the list in 2004.

INTERVIEW WITH WORLD BANK KNOWLEDGE MANAGEMENT OFFICER

Erik Johnson, Knowledge Management Officer at the World Bank, was interviewed on April 13, 2006. His remarks are summarized here. KM processes at the World Bank have evolved over approximately 10 years from a central unit providing KM services to a business process that is embedded into the organization. Mr. Johnson commented that on the day he was interviewed, he had been reviewing World Bank staff performance evaluations and every one of them has KM as one of its 4 to 6 core competencies and responsibilities. He commented that the term "knowledge management" is "seen everywhere." KM is a career track for a few individuals who work in specific sectors and facilitate KM processes, whether it is to get content on some topic or development area, facilitate a web portal, facilitate group learning, or build a document repository to support the unit's internal work. He sees as a sign of success that the central KM unit that launched and grew KM processes internally is no longer functioning as the central

internal unit. What he termed the "relic" of the historical central unit is now functioning in a consultant role engaged in assisting governments worldwide in KM capacity building. He defined capacity building as the institutional ability of organizations to use KM and to integrate KM strategies across organizations. The World Bank knows how to do KM, and wants to spread its expertise, moving KM from what may be perceived as a "fun-to-have luxury item" into the mainstream. The group is especially interested in KM in governmental organizations.

According to Mr. Johnson, the World Bank KM agenda has been integrated into operations, over a period of about 10 years, as part of the normal business process. Two web portals play a central role. The first is an operations web portal that is evolving for managing work processes. Through the portal, different databases, including transactional databases, are tied together. They include personal profiles and job histories, financial management data, project detail and status reporting, and other necessary documents such as environmental reports. This portal facilitates the loan process, which is the central business process for the World Bank.

The second web portal is a client portal, where the client, in this case governments, get a view of data for entire projects, across projects and within single projects. This portal is also tied to transactional databases.

He gave the "indigenous knowledge" database as an example of another, smaller, nontransactional portal, in this case one that captures local knowledge that adds dimension to projects. An example is indigenous knowledge regarding health in an African country.

He emphasized that KM at the World Bank also has an active competency focus for all staff. They are working on developing an integrated knowledge and learning platform, or "just-in-time" learning. Knowledge must be embedded and constantly refreshed in resource materials, subscriptions to internal mailing lists, and project documents. There is not a heavy emphasis on e-learning. The World Bank sees a good KM spin-off from the group interactions with face-to-face learning approaches. These group processes are clustered around sectors, such as energy. They also have COPs called "Thematic Groups," which are alive and well, but the KM group does little to stimulate them at this point, because they are mostly self-sustaining and managed by their sectors. The sectors decide which to support, budget wise. He mentioned that the groups do not use much technology, other than e-mail systems. Most COP work is face-to-face and they vary in levels of activity. KM officers in individual sectors have special skills and abilities in KM work depending on the nature of the work unit to which they are attached. For example, the skills may include some IT, website building, facilitating of annual learning events, designing training materials, setting up databases, or gathering content materials.

He mentioned that in the evolution of KM over about 10 years at the World Bank, much attention was paid to the taxonomy in the early years, and now that piece is pretty much done with minimal ongoing maintenance. Document management in database/web environment was paramount in the early days to build a platform. This has now generally become routine and does not require much attention.

To summarize, KM staff and activities at the World Bank have moved from a central unit that created platforms and practices internally within the organization to institutionalization—routine day-to-day functions across the operating units—to a current point at which the KM staff's cutting edge is acting as a consulting function for KM development both within the World Bank and with clients.

KNOWLEDGE SHARING AT NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

In 2002, the U.S. General Accounting Office (GAO), in its report to the Subcommittee on Space and Aeronautics, *NASA: Better Mechanisms Needed for Sharing Lessons Learned* (2002), found that although NASA officials had developed a strategic plan for KM, weaknesses were revealed in the collection and sharing of lessons learned agency-wide. This useful report might be titled "lessons learned about lessons learned," because it describes how one organization was analyzed in depth on its institutional memory processes, and suggests improvements. Much detail from this report is included here because it contains so many understandings regarding KM.

One of the first findings in this GAO report was that NASA managers themselves found cultural barriers to the sharing of lessons learned, including a perceived inability of employees to learn from mistakes. NASA uses various mechanisms to communicate lessons derived from past programs and projects, including policies and guidelines, programmatic and technical reviews, mentoring and training programs, and the Lessons Learned Information System (LLIS). The report found that managers did not routinely identify, collect, or share lessons, and that the LLIS was not the primary method for disseminating lessons learned agency-wide. Managers identified program reviews and informal discussions as the principal source. Respondents found that the LLIS covered so many topics that it was difficult to search for an applicable lesson. After a lesson was entered into the system, it remained in the database indefinitely without further review.

The report identified a number of other mechanisms used by NASA for KM. In addition to the LLIS, some NASA centers or programs maintain their own electronic lessons learned systems. Training programs employ case studies, with forums held on "hot topics." Annually, the best project managers are invited to discuss project management. Senior program managers are encouraged to share their knowledge through a series of short stories made available by means of

a website. In response to specific program failures, NASA has developed KM as a formal business strategy. They have created a KM team, and conduct projects in selected centers. A system of rewarding scientists whose knowledge is used by others was instituted. Investments have been made in IT. One project is an agency-wide web portal to bring together NASAs online resources (pp. 1–35).

The GAO report goes on to point to two underlying limitations to NASA's ability to share lessons learned; cultural resistance to sharing knowledge and the lack of an effective strategic framework and management attention for overcoming such resistance. NASA had a strategic plan, but not a business plan. The report specified that such a plan, at a minimum, should address the following:

- Roles and responsibilities;
- Knowledge needs and how they relate to the business processes;
- Role of IT;
- Timetable for implementing KM;
- Resources needed for implementing a knowledge strategy;
- Cultural barriers to learning; and
- Metrics needed for tracking and measuring results and training (p. 37).

The GAO report emphasized that many program and project managers believed senior management support was lacking. NASA had not established a central management function to coordinate and direct its lessons learning processes and systems. NASA investment in LLIS was minimal. Respondents complained that there was inadequate time for sharing lessons learned, an additional burden. Most knowledge is shared on an informal basis, which, although important, is not necessarily the most efficient way, because it does not allow the information to be further disseminated or validated.

The report provided examples of more formal communities of practice as organized by other organizations studied. It described incentives for knowledge sharing, and stressed that information needs to be trusted to be useful. It also described the pitfall of assuming that a database will automatically lead to knowledge sharing. It contended that well-designed information systems and databases are important, especially for organizations with employees located at multiple centers (pp. 38–43).

Finally, the report recommended:

- Using push technology, such as e-mail alerts;
- Dedicating gatekeepers to manage and monitor knowledge-sharing databases to keep the information up-to-date and relevant;
- Establishing technical linkages among the various center- and program-level lessons learning systems;
- Improving mentoring and storytelling mechanisms;
- Providing incentives to encourage collection and lesson sharing such as links to performance evaluations and awards; and
- Enhancing the LLIS by coding information, developing an easier search capability, including more positive lessons, soliciting user input on an ongoing basis, and tracking effectiveness using performance metrics (pp. 44–45).

Today, one can visit the NASA KM website and see, even by viewing just the "public" segment, the progress made. The LLIS is indeed codified on the public access site by topic, year, center, and mission directorates (see http://www.km.nasa.gov/home/index.html). Indeed, the website itself provides a wealth of KM ideas.

According to the NASA website:

> [K]nowledge management is getting the right information to the right people at the right time, and helping people create knowledge and share and act upon information in ways that will measurably improve the performance of NASA and its partners. For NASA this means delivering the systems and services that will help our employees and partners get the information they need to make better decisions (April 16, 2006).

To summarize, there are three key priority areas for KM at NASA:

- Sustain NASA's knowledge across missions and generations.
- Identify and capture the information that exists within NASA.
- Help people find, organize, and share the knowledge NASA already has.

Elsewhere on the site, the stated goal of the KM team is to increase collaboration, facilitate knowledge creation and sharing, and develop techniques and tools to enable teams and communities to collaborate across the barriers of time and space. Thus, NASA, not unlike the World Bank, is actively seeking to integrate technology, knowledge creation and sharing, and documentation and capturing to further strategic use of knowledge within the agency.

The Strategic Plan for Knowledge Management, available on the NASA KM website, is an excellent overview of the KM business process. NASA has also expressed its KM vision in graphic style in the 25-year Roadmap, also available on the website.

INTERVIEW WITH NATIONAL AERONAUTICS AND SPACE ADMINISTRATION KNOWLEDGE MANAGEMENT OFFICER

Jeanne M. Holm, Chair of the NASA Knowledge Management Team, was interviewed on April 21, 2006. According to Ms. Holm, NASA become involved with KM in about

2000, more or less during the same time frame as the GAO audit discussed earlier. NASA formed a central unit that investigated needs from operations groups and discovered from their investigation that the biggest frustration was the inability to access documents. Therefore, they focused first on document management, before focusing on tacit knowledge. However, along with document management, they did change the rewards systems, in which, to get specific prestigious rewards, certain HR-oriented KM practices had to be present. For example, an individual had to have a history of mentoring to get a specific award. This got management visibility as well. They worked to integrate their lessons learned efforts into their training department. They brought lessons learned into the policies and procedures process, which reached broadly across the agency. The KM group worked with printers, web masters, TV producers, etc., to pull together NASA communications into a "One NASA" approach to send a congruent, consistent message to all stakeholders. The group developed IT-based resources, which have now been turned over to the office of the chief information officer.

NASA has developed COPs, and there are two formal roles associated with these COPs. The first is the champion, who is the recognized expert, known as the Technical Fellow. They work with the Engineering Excellence unit to identify who would make a good Technical Fellow, based on peer recognition of being a top expert with good human interaction skills, service on technical committees, etc. The position is associated with a promotion, and is a job of considerable responsibility. The Fellow needs to play a broad role, facilitating the whole end-to-end collaboration of the COP. The second formal role is that of facilitator. This individual supports the Technical Fellow, and plays a similar role to the KM sector officers at the World Bank, as described previously. This program has been up and running since November 2005, so it is recent; however, so far it appears to be doing well.

Two programs are on the NASA KM horizon. The first is working with universities on open-source software to create and support web technologies, especially in very fast data analysis, and in the fast, accurate pinpointing of expertise within the agency. The latter is important to increase the capacity to form teams quickly for new projects, whether permanent or temporary, and to rapidly deploy individuals based on total skills sets, not just those that happen to be in use in a current position.

The second program on the horizon is on the HR side of KM. This program is aimed at finding skilled individuals, especially as identified by their peers. They are finding, in pilot programs, that indirect approaches work better than direct ones. For example, one pilot project is working with HR to find what knowledge artifacts people leave behind when they leave. Another asks people to react to, for example, a set of engineering standards, and then to identify which ones need revising and who might be the best person to do that. Still another seeks to determine who is most similar to someone else. For example, if an individual is off on another project or is otherwise unavailable, who might be best qualified to take her or his place? They are working with this type of social network analysis to try to improve and speed the process by which new projects are staffed, setting up teams with the right skills mix. Another social network analysis approach is to look at an individual within different systems. For example, the financial system reveals who charged to what projects, the HR system reveals degrees or prior responsibilities, and so on. Then, the KM team puts together all the data in a new way to get a more complete profile of the individual.

Ms. Holm stressed that as each KM project is launched, it is passed off to another group to actually manage. Sometimes the original project intent changes somewhat—sometimes projects wither, sometimes they grow. Her own group acts as a consultant within the agency, coming up with new projects and new ideas, in an entrepreneurial fashion, and then spinning them off as appropriate. They do not seek to manage KM processes once they have become institutionalized. They seek to find opportunities where someone wants a change, and sometimes the KM group is the right fit to help create new possibilities to implement the change. They can be especially helpful as groups seek to capture, manage, distribute, and learn knowledge. The KM group does not have a large budget, but is a catalyst for KM development across the agency. The overall goal is driving to decision tools. Cultural change and acceptance came with a "One NASA" initiative from the top NASA executive. Ms. Holm stressed the need for support and energy from the top level of management for success to occur.

CHAPTER ELEVEN

CONCLUSIONS

Thirty-three state transportation agencies (STAs) reported specific efforts to capture the knowledge of experienced retiring or exiting employees, which indicates that there is widespread recognition that this issue warrants attention. Key findings showed that

- The exit interview was the most common effort made (see Figure 1 in chapter three).
- Rehiring arrangements were typically on a temporary or contract basis.
- Seven STAs reported having a succession plan process in place.
- A few STAs assign individuals to document expertise.
- Some STAs assign knowledge-capturing tasks to senior staff.

However, overall, the questionnaire data plus the additional comments as given in detail in Appendix C do not show that STAs routinely have purposeful, ongoing, enterprise-wide programs to deal with leave-taking in a methodical manner, on an ongoing basis, as part of the normal knowledge management (KM) business process. The annotated literature survey in Appendix I and Figure 2 (chapter four) suggests numerous short- and long-term practices. These practices are listed not as recommendations, but as perhaps "brainstorm" ideas. Indeed, some practices may not be practical or even legally possible within government agencies. However, organizations can embed such practices into their normal business processes to ensure that employees stay on the job, retirements are anticipated, and leave-taking is not an unexpected event, but a normal part of the human resource side of the KM business process.

Based on questionnaire responses, 19 STAs were identified (including New Brunswick, Canada) that have adopted elements of KM programs or are trying to do so.

Overall, it was concluded that most KM efforts are being made by individual work units, or what could be termed "piecemeal" or work group-level projects, or are pilot programs. Although there are exceptions in California, Maryland, Ohio, Texas, and Virginia in some areas, in others agency-wide KM business strategies that permeate the culture and help define how business is done are not present. In addition, few STAs reported procedural or policy documentation that broadly define and support KM business practices.

It is evident from the many initiatives and processes reported by STAs that there is substantial attention being paid to institutional memory issues and, specifically, implementation of KM practices in the individual STAs at some level or by some individuals. However, a commonly acknowledged understanding of KM business processes was not found among agencies that might have been found if, for example, the focus had been on physical or financial assets.

With the responses to the questionnaire came many comments about practices, documenting what in most cases seem to be recent initiatives. Some self-criticism was included as well about possible shortcomings. Some STAs stand out, however. Certainly, Virginia, with its Knowledge Management Office and range of practices is one; however, its program at the time of the survey was just over two years old. One can see from the many comments and other results that Texas with its forensic pavement program and many other initiatives is another. The Texas Department of Transportation (DOT) views this program as a possible model. The California DOT, challenged by a large decentralized agency, has three specific functional units that carry most of the responsibility. The Ohio DOT possesses a strong KM initiative coming from its library function, with robust attention being paid to bringing external knowledge into the organization in a sophisticated, systematic manner, and with strong ties to transportation-rich repositories. Arizona, Kansas, Kentucky, Missouri, and Ohio reported enterprise-wide KM programs, with California, Idaho, Minnesota, Nebraska, New Brunswick, Pennsylvania, and Virginia indicating that although they had enterprise-wide programs, they were in the "roll-out" phase.

In spite of these efforts, when it came to STAs that indicated their KM programs were robust enough to continue through staff and administration changes, the list was reduced to eight (see Table H1 in Appendix H). Ten agencies noted that their programs were not evenly supported or well communicated by management, and four indicated that their programs might not survive a new budget cycle or top administration changes. These questionnaire results may suggest that even enterprise-wide recognized KM programs are not embedded as a normal, ongoing business process and that knowledge itself is not consistently regarded as a strategically important business asset.

This conclusion is supported by the few STAs that reported using metrics to gauge the effectiveness of their KM programs

(see Table H3 in Appendix H). In addition, eight STAs have training or mentoring programs to help staff transferred to new jobs, new hires, or those new to leadership understand the agency's KM practices and how to make the best use of KM resources (see Table H4, Appendix H).

As to points of contact to which individuals may turn when information is needed, the preponderance of responses indicated that there is frequently no specified central point of contact, and that the individual has to "know where to go." The most common responses were that:

- Individuals must go to different work units, depending on what is needed.
- On an informal basis, individuals go to knowledge individuals or supervisors.
- Individuals spend a lot of time figuring out where things are.

This finding may point to inefficiencies in business processes, because searching for internal documents and information can be a major source of non-value-added activity, especially for professionals, who most likely need the information for their work, and whose labor rates are high. Note that those STAs that have formal libraries were more likely to indicate them or the records management unit as the central point of contact.

The literature survey lists management standards that incorporate and, if an organization wants certification, require that knowledge and document practices be embedded into the management process (see Appendix J). Countries and international organizations have published guidelines for KM practices. Taken together with the other sources surveyed, it appears that the worldwide trend in the current global economy is to develop KM business processes ubiquitously throughout organizations with strong support and recognition from every level of management.

Taking into consideration the responses to questions regarding cultural receptivity, authority, leadership, day-to-day responsibilities, and management expectations, it is concluded that management attention can be characterized as "passively positive." In other words, there does not appear to be aggressive or assertive leadership from the executive level, but neither is there pervasive or persistent negativity. One can cautiously conclude from the job titles of those with KM responsibilities that most KM practices occur from bottoms-up or middle-out initiatives. The data do not indicate that managing knowledge as a valuable asset is a high priority of top STA executives. There are few normal ongoing business processes established similar to those one would expect to find for physical, financial, or human assets.

The job titles of those with have overall authority, who exercise leadership, or who have day-to-day responsibilities do not imply that these individuals have specialized training in KM practices or that there is a career path. Responsibilities are often shared, typically diffuse, vague, and in some cases piecemeal. Responsibility appears to some extent to be based on the format of the "explicit" resource (see Table F7 in Appendix F).

Most responding STAs indicated that management expects employees to consult prior organizational experience before embarking on new projects. However, the comments reveal that this is not typically a procedure-based normal business process, but is more a general, loosely defined activity. One STA, the Virginia DOT, commented that the practice is encouraged, but that directions on how to proceed are not necessarily given. This finding is further supported by indications of overall lack of training or mentoring programs to help employees use KM resources and practices, as documented in comments to Question 36 in Table H4.

Most of the STAs reporting the existence of KM programs (19) have at least one professional librarian on staff. Of those 19, 5 did not have a professional librarian on staff, and one of those hired a contract librarian to help with certain functions. One agency, Idaho, has a formal library but no professional librarian on staff. There appears to be a strong correlation and there may be a causal relationship. Although librarians are not necessarily trained or capable in the broad aspects and technologies of KM, their professional expertise seems to play an important enabling role in STAs that do have KM programs. The importance of their professional expertise in concert with information technology (IT) staff skilled in content management and web building in the beginning stages of KM implementation can be seen at both the World Bank and NASA. In both cases, typical skills of professional librarians such as document management, taxonomy building, indexing, and sophisticated search strategies were paramount in the early start-up phases of KM implementation and are now institutionalized as a normal business process.

That said, it is also apparent from Figure 7 in chapter six that there are currently few human resource professionals assigned to KM responsibilities in STAs. A review of the current literature and the practices of two leading institutions, NASA and the World Bank, reveal that well-developed KM programs incorporate human resource professional expertise. Indeed, their skills are paramount in helping organizations deal with tacit knowledge, knowledge transfer, incorporating new understandings or lessons learned into training programs, incorporating KM skills and competencies into performance evaluation and award systems, facilitating workshops and communities of practice, establishing mentoring systems, social network analysis, facilitating after-action face-to-face meetings, etc.

The World Bank, and other organizations revealed by the literature search, have harnessed IT skills to set up sophisticated, transactional web portals and other web-based tech-

nologies to manage KM resources. NASA, for example, is seeking to harness web technology in a more sophisticated fashion to facilitate KM processes. It is apparent that strong IT skills, in a supporting role to core operations, especially in the area of web portal design and integrated transactional databases, are paramount to organizations where KM pervades the culture. The literature survey reveals an emerging consensus, however, that IT professionals, human resource professionals, and librarians all play vital enabling roles in the KM business process.

One skill that appears to be pervasive in the KM process is the ability to communicate well, no matter what the professional specialty. There is no question that the information acquired for this study points to KM practices as transdisciplinary among staff and multi-skilled on the part of individual staff members. The emphasis is on teamwork, communication, respect for others, open and responsible communication across work units, and openness to relative impermanence and fluidity. In the NASA interview, the point was made that there is a need for project teams to be formed quickly, with just the right skill mix, whether on a temporary or permanent basis, as the need arises.

Overall, the questionnaire did not produce enough data to be able to report on budgeting. One STA, Virginia, reported that KM is a line item in the enterprise-wide budget. Four STAs reported KM budgeting as a line item on a divisional budget. Fifteen reported that there is no specific budget allocation.

Based on the responses to questions regarding specific practices, tools, and techniques utilized, the most commonly used can be characterized as more traditional practices, which view knowledge capturing as mostly a by-product of normal work in the form of writing up and keeping normal work documentation, by means of a records management system. Some STAs are implementing enterprise-wide electronic document management systems to manage, store, and provide ongoing access to this type of documentation. Most efforts seem to be in the area of documentation, which is very important and should not be underemphasized, especially as organizations move from hardcopy to an e-document environment. Indeed, both NASA and World Bank interviews revealed that the first phase of KM implementation involved a conscious and major effort in document management, which became an institutionalized ongoing platform to support other initiatives. However, our current understanding of KM is the vital importance, but less frequently used by STAs, of human resource-oriented methods, such as communities of practice, knowledge-generating teams, oral interviews, lessons learned, face-to-face workshops, or social network analysis, all of which specifically target an individual's implicit knowledge. Also less frequently used are the more sophisticated IT-oriented approaches, such as transactional portals tying multiple databases together for project management; sophisticated staff expertise identification by means of databases; advanced web-based approaches, such as team-share or "push" technologies; or incorporation of enterprise-wide taxonomies.

For storing KM resources, the biggest concern is in discrepancies between storage and preservation of hardcopy as opposed to electronic resources. Practices for hardcopy appear to be well ensconced in traditional, well-developed records management programs. Practices for electronic resources, however, are less well-defined, and seem to be based mostly on format rather than on the type of document or content. For example, in the hardcopy environment, one would expect without much thought, very different handling practices for, say, an agenda for a specific meeting as opposed to a formal final project proposal. It was not clear from this research that this kind of differentiation in handling based on type of document or content has been developed for the electronic environment. This also proved true regarding the question on destroying or making knowledge resources obsolete.

The questionnaire results indicated a weak focus on strategies to provide clear access paths to explicit KM resources. The emphasis seems to be on which department "owns" it, rather than on the end-user who needs it. The results show that in most STAs the user must "know where to go" depending on the nature—whether based on format or content or document type—of the resource.

In the matter of identifying and finding stored KM resources for application to current work and decision making, the most common responses indicated that overall, it depends on which work unit is handling the resource. STAs reported a variety of finding tools, mixtures of databases and manual (hardcopy) indexes, a substantial number of databases, clearinghouse-type websites, and knowledgeable individuals. A few states reported an intranet portal, which presumably offers a "one-stop-shopping" approach by means of some kind of unified display screen with links to various resources. Iowa and Minnesota reported on electronic document and records management systems. The Virginia DOT noted that an effort to create an enterprise-wide taxonomy is underway to allow searching of multiple repositories simultaneously.

Once the resources are identified, however, most DOTs reported that physical resources, at least, are stored in reasonably convenient and accessible locations, and that decisions to move or destroy records are done carefully. This probably is the result of well-established records management programs. Seven DOTs reported as a high priority transferring available KM resources to the desktop; two have a "push" or proactive system. Therefore, perhaps one can conclude that hardcopy resources are more readily available than electronic ones. Texas reported an effort to deliver information more readily to external customers by means of the public website.

The main conclusion is that institutional memory practices exist at some level in at least 19 responding STAs, but

that overall strategic intentionality or conscious effort is not strongly evident from the results of this study. It was found, as revealed from the literature search and interviews, that KM practices are not as well-defined or measurable as other business processes. In recent years, KM practices have been implemented by business as an underlying internal process to support their evolution into customer-oriented, team-based, highly flexible global enterprises, where internal knowledge is viewed as a major asset. There is not a set protocol or clear path for implementation such as may exist, for example, in the management of financial assets. Thus, it takes creativity and careful strategizing to implement KM practices that really deliver benefits and are embedded in day-to-day operations. According to the *CEN Workshop Agreement* 14924-1, efforts in many organizations have typically taken an IT approach, but the Agreements were written specifically to help organizations align culturally and socially to take advantage of knowledge sharing within and beyond their organizational boundaries. This people-centric approach adds value to technology-focused initiatives. The goal is to put in place the cultural, human, environmental, and technical ecology necessary to take advantage of collective knowledge.

This synthesis study focused on uncovering and documenting current KM-related practices, both on the part of STAs and in other types of organizations.

Further research might be undertaken to investigate whether workshops or a follow-up study identifying and recommending specific approaches for actually implementing agency-wide programs would be useful to STAs.

REFERENCES

A Guideline for Intellectual Capital Statements—A Key to Knowledge Management, Danish Agency for Trade and Industry, Copenhagen, Denmark, 2001, 112 pp. [Online]. Available:http://www.videnskabsministeriet.dk/fsk/publ/2001/AGuidelineforIntellectualCapitalStatements/videnUK.pdf [Feb. 20, 2006].

Australian Standard: Knowledge Management—A Guide, AS 5037-2005, 2nd ed., Standards Australia, Sydney, Australia, Oct. 10, 2005, 76 pp.

Bates, S., "Think Tank Warns of Impending Brain Drain," *HRMagazine,* Alexandria, Va., May 2003, 10 pp.

Boiko, B., *Content Management Bible,* Hungry Minds, New York, N.Y., 2002, 966 pp.

Burk, M., "Communities of Practice," *Public Roads,* Vol. 63, No. 6, May/June 2003 [Online]. Available: http://www.tfhrc.gov [Jan. 12, 2006].

Burk, M., "Knowledge Management: Everyone Benefits by Sharing Information," *Public Roads,* Vol. 63, No. 3, Nov./Dec. 1999 [Online]. Available: http://www.tfhrc.gov [Jan. 13, 2006].

Bush, A.A. and A. Tiwana, "Designing Sticky Knowledge Networks," *Communications of the ACM,* Vol. 48, No. 5, May 2005, pp. 67–71.

Carroll, J.S., *Knowledge Management in High-Hazard Industries: Accident Precursors as Practice,* National Academy of Engineering, National Research Council, Washington, D.C., 2004 [Online]. Available: http://www.riskinstitute.org/newsite/uploads/NAE_127-136.pdf [Jan. 12, 2006]. (Note: this document is also available from the National Academy of Engineering, but that version excludes a bibliography, which this author found to be useful.)

Chang-Albitres, C.M. and P.E. Krugler, *A Summary of Knowledge Management Information Gathered from Literature, Web Sites, and State Departments of Transportation,* Texas Transportation Institute, Texas A&M University, College Station, Feb. 2005, 41 pp.

Cleveland, A.B., "Knowledge Management: Why It's Not an Information Technology Issue," *Journal of Management in Engineering,* Nov./Dec. 1999, 28 pp.

Coffey, J.W., T.C. Eskridge, and D.P. Sanchez, "A Case Study in Knowledge Elicitation for Institutional Memory Preservation Using Concept Maps," *Proceedings of the First* International Conference on Concept Mapping, Pamplona, Spain, 2004.

Cohen, A., "Libraries, Knowledge Management, and Communities of Practice," *Information Outlook,* Special Libraries Association, Vol. 10, No. 1, Jan. 2006, pp. 34–37.

Conte, C., "Expert Exodus," *Governings,* Feb. 2006 [Online]. Available: http://www.governng.com/articles/2know.htm.

Cross, R.L. and L. Baird, "Technology Is Not Enough," Reprint 4135, *Sloan Management Review,* Spring 2000, pp. 69–73.

Davenport, T.H., *Thinking for a Living,* Harvard Business School Press, Boston, Mass., 2005.

Davenport, T.H. and J. Glaser, "Just-in-Time Delivery Comes to Knowledge Management," Reprint R0207H, *Harvard Business Review,* July 2002, pp. 107–111.

Davenport, T.H., D.W. DeLong, and M.C. Beers, "Successful Knowledge Management Projects," *MIT Sloan Management Review,* Vol. 39, No. 2, Winter 1998, pp. 43–57.

de Holan, P.M., N. Phillips, and T.B. Lawrence, "Managing Organizational Forgetting," *MIT Sloan Management Review,* Winter 2004, pp. 45–51.

DiCesare, F.P. and P. Demers, "Reengineering the Bridge Inspection Process to Enable a Knowledge Management Solution," *Eighth International Bridge Management Conference,* Denver, Colo., Apr. 26–28, 1999.

Drucker, P.F., *The Age of Discontinuity: Guidelines to Our Changing Society,* Harper & Row, New York, N.Y., 1969.

Drucker, P.F., "The Future That Has Already Happened," *Harvard Business Review,* Sept.–Oct. 1997, p. 24.

El-Diraby, T.E. and K.F. Kashif, "Distributed Ontology Architecture for Knowledge Management in Highway Construction," *Journal of Construction Engineering and Management,* May 2005, pp. 591–603.

Encyclopedia of Communities of Practice in Information and Knowledge Management, E. Coates and S. Clarke, Eds., Idea Group Reference, Hershey, Pa., 2006.

Encyclopedia of Knowledge Management, D. Schwartz, Ed., Idea Group Reference, Hershey, Pa., 2006.

European Guide to Good Practice in Knowledge Management, Part 1: Knowledge Management Framework, CEN Workshop Agreement CWA 14924-1:2004, European Committee for Standardization, Brussels, Belgium, Mar. 2004, 6 pp.

European Guide to Good Practice in Knowledge Management, Part 2: Organizational Culture, CEN Workshop Agreement CWA 14924-5:2004, European Committee for Standardization, Brussels, Belgium, Mar. 2004, 53 pp. [Online]. Available: http://www.cenorm.be/cenorm/businessdomains/businessdomains/isss/cwa/knowledge+management.asp [Feb. 16, 2006].

European Guide to Good Practice in Knowledge Management, Part 3: SME Implementation, CEN Workshop Agreement CWA 14924-3:2004, European Committee for Standardization, Brussels, Belgium, Mar. 2004, 77 pp. [Online]. Available: http://www.cenorm.be/cenorm/businessdomains/businessdomains/isss/cwa/knowledge+management.asp [Feb. 16, 2006].

European Guide to Good Practice in Knowledge Management, Part 4: Guidelines for Measuring KM, CEN Workshop Agreement CWA 14924-4:2004, European Committee for Standardization, Brussels, Belgium, Mar. 2004, 33 pp. [Online]. Available: http://www.cenorm.be/cenorm/

businessdomains/businessdomains/isss/cwa/knowledge+management.asp [Feb. 16, 2006].

European Guide to Good Practice in Knowledge Management, Part 5: KM Terminology, CEN Workshop Agreement CWA 14924-2:2004, European Committee for Standardization, Brussels, Belgium, Mar. 2004, 29 pp. [Online]. Available: http://www.cenorm.be/cenorm/businessdomains/businessdomains/isss/cwa/knowledge+management.asp [Feb. 16, 2006].

Geiger, D., P. Wells, P. Bugas-Schramm, L. Love, S. McNeil, and D. Merida, *Transportation Asset Management in Australia, Canada, England, and New Zealand,* Office of International Programs, Office of Policy, Federal Highway Administration, Nov. 2005, 162 pp. [Online]. Available at: http://international.fhwa.dot.gov/assetmanagement/2005tam.pdf [May 22, 2006].

Gilmour, D, "How to Fix Knowledge Management," *Harvard Business Review,* Oct. 2003, pp. 16–17.

Gordon, R. and D. Grant, "Knowledge Management or Management of Knowledge? Why People Interested in Knowledge Management Need to Consider Foucault and the Construct of Power," *Tamara: Journal of Critical Postmodern Organization Science,* Vol. 3, No. 2, 2005, 12 pp.

Gupta, A.K. and V. Govindarajan, "Knowledge Management's Social Dimension: Lessons from Nucor Steel," *MIT Sloan Management Review,* Vol. 42, No. 1, Fall 2000, pp. 71–80.

Halladay, M. and M. Burk, "Sharing What We Know: Leveraging Innovation Through Knowledge Management in the Transportation Community," *AASHTO Quarterly,* Vol. 77, No. 2, Spring 1998, pp. 32–36.

Hammer, M., D. Leonard, and T. Davenport, "Why Don't We Know More About Knowledge," Reprint 45402, *MIT Sloan Management Review,* Summer 2004, pp. 14–18. [Online]. Available: http://www.trb.org/committees/datasection/DataSection-Metadata.pdf.

Hammer, M., "Communities of Practice Are Tools for Knowledge Management," *The Road Ahead,* Dec. 2005, 12 pp. [Online]. Available: http://www.vtrc.net/vtttc/newsletters.htm [Jan. 13, 2006].

Information Standards Organization, *Dublin Core Metadata Element Set,* ANSI/NISO Z39.85-2001, NISO Press, Bethesda, Md., 2001 [Online]. Available: http://www.niso.org/standards/resources/Z39-85.pdf?CFID=22712802&CFTOKEN=45650674 [Feb. 27, 2006].

Jarboe, K.P., *Knowledge Management as an Economic Development Strategy,* U.S. Economic Development Administration, Washington, D.C., 2001, 36 pp. [Online]. Available: http://www.eda.gov/ImageCache/EDAPublic/documents/pdfdocs/1g3lr_5f6_5fjarboe_2epdf/v1/1g3lr_5f6_5fjarboe.pdf [Feb. 22, 2006].

Kahren, F.M., "Attrition Management: Application Opportunities for Transit Organizations," *Rail Transit Conference,* Miami, Fla., June 6–9, 2004, 4 pp.

Kiger, P.J., "With Baby Boomers Graying, Employers Are Urged to Act Now to Avoid Skills Shortages," *Workforce Management,* Costa Mesa, Calif., Vol. 84, No. 13, Nov. 21, 2005 [Online]. Available: http://proquest.umi.com/pqdweb [Feb. 8, 2006].

"Knowledge Sharing," The World Bank Group, World Bank Institute (WBI), Washington, D.C., 2006 [Online]. Available: http://web.worldbank.org/WBSITE/EXTERNAL/WBI/0,,contentMDK:20251495~menuPK:204788~pagePK:209023~piPK:207535~theSitePK:213799,00.html [Apr. 12, 2006].

Kucza, T., *Knowledge Management Process Model,* VTT Publications 455, Technical Research Centre of Finland, Espoo, Finland, 2001, 104 pp. [Online]. Available: http://virtual.vtt.fi/inf/pdf/publications/2001/P455.pdf [Feb. 28, 2006].

Leonard-Barton, D., *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation,* Harvard Business School Press, Boston, Mass., 1995.

Lesser, E., *The Maturing Workforce—Managing the Crisis Before It Hits, Learning Circuits,* American Society for Training and Development, Alexandria, Va., 2006 [Online]. Available: http://www.learningcircuits.org/2006/January/lesser.htm.

Lesser, E. and L. Prusak, "Preserving Knowledge in an Uncertain World," *MIT Sloan Management Review,* Fall 2001, pp. 101–102.

Liebowitz, J.B., "Developing Metrics for Determining Knowledge Management Success: A Fuzzy Logic Approach," *Issues in Information Systems,* Vol. 6, No. 2, 2005, pp. 36–42.

Liebowitz, J.B., D. Rubinstein-Montano, J. McCaw, J. Buchwalter, and C. Browning, *The Knowledge Audit,* Apr. 9, 2002 [Online]. Available: http://www.impactalliance.org/ev.php?ID=1383_201&ID2=DO_TOPIC [Jan. 12, 2006].

Mihai, F. and J. Robertson, "Applying Knowledge Management Principles for Implementing a Road Information System at Main Roads Western Australia," *Proceedings of the 21st AARB and 11th REAA Conference: Transport, Our Highway to a Sustainable Future,* Cairns, Australia, May 18–23, 2003.

NASA: Better Mechanisms Needed for Sharing Lessons Learned, GAO-02-195, Report to the Subcommittee on Space and Aeronautics, U.S. General Accounting Office, Washington, D.C., Jan. 2002, 50 pp. [Online]. Available: http://www.gao.gov/new.items/d02195.pdf [Feb. 22, 2006].

Nonaka, I. and H. Takeuchi, *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation,* Oxford University Press, New York, N.Y., 1995.

Powers, V.J., *Knowledge Retention Captures Critical Knowledge Before Baby Boomers Walk Away,* American Productivity and Quality Center, Houston, Tex. [Online]. Available: http://www.apqc.org/portal/apqc/ksn?paf_gear_id=contentgearhome&paf_dm=full&pageselect=include&docid=112079 [Feb. 13, 2006].

Quality Management Systems—Fundamentals and Vocabulary, International Standard ISO 9000:2000, 2nd ed., ISO—

International Organization for Standardization, Geneva, Switzerland, Dec. 15, 2000, 29 pp.

Quality Management Systems—Guidelines for Performance Improvements, International Standard ISO 9004: 2000, 2nd ed., ISO—International Organization for Standardization, Geneva, Switzerland, Dec. 15, 2000, 56 pp.

Quality Management Systems—Requirements, International Standard ISO 9001:2000, 3rd ed., ISO—International Organization for Standardization, Geneva, Switzerland, Dec. 15, 2000, 23 pp.

Rao, M., "Overview: the Social Life of KM Tools," In *Knowledge Management Tools and Techniques: Practitioners and Experts Evaluate KM Solutions,* M. Rao, Ed., Elsevier Butterworth–Heineman, Oxford, United Kingdom, 2004, 438 pp.

Seidman, W. and M. McCauley, "Saving Retiring Knowledge Workers' 'Secret Sauce'," *Performance Improvement,* Vol. 44, No. 8, Sep. 2005, 5 pp.

Snyder, W.M. and X. de Souza Briggs, *Communities of Practice: A New Tool for Government Managers,* IBM Center for the Business of Government, Nov. 2003 [Online]. Available: http://www.businessofgovernment.org/pdfs/snyder_report.pdf [May 22, 2006].

Stark, M., "High Turnover: Should You Care," *Harvard Business School Working Knowledge,* Cambridge, Mass., 2004 [Online]. Available: http://hbswk.hbs.edu/item.jhtml?id=4277&t=organizations [Feb. 13, 2006].

Thurm, S., "Companies Struggle to Pass on Knowledge That Workers Acquire," *The Wall Street Journal,* Jan. 23, 2006, p. B1.

Transportation Research Thesaurus, Transportation Research Board, National Research Council, Washington, D.C. [Online]. Available: http://ntlsearch.bts.gov.tris.trt.do [Jan. 5, 2006].

Wallentine, V., W. Hankley, and M. Zamfir-Bleyberg, *Knowledge Management Technologies,* Report K-TRAN: KSU-00-5, Kansas Department of Transportation, Topeka, Aug. 2000, 42 pp. [Online]. Available: http://ntl.bts.gov/lib/11000/11100/11137/KSU005.pdf [Feb. 28, 2006].

Yu, L., "Does Knowledge Sharing Pay Off," *MIT Sloan Management Review,* Vol. 46, No. 3, Spring 2005, p. 5.

Zack, M.H., "Managing Codified Knowledge," *MIT Sloan Management Review,* Vol. 40, No. 4, Summer 1999, pp. 45–58.

Zack, M.H., "Rethinking the Knowledge-Based Organization," Reprint 44410, *MIT Sloan Management Review,* Summer 2003, pp. 67–71.

BIBLIOGRAPHY

2005 Global Most Admired Knowledge Enterprises (*MAKE*), *Executive Summary,* Teleos, Bedford, United Kingdom, 2005 [Online]. Available from the KNOW Network, http://www.knowledgebusiness.com [Jan. 12, 2006].

Center for Army Lessons Learned (CALL), U.S. Army Combined Arms Center, 2006 [Online]. Available: http://call.army.mil/index.asp [Mar. 8, 2006].

Committee for a Future Strategy for Transportation Information Management, *Transportation Knowledge Networks: A Management Strategy for the 21st Century, Special Report 284,* Transportation Research Board, National Research Council, Washington, D.C., 2005, 76 pp. [Online]. Available: http://trb.org/publications/sr/sr284.pdf [Mar. 6, 2006].

Data and Information Technology Section of the Transportation Research Board, *Final Metadata Working Group Report: Transportation Metadata: Role of Data and Information Technology Section,* July 5, 2005, 9 pp. [Online]. Available: http://www.trb.org/committees/datasection/DataSection-Metadata.pdf [Feb. 27, 2006].

Economist, "How to Manage an Aging Workforce," London, United Kingdom, Feb. 18–24, 2006, p. 11.

Federal Chief Information Officers Council, Knowledge Management Working Group, *KM.GOV,* 2005 [Online]. Available: http://www.km.gov/quickplace/km/main.nsf/h_Toc/528af9ed5ba5f97a85256f65007453a0/?OpenDocument [Mar. 3, 2006].

FHWA Knowledge Application: FY 2005 Knowledge Application Balanced Scorecard Report, Federal Highway Administration, Washington, D.C., 2005.

Institute for Innovation in Information Management, 2006 [Online]. Available: http://www.ischool.washington.edu/i3m/index.html [Mar. 8, 2006].

KM Toolbox: Inventory of Tools and Techniques, National Electronic Library for Health, United Kingdom, May 31, 2005 [Online]. Available: http://www.nelh.nhs.uk/knowledge_management/km2/toolkit.asp [Jan. 12, 2006].

Knowledge Management—A Guide to Good Practice, PAS 2001, BSI, London, United Kingdom, 2001.

Knowledge Management, American Productivity and Quality Center, Houston, Tex., 2006 [Online]. Available: http://www.apqc.org [Jan. 12, 2006].

Lessons Learned, Intelligent Transportation Systems, U.S. Department of Transportation, Washington, D.C., 2004 [Online]. Available: http://www.itslessons.its.dot.gov [Jan. 16, 2006].

Snowden, D., Numerous papers on Cynefin's website, 2006 [Online]. Available at: http://www.cognitive-edge.com [May 19, 2006].

Strategic Plan for Knowledge Management, NASA Knowledge Management Team, Apr. 2002 [Online]. Available: http://km.nasa.gov/pdf/53490main_KM_Strat_Final.pdf [Feb. 21, 2006].

The Know Network, Teleos, Bedford, United Kingdom, 2006 [Online]. Available: http://www.knowledgebusiness.com/ [Mar. 2, 2006].

Transportation Division, Special Libraries Association, 2006 [Online]. Available: http://www.sla.org/content/community/units/divs/division.cfm [Mar. 8, 2006].

Walters, R.C. and L. Li, "Maintenance of Hypertext-Based Specifications for State Highway Projects," *Transportation Research Record 1861,* Transportation Research Board, National Research Council, Washington, D.C., 2003, pp. 132–139.

Wildfire Lessons Learned Center, The Interagency Lessons Learned Center, Tucson, Ariz., 2006 [Online]. Available: http://www.wildfirelessons.net/index.aspx [Mar. 6, 2006].

APPENDIX A

Survey Questionnaire

QUESTIONNAIRE FOR NCHRP SYNTHESIS TOPIC 37-02

PRESERVATION AND USE OF INSTITUTIONAL MEMORY

Thank you for agreeing to be a responder to this NCHRP Synthesis survey. After reading the Purpose, Background, Definition, and Scope sections below, you may find that specific questions may be better responded to by some other individual(s) in your organization. Please forward as appropriate.

Please return the completed questionnaire by February 24, 2006 to:

Maryanne Ward
NCHRP Synthesis Topic 37-02 Consultant
808 Addison Place
Mount Vernon, WA 98273
E-mail: ward.maryanne@verizon.net
Phone: 360-848-6568
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If you need clarification, or after completing the survey, if there are issues pertaining to preservation and use of institutional memory that you believe are important but which are not addressed adequately by the questionnaire, please feel free to contact the author directly.

PURPOSE

The purpose of this synthesis is to identify how state DOTs conduct knowledge management practices to preserve and enable use of institutional memory.

BACKGROUND

There are several reasons for conducting this synthesis at this time. State DOTs are being asked to do more with less. They seek to become more efficient at providing the information and knowledge that managers, technicians, and legal staff need to be able to deliver agency programs effectively, on time, and within budget. In addition, DOTs want to respond effectively and efficiently to requests for information from elected officials, media, historians, researchers, and the general public. Knowledge management practices can facilitate training and succession management. The report generated by this synthesis will provide an overview of practices of state DOTs and a resource for creating or evaluating practices in individual DOTs.

DEFINITION AND TERMINOLOGY CLARIFICATION

For this synthesis, the term "institutional memory" is defined as the body of knowledge, formal as well as informal, which is essential to the continuous and effective functioning of the agency at all levels.

Increasingly, the practices for managing institutional memory within an organization are collectively gathered under the trans-disciplinary approach known as "knowledge management" (KM). In organizations, accumulated knowledge can be considered the fourth asset to be managed as part of typical business processes, along with physical (buildings, equipment) and financial assets, and human resources. For consistency, in this survey we will use the term "knowledge management" or its abbreviation, KM, to refer to these types of practices overall. These practices involve

- creating or developing **knowledge;**
- transferring it from one human mind to another in "non-tangible" form (often termed "tacit") through, for example, face-to-face discussions, interviews, or roundtable sessions;
- capturing it in explicit form, as in written documents or in media such as videos, training films, photographs, graphics, or presentations;
- storing it in some fashion for future use, as in databases or physical repositories;
- providing finding and identification tools such as indexes, codification systems, or search software;

- using by applying prior knowledge to current work; and
- destroying when knowledge becomes obsolete or is found to be erroneous.

Your agency may use different terminology for essentially the same practices. Please respond regardless of your state's particular terminology for programs, job titles, organizational charts, work group names, functions, etc.

SCOPE
Specifically, this synthesis is focused on practices, at a practical level, for preserving and enabling use of **internally generated knowledge resources—that is, on those materials, knowledge, and resources in the unique possession of your individual DOT at the program, policy, project, and project detail levels**.

This survey deals with resources in both physical and electronic formats, as well as human activities, such as communities of practice or formal roundtable discussions. Resources in physical format include information captured in paper, videos, photographs, maps, films, and other hardcopy media. Usually these resources can be read with the naked eye or relatively simple optical equipment. Sometimes these physical resources are referred to as "hardcopy." Electronic resources include information captured in e-mails, databases, CDs, images, Internet, intranets, and other electronic formats. Sometimes electronic resources are referred to as "digital resources." One needs a computer with appropriate software to read these resources.

Examples of the kinds of materials and resources, whether in physical or electronic format, include, but are not limited to:

- Project-related documents and information, such as
  - planning documents
  - project reports
  - contracts
  - as-built plans
  - construction reports
  - photographs
  - maps
  - after-action reviews

- Administrative records and documentation, such as
  - correspondence
  - memos
  - policies and procedures
  - budget documents
  - policy changes
  - financial statements
  - management analysis reports
  - delegations of authority
  - agreements
  - audit reports

- Published information in all formats, such as
  - research reports
  - standards and specifications
  - manuals
  - annual reports
  - newsletters and journals
  - videos

- Knowledge and expertise of staff members, including
  technical and administrative expertise
  knowledge developed through on-the-job experience
  succession plans and related training
  presentations or papers by staff members published formally in journal articles, papers, etc. or informally in presentations

PART I. RESPONDENT INFORMATION (ADD NAMES AS NEEDED)

Name:

Title:

Agency:

Address:

City: **State:** **Zip:**

Phone: **Fax:** **e-mail:**

Name:

Title:

Agency:

Address:

City: **State:** **Zip:**

Phone: **Fax:** **e-mail:**

PART II. OVERALL ASSESSMENT OF KNOWLEDGE MANAGEMENT (KM) PRACTICES IN YOUR STATE'S DOT

1. Are specific efforts made to capture knowledge of experienced retiring or exiting employees?

Check all that apply

- ☐ We require exit interviews for retiring or exiting staff, and we document the results.
- ☐ When we know someone is close to retirement, we assign the individual to document his/her areas of expertise.
- ☐ We have a succession plan which provides for transfer of knowledge and training of replacement staff.
- ☐ We have a process whereby we assign, on an ongoing basis, knowledge-capturing tasks to senior staff, such as updating operations manuals, writing standards, or leading after-action sessions.
- ☐ Other. Please describe what methods are used or comment if desired:

2. Does your state DOT have an **enterprise-wide** active, ongoing KM program, or elements of such a program, to preserve institutional memory for future use?
(*Note: throughout this survey "enterprise-wide" refers to the entire organization; that is, the entire DOT including all divisions, departments, and work units*)

- ☐ Yes
- ☐ Yes. We have an enterprise-wide program, but at this point it is in the "roll-out" phase, and is unevenly developed among divisions. We are actively in the process of extending the program throughout the organization.
- ☐ No. We have no enterprise-wide program or elements of a program.

Comment if desired:

3. Does your state DOT have an active, ongoing KM program, or elements of a program, carried out by **certain divisions or work units**, but not at the enterprise-wide level?

☐ Yes
☐ No

If yes, please specify which division(s) and provide contact name(s) for possible follow-up interviews:
In addition, please pass this questionnaire to the contact(s) to complete with respect to their program:
Comment if desired:

4. Does your state DOT have an active, ongoing **pilot or prototype (start-up)** KM program or elements of a program, not necessarily enterprise-wide but at some level within the agency?

☐ Yes, and it's robust enough that it probably will be extended more widely throughout the organization.
☐ Yes, but it's not likely to be extended beyond its current scope.
☐ No

If yes, please describe and provide contact name(s) for possible follow-up interview:
Comment if desired:

5. Who or where is your DOT's institutional memory **point of contact**; that is, to whom do people go, or to whom are they referred, if there is a need for historical materials or documents about prior programs or projects?

Check all that apply

☐ Central functional unit at enterprise level (such as library, archives, records management, IT department, KM department). Please specify:
☐ Division level work unit or individuals who have KM-type responsibilities for that division only.
☐ We go to different work units, depending on the type of knowledge resource needed.
☐ On an informal basis, we go to knowledgeable individuals or supervisor, depending on where one is in the organization.
☐ We spend a lot of time just trying to figure out where to find things or if they even exist. There's no organized way to go about finding things.
☐ Other. Please explain or comment:

****

If you answered "No" to all three questions numbered 2, 3, and 4 above, there is no reason to continue. Please return the survey. If you answered "yes" to one of questions 2, 3, 4, please continue. The remaining questions are for those states where some type of program exists. Please return this questionnaire to the consultant. Thank you.

****

6. Overall, how would you rate your organization's cultural receptivity to knowledge management practices? Is knowledge sharing more common than knowledge hoarding? Are KM practices encouraged and supported by management, and entered into willingly by staff—practices such as documenting work, sharing lessons learned in after-action sessions, participating in discussions about what went right or what needs improvement, saving project documentation for future reference, building effective information repositories, or accessing information from external sources?
Please answer on a scale of 1–5 with 1 being overall negative receptivity and 5 being very high receptivity.
Comment if desired:

7. Before beginning new projects or programs, does management expect employees to consult prior organizational experience as evidenced in documents, databases, knowledgeable people, and other resources?

☐ Yes
☐ No

Comment if desired:

8. Who exercises **overall authority** over KM practices? Job title:

Comment if desired:

9. Who exercises the **strongest leadership** for KM practices? Job title:

Comment if desired:

10. Who has overall, day-to-day, enterprise-wide **responsibility** for KM practices? Job title(s):

Comment if desired:

11. Do you have written policies or procedures for KM practices?

☐ Yes
☐ No

If yes, please provide copy.

12. In general, are the authority, leadership, and day-to-day overall responsibilities for KM practices the same for both physical and electronic resources?

☐ Yes
☐ No

If no, please describe or comment:

13. What staffing is dedicated to responsibility for KM practices?

Please answer in full-time equivalencies (FTEs)

Knowledge management professionals
Professional librarians
Information technology professionals
Records managers
Human resource managers/specialists
Paraprofessional or technical specialists
Clerical support
Other. Please specify by title and skill set or professional training, and FTE:

Comment if desired:

14. Are KM responsibilities clearly defined?

☐ Yes
☐ No, there is overlap, or confusion, about who is supposed to do what.

Comment if desired:

15. Does your state DOT have a single point-of-contact by which individuals from within or from outside the agency can obtain published information or documents, such as research reports?

☐ Yes
☐ No

Comment if desired:

16. Does your DOT have a library function that deals mostly with external publications and provides formal or informal links and access to externally published references, literature/reference databases, other libraries, transportation research centers, etc.?

☐ Yes. If yes, what is the annual budget?
☐ No

Comment if desired:

17. Is the library staffed by at least one individual with professional librarian training?

☐ Yes
☐ No

If no, what is the skill set or professional training of the lead staff person?

18. How are costs for KM practices allocated in the budget?

☐ Line item in enterprise-wide budget
☐ Line item in divisional/department level budgets
☐ No specific budget allocation

Other or comment if desired:

19. Please estimate the total amount budgeted on an annual basis throughout the enterprise for all KM practices?

PART III. KM PRACTICES

20. What methods are used to **capture** knowledge?
(*Note: for this synthesis, "capturing" refers to the process of transferring knowledge from employees' minds into tangible resources, such as text documents, maps, photos, databases, websites, etc., so others can make use of it*)

Check all that apply

☐ We have explicit strategies for knowledge development and capture.
☐ Management expects staff to document experiences and lessons learned and make these accessible to the rest of the organization.
☐ Employees spend time and effort to contribute to the organization's store of knowledge in an ongoing and structured manner.
☐ Capturing is essentially achieved as a work by-product, part of the normal routine of project and program work, such as project plans, program proposals, write-ups of roundtable sessions, project reports, etc.
☐ More experienced staff members are given knowledge-capturing assignments, such as documenting important procedures or writing standards and specifications.
☐ Post-project reviews (also known as after-action reviews or post-mortems)
☐ Lessons learned database
☐ Best practices database
☐ Staff expertise database
☐ Communities of practice/expertise groups
☐ Oral interviews
☐ Oral histories (more formal than "interview," perhaps facilitated by trained historian)
☐ Knowledge development teams (specifically formed to develop new knowledge assets for the organization)
☐ Knowledge fairs
☐ Formal story telling
☐ Close-out reports or final project reports
☐ Enhanced communication practices (e.g., up-to-date e-mail system, internal listservs or electronic bulletin boards, effective meeting management, ad hoc discussions, team rooms, ad hoc discussions or verbal sharing of expertise among employees is encouraged, etc.).

☐ Staff specially trained as meeting facilitators
☐ Other. Please list or describe:
Comment if desired:

21. What **tools** are available for knowledge capturing?
Check all that apply
☐ Reasonably up-to-date personal computer systems and business/office software
☐ Meeting rooms well-equipped for group interactions (low-tech—whiteboards, markers, tablets, etc., or high-tech—web access, computer projection, video communication center, etc.)
☐ Project management software with capability to capture important project documents
☐ Specialized software tools such as geo-mapping, CAD, statistical analysis, flowcharting, resource utilization, process control and analysis, business process analysis, voice-to-text software, etc.
☐ Databases that are reasonably easy to maintain and search
☐ Content-management or text-base-type software specifically targeted to document/text management applications
☐ Intranet portals that provide an interface to the organization's knowledge resources
☐ Templates, outlines, or other specific content/format guidelines to provide guidance on what to include and how to go about writing
☐ Web-building tools for shared or team websites (such as may be used by communities of practice, cross-functional teams, internal–external teams, etc.)
☐ Meeting management software
☐ Wiki or blog software
☐ Phone systems equipped for conference calling
☐ Other. Please describe:
Comment if desired:

22. Are there active written administrative procedures to guide the capturing practices?
☐ Yes
☐ No
If yes, please provide copy.

23. Are practices for **storing** KM resources in place?
Check all that apply
☐ We have a clear strategy for storing our knowledge assets.
☐ Employees generally understand what needs to be stored, and how to get resources from their possession into storage. The process is well-defined for most resource types.
☐ Storage practices are well-defined for some critical resources, such as legal or financial documents, but not necessarily for all.
☐ Storage practices are well-defined for physical resources but not for electronic resources (please refer to the Scope section above for definitions of physical and electronic resources).
Comment if desired:

24. Where are captured resources stored?
Check all that apply
☐ Physical resources are stored in agency-owned enterprise-level archives.
☐ Electronic resources are stored in an enterprise-level repository.
☐ We capture a lot, short-term, on personal computers or group-level servers, but we don't really have an organized way or central repository to store electronic resources long-term.
☐ We store our resources at another organization (e.g., state archives, museums, etc). Please explain:
☐ Other (specify—provide details if possible):

Comment if desired:

25. Are there active written administrative procedures to guide storage practices?
- ☐ Yes
- ☐ No

If yes, please provide copy.

26. How are resources **preserved** over time, for differing resources types and formats?

Check all that apply
- ☐ We have defined retention periods for most resource types. We work with stakeholders such as legal counsel, professionals, and managers, or historians—and also consult laws and regulations, plus records and knowledge management conventions and best practices to determine appropriate retention policies.
- ☐ We have a mix of preservation practices, depending on whether the resource is in electronic or physical format. The same retention rules don't apply across formats for similar resources, such as a project report in paper or in electronic format.
- ☐ Physical resources are retained based on document type or content, but electronic resources are usually retained based on criteria other than document type or content.

Comment if desired:

27. How adequate is the storage infrastructure?

Check all that apply
- ☐ The physical storage infrastructure is adequate in terms of physical space, in a reasonably convenient location, with reasonable security against environmental damage or natural disasters.
- ☐ Physical storage uses established records management or archival practices, with adequate shelving, durable boxes, folders, labeling, etc.
- ☐ The repository for electronic resources has adequate capacity for long-term storage of electronic resources and is reasonably secured against environmental damage, natural disasters, or intrusion, either computer-borne or physical.
- ☐ The repository for electronic resources is backed up routinely, based on established and enforced procedures and protocols.

Comment if desired:

28. How do employees **identify and find** knowledge resources?
- ☐ We search an enterprise-wide database(s), populated with metadata, to find most resources that have been captured, stored, and preserved.
- ☐ Our intranet portal ties resources together and provides links or keyword-type index data to help find most resources, electronic or physical.
- ☐ We have a plethora of databases, clearinghouse type websites, and portal-type web pages, depending on the division/work group, resource type, or some other criteria. There is no central access point. One has to access each individually.
- ☐ We have various finding tools, depending on who is managing the resource (e.g., library, records management, knowledge management, archives, IT, division staff, etc.).
- ☐ We have a mixture of databases and manual (hardcopy) indexes.
- ☐ We mostly rely on knowledgeable individuals to help us find resources.

Comment if desired:

29. Are there active written administrative procedures to guide the practices for identifying and finding resources?
- ☐ Yes
- ☐ No

If yes, please provide copy.

30. Are stored KM resources readily available for use in current work and decision making?
Check all that apply

- ☐ The location of stored resources, physical and electronic, is reasonably convenient and accessible.
- ☐ We have a high priority to get as many KM resources as possible available via the personal computer at the desktop.
- ☐ We have a "push" or proactive system that delivers new resources as they become available to the user, based on individually defined criteria.
- ☐ Resources can be delivered to the user within a timeframe that fits reasonably well into the current work stream.
- ☐ There is a system in place that tracks the location of physical resources (check in/checkout).
- ☐ Decisions to move physical materials off-site or destroy them are based on reasonable needs for efficient access by staff for use in current work, as well as on physical space needs.

Comment if desired:

31. Are there active written administrative procedures to guide the resource retrieval practices?

- ☐ Yes
- ☐ No

If yes, please provide copy.

32. Is there an established practice for destruction of obsolete KM resources?

- ☐ Yes, for most physical and electronic resources.
- ☐ Yes, for physical, but not for electronic resources.
- ☐ No

Comment if desired:

33. Are there active written administrative procedures to guide obsolescence/destruction practices?

- ☐ Yes
- ☐ No

If yes, please provide copy.

PART IV. KM EFFECTIVENESS

34. Do KM practices enjoy continuity and persistence over time?

- ☐ The program is robust and continues through staff and administration changes.
- ☐ The program exists, but is not evenly supported or well-communicated by management.
- ☐ The program may or may not survive, depending on factors such as budget cycles, administrative changes, etc.

Comment if desired:

35. Does your agency use metrics to gauge the value-added and/or effectiveness of the KM program, or to justify costs?

- ☐ Yes
- ☐ No

If yes, please describe and provide contact name for possible follow-up interview:

36. Does the agency have training and/or mentoring programs for staff transferred to new jobs, new hires, or those new to leadership to help them understand the agency's KM practices and how to make best use of KM resources?

- ☐ Yes
- ☐ No

Comment if desired:

37. Has your agency found any specific initiatives to be especially effective in creating acceptance of and participation in ("buy-in") of KM practices within your organization?

☐ Yes
☐ No

Comment if desired and if yes, provide contact name for possible follow-up interview:

Please add any additional comments as desired:

THANK YOU FOR YOUR HELP AND COOPERATION
Please return the completed questionnaire by February 24, 2006 to
Maryanne Ward, Consultant

APPENDIX B

Questionnaire Responders

State Transportation Agency	Abbrev.	Job Title of Respondent
Alabama Department of Transportation	AL	Transportation Director
Alabama Department of Transportation	AL	Assistant Chief Engineer, Administration
Alaska Department of Transportation and Public Facilities	AK	Research and T2 Manager
Arizona Department of Transportation, Motor Vehicle Division Policy Unit	AZ	Management Analyst II
Arizona Department of Transportation	AZ	Librarian
Arizona Department of Transportation, Environmental and Enhancement Group (ITD)	AZ	Program Manager
Arizona Department of Transportation, Statewide Project (SPM)	AZ	Computer Specialist IV
Arkansas State Highway and Transportation Department	AR	Personnel Specialist
California Department of Transportation, Division of Business, Facilities, and Security	CA	Agency-Wide Records Manager
California Department of Transportation, Transportation Library and History Center	CA	Retired Supervising Librarian
California Department of Transportation, Transportation Library and History Center	CA	Supervising Librarian
Delaware Department of Transportation	DE	Support Service Administrator
Georgia Department of Transportation	GA	State Materials and Research Engineer
Georgia Department of Transportation	GA	Strategic Development Administrator
Idaho Department of Transportation	ID	Research Program Manager
Idaho Department of Transportation	ID	Records Program Manager
Iowa Department of Transportation	IA	Director, Office of Rail Transportation
Iowa Department of Transportation	IA	Librarian
Iowa Department of Transportation	IA	Manager, Electronic Records Management System
Iowa Department of Transportation	IA	Director, Operations and Finance
Kansas Department of Transportation	KS	Bureau Chief of Personnel Services
Kansas Department of Transportation	KS	Bureau Chief of Computer Services
Kentucky Transportation Cabinet, Department of Administrative Services	KY	Administrative Branch Manager
Louisiana Department of Transportation and Development	LA	Director, Louisiana Transportation Research Center
Maine Department of Transportation	ME	Transportation Research Engineer
Massachusetts Highway Department	MA	Assistant Chief Engineer

Michigan Department of Transportation	MI	Engineering Technician
Minnesota Department of Transportation	MI	Director, Document and Records Management
Missouri Department of Transportation	MO	Director, Organizational Results
Montana Department Of Transportation	MT	Disaster Recover/Records Supervisor
Montana Department of Transportation	MT	Research Engineer
Nebraska Department of Roads	NE	Communication Division Manager
Nebraska Department of Roads	NE	Communication Services Manager
Nevada Department of Transportation	NV	Chief Operations Analysis Engineer
New Jersey Department of Transportation	NJ	Executive Assistant I
New Mexico Department of Transportation	NM	Research Engineer
New York State Department of Transportation	NY	Acting Director, Human Resources
Ohio Department of Transportation	OH	Library Administrator
Pennsylvania Department of Transportation	PA	Training Manager
Rhode Island Department of Transportation	RI	Deputy Chief Engineer
South Carolina Department of Transportation	SC	Research Engineer
South Dakota Department of Transportation	SD	Research Program Manager
Tennessee Department of Transportation	TN	Director, Human Resources
Texas Department of Transportation	TX	Training Specialist, Human Resources Division
Utah Department of Transportation	UT	Director of Research and Development
Vermont Agency of Transportation	VT	Research and Testing Engineer
Vermont Department of Transportation	VT	Analyst in Human Resources
Virginia Department of Transportation	VA	Knowledge Management Officer
Wyoming Department of Transportation	WY	Training Manager
Department of Transportation and Works, Government of Newfoundland and Labrador	NL	Manager of Highway Design
City of Edmonton, Transportation Department	ED	Manager, Streets Engineering
New Brunswick Department of Transportation	NB	Research Engineer
New Brunswick Department of Transportation	NB	Policy Analyst
Northwest Territory Department of Transportation	NT	Assistant Director Highways

Note: Some STAs had more than one respondėr

APPENDIX C

Detailed Results for Question 1

TABLE C1
CONTAINS SPECIFIC STATE TRANSPORTATION AGENCY RESPONSES TO QUESTION 1

STA	Require Exit Interviews	Assign Documenting Individual Expertise	Have Succession Plan	Assign Knowledge-Capturing Tasks to Senior Staff	Other (see comments in Table C2)
AK					Yes
AL					Yes
AR	Yes				Yes
AZ	Yes	Yes	Yes	Yes	Yes
CA					Yes
GA					Yes
IA	Yes				
ID				Yes	
KS	Yes				
LA	Yes				
KY	Yes			Yes	
MA	Yes		Yes	Yes	
ME	Yes				
MI					Yes
MN	Yes				Yes
MO	Yes				
MT				Yes	Yes
NE	Yes	Yes	Yes	Yes	
NJ	Yes	Yes	Yes		
NM	Yes	Yes			
NV					Yes
OH	Yes		Yes	Yes	Yes
PA					Yes
RI				Yes	
SC					Yes
SD					Yes
TN	Yes				Yes
TX	Yes	Yes			Yes
UT	Yes	Yes		Yes	
VA					Yes
VT		Yes			Yes
NB			Yes		
NT					Yes

Note: Multiple selections were allowed.

TABLE C2
SPECIFIC COMMENTS FROM STATE TRANSPORTATION AGENCIES REGARDING QUESTION 1

STA	Comments
AL	We retain knowledge if person elects to work for a consultant (after 2 years removed from state government) or can be hired as a retired state employee ($20,000 cap).
AR	Exit interviews are conducted only with employees who resign their positions voluntarily, with the exception of retiring staff. Some of the other efforts mentioned above are done, but not on a steady basis. In most cases, the individual has already passed his or her institutional knowledge on to subordinates.
AZ	Arizona DOT has a closeout interview process that is optional, not mandatory. In the Statewide Project Management department, there are some instances where updating operations manuals, etc., by senior staff occur, but it is not done on an enterprise basis.
CA	There is a lack of consistency, enterprise-wide.
CA	No single strategy is required or consistently practiced agency-wide.
GA	Retired annuitants are hired to assist in the transfer of knowledge and the training of replacement staff.
MA	Exit interviews are generally used to obtain feedback from the employee to learn why they are exiting the agency. The focus of the interview is not KM, but this does play a minor role in the process. For the other two boxes checked above, we do not have any formal processes, but these things are generally practiced by the agency.
MI	Efforts are rarely made to capture that knowledge.
MN	Minnesota DOT began implementation of enterprise document management system (EDMS; document management, document workflow, and records management) in 2003. This is a department-wide (statewide) program. We are systematically implementing EDMS function by function.
MT	We have staff update operations manuals, policy, and procedures when needed.
NJ	I believe that our Succession Planning Program was intended to help ensure that we do not lose all of our institutional knowledge. Identifying a pool of resources and or "grooming" individuals who may be likely to fill the positions of current managers helps to focus on what we can expect to lose and the candidates likely to replace them.
NV	A few positions have been overlapped (usually for no more than three months) with the incumbent mentoring his or her successor.
OH	We try to hire or promote new employees into positions by overlapping retiree and new employee for 1–6 months, depending on the position, to provide transfer of knowledge.
PA	Occasionally, we bring back retired employees as "annuitants" and capitalize on their knowledge.
SC	A department-wide work force development program has been developed and will be initiated in the near future. The program should enhance transfer of knowledge and training of replacement staff in the future.
TN	The department is allowed to reemploy recently retired persons for a period not to exceed 120 workdays when the purpose is to provide on-the-job training for a newly promoted/employed person. This only includes retired persons who held a position that requires the passing of a great deal of work-related knowledge, which cannot be found at another learning source such as a university or college.
TX	Employees who are close to retirement may or may not be assigned to document expertise. There is no formal requirement for this; however, it is considered valuable in some situations and locations. Part of the ongoing project described later in this document to develop a Pavement Forensics KM System within the department's existing learning content management system/KM system includes interviews with exiting and retired employees to collect specific implicit knowledge on pavement forensics.
VA	1) The division or district contacts the KM [office] to conduct knowledge capture exercises, 2) the manager assigns the exiting staff to write up what they know, 3) another employee is assigned to shadow the exiting staff, and 4) nothing extra is done—do not have stats on how often the above occurs. KM division is called to conduct knowledge mapping.
VT	Specific key positions are double-filled with the retiree and new incumbent to ensure continuity.
NT	Acting roles for vacations, career management plans.

APPENDIX D

Detailed Results for Questions 2–4

TABLE D1
KNOWLEDGE MANAGEMENT PROGRAMS OR ELEMENTS OF PROGRAMS IN INDIVIDUAL STATE TRANSPORTATION AGENCIES

STA	Enterprise-Wide KM Program	Enterprise-Wide in Rollout Phase	Division/Work Unit Level KM Program	Pilot/Prototype Sustainable	Pilot/Prototype Possibly Not Sustainable
AZ	X		X	X	
CA			X		
IA			X		X
ID		X	X		X
KS	X	X		X	
KY	X				
MI			X		
MN		X		X	
MO	X		X	X	
MT			X	X	
NE		X			
NJ					X
OH	X				
PA		X	X		X
TX			X		X
UT			X		
VA		X		X	
VT			X		
NB		X		X	
Total	5	7	11	7	5

TABLE D2
CONTAINS COMMENTS ASSOCIATED WITH QUESTIONS 2, 3, AND 4

STA	Comments
AZ	Arizona DOT (ADOT) has a library and a records retention schedule. These are elements of a knowledge management program. For Statewide Project Management (SPM), we have nothing [in the way of a library or retention schedule]. Some SPM units have "in-house" collections of materials. The following response is all for the Statewide Project Management Department: There are several pilot efforts in current usage with more being prototyped. Some others are already in production. Estimated Engineering Construction Costs is in production as an active enhancement effort. As it progresses it will allow for analysis of project scope and cost changes. As-Builts is actively collecting and indexing the as-built plans for completed projects. Project Reference is an effort toward a uniform physical storage of project documents with transition to electronic storage. Project Team Management System is a prototype of a system to provide electronic creation and storage of project team members and stakeholders through development, design, and construction of the project with continuation through maintenance. Computer-Aided-Engineering is planning a system to archive and make available electronically the computer-aided design files. The Predesign Portal provides a method of storing scoping documents to make them available to successors on a project or new personnel. Project Folder is an electronic storage facility with the ability of document owners to check in documents to make them widely available and check out for modification or update. The Project Reference above will be accessible from the Project Folder. The Project Folder is very flexible in the formats it can accept. ADOT Data Warehouse is in production to make agency data excerpted from production systems at a more granular level available for research and reporting. The examples listed above are not represented as being a complete list. Some of these systems are being developed with the intent of working with other systems. The development should become more collaborative in the future.
CA	Caltrans has varying elements of a KM program found at the division level. Some examples include: (1) the Records Management Program; (2) the Library & History Center; (3) databases containing shared information related to project delivery, engineering, research, and transportation planning; (4) an extensive intranet that serves as a major communication tool to reach more than 22,000 staff statewide, providing access to databases, policies and procedures, publications, and other information.
IA	We have an enterprise-wide electronic content management/document management program. We have a photo archive committee that is working on conserving historic resources in the agency. We will hire a consultant to visit and prepare a plan of action to save these resources. There is a Records Management staff and budget for the capture and management of departmental documents and records.
MN	Minnesota DOT EDMS program is not a pilot, it is a program.
MT	To [responder's] knowledge, MDT does not have an agency-wide KM program. The Information Management Unit (records) does have KM practices implemented, which are available to the entire agency.

TX	There is a current project to redesign the department's external website to make it more searchable and user-friendly, based on citizen and business customer input and feedback. The Office of Primary Responsibility on this project is the Public Information Office. All Texas DOT districts, divisions, and offices have specific policies and procedures for some sort of "knowledge management," or data or recordkeeping for their own purposes and for general distribution. I include the six divisions and offices because they each handle a considerable amount of information for widespread internal and/or external distribution. The Texas DOT Construction and Human Resources Divisions are working on a project with the Texas Transportation Institute to develop a pilot KM system specifically on pavement forensics. The project scope includes identification of explicit knowledge and identification and capture of implicit knowledge gathered from key individuals identified as part of the project. Data are currently being collected, assembled, and uploaded into the department's already existing Learning Content Management System ("the I-Way"), which was acquired to serve as host for internal online training, but which also has KM features that allow for user input and advanced search capability.
UT	Research Division, Library, Administrative Records. We [see to] the maintenance and preservation of knowledge, and archive of all significant documents, safety data, traffic data, asset management.
VA	Although this is an enterprise-wide program, we are more widely involved in some divisions and districts than in others. [We have] Communities of Practice to support the redundancy of knowledge, share institutional and tacit knowledge with new employees, identify and organize existing explicit knowledge, share knowledge across districts and divisions, and identify process improvements and collect lessons learned. (1) There are 11 established communities and 6 in development that span across the agency; (2) Knowledge mapping is used to support the identification and collection of unique knowledge and to identify experts. The division is called to do individual knowledge mapping of high knowledge risk areas or employees; i.e., pending retirements, and is kicking off a district-wide knowledge mapping project using social network analysis software. (3) The division is charged with ensuring that the agency intranet addresses knowledge sharing. The intranet is currently undergoing revisions and upgrades to improve the usability through the development of a taxonomy (using the *Transportation Research Thesaurus* as a base) and in improving the search engine beyond keyword searching. There is a developing "lessons learned repository" that is being used in the pilot. (4) A study was undertaken to determine knowledge sharing across the organization through employee networks to establish an as-is and serve as a basis for future projects. Supporting documentation: book chapter outlining the first two years of KM at Virginia DOT and a PowerPoint presentation outlining communities and outcomes.
VT	All construction plans from 1930s to date are recorded digitally. All documents pertaining to projects are stored in state government central files (hardcopy). There are units within the agency that maintain unit manuals and require periodic updates of both procedures and standards. The scope is not well-known as it is not complete to a specific level of detail or accuracy. The agency is actively participating in a state government-wide effort called the "Strategic Enterprise Initiative." This effort extends across the agency at all levels to identify existing business processes and opportunities to become more efficient. It is anticipated that this statewide effort will result in an expanded web portal with electronic document management and information sharing among state agencies. It is hoped that this will expedite such processes as the permitting of projects.

APPENDIX E

Detailed Results for Question 5

TABLE E1
CONTAINS DETAILED RESULTS BY STATE TRANSPORTATION AGENCIES FOR QUESTION 5

STA	Central Functional Unit	Division Level Work Unit or Individual with KM Responsibility	Go to Different Work Units Depending on What Is Needed	On Informal Basis Go to Knowledge Individuals	Spend a Lot of Time Figuring Where Things Are	Other (see comments below)
AK			X	X		
AL					X	
AR	X		X	X		
AZ	X	X	X	X	X	X
CA	X	X	X	X	X	
DE					X	
GA			X	X		
IA	X		X			X
ID			X	X	X	
KS	X		X	X		
LA						X
KY	X	X	X	X		
MA	X			X		
ME	X		X	X		
MN	X		X	X		X
MO			X			
MT	X		X	X	X	
NE	X	X	X	X		
NJ		X	X	X	X	
NL				X		
NM			X	X	X	
NV			X	X	X	
NY			X	X	X	
OH	X	X	X	X		
PA	X		X		X	
RI				X		
SC			X			
SD				X	X	
TN	X		X	X		X
TX	X	X	X	X	X	X
UT	X		X	X		X
VA	X		X	X		X
VT			X	X		
ED		X	X			
NB			X			
Total	17	8	28	26	13	8

Note: Multiple selections allowed.

TABLE E2
LISTS COMMENTS REGARDING QUESTION 5

STA	Comments
CA	Library and History Center that includes archival information, records manager, individual units
IA	Library, records management. The Records Center is working toward recentralizing access to information through the use of the document management system.
MA	Transportation Library; archives
ME	Library, archives, TEDOCS (our e-filing system)
MN	Enterprise Document Management System (EDMS) staff and library staff. EDMS is in roll-out; transition from current storage to central repository.
MT	Library, records management, information technology (IT) (electronic data). Knowledge and written documentation is spread out throughout MDT. At times, different offices are contacted to share information.
NE	Library, archives, records management, IT
PA	It was in our training department, but I have changed positions and am now in the Drivers License/Motor Vehicle arena. (Note: the Pennsylvania respondent was the Training Manager.)
TN	Library, archives, and records management [are the central functional units]
TX	The agency's intranet, known as "Crossroads," contains links to all internal policy and procedures manuals, such as the *Occupation Safety Manual*, *Human Resources Manual*, *Records Management Manual*, and many more. It also gives employees access to information from each district, division, and office, including those listed in the answer to Question 3 (Appendix D). Much of this information is also available to the general public through the department's public website, www.dot.state.tx.us, as well as information of interest to the general public, such as news, programs, manuals, roadway information, transportation studies, customer services, etc. Search capabilities are very limited on both the intranet and Internet sites. You pretty much need to know which links to start with to drill down to find the information you need, especially on the intranet. A current project is to redesign the Internet site, among other things, addressing the public site's search capability.
UT	The library and archives [are the central units]. Also, the technology transfer engineer will acquire most requests.
VA	Have spent a lot of time trying to figure out where things are—we are trying to establish a systematic process.
VT	Selecting staff with experience and topic-based expert selection are possible within the size of the agency.

APPENDIX F

Detailed Results for Questions 6–17

TABLE F1
RESPONSES BY STATE TRANSPORTATION AGENCIES REGARDING OVERALL CULTURAL RECEPTIVITY TO KNOWLEDGE MANAGEMENT PRACTICES

STA	Overall Negativity	Largely Negative	Neutral	Largely Receptive	High Receptivity
AZ			X		X
CA			X		
IA			X		
ID			X		
KS				X	
KY				X	
MA		X			
MN			X		
MO			X		
MT			X		
NE				X	
NJ				X	
NV		X			
OH					X
PA			X		
TX					X
UT				X	
VA				X	
VT				X	
NB		X			
Total	0	3	8	7	3

TABLE F2
COMMENTS REGARDING OVERALL CULTURAL RECEPTIVITY TO KNOWLEDGE MANAGEMENT PRACTICES

STA	Comments
AZ	[We rated] Motor Vehicle Division as a "5," and the Statewide Project Management as a "3." I feel that the Arizona DOT (ADOT) culture is moving toward a more active support KM effort.
CA	Receptivity of KM practices has varied over the years. In 1984, the department developed a History Program under a written policy (now Deputy Directive D-58), which created a statewide History Committee and a staffed History Center in the Library. The program is dedicated to ensuring preservation and access to the department's historical materials. During the past 5 years, efforts to maximize knowledge sharing have increased enterprise-wide through online databases and an extensive intranet.
IA	Management is receptive to saving historic resources. No formal program has been established in this agency. Management is supportive of the electronic document management system (EDMS) and is receptive to revisiting the policy on its use.
MN	EDMS is a major change management initiative. Employees involved in the work are learning new skills. Standardization of document naming conventions, "metadata" profiling, and workflow processing ("reengineering") is occurring.
NE	Some do not think to share their specialized knowledge until they leave.
PA	There are pockets of knowledge sharing, but there is no overall strategy or support for KM. A few of our executives are supportive of knowledge sharing, but the idea has cooled considerably the last three years. We still do some After Action Reports, but it is not a requirement.
TX	Knowledge management (KM) is pervasive throughout the department, although it may be contained in various print and electronic formats across the organization. Continuous efforts are made to keep both employees and the general public informed about ongoing and upcoming programs, activities, and other factors that affect the department.
UT	We are using document management for sharing of information with internal and external customers.
VT	Management emphasis on preserving institutional memory has been articulated for at least the past three years. The review of unit manuals has been afforded priority, with focused attention from FHWA in review processes. There remains some reticence to embrace a KM philosophy in isolated staff enclaves, where knowledge hoarding may be an issue.

TABLE F3
COMMENTS REGARDING QUESTION 7

STA	Comments
AZ	The level of these efforts needs to be increased.
IA	Enterprise applications are reviewed by Management and Information Technology.
MT	Management encourages staff to consult other employees to tap into their past organization experience when needed.
PA	This is a sometimes in our organization. It depends on the project and the culture of that unit.
TX	This could include a combination of both electronic searching and old-fashioned legwork. Most information in the department is obtainable; sometimes the trick is finding it. Internal networks abound. Someone knows someone who knows someone who knows whatever it is. Compiling the information for this survey is a good example.
VA	Depending on the area, employees are encouraged but not necessarily given direction on how to do this.

Question 7: Before Beginning New Projects or Programs, Does Management Expect Employees to Consult Prior Organizational Experience as Evidenced in Documents, Databases, Knowledgeable People, and Other Resources?

TABLE F4
COMMENTS BY STATE TRANSPORTATION AGENCIES REGARDING QUESTION 8

STA	Who Exercises Overall Authority Plus Comments
AZ	N/A—Motor Vehicle Division; Program Manager—Intermodal Transportation Division (ITD). No one at Statewide Project Management
CA	No single individual currently has authority for KM programs.
IA	No one
ID	N/A
KS	Director of Design
KY	Executive Director
MN	Minnesota DOT has an EDMS Advisory Team, co-chaired by two division directors. The Enterprise Document Management System (EDMS) Director is responsible for design, development, operations, and maintenance.
MO	None assigned
MT	KM practices are accomplished by each office area.
NB	Executive
NE	Director, division heads
NJ	I am not certain that I would assign that authority to any individual or unit within the department. I presently believe that much of what we accomplish is the result of the concerted efforts of staff at varying levels of the organization who recognize the need to preserve this knowledge; a strong sense of loyalty developed during their collective years of service to this organization.
OH	The Director/senior staff. Shared responsibility supported by district deputy directors and their administrators in planning and production, highway management, and human resources.
PA	This is a sometimes in our organization. It depends on the project and the culture of that unit.
TX	N/A. Cannot say this resides with any one particular person or even just one office, although if I had to pick one, I guess I'd have to pick the General Services Division, since that division is responsible for Intellectual Property, Plans Online, and Records Management and Retention.
UT	Senior leaders
VA	Knowledge Management Officer
VT	Division Directors

Question 8: Who Exercises Overall Authority over Knowledge Management Practices?

TABLE F5
COMMENTS BY STATE TRANSPORTATION AGENCIES REGARDING QUESTION 9

STA	Who Exercises Strongest Leadership Plus Comments
AZ	Not applicable for the Motor Vehicle Division (MVD); Section Managers lead in the ITD department. For the Statewide Project Management department, the support for KM practices is scattered throughout the Division. Support is increasing, although no strong leader has emerged with high visibility.
CA	Agency-wide records manager, Library and History Center, division heads
IA	Librarian, records managers, management professionals. Traditionally, records management and the library have been the repositories for such information and have experience managing this content. Computer technology has decentralized the storage model and access to information.
ID	The Bridge Engineer and the Engineer-in-Training Program Manager for the ITD Division of Highways
KS	Director of Design
KY	Executive Director
MN	Lieutenant Governor/Commissioner Molnau and her staff of division directors
MO	None assigned
MT	Research engineer
NE	Communication Division Manager, who oversees library and records management (includes archives)
NJ	I believe that it has to be adopted as a culture of sorts, with leadership and support from senior management.
OH	The Assistant Director for Planning/Production and the Assistant Director for Highway Management
PA	Not sure
UT	Project Development Director
VA	Commissioner, chiefs, and district administrators
VT	Information Technology Manager
NB	Executive

Question 9: Who Exercises the Strongest Leadership for Knowledge Management Practices?

TABLE F6
RESPONSES BY STATE TRANSPORTATION AGENCIES REGARDING QUESTION 10

STA	Day-to-Day Responsibility Plus Comments
AZ	These responses are not on behalf of the entire agency, but just reflect the activities in the environmental work unit (Environmental and Enhancement Group). [On behalf of] the Statewide Project Management group, insofar as I am aware, no one at ADOT has been formally assigned this responsibility. [In my opinion] the Information Delivery Solution (IDS) section of the Information Technology Group (ITG) and the Program and Project Management section are the most active in KM work at ADOT. The ITG IDS section has the largest role in widely disseminating the knowledge via the Data Warehouses On-Line Analytical Processing (OLAP) functionality. The systems Program and Project Management System (PPMS) is active in developing [capabilities] to allow capture of information for KM purposes as part of their design.
CA	None officially assigned. However, agency-wide Records Manager responds to records-related questions.
IA	No one. The Electronic Records Management System (ERMS) Project Manager is responsible for the operation of the ERMS for the storage of departmental records.
ID	N/A
KS	Bill Roth, System Software Specialist
KY	Executive Secretary
MN	EDMS Director
MO	None assigned
MT	Records Management Unit
NE	Everyone
NJ	Certainly, if we speak to it as a “program” it would be administered through our Human Resources or Training Units under the Assistant Commissioner of Administration.
OH	Division Deputy Directors and District Deputy Directors and related administrators in Planning/Production, Highway Management, and Human Resources
PA	There is none now. We are conducting a research project to provide next steps and recommendations.
TX	Everyone in the department. It would probably be fair to say that every employee in the department is responsible for compiling, collecting, and retaining some sort of data or information. All employees answer to the general public and, at times, the media.
UT	The Research Division has the most responsibility, but not enterprise-wide.
VA	Knowledge Management Officer
VT	Division Directors; e.g., Program Development Division and section managers, such as IT manager. Each contributes within their respective areas.
NB	Training and Development Manager

Question 10: Who Has Overall, Day-to-Day, Enterprise-Wide Responsibility for Knowledge Management Practices?

TABLE F7
RESPONSES BY STATE TRANSPORTATION AGENCIES REGARDING QUESTION 12

STA	Yes	No
IA	X	
ID		X
KS		X
KY	X	
MN		X
MT	X	
NE	X	
NJ		X
NV	X	
OH	X	
PA		X
TX		X
UT		X
VA		X
VT		X
NB		X
Total	6	10

Question 12: In General, Are the Authority, Leadership, and Day-To-Day Overall Responsibilities for KM Practices the Same for Both Physical and Electronic Resources?

TABLE F8
COMMENTS FROM STATE TRANSPORTATION AGENCIES REGARDING QUESTION 12

STA	Comments
AZ	Yes, [for the departments of] Environmental and Enhancement Group, Motor Vehicle Division, and Transportation Planning Division. No at Statewide Project Management Division.
MN	EDMS is new (starting in 2003). We are evolving a department-wide strategy for all information assets.
NJ	Our Information Technology Unit is responsible for the development and maintenance of electronic resources with wide-based applications.
TX	Policies and procedures for gathering, reporting, and retention of data and knowledge vary widely across the organization, depending on the type of data it is, whether it is for internal and/or external distribution, available space, and whether external standards exist. Standards and procedures for the management of both physical and electronic records, as well as for retention and destruction of physical and electronic records, are established by specific government codes that deal with each.
UT	Electronic has different systems to track, and physical is in each division and in the library.
VA	Currently there are many repositories for existing knowledge. We are working on bringing these under the authority of the KM Division.
VT	Well-defined procedures for management of electronic records exist. The standards ensure protection from virtually any possible destructive event. The organization of these knowledge assets has to some degree followed the age-old filing systems used for paper records. Physical records have a standard of practice defined for all state government, including archival and retrieval practices. Unrecorded knowledge is unavailable in all cases.

TABLE F9
RESPONSES BY STATE TRANSPORTATION AGENCIES REGARDING QUESTION 13

STA	Job Title	FTE
AZ	Professional librarians	1
CA	Professional librarians	4
CA	Paraprofessional or technical specialists	5
CA	Records managers	13
IA	Knowledge management professionals	2
IA	Professional librarians	1
IA	Scanning/indexing/records management staff	5
IA	Records managers	2
IA	ERMS support staff	3
ID	Customer relations manager	1
ID	Information technology professionals	2
ID	Records managers	1
KY	Knowledge management professionals	1
KY	Information technology professionals	0.75
KY	Records managers	1
KY	Clerical support	1
MA	Professional librarians	1
MN	Knowledge management professionals	6
MN	Records managers	1
MN	Clerical support	1
MT	Records managers	1
MT	Clerical support	2
NE	Professional librarians	1
NE	Information technology professionals	1
NE	Records managers	1
NE	Human resource managers/specialists	1
NE	Paraprofessional or technical specialists	2
OH	Professional librarians	1
OH	Information technology professionals	1
OH	Records managers	1
PA	Professional librarians	1
PA	Training manager	1
UT	Professional librarians	1
UT	Information technology professionals	1
UT	Clerical support	1
UT	Records managers	1
VA	Knowledge management professionals	4
VA	Professional librarians	2.5
VA	Information technology professionals	10
VA	Records managers	2
VA	Clerical support	2
VT	Information technology professionals	10
VT	Human resource managers/specialists	2
VT	Paraprofessional or technical specialists	0.5

Question 13: What Staffing Is Dedicated to Responsibility for Knowledge Management Practices, with Full-Time Equivalencies?

TABLE F10
COMMENTS REGARDING KNOWLEDGE MANAGEMENT STAFFING

STA	Comments Regarding Staffing
AZ	ADOT has others (e.g., Engineering Records and Data Warehouse staff) but [responder] only entered for Transportation Planning Division. [There is] no full-time dedicated staff. The primary responsibilities are carried out by the management positions and team leaders for Environmental and Enhancement Group. Currently there are no dedicated FTEs in place for the Motor Vehicle Division. In the Statewide Project Management Division, there are some FTEs who would meet the criteria but their numbers and location are uncertain. These functions are decentralized.
MT	I think each individual is responsible for KM practices in their office area. There isn't one set person assigned to KM practices.
NB	Involves varying levels of effort from each of the above groups. Unable to estimate actual FTE total.
NE	Each division responsible
TX	Not easily determined

TABLE F11
RESPONSES BY STATE
TRANSPORTATION AGENCIES
REGARDING QUESTION 14

STA	Clearly Defined	Not Clearly Defined
AZ	X	X
CA		X
IA		X
ID		X
KS		X
KY	X	
MA		X
MN	X	
MO		X
MT		X
NE	X	
NJ		X
NV		X
OH	X	
PA		X
TX	X	X
UT		X
VA	X	
VT		X
NB	X	
Total	8	14

Question 14: Are Knowledge Management Responsibilities Clearly Defined?

TABLE F12
COMMENTS FROM STATE TRANSPORTATION AGENCIES REGARDING ARE KNOWLEDGE MANAGEMENT RESPONSIBILITIES CLEARLY DEFINED?

STA	Comments
AZ	Yes for ITD, Transportation Planning Division (TPD), Motor Vehicle Division (MVD). No, there is overlap or confusion about who is supposed to do what in the Statewide Project Management. My responsibilities as ADOT librarian are clearly defined and responsibilities under the records retention schedule are clearly defined. Some practices are currently in place in MVD. The Policy Unit is refining policies and procedures for maintenance of KM documents.
MN	EDMS staff roles are clear. Each office and district approaches KM differently. As EDMS is implemented, clarification is occurring.
MT	I think individuals use KM practices when they are needed. Some KM practices are defined, such as the retention process for records management. Other areas may not be defined as well as they should be.
OH	Process is informal but works well.
TX	I would say that even though most KM responsibilities are clearly defined, that there is still sometimes overlap and/or confusion.
VA	Within the KM Division they are. Within the agency, it is understood that the KM Division is the authority, but we do not yet have policies established.

TABLE F13
RESPONSES BY STATE TRANSPORTATION AGENCIES REGARDING QUESTION 15

STA	Have Point of Contact	Do Not Have Point of Contact
AZ		X
CA		X
IA	X	
ID	X	
KS	X	
KY	X	
MA		X
MN	X	
MO	X	
MT	X	
NE		X
NJ		X
NV	X	X
OH	X	
PA	X	
TX	X	
UT	X	
VA		X
VT		X
NB		X
Total	12	9

Question 15: Does Your State DOT Have a Single Point-of-Contact by Which Individuals from Within or Outside the Agency Can Obtain Published Information or Documents, Such as Research Reports?

TABLE F14
COMMENTS REGARDING EXISTENCE OF SINGLE POINT-OF-CONTACT FOR OBTAINING PUBLISHED INFORMATION OR DOCUMENTS

STA	Comments
AZ	We send Arizona Transportation Research Center (ATRC) reports to Engineering Records to sell, as do other ADOT units. My sense is that this is not systematic. If someone wants a report that is not available through Engineering Records, they would have to know which unit published it, which is not always clear on the reports. Many units are posting their publications on the web, but a person would need to know that said item existed and the unit that published it in order to find it. Communication and Community Partnerships would be the primary contact point for the public. The ADOT Data Warehouse is probably the best candidate to fulfill this role for most purposes, which might be project-related or for ad hoc database reporting. The ATRC would probably be best for research reports.
CA	Publications are obtained from several sources including the publications unit, library, research unit, and individual divisions.
IA	Requests for published information and records requests follow different channels.
MN	Principal contact is the librarian.
MT	Research staff can obtain any document published within the department. However, access is not limited through research staff. Individuals can contact the publishing office directly.
NE	Various sources, usually from division responsible
NV	We have a customer-service coordinator who is extremely knowledgeable as to where he can obtain resources; however, the customer's first point-of-contact will not necessarily be this individual.
TX	Texas DOT's Research Library is housed and managed by the Center for Transportation Research (CTR) at the University of Texas, Austin, which is open to the public. General information is also available on Texas DOT's public website (www.dot.state.tx.us), through our Public Information Office (PIO) in Austin, and from the PIOs in each district.
VA	Research reports can be obtained from a single point-of-contact [which is the]: Library. Virginia DOT reports (annual reports, news items, project reports, manuals, etc.) can be obtained from public affairs.

TABLE F15
RESPONSES BY STATE TRANSPORTATION AGENCIES TO QUESTION 16

STA	Yes	No
AZ	X	X
CA	X	
IA	X	
ID	X	
KS	X	
KY	X	
MA	X	
MN	X	
MO	X	
MT		X
NE	X	
NJ	X	
NV	X	
OH	X	
PA	X	
TX	X	
UT	X	
VA	X	
VT	X	
NB		X
Total	18	3

Question 16: Does Your DOT Have a Library Function That Deals Mostly with External Publications and Provides Formal or Informal Links and Access to Externally Published References, Literature/Reference Databases, Other Libraries, Transportation Research Centers, etc.?

TABLE F16
CONTAINS COMMENTS REGARDING EXISTENCE OF LIBRARY FUNCTION (QUESTION 16)

STA	Comments
MT	The library budget is a part of the research budget ($2 million).
VT	The Materials and Research Section maintains a document library with an electronic file card system. Copies of TRB, NCHRP, and New England Transportation Consortium publications are retained there. A room dedicated to the storage of written materials exists in the main offices of the agency as well. Here have been several efforts to establish a stronger library function within the agency, cataloging has improved greatly as a result of those efforts. A trained librarian assisted with the cataloging efforts and supplied training for paraprofessionals.
TX	A list of other transportation-related links is maintained on our public website, as does the Research and Technology Implementation Office and the Research Library at CTR–UT.
ID	Budget not broken out to library function; part of Idaho's Transportation Research Program administrative function
OH	Joint online catalog with state library/access to OhioLINK–Statewide resource sharing, OCLC's WorldCat and TLCat. Library has an intranet site and Internet site: http://www.dot.state.oh.us/library.
MA	The transportation library is currently reorganizing.

TABLE F17
CONTAINS RESPONSES BY STATE TRANSPORTATION AGENCIES TO QUESTION 17

STA	Yes	No
AZ	X	X
CA	X	
IA	X	
ID		X
KS	X	
KY		X
MA	X	
MN	X	
MO	X	
MT	X	
NE	X	
NJ	X	
NV	X	
OH	X	
PA	X	
TX	X	
UT	X	
VA	X	
VT		X
NB		X
Total	16	5

Question 17: Is the Library Staffed by at Least One Individual with Professional Librarian Training?

TABLE F18
COMMENTS REGARDING WHETHER LIBRARY IS STAFFED BY PROFESSIONAL LIBRARIAN

STA	Comments
AZ	Yes, for TPD; no for MVD. Do not know for ITD and unknown for Special Purpose Monitors.
ID	Research Program Manager and Research Program Assistant [library staff]
TX	Professional engineer heads the Research and Technology Implementation Office; CTR is staffed by the University of Texas [library staff].

APPENDIX G

Detailed Results for Questions 20–33

TABLE G1
RESPONSES FROM STATE TRANSPORTATION AGENCIES FOR QUESTION 20

STA	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
AZ	x	x	x	x	x	x			x		x					x	x	x	x
CA	x	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	
IA													x						
ID		x		x	x	x				x						x	x	x	
KS				x	x		x									x			
KY		x		x	x								x			x	x	x	
MA				x	x												x		
MN		x		x						x	x					x	x		x
MO	x	x		x	x	x		x	x							x	x	x	
MT	x	x		x	x	x				x	x					x	x		
NE	x	x	x	x	x						x	x				x	x	x	
NJ		x		x		x										x	x		
NV		x		x	x											x			
OH		x	x	x		x				x	x			x		x	x		
PA				x		x				x						x	x	x	
TX	x	x	x	x	x	x		x		x	x		x	x		x	x	x	x
UT		x	x	x	x	x	x	x	x							x			
VA	x	x			x	x	x	x	x	x	x	x				x	x	x	
VT				x	x														
NB				x		x													
Total	7	14	6	18	14	12	4	5	5	8	8	3	4	2	0	16	14	9	3

Question 20: What Methods Are Used to Capture Knowledge?
Key to letter designations in Table G1:
A—We have explicit strategies for knowledge development and capture.
B—Management expects staff to document experiences and lessons learned and make these accessible to the rest of the organization.
C—Employees spend time and effort to contribute to the organization's store of knowledge in an ongoing and structured manner.
D—Capturing is essentially achieved as a work by-product, part of the normal routine of project and program work, such as project plans, program proposals, write-ups of roundtable sessions, project reports, etc.
E—More experienced staff members are given knowledge-capturing assignments, such as documenting important procedures or writing standards and specifications.
F—Post-project reviews (also known as after-action reviews or post-mortems).
G—Lessons learned database.
H—Best practices database.
I—Staff expertise database.
J—Communities of practice/expertise groups.
K—Oral interviews.
L—Oral histories (more formal than "interview," perhaps facilitated by trained historian).
M—Knowledge development teams (specifically formed to develop new knowledge assets for the organization).
N—Knowledge fairs.
O—Formal story telling.
P—Close-out reports or final project reports.
Q—Enhanced communication practices (e.g., up-to-date e-mail system, internal listservs, or electronic bulletin boards, effective meeting management, ad hoc discussions, team rooms, ad hoc discussions or verbal sharing of expertise among employees is encouraged, etc.).
R—Staff specially trained as meeting facilitators.
S—Other.

TABLE G2
CONTAINS COMMENTS REGARDING QUESTION 20

STA	Comments
AZ	The Environmental and Enhancement Group added training and orientation programs.
MN	Electronic Document Management System
TX	An internal quarterly publication "Transportation News" is distributed to all employees. Also, internal conferences on topics such as Construction, Design, Information Resources, Human Resources, and others are held several times every year at various locations around the state. The largest and longest-running "knowledge fair" is the annual Transportation Short Course held every October at Texas A&M University, which draws thousands of Texas DOT (TxDOT) employees, engineering students, contractors, consultants, and other interested parties. The department makes extensive use of e-mail to distribute timely information to a broad audience on subjects ranging from local retirements to state and national transportation issues in the news. TxDOT has an extensive training catalog made up of both internally developed and externally acquired classroom and online training. In-house course development is accomplished with the help of one or more internal subject matter experts. Their input and "war stories" are often incorporated into instruction.

TABLE G3
RESPONSES FROM STATE TRANSPORTATION AGENCIES FOR QUESTION 21

STA	A	B	C	D	E	F	G	H	I	J	K	L	M
AZ	x	x		x	x		x	x	x			x	x
CA	x	x	x	x			x	x	x	x		x	
IA	x	x	x	x	x	x	x	x				x	
ID	x	x		x	x		x	x				x	x
KS	x	x	x	x			x		x			x	
KY	x	x	x	x			x	x	x	x		x	
MA	x		x	x	x		x	x					
MN	x	x	x	x	x	x	x	x	x			x	x
MO	x	x		x	x		x	x	x			x	x
MT	x	x	x	x	x	x	x	x	x			x	
NE	x	x	x	x	x	x	x		x	x		x	
NJ	x	x	x	x	x		x	x				x	
NV	x	x			x		x		x			x	
NY													
OH	x	x	x	x	x		x		x	x		x	
PA	x	x	x	x		x						x	
TX	x	x	x	x		x	x	x	x			x	x
UT	x	x	x	x	x	x	x		x			x	x
VA	x	x	x	x	x		x	x	x	x		x	
VT	x	x	x	x									
NB	x	x		x									
Totals	20	19	15	19	13	7	17	12	13	5	0	17	6

Question 21: What Tools Are Available for Knowledge Capturing?
Key to Letter Designations in Table G3:
A—Reasonably up-to-date personal computer systems and business/office software.
B—Meeting rooms well-equipped for group interactions (low-tech—whiteboards, markers, tablets, etc., or high-tech—web access, computer projection, video communication center, etc.).
C—Project management software with capability to capture important project documents.
D—Specialized software tools such as geo-mapping, computer-aided design (CAD), statistical analysis, flowcharting, resource utilization, process control and analysis, business process analysis, voice-to-text software, etc.
E—Databases that are reasonably easy to maintain and search.
F—Content-management or text-base-type software specifically targeted to document/text management applications.
G—Intranet portals that provide an interface to the organization's knowledge resources.
H—Templates, outlines, or other specific content/format guidelines to provide guidance on what to include and how to go about writing.
I—Web-building tools for shared or team websites (such as may be used by communities of practice, cross-functional teams, internal–external teams, etc.).
J—Meeting management software.
K—Wiki or blog software.
L—Phone systems equipped for conference calling.
M—Other.

TABLE G4
COMMENTS REGARDING QUESTION 21

STA	Comments
AZ	The library catalog is on the web and the intranet. In addition to electronic databases and geographic information systems, as well as intranet and Internet applications internal to the environmental work unit, the Environmental and Enhancement Group also is interfacing with other areas in the agency to contribute information to existing Project Management databases and the Arizona DOT (ADOT) data warehouse. Video conferencing is available between a limited number of sites. Databases that are easy to maintain and search are not yet common at ADOT, but there is an increasing emphasis on these attributes. Likewise, intranet (and Internet) portals are increasing in number and functionality.
IA	Electronic Records Management System
ID	Video conferencing facilities available statewide at headquarters and regional offices.
MN	Electronic Document Management System (EDMS)
TX	Robust video teleconferencing system. DynaText and DynaWeb are used for manual development on the web. Templates for developing manuals in MS Word are provided by the General Services Division.
UT	Video conferencing, WebX

TABLE G5
RESPONSES FROM STATE TRANSPORTATION AGENCIES REGARDING QUESTION 23

STA	Clear Strategy for Storing Knowledge Assets in Place	Employees Generally Understand. Process Well-Defined for Most Resource Types	Well-Defined for Most Resource Types; e.g., Financial and Legal, but Not for Most Sources	Well-Defined for Physical but Not Electronic Resources
AZ		X	X	X
CA	X		X	
ID			X	X
KS		X	X	
KY	X			
MA			X	
MN	X			
MO			X	
MT		X	X	X
NE	X	X		
NV		X	X	
OH		X	X	
TX		X	X	X
UT		X	X	X
VA	X		X	X
VT				X
NB			X	
Total	5	8	13	7

Question 23: Are Practices for Storing Knowledge Management Resources in Place?

TABLE G6
COMMENTS REGARDING QUESTION 23

STA	Comments
AZ	EEG is currently developing written procedures for electronic document storage. Database manuals and other procedures are already in existence for specific areas and functions.
MN	[Well-defined storage practices for resources] where EDMS has been implemented. [There is] considerable variation among offices and among districts as to storage practices.
MT	We have a records management system that is defined, but needs enhancement. Our electronic storage and retention requirements still need to be defined.
TX	We obviously collect and store a lot; however, we could probably do better, especially when it comes to intangible knowledge. That is part of what the Pavement Forensics KMS Project is attempting to address.
VT	Most agency electronic records are maintained well; however, there is a substantial number of electronic records at the individual level in staff that are not defined or categorized.

TABLE G7
RESPONSES REGARDING QUESTION 24

STA	Physical Resources Stored in Agency-Owned Enterprise-Level Archives	Electronic Resources Stored in Enterprise-Level Repository	Capture a Lot Short-Term but Limited Organized Method or Central Repository to Store Electronic Resources Long-Term	Store Resources at Another Organization	Other (see Table G8)
AZ	X	X	X	X	X
CA	X			X	
IA	X	X			X
ID			X	X	
KS	X	X			
KY		X	X	X	
MA	X	X			
MN	X	X	X		X
MO	X	X		X	
MT	X	X		X	
NE	X	X		X	
NJ	X	X	X		
NV	X	X			
OH	X	X		X	
PA			X		
TX	X	X	X	X	X
UT	X	X		X	
VA	X	X	X	X	
VT			X	X	
NB			X		
Total	15	15	10	12	4

Question 24: Where Are Captured Sources Stored?

TABLE G8
COMMENTS EXPLAINING CHOICE OF "OTHER" FOR QUESTION 24

STA	Comments
AZ	The Data Warehouse is an enterprise-level repository that is under development. It has both a data and a document storage aspect. [Resources are] stored on servers that are maintained by the ADOT Information Technology (IT) Group.
CA	Hard copies of many department documents and records are stored at the California State Records Center; the California State Archives stores selected documents and records that the department no longer wishes to keep.
IA	There are multiple enterprise systems that function independently of an Environmental Concurrence Meeting system.
ID	Physical research project outputs are stored in Research Program Library.
MN	Physical resources are stored in vendor-contracted off-site storage. [We are] transitioning from physical files and personal computer files to centralized electronic repository.
MT	Records that are retained permanently are sent to the state archives.
NE	Off-site storage—state records management and state historical society
PA	Some of our resources are stored in the state archives. Our research reports are stored in our PennDOT Library. Some of our materials are stored in our state library.
TX	TxDOT's Research Library is housed and managed by the Center for Transportation Research (CTR) at the University of Texas at Austin. Section 441.101 et. Seq. of the Texas Government Code requires state agencies to deposit copies of their publications with the Publications Clearinghouse at the Texas State Library (hereafter called "The Clearinghouse"). This requirement applies to publications produced both "in-house" and by contract services. The Clearinghouse serves to disseminate information produced by state agencies to the public, through public and university depository libraries.
UT	State archives keep our hardcopy files.

TABLE G9
RESPONSES BY STATE TRANSPORTATION AGENCIES REGARDING QUESTION 26

STA	Defined Retention Periods for Most Resource Types. Work with Stakeholders. Consult Laws/Regs., Records, and KM Best Practices, etc.	Have Mix of Preservation Practices, Depending on Whether in Physical or Electronic Format. Same Practices Do Not Necessarily Apply Across Formats for Similar Resources	Physical Resources Are Retained Based on Document Type or Content. Electronic Resources Retained on Other Criteria
AZ	X	X	X
CA	X		
IA	X	X	
ID	X		X
KS		X	
KY	X	X	
MA	X		
MN	X		
MO	X	X	
MT	X		
NE	X	X	X
NJ	X	X	
NV	X	X	
OH	X	X	X
TX	X	X	X
UT		X	X
VA	X		
VT	X		
NB		X	
Total	16	12	6

Question 26: How Are Resources Preserved over Time, for Differing Resource Types and Formats?

TABLE G10
RESPONSES REGARDING QUESTION 27

STA	Physical Storage Infrastructure Adequate	Physical Storage Uses Established Records Management Practices	Repository for Electronic Resources Has Adequate Capacity, Is Secure	Repository for Electronic Resources Backed Up Routinely
AZ	X	X	X	X
CA	X	X	X	X
IA	X	X	X	X
ID		X		X
KS	X	X	X	
KY	X	X	X	X
MA		X	X	
MN	X	X	X	X
MO	X	X	X	X
MT		X		X
NE	X	X	X	X
NJ		X		X
NV	X	X	X	X
OH	X	X	X	X
TX	X	X		X
UT	X	X	X	X
VA	X	X	X	X
VT				X
NB	X			
Total	14	17	13	16

Question 27: How Adequate Is the Storage Infrastructure?

TABLE G11
RESPONSES BY STATE TRANSPORTATION AGENCIES TO QUESTION 28

STA	Enterprise-Wide Database with Metadata	Intranet Portals	Databases, Clearinghouse Websites, Work Group Web Pages, etc. No Central Access Point	Various Finding Tools Depending on Which Unit Manages the Resource	Have Mixture of Databases and Hardcopy	Mostly Rely on Knowledge-able Individuals
AZ		X	X	X	X	X
CA		X	X	X	X	
IA	X		X	X		X
ID		X	X		X	X
KS		X		X	X	
KY				X	X	
MA				X		
MN			X		X	X
MO		X	X	X	X	X
MT	X		X	X	X	
NE				X	X	
NJ			X	X	X	
NV			X	X	X	X
NY						
OH		X		X	X	
PA				X		
TX			X	X	X	X
UT		X	X	X	X	
VA		X	X	X	X	X
VT				X	X	X
NB					X	
Total	2	8	12	17	17	9

Question 28: How Do Employees Identify and Find Knowledge Resources?

TABLE G12
RESPONSES BY STATE TRANSPORTATION AGENCIES REGARDING QUESTION 30

STA	Location Reasonably Convenient	High Priority to Get KM Resources to Desktop via PCs	Have "Push" Proactive System	Resources Are Delivered to User Within Time Frame That Fits Current Work Stream	System to Track Location of Physical Resources	Decisions to Move Physical Materials Off-Site Based on Reasonable Need for Efficient Access by Staff
AZ	X			X	X	X
CA	X	X		X	X	
IA						X
ID	X				X	X
KY	X			X	X	X
MA	X	X	X	X	X	X
MN		X		X		X
MO	X			X	X	X
MT	X	X			X	X
NE	X			X	X	X
NJ	X					
NV	X				X	X
OH	X	X	X	X	X	X
TX	X				X	X
UT	X	X		X	X	X
VA	X	X				X
VT				X		
NB					X	
Total	14	7	2	10	13	14

Question 30: Are Stored Knowledge Management Resources Readily Available for Use in Current Work and Decision Making?

TABLE G13
LISTS COMMENTS REGARDING QUESTION 30

STA	Comments
AZ	The Data Warehouse is available over the intranet, so the information there is reasonably accessible. ADOT has become aware of deficiencies in this area and is working to make improvements.
MN	Desktop access to information assets is a top priority.
PA	We use our commonwealth guidelines and a few PennDOT guidelines.
TX	There is a current "push" on to deliver information more readily to external customers, by means of the department's public website. Decisions to destroy materials are based not only on practical reasons but also on government administrative code (in other words, the law says certain things must be kept for a certain time regardless of space).

TABLE G14
CONTAINS RESPONSES BY STATE TRANSPORTATION AGENCIES TO QUESTION 32

STA	Yes, Practice Exists for Most Physical and Electronic Resources	Yes, Practice Exists for Physical, but Not for Electronic Resources	No Practice Exists
AZ	X	X	X
CA	X		
IA	X		
ID		X	
KS		X	
KY	X		
MA		X	
MN		X	
MO			X
MT		X	
NE	X		
NJ	X		
NV		X	
OH	X		
PA			X
TX	X		
UT			X
VA	X		
VT		X	
NB		X	
Totals	9	9	4

Question 32: Is There an Established Practice for Destruction of Obsolete Knowledge Management Resources?

APPENDIX H

Detailed Results for Questions 34–37

TABLE H1
RESPONSES BY STATE TRANSPORTATION AGENCIES REGARDING QUESTION 34

STA	Program Is Robust. Continues Through Staff and Administration Changes	Program Exists, but Is Not Evenly Supported or Well-Communicated by Management	Program May or May Not Survive, Depending on Budget Cycles, Administrative Changes
AZ	X	X	
CA		X	
IA		X	X
ID		X	
KY	X		
MA		X	
MN	X		
MO		X	
MT		X	
NE	X		
NJ			X
NV		X	
OH	X		
PA		X	
TX	X	X	
UT		X	
VA	X		
VT			X
NB			X
Total	8	11	4

Question 34: Do Knowledge Management Practices Enjoy Continuity and Persistence Over Time?

TABLE H2
COMMENTS REGARDING QUESTION 34

VA	KM has strong support within the agency and will continue through changes, but it is just two years old.
TX	Depends on which "program" is being referred to. Current recordkeeping and retention practices are robust; the pilot program on the Pavement Forensics Knowledge Management System has not yet been communicated or supported throughout the department.
AZ	Arizona DOT's (ADOT's) knowledge management practices and the units that conduct them are stable, but underutilized. There is no "program" per se, but various practices that result from statutory requirements or need.

TABLE H3
RESPONSES OF STATE TRANSPORTATION AGENCIES TO QUESTION 35

STA	Yes	No
AZ	X	X
CA		X
IA		X
ID		X
KS		X
KY		X
MA		X
MN	X	
MO	X	
MT		X
NE		X
NJ		X
NV		X
OH		X
PA		X
TX		X
UT		X
VA	X	
VT		X
NB		X
Total	4	17

Question 35: Does Your Agency Use Metrics to Gauge the Value-Added and/or Effectiveness of the Knowledge Management Program or to Justify Costs?

TABLE H4
RESPONSES BY STATE TRANSPORTATION AGENCIES TO QUESTION 36

STA	Yes	No
AZ	X	X
CA		X
IA		X
ID		X
KS	X	
KY		X
MA		X
MN		X
MO	X	
MT		X
NE	X	
NJ		X
NV		X
OH	X	
PA		X
TX		X
UT	X	
VA	X	
VT		X
NB	X	
Total	8	13

Question 36: Does the Agency Have Training and/or Mentoring Programs for Staff Transferred to New Jobs, New Hires, or Those New to Leadership to Help Them Understand the Agency's Knowledge Management Practices and How to Make the Best Use of Knowledge Management Resources?

TABLE H5
RESPONSES BY STATE TRANSPORTATION AGENCIES TO QUESTION 37

STA	Yes	No
AZ		X
CA		X
IA		X
ID		X
KS	X	
KY		X
MA		X
MN	X	
MO		X
MT		X
NE		X
NJ		X
NV		X
OH	X	
PA		X
TX		X
UT		X
VA		X
VT		X
NB		X
Total	3	17

Question 37: Has Your Agency Found any Specific Initiatives to Be Especially Effective in Creating Acceptance of and Participation in ("Buy-In") of Knowledge Management Practices Within Your Organization?

TABLE H6
COMMENTS FOR QUESTION 37

TX	The Pavement Forensics KMS Project includes a marketing plan for promoting the Pavement Forensics KMS when it gets closer to implementation.
OH	One of our most successful programs for succession planning and knowledge transfer is our Engineer-in-Training program.
OH	Ohio DOT (ODOT) Library has begun participating in a program offered by the State Library of Ohio to begin digitally capturing ODOT's Research and Development (R&D) reports that are currently available electronically via ODOT's website. Archived publications are "housed" at OCLC and are available to the public through the State Library/ODOT Library joint catalog. OCLC is also making its bibliographic records available through Google with Open WorldCat. If one of ODOT's R&D reports is pulled up through a Google search, clicking on the Digital Archive URL will lead the searcher to the archived R&D report.
MN	Enterprise Document Management System (EDMS) is supported by senior management. Day-to-day work between EDMS staff and employees is fostering a common understanding of the importance of information asset management and the need to share information across the organization.

APPENDIX I

Annotated Literature Survey Regarding Challenges Owing to High Rate of Retirements and Leave-Taking

SHORT-TERM IDEAS

Steve Bates (2003) interviewed Thomas H. Davenport, director of the Accenture Institute for Strategic Change. According to Bates, Davenport recounted an event involving an explosion in a petroleum plant in which investigators discovered that the company's engineer and control room operators had been on the job for less than one year and lacked the experience to prevent the accident. Often less attractive jobs are vulnerable to knowledge loss. According to Bates, recommended steps for capturing the expertise and knowledge of workers near retirement include: (1) mentoring programs; (2) identifying knowledge at-risk by establishing a process to determine which employees have the most critical knowledge; (3) instituting succession and career development planning; (4) building knowledge that professionals will need as they move through the organization; (5) mastering practices of knowledge transfer, including face-to-face, training programs, and other human resources tools; (6) using information technology, which can supplement person-to-person knowledge transfer; (7) exploring phased retirement and looking for new ways to hold on to key workers; (8) using retirees effectively and considering formal programs to re-employ former employees; and (9) building a retention culture and making retention part of the organization's mission.

Eric Lesser and Laurence Prusak (2001) wrote that voluntary reductions in the work force may have a negative effect on preserving knowledge. Unfortunately, often the most marketable and knowledgeable individuals leave first. In addition, sometimes early retirement programs are offered in conjunction with voluntary reductions, which only compounds the problem. Downsizing can hurt the social networks that play a critical role in helping people identify, share, and work with corporate knowledge. Worse, managers may not even be aware of the roles that individuals play as knowledge activists—the authors tell us the World Bank calls them "bonders and bridgers"—who oil the wheels that keep information flowing. Cutbacks and outsourcing can undermine trust that is critical to knowledge transfer. Tightened business conditions can lessen the slack time needed for knowledge sharing. In times when immediate, quantifiable payback is sought, managers may send an unspoken message that managing knowledge is something we can live without. The authors recommended some solutions. By spreading pay cuts rather than layoffs, the underlying social networks can be maintained. Organizations can develop systematic processes for recording knowledge of employees on the verge of retirement by using video interviews and hyperlinks to documents and reports. Bonuses can be paid to departing employees willing to share their working knowledge with their replacements. Newer employees can work alongside most knowledgeable employees, especially in project-based situations. Because tacit knowledge is more easily reproduced through imitation and adaptation than through traditional documentation, letting workers with varying levels of expertise mingle can facilitate transfer of essential knowledge.

LONGER-TERM ORGANIZATIONAL DEVELOPMENT APPROACHES

Christopher Conte (2006) described how state and local officials are grappling with the unprecedented loss of institutional memory because of the number of public officials approaching retirement. Those concerned with institutional memory must focus on knowledge management (KM), especially tacit knowledge. Some organizations try to collect lessons learned; however, it is unclear if such systems work. Do people really have time to read through past case studies and, if they do, are the studies relevant to the new project at hand, which may well be a brand-new problem? Too much focus on the past can make government less flexible and effective; past information may be irrelevant, given the pace of change. Another strategy often used is training, but much learning goes on in real life, so the effectiveness of training is subject to question. For example, the Georgia Merit Systems, the central personnel agency for the state of Georgia, urges agencies to give promising employees accelerated opportunities to broaden their experience through job shadowing, mentoring, job rotations, and various special assignments. However, there are only so many slots and not all employees can be given one.

Conte described a promising new technique called "social network analysis" or "knowledge mapping," based on the idea that it's not what you know but whom you know. He described a pilot project in this technique in the Canadian federal government's environmental agency that used social networking, whereby people were asked whom they rely on for help with different issues. Patterns of interaction were mapped and some individuals were identified as "nodes" in the network. In some areas, a few key individuals were heavily relied on; therefore, management must take steps to develop skills in others. There were risks: some saw the process as an invasion of privacy, some managers saw it as threatening to their control, and some workers who played essential functions outside their official duties were afraid of being punished for not adhering to their job descriptions.

Conte further asserted that if effective use of knowledge catches on in the public sector, credit must go to individuals

such as Maureen Hammer, Virginia Transportation Department Knowledge Manager Officer. She found that networks of contacts among employees were becoming more localized in the face of fiscal austerity that limited travel in the state, membership in professional associations, etc. She used knowledge mapping to find out whom employees relied on to get their job done. Hammer instituted communities of practice. According to Conte, Hammer believes communities of practice have to yield short-term dividends, and must secure continued support from top management and policymakers to buy time to put into effect longer-term efforts. In one instance, an online community of practice stalled because participants did not know or trust each other well enough to discuss problems openly. Conte wrote that Hammer argued that KM must transcend turf battles and must not be used against people. KM leaders must facilitate, not direct, and stay neutral.

Quality Management Systems—Guidelines for Performance Improvements, ISO 9004:2000

Guidelines for Performance Improvements (2000) Section 6.2.1 states that "As an aid to achieving its performance improvement objectives, the organization should encourage the involvement and development of its people" (p. 15). It goes on to list 12 ways to do that, including "by investigating the reasons why people join and leave the organization" (p. 15).

Frank M. Kahren (2004) advised paying close attention to worker demographics. Managers should staff positions requiring extensive experience with the intention of allowing more junior employees to grow in experience. Allow succession in positions where workers are so specialized as to be key to some segment of the operation, especially in those day-to-day jobs of people who actually run the system. Shape the organization to mirror more closely future demands. For example, organizations typically go through cycles. Growth cycles require more planners; stewardship cycles require people to operate, sustain, and upgrade existing systems. One action the organization can take is not to replace departing employees whose skills are not as applicable to the cycle the organization is in. Organizations can also encourage employees to transfer between disciplines and increase their skill sets. As an example, during stewardship cycles planners can become operations, training, or human resources personnel, and this cross-discipline work provides a great overall benefit to the organization. Such reorganization can be particularly useful when there is an executive vacancy and less likelihood of protecting territorial boundaries. Kahren reminded us that people leave, there are terminations, individuals quit to pursue other opportunities, and people choose to retire. This employment cycle is inevitable and organizations can use it to save money, make the workplace less threatening, preserve the level of experience, and facilitate necessary reorganizations.

Patrick J. Kiger (2005) described the predicament caused by the aging of the baby boom generation as a "Y2K" problem. He warned that if companies do not prepare now, no amount of money thrown at the problem will be enough. The problem will span at least a decade. Kiger made the point that the vulnerability may be not so much in the positions of current "top talents," but in the less glamorous jobs that are hard to fill, such as jobs on oils rigs, maintenance, in difficult environments, or that require significant time away from families. Among his solutions to help companies cope was including social scientists and cultural anthropologists along with conventional business consultants on consulting teams. Use sophisticated software to analyze the problem within individual organizations to figure out where make-or-break losses in key competencies may occur. Entice older workers to remain on the job. Make jobs interesting for retirement-eligible workers. Redesign jobs to provide more flexible working hours or telecommuting. Redesign work environments to be more ergonomically comfortable, including easier-to-read computer monitors and other tools. Do succession planning beyond the top executive level. Develop extended supply chains of people by creating a pool of individuals to train and develop so they are ready to move into positions in about three years. Capture departing workers' knowledge, through mentoring programs and better documentation. Change the business strategy to reduce the importance of the positions and skills of retiring workers by revamping jobs or outsourcing.

Vicki J. Powers (2006), in an article published on the "Free Resources/Knowledge Management" section of APQC's (formerly known as American Productivity & Quality Center) website, referenced some of the ideas of Darcy Lemons, also of APQC, who argued that one of the best ways to retain critical knowledge is to embed knowledge retention efforts in the overall management strategy by redesigning existing processes to focus on knowledge retention needs. First, identify critical knowledge that may be at risk because of retirements or layoffs; second, communities of practice and other such human resource approaches, although in themselves useful tools, are not always the proper tools for identifying and retaining critical knowledge. Powers recommended calculating the cost of lost critical knowledge—how much productivity will be lost? How will research and development remain competitive? She went on to discuss how choosing the right tools to capture knowledge depends on the culture of an organization, but the most important aspect is leveraging what is already in place. For example, if human resources already conduct exit interviews, record the responses and capture that knowledge. In some organizations, communities of practice work better; in others, focus groups are better. Tool selection depends on the person who has the knowledge and who will be the recipient. A scientist will probably pass on documents; however, that can be augmented by mentoring, or having another employee "shadow" the scientist. Hire people with strong knowledge-sharing behaviors such as "high-touch" capabilities; ability to function well in communities of practice, face-to-face meetings; and also ability to use dedicated KM repositories effectively. Use phased programs during which retirees are brought back with more flexible or

shorter hours. Give current employees "just-in-time" access to retirees as they need them for current work.

William Seidman and Michael McCauley (2005) presented methods for protecting an organization against the potential loss of retiring knowledge workers (RKWs). They recommended that although the conventional wisdom is to gather the knowledge of everyone approaching retirement age, in fact it is necessary to gather the knowledge of only critical, high-performing knowledge workers, the "best of the best." They recommended aiming for quality assurance of the content; at some companies, individuals nearing retirement have mentally retired years before and their knowledge may be out of date and of marginal value to the organization. Focus on the highest performers, those who know how to get things done, and harvest their knowledge regardless of age. Determine the critical or most core processes in the organization that most require protection and identify the top performers in those processes. It may be seen as socially unacceptable to identify publicly that some parts of an organization are more important than others; however, from a knowledge perspective, it is essential to prioritize. Preserve only the knowledge of the few top-performing RKWs in key areas.

Seidman and McCauley go on to assert that only tacit knowledge of the top-performing RKWs matters. One of the most critical pieces of RKW knowledge is the subtle cueing and categorization process that enables quick discrimination between a number of alternatives. They recommended a specialized interview called a "naïve new person interview," led by a human facilitator, supported by digital coach technology, which is software that simulates the human coaching experience. Using it, the RKW can polish their knowledge into a best practice, which can then be made available through an electronic library. They recommended that RKW knowledge not necessarily be stored to be used only after the worker retires, but that it is promptly made available both for immediate improvement to the organization and is protected for use in the future, when the RKW is no longer there for personal contact. Thus, the RKW knowledge can immediately be used to improve less-effective performers, rather than for just one successor. Gathering RKW knowledge is not just a one-time event; however, successors should regularly update the knowledge through continuous use and feedback. Thus, the problem is not so much an RKW problem, but a knowledge problem. The goal is to make what is today considered "RKW knowledge loss" into a process that protects knowledge losses generally from layoffs, illness, transfers, or other forms of departure. The authors believe that the potential for massive retirements can present an opportunity to improve overall productivity and that by following their approach, the RKW problem can be resolved permanently.

Mallory Stark (2004) discussed "knowledge nomads"; that is, workers who job hop taking their knowledge with them. She recommended that managers seek not to "retain" workers who are knowledge-rich, but to "re-recruit" them; maintaining that workers do not want to be "retained," they want to be valued and engaged. Typical retainment approaches of raising salaries or changing job titles have little to no effect. Provide opportunities for formal and informal learning; set up situations where workers do not have to choose between loyalty to their careers and loyalty to their organizations; and nurture small work groups, which fosters commitment. Develop a culture conducive for eliciting commitment and engaging knowledge workers.

UTILIZING RETIREES POST-RETIREMENT OR KEEPING RETIREMENT-ELIGIBLE EMPLOYEES ON THE JOB

Eric Lesser (2006) recommended a number of strategies for addressing the aging work force. Create a cross-functional team of executives who have a solid understanding of overall business objectives and marketplace needs, and have it prioritize individual positions and groups where intervention is critical. Redirect recruiting and sourcing efforts to include mature workers. Offer flexible benefits, including unpaid leave around holidays or on the birth of a grandchild. Make use of the benefits that older workers bring to the work force, which are decreased absenteeism and customer retention. Institute programs in which older workers work on a project-consulting basis. Use telecommuting. Elicit tacit or experiential knowledge through detailed interviewing and/or documentation. Store knowledge in explicit form for future use. Use mentoring arrangements and communities of practice. Use technology to help employees share lessons learned, expand the organization's knowledge base, and improve operational quality. Use videotaping with or in addition to storytelling. Use websites. The author cautioned that age alone is not linked directly to difficulty in adopting computer use in the workplace. There are accessibility issues such as deciphering smaller typefaces, understanding the audio portion of a streaming video, or controlling hand motions for use of a computer mouse. Incorporate ample time for the practice of new technology. Address learning needs by considering programs that focus on building new skills and leveraging the wealth of experience.

Jay Liebowitz (2004) reported on the issue of determining and closing knowledge and skills gaps in the federal government. He cited numerous studies about the dimension of the challenge and detailed numerous initiatives that can be taken by the federal government to deal with the problem. One often overlooked source is the untapped pool of talent: the federal retirees themselves. Options are a knowledge retention program, mentoring activities, and knowledge sharing forums with retirees and current government employees. He asserted that many retirees would like to work in some capacity and seek opportunities to share their insights to help bridge possible knowledge gaps. Another initiative is the creation of a more flexible work force, with a segment of the work force kept on-call to deal with specific issues. He referred to management theorist Charles Handy's frame-

work for organizational workers: (1) a core group of managers and skilled workers who lead the organization and provide stability and continuity; (2) the contractual fringe; and (3) a flexible labor-force of a project-based employee pool, composed of people loosely connected to the organization on a job-by-job basis. Older workers might be useful in items 2 and 3.

Other ideas from Liebowitz include tapping retirees as reemployed annuitants; use retirees as part-time employees through reemployed part-time or phased retirement programs. Unions, however, may look unfavorably on this approach as taking jobs from current employees. Other options include Canada's technique of "casual employment," especially when specialized expertise is required; limited-term appointments; using retirees as mentors, emeriti, or as participants in knowledge sharing forums; and knowledge capture activities such as knowledge sharing workshops, storytelling, and one day "transfer wisdom" workshops. He suggested expert databases of current and retired practitioners, programs where a new employee shadows a prospective retiree, documenting procedures and processes, and brown bag lunches twice a week.

Liebowitz reviewed a survey of NASA and NIST (National Institute of Standards and Technology) retirees and alumni that found that 91% agree they would be interested in working part-time with their former employers. They favored phased retirement programs, retiree job banks, emeritus programs, part-time retired annuitant/project team consultant programs, and mentoring programs. They were less interested in knowledge-sharing forums, rehearsal retirement/boomerang jobs, job sharing, facilitating online communities of practice, or a knowledge capture/retention program. He made four recommendations: (1) that there be legislation giving all federal agencies authority to reemploy annuitants and to institute phased retirement programs, (2) that federal employees should be brought back into the work force for knowledge sharing and management roles, (3) that each agency have an association of retirees and alumni to allow quick access to talent, and (4) that each agency have a more flexible work force and that retirees be a part of that work force.

APPENDIX J

Annotated Literature Survey: Standards and Guidance Documents Issued by International Standards-Developing Organizations Regarding Knowledge Management

Australian Standard: Knowledge Management—A Guide AS 5037-2005 (2005) was released October 15, 2005, as a nonprescriptive guide on knowledge management (KM). An update to an earlier interim standard (AS 5037-INT) in 2003, the 2005 revision incorporates insights gained as a result of feedback on the interim standard by many Australian and international KM practitioners. The Standard provides guidance on what KM is and how it may be implemented using a flexible framework. It can be used by any individual, community, or organization. The document walks one through the steps and implementation options for KM to suit the requirements of your own organization's context, capabilities, and readiness. Perhaps the most useful feature is a listing and descriptive details of 33 "enablers"; that is, tools, techniques, and activities for KM implementation. It also includes a chapter on specific ways to evaluate and measure KM in organizations. The document outlines an ecosystem model of KM based on relationships, networks, processes, content, and technology. It is not hierarchy based. This document is, in the opinion of this author, the single most useful practical reference on KM reviewed in this report, especially in the initial phase when developing KM processes.

Quality Management Systems—Guidelines for Performance Improvements, ISO 9004:2000 (2000) includes, in Section 6.2.2.2, a recommendation to include tacit and explicit knowledge when planning for training and education of staff (p. 16). Section 6.5 specifies that the continual development of an organization's knowledge is essential for decision making and innovation. It recommends identifying information needs, identifying and accessing internal and external sources of information, converting information to knowledge of use to the organization, and using knowledge to meet objectives (p. 18). ISO 9004:2000 specifically describes in Section 4.2, Documentation, how the generation, use, and control of documentation should be evaluated with respect to the effectiveness and efficiency of the organization against such criteria as functionality; user friendliness; resources needed; policies and objectives; current and future requirements to managing knowledge; benchmarking of documentation systems; and interfaces used by the organization's customers, suppliers, and other interested parties. It recommends that access to documentation should be ensured for people in the organization and to other interested parties (p. 3).

Quality Management Systems—Requirements ISO 9001 (2000) lays out the requirements of process-based quality management systems in Section 4.2, Documentation Requirements. It states: "that the quality management system be documented" (p. 2). Included in the list of required documentation are "documents needed by the organization to ensure the effective planning, operation, and control of its processes" (p. 2). The standard allows documentation to be in any form or type of medium. Furthermore, Section 4.2.3, Control of Documents, requires a documented procedure be established for document approval, review, updating, reapproving, version control, and legibility. Documents must be identifiable. Documents of external origin must be identified. Unintended use of obsolete documents must be prevented and obsolete documents must be suitably identified if they are retained at all (p. 3).

In *Quality Management Systems—Fundamentals and Vocabulary,* ISO 9000 (2000), under Section 2.7.2, Types of Documents Used in Quality Management Systems, among others these types of documents are listed

c) documents stating requirements . . .
d) documents stating recommendations or suggestions . . . guidelines . . .
e) documents that provide information about how to perform activities and processes consistently . . . procedures, work instructions, and drawings
f) documents that provide objective evidence of activities performed or results achieved . . . records . . . (p. 4).

In 2004, the European Committee for Standardization, known by the acronym CEN issued a 5-part series of Workshop Agreements entitled *European Guide to Good Practices in Knowledge Management.* As with the Australian standard described earlier, this series of documents provides guidance and is not prescriptive. The *Guide* was written to give Europeans a practical guide to both mainstream thinking and emerging new thinking in KM. Although it is aimed at business environments, other organizations will find it useful owing to its structured, practical approach. Because it stresses the business focus, it puts KM in the value-adding processes of an organization, and concentrates on critical knowledge. It also deals with processes that are part of interorganizational business networks, which include suppliers, partners, and clients. It describes three layers of activity: (1) the five core knowledge activities as identifying, creating, storing, sharing, and using knowledge; (2) the integration of these activities into an integrated framework by forming an integrated process; and (3) identifying and implementing the right KM tools and methods within two main categories—

personal and organizational—which complement each other. Part 1 describes the overall KM framework. Part 2 discusses organizational culture. Part 3, "SME Implementation," is devoted to the SME (small and medium-sized enterprise), because the Committee believed that knowledge in SMEs tends to be tacit, informal, and not recorded; know-how in SMEs may not be valued as highly as it might be; SMEs may use short-term approaches to knowledge gaps; and the knowledge in SMEs may be more easily lost when an owner sells the business or retires (pp. 5–6). One could substitute "CEO" or similar title for "owner." Part 4 spells out guidelines for measuring KM. Part 5 is devoted to KM terminology. In short, all five parts of the *Guide* offer a wealth of distilled, structured, easy-to-read information on KM implementation, albeit it for U.S. readers, with a slight European twist. Note that all five parts, although copyrighted, are available free of charge, as of this writing, on the CEN website (see References).

In 2001, the BSI Group, which issues British standards among other activities, published *Knowledge Management—A Guide to Good Practice,* PAS 2001. PAS stands for "publicly available specification," which indicates that the document is, as is the case with the Australian and CEN documents, not a "standard" in the usual sense, but a nonprescriptive guide to practice. Written in cooperation with PriceWaterhouseCoopers, the document disseminates KM good practices to both United Kingdom and global audiences, gives case studies, and provides details about KM resources (http://www.bsi-global.com). Its target audience is broad and not limited to business and industry. Since the publication of PAS 2001, BSI has issued six related detailed KM guides.

Similarly, the Danish Agency for Trade and Industry published *A Guideline for Intellectual Capital Statements: A Key to Knowledge Management* (2001). Although the term "capital statements" might be confusing, the introduction makes clear that the document is about knowledge resources and how companies manage, deploy, and develop the resources, including their employees, customers, processes, and technologies, and how they manage these resources. Seventeen companies worked with the agency on the document. It is quite business oriented; however, it does contain numerous examples of internal practices by the 17 companies. This very useful document is also provided free-of-charge through the website given in the References. It must be noted that, to the author's knowledge as of this writing, the U.S. standards-developing community, as generally coordinated by the American National Standards Institute, has not published any nationally recognized standards or guidelines dedicated to KM. However, the *Dublin Core Metadata Element Set: An American National Standard,* ANSI/NISO Z39.85-2001, developed by the National Information Standards Organization, is highly useful for KM content management applications. It provides a basic metadata element set of 15 descriptors for cross-domain information resource description. This standard has been applied, extended, and adopted by countries and organizations. Simple and easy to apply, the 15 elements describe almost any resource adequately for discovery. Additional metadata schemes can be added to the basic set for richer description. The Dublin Core Metadata Initiative website (http://dublincore.org) offers a wealth of details about the development worldwide of the use of Dublin core.

On July 5, 2005, a brief report was issued as the collaborative product of a work group convened under the auspices of the TRB Data and Information Technology Section (ABJ00) (2005). The Library and Information Science Committee (ABG40) from the Research and Education Section (ABG00) was a full partner. At their Section meeting on January 12, 2005, data committee chairs agreed to examine options for a Section-level focus on metadata specifically for transportation-related resources. The work group strongly recommended that a data section, focused on metadata, is needed immediately, and that a staged approach be used to institutionalize a metadata group within TRB with the aim of eventually issuing a metadata standard for transportation resources.

Although not a standard, the *Transportation Research Thesaurus* (TRT) is a standardized metadata tool to improve the indexing and retrieval of transportation information. The thesaurus covers all modes and aspects of transportation. The TRT's purpose is to provide a common and consistent language between producers and users of transportation information. Anyone needing keywords, categorization terms, or standard terminology in the field of transportation is a potential TRT user. The TRT is maintained on a regular basis and is available at http://trt.trb.org/trt.asp.

APPENDIX K

Annotated Literature Survey on Knowledge Management Practices

The sources in this appendix are organized around the main knowledge management (KM) topics. For the most part, they concentrate on specific practices organizations can develop to manage institutional memory long-term. Sources were selected for their practical nature, their currency, and inclusion of case studies. The focus is not on theoretical works that justify or provide the underlying philosophical framework for institutional memory practices' rather the focus is on a variety of contemporary high-quality sources that, collectively, provide a window into a wide range of KM understandings and practices. To some extent, sources were chosen because they are reasonably accessible to ordinary practitioners in state transportation agencies (STAs) regardless of the sophistication of the information services in their individual agency or availability of the services of academic or research libraries or document repositories. A wide variety of types of sources were included. Among the selected choices listed here and elsewhere in this report are standards, guidance documents, a few scholarly works, business journals, outstanding websites, and selected writings from the trade and popular press. In short, a fairly large number of references have been provided that focus on the practical, and although no specific practices are recommended, it is hoped that these summaries and the many pragmatic ideas found in them will stimulate thinking in STAs.

KNOWLEDGE AS AN ASSET

In 1969, Peter F. Drucker in the book *The Age of Discontinuity: Guidelines to Our Changing Society* laid out the overall management concept of the value of knowledge and knowledge workers. Thanks to him, the overall management concept—that of the value of knowledge and of knowledge workers—has been around for some time. Near the end of the book, after a complex, insightful discussion detailing what he saw as profound changes occurring in the nature of work and the global economy, he gave his view of the future:

> To make knowledge work productive will be the great management task of this century, just as to make manual work productive was the great management task of the last century. The gap between knowledge work that is managed for productivity and knowledge work that is left unmanaged is probably a great deal wider than was the tremendous difference between manual work before and after the introduction of scientific management (1969, p. 290).

This focus on the management of knowledge work was reinforced by Drucker himself in 1997, nearly 30 years later, when he wrote in the *Harvard Business Review:*

> Management will increasingly extend beyond business enterprises, where it originated some 125 years ago as an attempt to organize the production of things. The most important area for developing new concepts, methods, and practices will be in the management of society's knowledge resources. . . . Predictions? Not at all. Those are solely the reasonable implications of a future that has already happened (Drucker 1997).

Ikujiro Nonaka and Hirotaka Takeuchi (1995) in *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation,* described myriad examples from Japanese firms to support their view that "knowledge creation has been the most important source of their [Japanese firms] international competitiveness" (1995, p viii). They articulated the idea that KM is an organizational responsibility. Knowledge itself, for them, is an organizational asset and therefore to be managed not just by specific individual employees or selected managers, but also by the entire organization at all levels. In the introduction to their book, they assert that

> . . . in the dominant Western philosophy, the individual is the principal agent who possesses and processes knowledge. In this study, however, we shall show that the individual interacts with the organization through knowledge. Knowledge creation takes place at three levels: the individual, the group, and the organizational levels (1995, p. ix).

They wrote within the context of Japanese manufacturing companies, but their book not only lays out a succinct rational for KM, but also details numerous specific practices and applications, especially using information technology (IT), but in a way that incorporates and enables better human interactions and content management.

KNOWLEDGE MANAGEMENT AS A BUSINESS PROCESSES

In *Thinking for a Living* (2005), Thomas H. Davenport, who began writing on the topic of KM at least as early as 1993, focuses not so much on knowledge as an asset, but on the knowledge worker and the knowledge work process. He warns not to simply impose KM on top of existing business processes. He cautions that few knowledge workers have the spare time to record lessons learned or to share their expertise with co-workers. Although he is, in his words, a "big supporter" of the idea of KM, he believes that knowledge behaviors must be "baked into" the job (2005, pp. 62–63). Davenport discusses knowledge workers, their antipathy to formalized processes, love of autonomy, and tendency to value their knowledge and not to share it easily. He describes interventions, measures, and experiments managers can use to make knowledge work more productive; knowledge work processes; organizational technology for workers; how to

develop individual workers' networks and learning; how to set up the physical environment for best performance; and generally how to manage knowledge workers.

de Holan, Phillips, and Lawrence (2004) describe how "failure to capture" is a form of organizational forgetting. To avoid loss, information must be captured from individuals and made institutional, a process that involves a range of activities to routinize, codify, and store knowledge. First is the process of making knowledge explicit, which they term "articulation." Then it must be communicated, which the authors called knowledge institutionalization. They offered the following advice:

- Avoid heroes because resident experts whose knowledge is not managed properly make the organization vulnerable and stifle institutional learning.
- Structure the work to replicate knowledge among individuals.
- Some individuals prefer not to share their knowledge—they prefer to try to remain indispensable. Management must correct that, perhaps by instituting a bonus system that rewards sharing.
- Link the old to the new. Organizational knowledge is interconnected in complex ways; new knowledge has to fit in to the existing structure.

The authors also discussed how to "forget"; learning is a double-edged sword because we can learn bad habits that are actually counterproductive. It is easy to learn, but hard to learn the right things. Make concerted efforts to break routines and practices based on unquestioned assumptions. Restructure organizations to dismantle interconnections that make change difficult. The organization must have an adaptive ability to recognize change and discontinuity and incorporate it continuously.

Gordon and Grant (2005) argued that the literature has insufficiently addressed the issue of power in KM. The practice of KM can be enriched by research that recognizes how the struggle for power within an organization may influence the KM system and the KM system will, in turn, influence the power struggle. The authors performed very wide-ranging searches on KM in the ABI/Inform database and analyzed the resulting articles. Of the more than 4,000 articles found, only 138 contained the keyword "power." Of those, most discussed "knowledge as power," and only four treated the relationship between KM and power as problematic. With the knowledge-as-power approach, possession of knowledge implies possession of power. The authors contend that the power-as-strategy approach has been ignored by KM literature and therefore does not reflect the potential problematic relationship between power and KM systems. They call for KM research that explores a more in-depth approach to power in organizations (pp. 1–9).

Gupta and Govindarajan (2000) documented the experience of Nucor Steel with KM. They wrote that although there is widespread awareness of the economic value of creating and mobilizing intellectual capital, most companies do not realize the potential. Thinking of a sophisticated IT infrastructure as the be all and end all of KM is mistaken. Effective KM depends on the social ecology of the organization as well. IT does play a central role because it is the only mechanism to connect effectively large numbers of geographically dispersed people; however, success relies on how people use the knowledge. Effective KM must create and acquire new knowledge and share and mobilize it throughout the organization.

They discussed knowledge pathologies; for example, "knowledge as power," which may result in a limited transfer of knowledge because the owner wishes to control it. They reported that Nucor's success at knowledge creation sprang from superior human capital, high-powered incentives, and a high degree of empowerment.

As KM business processes, Nucor:

- Instituted continuous, on-the-job multifunctional training;
- Acquired knowledge because every employee is driven to search for better ways to make steel and steel-related products in teams that included operational, engineering, and management staff;
- Retained knowledge by reducing the work week rather than the work force during difficult times;
- Made performance data visible within the company;
- Encouraged sharing best practices;
- Implemented incentives that ensured that one individual's superior performance would have minimal impact on his or her bonus;
- Exploited IT to develop rich transmission channels to transfer both codified and unstructured knowledge; and
- Had a policy of keeping plant size at between 250 and 500 individuals to build social community and open communication.

The authors also contended that investing in codifying and making tacit knowledge explicit can have high payoffs. All knowledge transfer occurs through a limited set of exchange mechanisms: exchange of documents, conversation and coaching, and transfer of people and teams. The mechanisms must be tailored to the knowledge type being transferred (pp. 71–80).

Hammer et al. (2004) argued that it is incorrect to focus on individual knowledge workers' productivity. Rather, Hammer asserted in this three-part article that the goal is to get more out of the organization by improving the performance of the end-to-end business processes. The task is to eliminate non-value-adding work. It cannot be done by fiat and technology is not much help. Such work needs to be designed out of the process. Knowledge workers may be negative at the notion of process, seeing it as an intrusion on their creativity and individuality. However, that is a misunderstanding of process, which is not about the routinization

and bureaucratization of work but "about positioning all individual activities in the larger context in which they are performed" (p. 16).

Leonard-Barton likened modern workers to cave dwellers. The cave walls are computers, but people still like storytelling and learning in communities. However, we do not have the time and technology cannot create shortcuts to the most valuable kinds of knowledge. She recommended that managers look for what she called "deep smarts" and protect "shallow smarts"—their promising but inexperienced workers. People with deep smarts draw on a huge store of tacit knowledge. Computers help, but coaches (experts) are needed to help relative novices through guided experiences. They help their protégés build experiences through guided practice, observation, problem solving, and experimentation (pp. 16–17).

Davenport, in the same article, described what we know about knowledge workers. Scientists and engineers need to work very near each other to be able to exchange ideas. Software engineers need process and practice combined. He also described what we do not know, but asserts that without too much additional effort, companies can resolve the issues. He also recommended experimental design as a tool to measure productivity, performance, or satisfaction of knowledge workers (pp. 17–18).

Halladay and Burk (1998) presented a knowledge "problem" for the reader to solve with FHWA. They reviewed the resources available including training, technical assistance, technical committees, and tapping into the academic community. They went on to discuss what was in 1998 a relatively recent approach: KM. They described KM approaches, such as taking advantage of electronic communication and knowledge sharing repositories. The knowledge cycle is find/create, organize, share, and use/reuse, with the central theme being communication. Successful operation of KM requires balance between top management sponsorship and proactive participation of individuals. They detailed the role of "Knowledge Manager." KM involves more than databases and networks. The key is to create a culture that is collaborative and open to innovation and knowledge sharing within and beyond FHWA. They described how communities of practice (COPs) can foster that culture (pp. 32–36).

Timo Kucza (2001) did the KM community a major favor when he wrote his *Knowledge Management Process Model.* Kucza, of the Technical Research Centre of Finland, took the approach used in software process improvement projects. His goal was to create a KM process model that would allow a common understanding of KM and a possible framework for analyzing KM (p. 13). Making liberal use of charts, graphs, tables, flowcharts, etc., he modeled the entire process in a highly structured manner familiar to computer scientists, software engineers, etc. It is a model of straight thinking.

Many authors recommend that an organization embarking on a KM program begin with a knowledge audit. A paper by Liebowitz et al. (2002) is a good resource for this process. It focuses on how an organization can determine what knowledge is needed, what is available and missing, who needs the knowledge, and how it will be applied. Although not quite a recipe book, it is a succinct, easily readable guide. The paper includes a useful case study of a knowledge audit in a behavior health care organization called ReVisions Behavioral Health Systems. It ends with KM recommendations for ReVisions, based on the results of the audit (pp. 1–16).

Scott Thurm (2006) wrote amusingly but seriously about the knowledge of a package-delivery courier. He asked the courier whether it was more efficient to start at the top of a very tall building and work down or begin at the bottom and work up. The courier had a definitive answer, based on experience—"it depends . . ." Thurm then wondered how long it would take the next courier, assuming the current one leaves, to figure out the best approach.

In a more serious vein, Thurm wrote that businesses have dozens of solutions for managing knowledge, but most involve technology, and he argued that such a focus obscures the crucial human issues in learning and teaching. People need to have opportunities to trade the vital tricks of their trade. However, informal learning is limited in scope. Thurm referred to Dorothy Leonard-Barton's recommendation to use a guided experience by which employees with extensive knowledge pass it on with the help of a coach. He cited Raytheon's missile systems unit in Arizona as an example of this technique. Thurm discussed how companies struggle to create the critical mass in a database of knowledge such as might be found in repair databases for technicians. In some cases, companies "seed" these databases until finally critical mass is achieved where more people use the system, which leads more people to contribute. He reported that Xerox's repair database now contains approximately 70,000 suggestions and saves the company millions of dollars per year. According to Thurm, executives surveyed by Bain & Co in 2005 increased their use of KM systems last year, in spite of their misgivings about their effectiveness.

HUMAN RESOURCE AND ORGANIZATIONAL DEVELOPMENT IN KNOWLEDGE MANAGEMENT

Dorothy Leonard-Barton (1995) articulated in *Wellsprings of Knowledge* how cultural climate affects an organization's ability to take full advantage of knowledge as an asset. She moved us beyond the IT and document management paradigms common at the time to include the human resource dimension to knowledge-based organizations, and to clarify that, in her view, all managers and level of managers, as opposed to mostly IT managers, have responsibility for KM. Using scores of examples in the United States and international technology companies, she showed how a cultural climate open to KM approaches can directly improve decision

making and, therefore, the chance for success. To fully express her vision of KM, Leonard-Barton, reached for a metaphor.

> A wellspring, the source of a stream, sustains life within and beyond the riverbanks or, by becoming damned up or polluted, denies its existence. The most useful wellsprings are constant, reliable, and their waters pure. As flows of water from such wellsprings feed the biological systems around them, so in the same way, flows of appropriate knowledge into and within companies enable them to develop competitively advantageous capabilities.
>
> Managers at all levels of the organization are the keepers of the wellsprings of knowledge. To them falls the responsibility for selecting the correct knowledge sources, for understanding how knowledge is accessed and channeled, and for redirecting flows or fighting contamination (Leonard-Barton 1995, p. xiii).

David Gilmour (2003) asserted that KM technology is not working. In his view, most organized corporate information sharing is based on publishing, which he saw as a failed paradigm. Even the most organized effort collects only a fraction of what people know, plus the process is time-consuming and expensive, and retrospective, in that it captures what was useful in the past. He recommended a shift from the publishing model to a brokering model based on collaboration management. The challenge with the brokering model is to connect people who should be connected. Software can be used to sift through e-mail, network folders, and other sources to identify common information threads, which can then alert people about their shared interests. Parties can connect or confidentially decline. His experience showed that brokering works best when people can share information they want when they want, and the more privacy privileges are extended, the more people will choose to share (pp. 16–17).

TRANS-DISCIPLINARY NATURE OF KNOWLEDGE MANAGEMENT

According to Chang-Albitres and Krugler (2005), KM emerged in the mid-1970s, beginning with the implementation of database management software, moving into data handling in the mid-1980s, and in the 1990s developing enterprise-wide database systems and document management systems. It emerged as a business process in the late 1990s. They list the disciplines having the most profound effect on the development of KM concepts as organizational science and human resource management, computer science and management information systems, management science, psychology, and sociology (pp. 3–4). Note that the report also contains KM website and software reviews.

A.B. Cleveland (1999), somewhat earlier, broadened our understanding of KM as being more than an IT issue. He acknowledged that we live in an information economy and that companies are investing increasingly greater levels of resources to maximize the benefits of KM. He cited a broad array of software companies and consulting firms offering technology-based products and services under the KM listings. Although these information technologies contribute significantly to the management of corporate knowledge, Cleveland argued that KM is fundamentally not an IT issue and operating as if it were totally misses the point. He explained that IT projects often fail to meet expectations because the connection between the IT project and the expected business outcomes is not clearly articulated. The process is much more complex than the delivery of an IT system. IT systems are enablers. No IT can succeed without addressing the organizational change issues. He recommended hiring good people, creating an environment where intuition, exploration, guesswork, and creativity can be exercised, and connecting people with one another, with customers, partners, and the world (p. 28).

A. Cohen (2006) highlighted the role of the librarian in organizing research collections, without which the organization cannot be successful. Optimization of content influences organizational growth. Organizations must integrate the library into its KM strategy, because in physical or digital form it is the organization's main research repository. Traditionally, library collections were designed to support knowledge sharing. The librarian's core competency is really at the heart of the matter—information can only flow freely when it is controlled and organized. Librarians manage the content for COPs to maximize COP effectiveness. Digital libraries created by COPs need maintenance and vetting. Physical libraries are spaces for meeting meet face-to-face and are a digital hub.

El-Diraby and Kashif (2005) discussed the "semantic web" as an extension of the current web in which information is accessed based on meaning, not hypertext. Ontology is one of the main components of the semantic web. Ontology is a mechanism to categorize and classify domain knowledge items or information into interrelated concepts. The architecture they detailed classifies highway concepts into processes, projects, products, actors, resources, and technical topics. The architecture was built as an extension to the e-COGNOS ontology and is the first ontology aimed at covering the whole highway construction domain. It was developed to allow for future expansion and customization of terms and relationships. This paper is valuable for illuminating the need for categorizing and classification—typical domains of the librarian and the engineer, both of whom have much to learn from each other in this area of KM!

Kenan Jarboe (2001) stressed the importance of a suitable IT infrastructure as a production as well as a consumption tool. He discussed the importance of "local knowledge," sometimes known as "indigenous knowledge" (p. 7), and pointed out that this tacit knowledge is usually transmitted orally, experiential rather than theoretical, learned through repetition, and constantly changes. It has the advantage of speed. However, it is also generally location-specific, which limits its value. Capturing it is an important economic activity. One way to do that is by geographically clustering people

(p. 8). He described the World Bank's indigenous knowledge program by means of an Internet-based database. Jarboe contended that the social network, which included ad hoc interactions, was responsible for Silicon Valley's success early on, as compared with Boston's Route 128 geographical area, which did not have the same social network (p. 9).

According to Jarboe, KM is often described using two tracks: the "IT Track" and the "People Track." Although the IT Track is relatively new and evolving rapidly, the People Track is much older, more fragmented, and slower to incorporate into the KM management process. He discussed four broad objectives in a KM project:

- Creation of knowledge repositories,
- Improved knowledge access,
- Enhanced knowledge environment, and
- Management of knowledge as an asset (p. 11).

Success, Jarboe maintained, is a combination of IT tools and organizational techniques. IT tools include data capturing, document scanning and retrieval programs, expert systems, data mining tools, and collaborative work software. However, Jarboe warned that IT tools should not take precedence over activities, including as face-to-face approaches, conferences, workshops, meetings, reports, or papers. He welcomed "e-government" initiatives, but also cautioned against simply imposing best practices from one location to another. Organizational changes may be needed, as contrasted with IT approaches (p. 20).

F. Mihai and J. Robertson (2003) described how Main Roads Western Australia replaced an old information system with a new Integrated Road Information System (IRIS). Probably the most interesting and useful aspect of this paper is their description of specific KM principles and the practices related to those principles that were actually applied in the development of IRIS. The practices ranged from the development of a software solution to managing a large amount of documentation, handling a diversity of users, and overcoming the human reluctance to change old work patterns. They clearly showed the multidisciplinary skills required for this project.

Wallentine et al. (2000), Department of Computing and Information Sciences at Kansas State University, presented recommendations for technologies with the potential for the development and management of Kansas Department of Transportation's (DOT) information systems. As one might expect, the recommendations fall in the area of the IT aspect of KM, including recommendations for object models, languages, and tools; network technologies; Visual Basic scripts for workflow processing in a network-based environment; and a data warehouse structure to support research. Because this report is approximately six years old as of this writing, it is not that useful from a technical standpoint in the current web technology environment. However, it is highly useful for nontechnologists trying to get an understanding of the nature of the work the IT team must accomplish to support KM processes.

CHARACTERISTICS OF SUCCESSFUL KNOWLEDGE MANAGEMENT PROGRAMS

Cross and Baird (2000) reported on their project on organizational memory. They examined learning from 22 projects in professional services, financial services, and manufacturing organizations. These case studies were mostly from Fortune 250 organizations. They learned that organizations remember lessons from the past in various ways:

- In the minds of employees and the relationships employees tap into,
- In repositories such as computer databases and file cabinets, and
- As embedded in work processes or product and service offerings that have evolved over time.

They contended that managers can improve performance by deliberately developing organizational memory and using the growing stores to guide organizational activities and decision making (p. 70). The first step for managers is to determine which experiences are worthy of learning from and then determine ways to maximize their inherent learning potential. Finally, the knowledge must be embedded into the organization.

They discussed examples of how the U.S. Army and companies such as Chrysler, Ford, and Analog Devices go from individual experience to organizational knowledge. One example is the use of after-action reviews; they detailed how they are executed. The authors discussed how personal relationships can be turned into organizational know-how. They described the process by which British Petroleum uses peer reviews to tap into the knowledge of group members. They described how COPs are used by the exploration division of Shell Oil (pp. 69–72).

Cross and Baird also asserted that organizations that successfully leverage IT to support organizational memory must:

- Have the technology, policies, and procedures to ensure that reusable materials are screened by panels of experts and are entered rapidly into distributed databases so others can benefit;
- Seek to leverage the knowledge contained in databases using technology that enables dialogue;
- Provide structured learning processes so newly acquired knowledge can be integrated into daily activities; and
- Embed the knowledge constantly into databases, work processes, support systems, products, and services.

They used examples from a variety of consulting firms and also described how the U.S. Army uses an information exchange to promote collaboration and learning. At Chrysler,

product development teams capture lessons learned and translate them into suggested modifications to the product development process. Xerox created a distributed database to capture knowledge about how to fix and service copiers, with rewards and potential for assignment to the coveted "Tiger Team." Organizations must do more than just accrue and store knowledge (pp. 72–77).

Davenport and Glaser (2002) found that the key to KM success is to implant specialized knowledge into the jobs of highly skilled workers, and the best way to do that is to embed it into the technology that knowledge workers need to do their job. That way KM is no longer a separate activity requiring additional time and motivation. They compare this embedding process with just-in-time delivery systems that revolutionized inventory management. They admit that embedding knowledge into everyday work processes is time-consuming and expensive. They described a case study of a physicians' order entry system at Partners HealthCare in Boston. Partners' approach built on other key work processes as well, including an on-line referral and medical records system. All these systems draw on a single database of clinical information and use a common logic engine. The process is difficult because information in the database cannot be untested or obsolete. Therefore, these solutions should be used only for the most critical processes. To justify such a system, a measure-oriented culture must be present. IT professionals must know the business as well as technology. The authors briefly describe similar projects at Hewlett–Packard, Dell, Xerox, and GM's Vehicle Engineering Centers (pp. 107–111).

Davenport et al. (1998) studied 31 KM projects in 24 companies. In these case studies they identified eight factors that characterize a successful project. To summarize (p. 1):

- The project involves money saved or earned.
- The project uses a broad infrastructure of both technology and organization.
- The project has a balanced structure that while flexible and evolutionary, makes knowledge easy to access.
- People are positive about creating, using, and sharing knowledge.
- The purpose of the project is clear in language common to the company's culture.
- The project contains motivators.
- The project may use multiple channels to transfer knowledge, such as the Internet, communication systems, and face-to-face communication.
- Senior managers support the project.

The authors identified four broad types of objectives for these KM projects:

- Create knowledge repositories
- Improve knowledge access
- Enhance knowledge environment
- Manage knowledge as an asset (pp. 1–2).

Many projects had multiple characteristics. Success indicators included:

- Growth in the project resources
- Growth in volume of content
- Likelihood project would survive without support of particular individuals
- Some evidence of financial gain.

Projects were more likely to succeed when they used both technology and organization. Some important factors for this dual approach were:

- Pervasive desktop and communications technology;
- Establishing a set of roles and organizational groups whose members have the skills to serve as resources for individual projects;
- Finding the right balance for knowledge structure;
- The repository has to have structure, including categories and key terms;
- Identifying someone to control decisions about knowledge structure; and
- Allowing for continual evolution of knowledge structure.

Some other important management aspects were:

- Establishing a "knowledge friendly" culture;
- Avoiding "hero" mentalities or the strong need to be seen as very creative;
- Using language common to the company culture;
- In some cases excluding the term "data" to ensure that raw, undistilled information did not get into the repository;
- Framing the project in business terms understandable to employees;
- Instituting incentives and motivational aids that were not trivial and were long-term and tied into the overall evaluation and compensation system; and
- Senior managers had to send the message that the KM and organizational learning are critical to organization, provide funding and other resources, and had to clarify what types of knowledge were most important (pp. 44–54).

Michael Zack (2003) found that the knowledge-based organization pays attention to the application of existing knowledge and the creation of new knowledge. He used two companies as case studies. Holcim Limited, a cement, aggregates, and gravel company headquartered in Zurich, Switzerland, is highly decentralized, but it reorganized its company to develop, identify, transfer, and apply strategic knowledge among all its entities worldwide. Although its main product has remained unchanged for approximately 100 years, it is clearly operating as a knowledge-based organization.

In contrast, Zack documented an unnamed company as having not leveraged the information and expertise residing within the company as a whole. Although its product, economic

forecasts, is a "knowledge" product, it did not have the processes in place to make it a knowledge-based organization.

Zack maintained that the knowledge-based organization is a collection of people and supporting resources that create and apply knowledge by means of continued interaction. Such an organization seeks knowledge where it exists. Organizations that are truly knowledge-based stop worrying about "who works for whom and focus instead on who needs to work with whom" (p. 69). Knowledge communities at Holcim transcended formal boundaries. The company also made investments to learn from customers. In contrast, the unnamed company did a good job of extracting information from outside the organization; however, it could not surmount the boundaries raised among the many mini-companies it had created (pp. 68–69).

Zack described a case study of Polaroid. Although it had a strong culture of sharing knowledge, that knowledge was focused entirely on analog products. The KM activities were not aligned with the company's strategy, and eventually the company declared bankruptcy. Organizations have to close the knowledge gaps, both externally and internally. Holcim engaged the entire organization in determining more efficient, sustainable, and environmentally friendly processes; the unnamed company never made the link between knowledge and strategy (p. 69). The knowledge-based organization holds a knowledge-oriented image of itself. It takes knowledge into account in every aspect of operations, including how it is organized, what it does, where it locates, whom it hires, how it relates to customers, and its image. Zack also documented in the same reference a brief case study of Buckman Labs as a company with a knowledge perspective.

Zack compiled key actions managers need to take to turn their organizations into knowledge-based organizations (pp. 69–71):

- Define the organization's mission and purpose in terms of knowledge.
- Define the organization's industry and position within it in terms of knowledge.
- Formulate strategy with knowledge in mind.
- Implement knowledge-management processes and structures that directly support the company's strategic knowledge requirements.
- Transform the company into a strategic learning organization.
- Segment the company's customers and markets not only on the basis of products and services but also according to how much can be learned from them.
- Treat the cost of learning as an investment, not an expense.
- Rethink the business model.
- Take human resource management seriously.
- Reinforce the organization's mission through coordinated internal and external communication.

SPECIFIC KNOWLEDGE MANAGEMENT PRACTICES

Bob Boiko (2002) focused on content management. In his view, content management is important because it makes e-business real and workable, it is an antidote to today's information frenzy, and it can create and manage pieces of information and tag them with all the information one needs to figure out what they are worth (p. xxxiv). Part philosophy, part handbook, he answers for us:

- What is content?
- What is content management?
- How does one actually create a content management system?
- What is the metadata framework (logical design) that is needed to tie all the content together?
- How does one actually build a content management system?

This excellent source balances the emphasis of many authors on the human or organizational aspects of KM. In this glimpse into his thinking, he described his own organization, the Institute for Advanced Metatation, as a system of institutes; schemas; taxonomies; and methods to acquire, remember, and deliver facts and stories on demand. Job titles include hierarchists, indicists, and associationists (pp. 922–923). Boiko's book is useful for practical day-to-day applications as well as for stimulating the imagination.

M. Burk (1999) explained the concept of KM to the transportation community, using the experience at FHWA. He argued that the transportation community has always put great value on sharing of knowledge, including an emphasis on the continuous gathering and sharing of information through informal, person-to-person contacts, conferences, and the like. KM, he asserted, offers the opportunity to improve the effectiveness and efficiency of this sharing process.

He described the "knowledge cycle": find/create, organize, share, use/reuse. He described the tasks of knowledge managers:

- Indexing and cataloguing new information as it comes in.
- Serving as information brokers by assisting people to obtain the information they need, and
- Advocating for knowledge-sharing practices.

Burk wrote that much knowledge can be made available through the Internet; however, KM is more than databases and networks. He described COPs, which are professional networks that identify issues, share approaches, and make results available to others. The "output" of the COP—the research papers, technical briefings, product evaluations, identification of experts, good practices, and so forth—is made available by means of the knowledge repository. An important task of the COP is to identify knowledge gaps and create new knowledge as needed to fill it.

He directed the reader to the FHWA website on rumble strips as an example. Burk asserted that an organization does not need a wholesale transformation of its culture to implement KM. Some individuals are proprietary about knowledge; some managers fear loss of control; some staff members resent, at least initially, the perceived extra effort. Burk recommended examining rewards and recognition programs. He reiterates that implementation of a KM program is not a one-time project, but an evolving process.

Burk (2003) described COPs as networks of people that identify issues, share approaches, and make results available to others. COPs can exist solely within an organizational unit or can cross divisional and geographical boundaries. They can even span several different companies or organizations. However, they all have a core group of participants who provide intellectual and social leadership.

Burk described how COPs differ from work teams: teams are formed by management and report to a boss, have a defined membership, and specific deliverables. COPs can be voluntary, usually have longer life spans than teams, have no specific deliverables imposed, and are largely responsible to themselves.

Burk reported that FHWA is facilitating COPs. He maintained that their value will increase as a relatively large percentage of FHWA's technical and operational staff near retirement. He warned against

- Too much official scrutiny,
- Unsuitable IT systems,
- Unsupportive reward structures,
- Lack of legitimacy, and
- Inadequate budgets.

He discussed an example where a group of quality coordinators had been meeting formally a few times a year to discuss best practices and share information. However, they realized they needed to meet more frequently; therefore, they started a virtual COP. A COP does need maintenance, and it may be difficult to integrate new people. Burk pointed out that technical support is needed including:

- Web-enabled software for online discussion,
- Document sharing and storage,
- Community member information,
- Group e-mail lists,
- E-mail notification of new information, and
- Online meeting spaces.

He asserted that even with a positive corporate culture and good technology in place, it still really is the COP itself that determines its own success.

Bush and Tiwana (2005) discussed collaborative knowledge networks, which they described as peer-to-peer digital networks connecting individuals with relevant experience to their peers who need it. Individual users frequently abandon such networks; to be sustaining, knowledge networks must be "sticky." They define stickiness as "the users desire to continue using a knowledge network system" (p. 68). Networks must enhance the interplay of people, relationships, and systems with careful attention paid to intersections of IT and human psychology. They traced three key drivers of stickiness:

- Individual relationship capital,
- Individual user reputation, and
- Personalization.

Additionally, individuals with a long history of using the network tend to continue using it; however, the intensity increases only marginally over time. They described peer-to-peer networks using the "café" metaphor, as opposed to repositories, for which they used the "library" metaphor. There is a need for both, but their research focused on the former. Increasing stickiness requires that the network be designed so that users can perceive the costs of not using the system (pp. 68–71).

John Carroll (2004) wrote that attention or, as he put it, "heedfulness" is the first ingredient in making a KM system capable. He asserted that:

- Reporting systems are an institutionalization of heedfulness.
- Storytelling is an important way to capture knowledge.
- Knowledge-developing COPs with specific boundary-spanning or bridging practices are useful for capturing knowledge.
- Incident investigations and root cause analyses not only include techniques for looking beyond the immediate, but also for conversations with shared purposes.
- Mixing people of differing occupational and educational backgrounds and cognitive styles can lead to informational diversity.

He discussed the stock versus the flow models of KM and emphasized that both models are needed (pp. 129–130).

"Stock" refers to codified repositories of explicit information and know-how including:

- Databases,
- Procedural manuals,
- Drawings, and
- Planning documents.

The stock model works especially well for routine operations and problems. The key issue for the stock model is where the knowledge resides.

However, most problems are local and contextual; therefore, additional knowledge is needed and that's where tacit

knowledge comes in, which he called the "flow" model. That model relies on such practices as:

- Liaisons,
- Job rotations,
- Temporary exchanges,
- Informal contacts,
- Broad personal networks, and
- Strong connections between individuals and groups.

Coffey et al. (2004) described a case study of how concept maps were used in a knowledge-retention study at a nuclear power plant. The technique was used with a nuclear physicist over a 2.5 day site visit. A final wrap-up visit incorporated tangibles from the work into training materials, policies, and procedures, etc. Concept mapping has proven to be an effective means of capturing an expert's key concepts of a knowledge domain. The experts for the study were selected by plant management based on a survey of employees who held critical positions and would shortly be eligible for retirement. The actual techniques used to implement the interview sessions are described in detail. A detailed knowledge model of critical knowledge and activity maps was created to capture the basic activities and relationships associated with a job. The author encourages the reader to consult this paper for its step-by-step guide to how to achieve concept mapping with a single expert.

DiCesare and Demers (2000) reported on reengineering the bridge inspection process, eliminating all non-value added steps, and enabling the new process with a knowledge management-based inspection solution that integrates an enterprise document management system (EDMS) and an electronic forms system. They described the two distinct information worlds: structured and unstructured. The challenge is to envision a physical KM infrastructure that bridges these two worlds. They described how the EDMS, built on a relational database model with built-in workflow, enables team members to coordinate and control the document life-cycle process, from creating to archiving. Documents are stored as objects. Version control is assured.

The resulting KM system required a culture change and shift in work methods to be successfully integrated. This KM implementation can be achieved by adopting the methodology of process reengineering, including a rethinking of jobs, organization, structure, management systems, values, and beliefs.

Maureen Hammer (2005) reported on the Virginia DOT Knowledge Management Office's effort to establish COPs. By the end of June 2005 there were 10 such communities, with four more under development. Hammer provided myriad useful details about how specifically these COPs operate. No two communities developed similarly, but they all provided sharing of lessons learned. She noted that each COP has an executive sponsor to ensure that participation is supported and that the Virginia DOT will get a return on its investment. One of the COPs was surveyed on what value they had gained from their COP and from the support of the Knowledge Management Office. Values included:

- Ongoing improved communication;
- Improved processes and/or integration of people and ideas;
- Lessons learned, best practices, and effective process model for use elsewhere in the Virginia DOT;
- Effective meeting facilitation;
- Effective communication support;
- Collection of useful information;
- Analysis of information;
- Integration that respected differences among group members;
- Neutral perspective;
- Access to decision makers; and
- Better understanding of how to increase collaboration.

Madanmohan Rao (2004) wrote a wonderfully rich introduction to the book *Knowledge Management Tools and Techniques: Practitioners and Experts Evaluate KM Solutions* titled "Overview: the Social Life of KM Tools." In it, he asserted that the concepts and practices of KM are approaching mainstream adoption, and that the focus must now be on practical applications of tools and technologies, which are essentially people-centric. IT appears to be a supportive enabler in his scheme, but is not in itself a tool or technique.

Rao's tool categories clearly show his understanding of the trans-disciplinary nature of KM and how KM as a business management process flows across all levels and work units of an organization. We encourage the reader to consult the wealth of useful ideas in this book, which contains 32 chapters written by numerous authors providing case studies of the use of KM tools within real organizations, with examples from business, non-profit, and government.

William M. Snyder and Xavier de Souza Briggs (2003) provide an excellent overview of COPs. The authors document federal experience with COPs, explain how federal agencies can cultivate COPs, and describe how COPs are implemented. They highlight the FHWA Rumble Strips Initiative in a case study and provide reflections on other case studies. This very useful guide is especially applicable to government agencies.

Russell C. Walters and Lifeng Li (2003) described the development of an electronic reference library (ERL) that provides a virtual library for construction design and management of state highway projects in Iowa. The ERL is a very large document which uses hyperlinks as navigation tool (p. 132).

L. Yu (2005) reported in his synopsis of *How to Support Knowledge Creation in New Product Development: An Investigation of Knowledge Management Methods* (2004) that researchers Anja Schulze and Martin Hoegl found that managers are familiar with a range of KM techniques and rate

some higher than others. The 10 highest ranked for sharing knowledge were:

- Informal events,
- Experience workshops where team members review completed projects,
- Communities of practice,
- Project briefings before beginning new projects,
- Expert interviews,
- Best practice cases,
- Knowledge brokering by a third party connecting knowledge seekers to resources,
- Reports documenting positive and negative experiences on projects,
- Databases, and
- Professional research services.

According to Yu, the researchers assert that the effectiveness of any KM effort must balance how often users draw on the particular activity as measured against how much the method actually contributed to knowledge sharing or creating (p. 5). (Note: unfortunately the author was unable to locate the original working paper by Schulze and Hoegl, but decided to include the synopsis anyway.)

Michael Zack (1999) asserted that explicit knowledge is becoming more important in organizations. He suggested that organizations face a fundamental challenge in determining which knowledge should be made explicit and which should remain tacit. Certain knowledge might not be articulated because to do so might be politically incorrect or not culturally legitimate. If knowledge is made explicit, it can be routinely integrated and applied. Some knowledge may be inherently inarticulable; a balance must be maintained. Managers should not accept tacitness blindly. Process knowledge is more valuable at the explicable level; when imagination and flexibility are important; perhaps the tacit form is better (pp. 46–47).

MEASURING KNOWLEDGE MANAGEMENT EFFECTIVENESS

J. Liebowitz (2005) asserted that part of the possible failure of KM initiatives, or management's skepticism towards KM, is the result of the inability to develop metrics to measure KM success. Because KM deals with intangible assets, metrics may be more difficult to obtain than from other assets. However, for-profit and not-for-profit organizations are developing such metrics. Liebowitz's article contains a highly useful chart detailing KM performance measures developed by the U.S. Navy. He detailed key factors as to why organizations embark on KM initiatives under the general categories of adaptability and agility, creativity, institutional memory building, organization internal effectiveness, and organizational external effectiveness. He concluded that fuzzy logic is a reasonable approach to explore for determining KM effectiveness measures (pp. 36–39).

APPENDIX L

Annotated Survey of Other Knowledge Management Resources

WEBSITES

APQC, formerly known as the American Productivity & Quality Center, is primarily an organization that seeks ways to improve productivity in America's business community, although affiliate members are non-profit organizations. APQC's website has, however, a "Knowledge Management" page in its free resources area. This part of the website contains many highly useful articles, case studies, white papers, and publications regarding knowledge management (KM). Note that although membership requires a fee, anecdotal evidence in this author's experience would confirm that it is worth the investment. The general website can be accessed at: http://www.apqc.org.

Dave Snowden is the founder of Cognitive Edge, headquartered in Singapore. Cognitive Edge Pte Ltd was created in 2006 to take on the work originally initiated at IBM as the Cynefin Centre for Organisational Complexity. Dave has posted numerous short papers, case studies, etc. (see: http://www.cognitive-edge.com). Dave is a thinker; it is impossible not to be inspired by his fountain of ideas regarding KM specifically and management generally. He is especially interested in social complexity, and his writings are helpful for managers trying to change the paradigms within their organizations. His individual papers are not summarized here, except to note *Tools for Chief Knowledge and Learning Officer*s, which is available for viewing on the website. His company, Cognitive Edge (formerly The Cynefin Centre for Organizational Complexity) was spun off from IBM in July 2004. His relatively new website is at http://www.cognitive-edge.com.

The Intelligent Transportation Systems Joint Program Office's Lessons Learned website presents a good example of the use of major classification schemes used for capturing and finding lessons learned. Therefore, it may be able to serve as a resource for state-level organizations creating their own similar sites (see: http://www.itslessons.its.dot.gov).

KM.GOV, sponsored by the Federal Chief Information Officers Council (the CIO Council), established the Knowledge Management Working Group as an interagency body to bring the benefits of the government's intellectual assets to all federal organizations, customers, and partners. This site may be helpful to departments of transportation as a model for supporting KM practitioners.

The KNOW Network describes itself as a "global community of knowledge-driven organizations dedicated to networking, benchmarking, and sharing best practices leading to superior performance" (see: http://www.knowledgebusiness.com). It is an international web-based professional knowledge-sharing network. The KNOW Network provides an array of web-based services including access to Most Admired Knowledge Enterprises (MAKE) studies, self-assessment audits, external benchmarking comparison, and by facilitating transfer of best KM practices and communication technologies such as blogs that enable members to tap into the best minds in knowledge organizations worldwide. There is a membership fee; however, much information on the site can be accessed by non-members. As a business-oriented resource, the focus is on the economic and competitive advantages of using business strategies based on knowledge leadership; however, the underlying ideas may be useful to government agencies.

Annually, the company Teleos, in association with the KNOW Network, identifies winners of the Global Most Admired Knowledge Enterprises (MAKE) study. The executive summaries of the annual MAKE reports are available free of charge on the website, along with other resources. The 2005 winners were selected by a panel of Global Fortune 500 executives and KM experts [2005 Global Most Admired Knowledge Enterprises (MAKE) Report, Executive Summary] and are recognized leaders in:

- Creating a corporation knowledge culture
- Developing knowledge workers through senior management leadership
- Delivering knowledge-based products and solutions
- Maximizing enterprise intellectual capital
- Creating an environment for collaborative knowledge sharing
- Creating a learning organization
- Delivering value based on customer knowledge
- Transforming enterprise knowledge into shareholder value (p. 2).

In *Knowledge Networks: A Management Strategy for the 21st Century: Special Report 284,* the Committee for a Future Strategy for Transportation Information Management (2005) highlighted Parsons Brinckerhoff (PB), a planning, engineering, and program and construction management company, for their KM practices. According to the Special Report, PB organizes its professionals by 53 disciplines in people networks known as practice area networks and describes other aspects of the company's KM program (p. 21). PB's accessible website, called The Research Library, can be accessed at http://www.pbworld.com/library, which is "devoted to showcasing the broad technical excellence of our employees around the world." Drilling down, one finds the PB Network (http://www.pbworld.com/news_events/publications/network), a publicly available website designed to:

- Promote technology transfer within the entire firm;
- Encourage widespread dissemination and exchange of technical information for the sake of solving problems, creating new applications, and completing projects;
- Educate employees on PB's new, developing, and emerging technical capabilities;
- Broaden the understanding and use of computer tools and information technology by PB staff;
- Foster the professional development of employees by providing opportunities for writing and publication; and
- Support PB in becoming the premier provider of infrastructure services worldwide.

The PB website may be useful to STAs not so much for its content, but as a possible model for design, philosophy, and overall technical approach.

The Specialist Library for Knowledge Management within the National Library for Health, United Kingdom National Health Service (NHS), maintains a website directed at staff and organizations throughout the NHS and its partner organizations. More importantly for readers of this report, however, is that it is an exceptionally rich site for anyone with an interest in learning about KM techniques, and in sharing ideas and best practices. The stated aim of the site, to paraphrase the information given on the homepage, is to support a knowledge-sharing culture within the NHS, by providing access to high-quality research, practical examples in the form of case studies, tools to help implement KM within individual organizations, and details of events relevant to this area. Although the content of the site is not related to transportation, the site itself provides an excellent model of how such a site can be developed, and it also provides a wealth of useful, practical advice on KM practices, especially in the toolkit section at http://www.nelh.nhs.uk/knowledge_management/km2/toolkit.asp (2005).

The U.S. Army's Combined Arms Center's Center for Lessons Learned (CALL) website is another potential model for how to use web technology for lessons learned applications. According to its mission statement it

- Collects and analyzes data from a variety of current and historical sources, including Army operations and training events;
- Produces lessons learned for military commanders, staff, and students; and
- Disseminates these lessons and other related research materials through a variety of print and electronic media, including the website at http://call.army.mil/mission.asp.

The Wildfire Lessons Learned website is located at the National Advanced Resource Technology Center (NARTC) in Arizona and serves as a resource center for the wild land firefighter professional. It promotes a program of "train as you work and work as you train." The LLC was modeled after the U.S. Army's Center for Army Lessons Learned. The site includes many examples of after action reviews, case studies, and other resources. It provides a potential model for STAs developing a lessons learned resource.

The WWW Virtual Library on Knowledge Management website is aimed squarely at KM professionals. There are plenty of links and lots of information on events around the world. This website can be found at: http://www.brint.com/km.

OTHER RESOURCES

An example of the academic world's involvement in KM is the newly formed Institute for Innovation in Information Management (I3M) at the University of Washington, Seattle, which is chartered with the mission to be the premier research institute that will help organizations attain agility and competitive successes by managing their most vital assets—information and knowledge. I3M will undertake research projects shaped by the interests of its partners and expertise of Institute faculty (see: http://www.ischool.washington.edu/i3m/index.html). According to Michael Crandall, one of the Institute's faculty members (as of March 6, 2006), results of I3M studies will be made available at seminars and ultimately be published. In addition, the I3M will host a one-week, intense summer program, Knowledge Management Summer Institute. There are many other examples of graduate and undergraduate programs, seminars, symposiums, etc., in KM now available at various universities—the University of Washington example serves as a model.

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation