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A Systems-Based Methodology for the Construction and Representation of Organizational Knowledge Systems

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CONSTRUCTION AND REPRESENTATION OF

ORGANIZATIONAL KNOWLEDGE SYSTEMS

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ABSTRACT

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The purpose of this research was to develop and apply a systems-based analysis methodology which constructs and represents an organization's knowledge system. The research inquiry was guided by four questions: (1) "what is an organizational knowledge system?", (2) "how can it be made explicit?", (3) "does the representation accurately depict the organization's perspective of their unique knowledge system?", and (4) "what results from the deployment of the organizational knowledge system methodology?". The resultant answers to these research questions advanced and established the theoretical conception of an organization's knowledge system through the development of a methodology that fosters the construction and representation of the knowledge system.

This study extends the existing scholarly literature by developing the concept of an organizational knowledge system through the synthesis of organizational learning and knowledge literature, thereby bridging a gap in the literature by holistically linking knowledge creation with current learning processes. The developed organizational knowledge system and model graphically present an organization's unique knowledge system transforming what is most often a tacit understanding into a form that is explicit at a collective level. The research design applied the organizational knowledge system

methodology to two organizations using a detailed step by step process, and evaluated each organization's knowledge system using a mixed methodology analysis which combined quantitative and qualitative data collection methods and analysis techniques.

The findings of this research indicated that an organization's knowledge system can be explicitly constructed and represented. Furthermore, the research clearly indicated that an organization's knowledge system is unique. This is evidenced not only in the mechanisms of an organization's knowledge system, but more importantly the relational links between the components of their knowledge system. Also, the research indicates that the organizational knowledge system methodology is transferable to other organizations. This was accomplished by assessing each organization as an independent entity with its own unique knowledge system and contextual environment. Lastly, this research develops new theory (the organizational knowledge system) that addresses the holistic perspective and relationship between organizational learning and knowledge. In summary, this research equips organizations with the capability to know, understand, and manage their unique organizational knowledge system.

This dissertation is dedicated to the four
motivators in my life from whom I receive
daily encouragement and the strength to press on.

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This dissertation is the result of over two years of research involving dozens of books, articles, internet material, and textbooks. It has been a joy and a tremendous learning experience researching and writing this dissertation. I can honestly say that this endeavor has stimulated a passion for increasing my learning and understanding of organizational knowledge and organizational learning, and I hope to continue to work and learn in this and other related fields for many years to come. Although it may appear that this is from the fruits of my labor, I would be remiss if I did not give credit to all those who have influenced and challenged my thinking.

My parents, Willie and Gloria McFadden, who inspired me to reach for ever higher challenges have encouraged me in this research. My family, Sheila, Jason, and Caitlin, who consistently love me and provided me with encouragement and inspiration in sharing this research with others.

In addition, I would like to acknowledge Dr. Charles Keating, without whose assistance this research might not have begun, but would not have been completed. His guidance has been critical to this research and my continued education.

Lastly, I would like to thank Deborah Dawson and Laura Buckley for their diligent assistance with this research. Their help has been crucial to this research effort. Likewise, the office space and assets provided by the Director, Joint Warfighters were essential to my completing this research. I would like to thank the Accelerator Development Department of Jefferson Labs and the Joint Warfighters for allowing me to

implement my methodology and model on them. They have enabled me to demonstrate that this research not only works, but has been able to make a difference.

I trust that the information presented in the following pages will be helpful in the understanding of organizational dynamics. It is my desire that the knowledge you take away will enable you to effectively transform your workplace into a knowledge-creating and -sustaining organization.

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INTRODUCTION

Organizational knowledge and knowledge management have been increasingly recognized as an underdeveloped aspect of technology-based organizations (Nonaka, 1988; Brown & Duguid, 1998). Because of this, the following research is devoted to identifying and addressing a primary gap in the literature concerning organizational knowledge. The gap is the lack of a holistic methodology and models which provide for further understanding of the organizational knowledge and knowledge management phenomena.

> Intellect and innovation are the sources of virtually all economic value, growth, and strategic edge today. Unfortunately, despite much popular discussion about "knowledge creation" and "managing knowledge assets," few managers systematically understand the basic interrelationships among intellect, professional knowledge, technology, and innovation (Quinn, Baruch, and Zien, 1997, p. 1).

Since this quote, substantial steps have been made toward understanding organizational knowledge and knowledge management, but there is a need for continued research and enlightenment.

The research introduction is subdivided into five areas: background, purpose of the study, research questions, study limitations, and significance of the study. The background section provides a discussion of the organizational knowledge issues that are confronting engineering managers and engineering management researchers and

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This dissertation uses the *Engineering Management Journal* as its journal model.

demonstrating the necessity for further research on the subject. It is followed by the study purpose. This section clearly identifies the research focus, why the research is being conducted, and what the research will accomplish. Four research questions have been derived from the purpose of the study: What is an organizational knowledge system? How can it be made explicit? Does the representation correctly depict the organization's perspective of their unique knowledge system? What results from the deployment of the organizational knowledge system methodology? These questions guided the research inquiry. The study limitations section addresses some of the research parameters required to ensure the study maintains the proper research focus and accomplishes a thorough and complete analysis. Next, the significance of the study is addressed from the perspectives of the literature and engineering practice. These areas highlight the significance and benefit the research provides to the academic body of knowledge and the practice of engineering management. Lastly, the important points developed in this introduction will be summarized and a brief layout of the research will be presented.

BACKGROUND

Over the past 35 years, manufacturing and production processes, through the advent of technology, have been streamlined to provide better quality products at reduced cost to the manufacturer. There has been a revolution in the use of the personal computer, as evidenced by its proliferation throughout all segments of our lives. The widespread use of the personal computer and the resultant connectivity between intra-related industries, inter-related industries, governments, financial markets, and individuals has provided a profusion of information for processing and use in organizations. As one looks back and

reflects on this technological explosion, we are able to see the many changes that are the natural flow and by-product of this technological revolution. A few examples are cellular phones, portable computers, pagers, and electronic organizers. These and other technology advances place information gathering and dissemination at our fingertips, while ensuring that we, as organizational members, are always informed of organization action and decisions.

The increased sharing of information between individuals and organizations, coupled with the aptitude to leverage the power of knowledge new information can provide, has caused many academic and business professionals to question the standards of judging the effectiveness and efficiency of organizations based solely on their technological capability. Brown and Duguid (1998) support this concept. Likewise, Quinn, Baruch, and Zien see the significance of knowledge and innovation as the key ingredient to organizational viability and growth. There is an increased understanding that knowledge creation is a critical factor of organizational success. If the business health and the future welfare of an organization is tied only to its technological ability to compete in its chosen market, then why the current emphasis on capturing, disseminating, and safeguarding knowledge products like innovation and acquiring and retaining "knowledge engineers"? The need or desire to increase profits or array the organization for future business opportunities are but two of many reasons for these phenomena. However, another reason for questioning the existing standards for determining the health and welfare of businesses is because the bottom line (dollar revenues) does not address the totality or complete aspect of what effects business operations. "It's knowledge, not its (organization) transaction costs, (which) holds an organization together" (Brown &

Duguid, 1998, p. 90). The harnessing and management of knowledge has shown professionals in all fields the potential of increasing corporate efficiency. Understanding that knowledge is power is not a new concept. This has been a catchphrase for quite some time. However, the substantial expansion in information technology has fostered increased connectivity and richness of relationships, which in turn has increased information exchange and the possibilities of creating and restructuring knowledge in ways not previously imagined (Nonaka, 1994; Brown & Duguid, 1998). The improved availability and additional demand for information has developed new strategies and relationships between industries, governments, and businesses (Senge & Sterman, 1992). Likewise, it has also focused many scholars on the need for studying the organizational knowledge processes that are key to the transformation of information into knowledge (Dretske, 1981; Huber, 1991; Lyles and Schwenk, 1992; Sackman,1992; and Nonaka, 1988, 1991, and 1994). Organizations view organizational knowledge as an untapped resource that can provide a competitive advantage. This has led to the field of organizational knowledge becoming recognized as increasingly important for many of this country's and the world's major business entities and academicians over the past few years (Hiebeler, 1996).

However, much of the focus of organizational knowledge literature centers on individual and collective learning (Argyris & Schön 1978; Fiol & Lyles, 1985; Dixon, 1992). Additionally, current literature focused on organizational knowledge is most often derived from a static organizational framework based on ontological studies (Lyles & Schwenk, 1992; Sackmann, 1992).

There is clearly a need for the further study of organizational knowledge. Understanding and managing knowledge can improve the effectiveness and efficiency in an organization. The processing and understanding of information is what influences people to make certain decisions or drives them to particular actions. This is no different for organizations. However, the ability of organizations to gather much more diverse information and analyze, interpret, and represent that information in multiple ways provides a dynamic that has not yet been fully understood or exploited. The capturing of the resultant knowledge that organizations create, as well as the safeguarding of that knowledge, has rightly been identified as a key element to an organization's viability in future business environments (Gavin, 1993). However, knowledge by itself is not a panacea for what incompetence may plague an organization. Organizational knowledge management is part of the answer; a part that has been recognized as an organization enhancement and has emerged as a significant, but difficult to understand, component of organization management. This research provides researchers and organizational managers with a methodology and model from which to more fully understand organizational knowledge and plan and implement knowledge management initiatives that are focused toward achieving organizationally defined results.

PURPOSE OF STUDY

The purpose of this research is to develop and apply a system-based analysis methodology which constructs and represents an organizational knowledge system. Thus, the research focus is two-fold: first, to develop a systems theory-based methodology for understanding the organizational knowledge system; and second, to apply the methodology in an organizational setting. The methodology must be systems-

based to take into account the systems nature of the knowledge system. The knowledge system follows the tenets of systems theory because as it is composed of entities, a boundary, relationships between the entities, and exists in an environment. Briefly, systems theory is a comprehensive model that describes the elements of an organization and their dynamic interrelationships (Hanna, 1988), where organizations are an arrangement of elements that have an interdependence with one another. This is discussed in further detail in the systems theory section of the Literature Review chapter. The methodology and the application model will be used to guide construction of the organization's unique knowledge system. This construction is based on the organization's own input and represents the system explicitly through analytic and graphical techniques. To this end, the research will be guided by the research questions presented below.

RESEARCH QUESTIONS

This research attempts to extend the understanding of organizational knowledge. This will be done by first developing an understanding of the foundations and evolution of organizational learning and organizational knowledge, then by developing a literature-based methodology and model of the organizational knowledge system that synthesizes the two primary literature streams. The second step is to deploy the organizational knowledge system for application in selected organizations. To ensure that the research is focused and supports the study purpose, four questions have been developed to guide this inquiry. The following diagram (Figure 1) represents a visual flowchart of the study goal and major objectives that lead to the four research questions.

Study Purpose (GOAL)
Develop and apply a systems-based analysis methodology
which constructs and represents an organizational knowledge system

(OBJECTIVE)

Develop a literature based methodology and model
of the organizational knowledge system

Deploy the organizational knowledge system
for application in selected organizations

Questions:

What is the organizational
knowledge system?

How can an organizational knowledge
system be made explicit?

Does the representation correctly
depict the organization's perspective
of their unique knowledge system?

What results from the deployment
of the organizational knowledge
system methodology?

Figure 1. Systems Engineering of Study Goals and Objectives

The first question is, *"What is an organizational knowledge system?"*. The response to this question is based upon synthesizing and extending the literature, which serves as the research foundation and develops the concept of the organizational knowledge system. This study presents a methodology to understand what composes an organizational knowledge system and how the components of that system are interrelated. The methodology synthesizes the literature on organizational learning and organizational knowledge and draws upon the cognitive hierarchy and open system theories to complete the methodology. The second research question, *"How can an organizational knowledge system be made explicit?"*, addressed the process of changing the tacit nature of knowledge to a form that can be visually interpreted by the organization. This question is focused on the construction and representation of the knowledge system. The third question is, *"Does the representation correctly depict the organization's perspective of their unique knowledge system?"*. This is the corroboration of the organizational knowledge system methodology and model as it is applied to an existing organization. The participating organizations provided a qualitative and quantitative assessment of their knowledge system construction and representation based on the employed methodology and model. The fourth and final question is, *"What results from the deployment of the organizational knowledge system methodology?"*. This question provided insight into the organization's learning processes as the organization assessed its knowledge system.

The answering of these questions led to achieving the purpose of this research study. However, as with all studies, there are limiting circumstances that must be discussed. The following section highlights the limitations of this study.

STUDY LIMITATIONS

This section addresses two research limitations required to ensure the study maintains the proper research focus and accomplishes the study purpose. The limitations to the research are: (1) including only those organizational knowledge system elements that can be made explicit, and (2) the issue of generalizability of the research findings. Both limitations will be explored in detail below.

This study was limited to those elements of the organizational knowledge system that can be made explicit. This allows for the inclusion of those elements or aspects of the informal structure of an organization, which provide a richness of relationship that is so essential to all organizations. There are many nonstandard relationships within the informal structure of an organization that have an impact on the organization's knowledge system.

> The importance of informal networks ... much more than formal management structures, seem vital to how people learn about new ideas, coach one another in trying them out, and share practical tips and lessons over time... networks of people who rely on one another in the execution of real work. They are bound together by 'a common sense of purpose and real need to know what each other knows.' Xerox Vice President John Seely Brown regards them as "the critical building block of a knowledge-based company." (Senge, 1999, p. 49).

However, capturing the overwhelming complexity and diverseness of an organization's informal structure in its entirety is outside the scope of this study. A more feasible course of action is to capture the most important organizational knowledge system informal and formal mechanisms identified by organization members. This does not detract from adequately responding to the research questions, but rather provides focus and clarity to the research by identifying only the most important aspects of the organization's

knowledge system. To go beyond would require an ethnographic study of the organization, which is beyond the purpose of this study.

Another limitation to this research is related to generalizability of the findings. The generalizability of research findings beyond the specific organizational context must be questioned. Generalizing the themes, constructs, and conclusions gathered from participating units has little to no meaning when taken out of the context of that particular organization. Thus, the research will not be consumed with proving generalizability. One focus of the study will be to determine the fitness and transferability of the methodology and methods to other organizations. The transferability of the research methodology, methods, and model is an important aspect of this study. One of the underlying goals of this research is to provide engineering managers with an original methodology and application strategies to understand, explain, and visualize their organization's knowledge systems. Therefore, the methodology and methods must be robust and flexible enough to aid an organization in its desire to understand and make explicit its knowledge system to the organization members. It is assumed that the knowledge system for any organization is unique and, therefore, cannot be directly transported to other organizations to obtain the same positive or negative results. Therefore, the research purpose is to develop and apply a system-based methodology which constructs and represents an organization's knowledge system.

SIGNIFICANCE OF THE STUDY

This research contributes to the body of knowledge by synthesizing and extending the literature through the building of an intellectual connection between organizational learning and organizational knowledge and developing a methodology to establish and

explain the organizational knowledge system. Currently, no methodology exists to make explicit an organizational knowledge system or link organizational learning and organizational knowledge. The contribution continues with the application of the methodology in an organization to demonstrate its utility.

Literature

Through the literature, this study draws a clear distinction between organizational learning and organizational knowledge and provides a synthesis of both the organizational knowledge and organizational learning literature. This research extends the existing literature by developing the concept of an organizational knowledge system and providing a methodology that constructs and represents the organizational knowledge system. This is a significant contribution as it represents a completely new but literature-based perspective of organizational knowledge. Using the literature to generate the theoretical underpinning, the research develops a model that explicitly represents an organizational knowledge system where the methodology is based on a systems perspective of organizational knowledge. Ultimately, this research refines the theories of organizational learning and organizational knowledge providing a new theory that addresses the holistic perspective and relationship of the two.

Practice

In addition to a methodology that constructs and represents an organizational knowledge system, this study also provides a powerful tool as part of the representation process. The research used computer technology to provide a robust, reusable method to help organizations identify and understand their knowledge system. This approach is different and novel from the current knowledge tools developed for organizations in pursuit of knowledge management. Current knowledge tools (Collaboration

Management Systems, Knowledge-Based Systems, Digital Journals, and Expert Systems) promote the sharing, storage, and dissemination of information (Yoon & Guimaraes, 1992; Gaines, 1993; Bose, 1994). These tools do provide a means to create knowledge if there is collaboration and dialogue between system entities. However, they do not explore or identify how the unit constructs and represents knowledge. This research also provides an organization the ability to look at its knowledge system to determine its adequacy for their current or future environment. The result will provide engineering managers a practical method of evaluating their organization's knowledge system in the areas of knowledge requirements analysis, determination of information requirements, purposeful knowledge work system design, and knowledge creation to identify deficiencies and correct them at any organizational level.

INTRODUCTION SUMMARY

In summary, this research provides a real and perceptible methodology and model that can transform the tacit nature of organizational knowledge into an explicit representation for the organization. The purpose of the study is to develop and apply a system-based analysis methodology which constructs and represents an organizational knowledge system. The research accomplishes this by establishing the intellectual connection between organizational learning and organizational knowledge, then binds these concepts together using the cognitive hierarchy theory and open systems theory. The result is the concept of the organizational knowledge system. To maintain a clear and precise focus towards achieving the research purpose, four questions were developed to guide the research inquiry and two study limitations are imposed to further ensure a complete and thorough study. Lastly, this research capitalizes on the use of computer

technology to develop a robust reusable tool for organizations to evaluate their knowledge systems to detect deficiencies, allocate resources to correct any deficiencies, and manage what is a complex and dynamic essential element to organizational success.

DOCUMENT LAYOUT

The introduction lays the foundation for the importance of the research. This will be followed by the literature review which summarizes and synthesizes the relevant literature to identify the important themes and gaps in organizational knowledge and organizational learning literatures. Here the research establishes the intellectual reality of the existence of a unique organizational knowledge system within an organization. The organizational knowledge system and model chapter will address the details concerning the concept of the organizational knowledge system and present the associated model that was applied to the organizations participating in this research. The application of the developed methodology is important as it provides a demonstration of the efficacy of the methodology. Next, a detailed synopsis of the research design methods and procedures will be presented. This chapter will explain the research design used to develop the organizational knowledge system and how it will be applied to existing organizations to construct and represent their unique knowledge systems. The following chapter will present two organizations where the research was employed along with the research assumptions, facts, data, analysis, and findings. The final chapter of this research will present the research conclusions, findings, implications, and areas where continued study is warranted.

LITERATURE REVIEW

The purpose of this chapter is to chronicle the existing literature that underpins the methodology and model of the organizational knowledge system. The first section traces the contributing organizational learning literature that supports the concept of an organizational knowledge system. In this section, definitions of organizational learning are presented and the distinction between organizational learning and organizational knowledge is identified. The second section addresses the existing organizational knowledge literature and categorizes it into three general areas: knowledge creation, understanding organizational knowledge, and knowledge tools. This section concludes by synthesizing the organizational learning and organizational knowledge literatures into the concept of the organizational knowledge system.

ORGANIZATIONAL LEARNING

The literature on organizational knowledge is somewhat sparse when compared to existing literature of organizational learning. In fact, the study of organizational knowledge has in many instances been intermingled with the study of organizational learning. This is very problematic. The interchange of the terms organizational knowledge and organizational learning has blurred the distinction that learning and knowledge are really two separate concepts.

When searching the literature one finds many different definitions of organizational learning. The following are examples of organizational learning definitions:

- Simon (1969) defined organizational learning as the growing insights and successful restructurings of organizational problems by individuals reflected in the

structural elements and outcomes of the organization itself (Fiol & Lyles, 1985, p. 803)

- Organizational learning is defined as the process by which knowledge about action and outcome relationships between the organization and the environment is developed (Duncan & Weiss, 1979, p. 84)

- Process of improving actions through better knowledge and understanding (Fiol & Lyles, 1985, p. 803)

- Organizational learning is the capacity of an organization to gain insight from experience and to modify the way it functions according to such insight (Shaw & Perkins, 1991, p. 1)

- Organizational learning is defined as the process by which knowledge about action outcome relationships between the organization and the environment is developed (Dixon, 1992, p. 31)

The unifying philosophy in these and other definitions is that organizational learning is a process which brings about organizational change. This does not diminish the importance or significant contribution the study of organizational learning has provided industry and academia in understanding and improving organizational processes. "Learning is about acquiring new skills and perspectives, not about acquiring new facts" (McGee & Prusak, 1993, p. 207). Organizations learn by supporting and promoting the learning of the organization's individuals and through the creation of systems and relationships to meet organizational goals by leveraging individual learning.

The literature on organizational learning is exceedingly diverse, fragmented, and sometimes convoluted. Fiol and Lyles (1985) trace the confusion back to Simon (1969) when he associated learning with the development of structural outcomes, insights, and other forms of outcomes. This view implies that learning is a means to influence

organizational outcomes, while also establishing reciprocity between learning and the creation of knowledge. Fiol and Lyles (1985) correctly see this as a problem from the perspective of organizational learning and organizational adaptation as it relates to strategic management. Moreover, it creates a further difficulty, wherein it fostered the existing interchange of the concepts of organizational learning and organizational knowledge. Subsequently, the study of organizational learning has grown and flourished, while the study of organizational knowledge has only in recent years become an area of intense research. This may be due to the perception that organizational learning is ultimately organizational knowledge. Still, more and more researchers pressed forward from this early work in organizational learning by developing new ideas and exploring organizational learning from new perspectives. Argyris's and Schön's (1978) work on 'double-loop' learning is a seminal work focused on increasing organizational effectiveness. The concept of "double-loop' learning was extended by Issacs's (1994) development of 'triple-loop' learning, where triple-loop learning was concerned with why organizations chose their particular goals, pick certain learning processes to use, and settle on using certain strategies to achieve organizational goals, objectives, and missions. Ultimately, Issacs concludes that the dialogue fostered by asking and evaluating 'why' enables organizations to learn and understand about their organization's underlying context of beliefs and norms that guide their processes and procedures used to form organizational paradigms and thus take action. Schein's (1983) work on organizational behavior development provides an understanding of the levels of complexity organizations embody, where critical guiding organization influences (norms, values, and beliefs) are not espoused or easily identified, but are buried at the fundamental level of an

organization's character. Senge (1990) discusses the key principles organizations must learn to become learning organizations. The ability of an organization to respond to change has been identified as a crucial organizational issue of the 1990s. Senge provides organizations and corporations with practical ways to overcome inherent obstacles to learning and develop dynamic ways to recognize new opportunities. Shaw and Perkins (1991) determined that learning-efficient organizations are engaged in two major issues. The first is experimenting, where the organization is continuously engaged with new innovations and experiments designed to improve the overall performance of the organization. The second issue is that concept of reflection, where the organization objectively assesses and analyzes the innovations and experiments to drawn results and insights that can be applied to the organization to meet present or future requirements. McGee and Prusak (1993) define learning as both the impetus and engine for change. As the engine of change, learning provides the processes to close the gap between current business practices and a dynamic and ever-changing environment (McGee and Prusak, 1993). The stimulus for change can range from loss of market share to a loss of the intellectual brain trust that supplies the ideas and concepts needed for an organization's continued vitality and growth. McGee and Prusak (1993) go on to say, that by supporting and promoting the skill development of its individuals, organizations are then able to leverage individual learning to meet corporate goals by creating new systems and relationships. What is not explained is what these new systems and relationships are or how the organization comes to know, understand, manage, and capitalize on these systems and relationships. This raises several questions. Are these new systems or relationships formal or informal? Are they structural? Are they procedural? Do they

require changes or restructuring in organizational communication? Are these new systems and relationships a combination of some or all of these formal and informal changes? Which of these new systems provides the organization with the greatest possibility of achieving corporate goals? Which of these new systems should corporate resources be focused towards?

Although there is great depth and richness to the current organizational learning literature, in effect, the broad scope of this important concept lacks structure. This entanglement of concepts has led many scholars to refer to organizational learning as insights and knowledge (Argyris and Schön, 1978; Hedberg, 1981), perspective development (McGee and Prusak, 1993), cognition development (Nonaka, 1988), and innovation (Bohen and Fry, 1992; Mohrman and Mohrman, 1993). However, one important point of convergence is that learning is clearly a critical component to organizational improvement and continued existence.

Nonetheless, there has been work under the auspices of organizational learning that seems to suggest a distinction between organizational knowledge and organizational learning. Work by Daft and Huber (1987) explores the concepts of systems-structural perspective and interpretive perspectives. The systems-structural perspective emphasizes information acquisition and distribution as essential elements for organizational learning; the interpretive perspective focuses on the underlying purpose and meaning of messages (Daft and Huber, 1987). Closer intellectual inspection of these two concepts suggests that organizational knowledge is the outcome of organizational learning. Weick (1991, p. 121) alluded to this relationship when he wrote, "an information processing perspective

portrays the stimulus terms not as physical terms, but as events that are perceived and interpreted by the learner." This notion is supported by Estes.

> The product of a learning experience resides in memory for relationships between encoded stimulus information and behavioral dispositions. In the information processing approach, one probes more deeply into what the individual is doing while learning is taking place. The goal is to construct a theoretical representation of the sequence of events that occur while stimulus information is transformed by perceptual and cognitive operations into encoded forms that are preserved in organizational memory (Estes, 1988, p. 352).

The fact that some scholars are beginning to make the distinction between organizational learning and organizational knowledge is heartening, but by no means diminishes the insights and understanding of past and current organizational learning literature. On the contrary, the distinction allows for a fuller and more focused discovery of the two concepts and an examination of the relationship between them as well. Huber suggests that:

> It is important to challenge narrow concepts of organizational learning, or of any phenomenon early in the history of inquiry, as narrow conceptions decrease the chances of encountering useful findings or ideas (Huber, 1991, p. 89).

This understanding makes it clear that a too narrow focus on any subject or issue precludes individuals from perceiving its broader implications. Thus it is critical to examine and determine the relationship between organizational learning and organizational knowledge.

ORGANIZATIONAL KNOWLEDGE

Unlike organizational learning, one does not find clearly identified definitions for organizational knowledge. The literature provides what can be best termed as a working

understanding of what constitutes organizational knowledge. Nonaka (1991, 1994) explains that organizational knowledge is not limited to formal, systematic knowledge derived from the organization's ability to process information, but it also encompasses the tacit insights and intuitions of individuals for use by the organization. Another organizational knowledge perspective is provided by Sackmann. She categorizes knowledge into four groups; dictionary knowledge, directory knowledge, recipe knowledge, and axiomatic knowledge (Sackmann, 1992). "Dictionary knowledge comprises commonly held descriptions, including labels and sets of words or definitions that are used in a particular organization" (Sackmann, 1992, p. 142). Directory knowledge refers to chains of events and their cause and effect relationships (Sackmann, 1992). "Recipe knowledge refers to prescriptions for repair and improvement strategies" (Sackmann, 1992, p. 142). Finally, "...axiomatic knowledge refers to reasons and explanations of final causes perceived to underlie a particular event" (Sackmann, 1992, p. 142). Sackmann's categorization of knowledge is meant to bring clarity to understanding knowledge. However, the different sub-classifications oftentimes raise more questions as organizations attempt to understand and determine how to classify their organizational knowledge. Brown and Duguid (1998) express organizational knowledge as "know-what" and "know-how." The "know-what" is characterized by explicit knowledge that can be shared, while "know-how" is the ability to put know -what into practice (Brown & Duguid, 1998). Again, this is another way to stratify knowledge. However, an important theme emerges from these definitions. That is, organizational knowledge is a complex concept that is difficult to understand and explain with a wide variation in perspectives, none of which is universally accepted by the community of scholars and practitioners.

As can be seen, there is no clear definition of organizational knowledge, but the above perspectives provide a rich and diverse explanation of knowledge. On the other side, these multiple perspectives have the potential of causing confusion when attempting to develop an understanding of organizational knowledge. This research is not devoted to presenting a new definition of organizational knowledge, but is poised to identify the linkage between organizational learning and organizational knowledge and provide organizations with a literature-based methodology and a model that can guide construction and representation of an organization's unique knowledge system.

Acceding to the supposition that learning is the process whereby knowledge is created provides a more holistic perspective to analyze organizations. This understanding of learning provides organizational analysts the flexibility needed to clearly address what methods, processes, and strategies organizations employ to facilitate learning. Huber (1991) provides the framework of organizational learning in four constructs: knowledge acquisition, information distribution, information interpretation, and organizational memory. Huber goes on to surmise that "an organization learns if any of its units acquires knowledge that it recognizes as potentially useful to the organization" (Huber 1991, p. 89). This perspective intuitively assumes that organizational knowledge is the result of the organizational learning process.

As stated earlier, the related organizational knowledge literature can be parsed into three general categories: understanding organizational knowledge, knowledge creation, and knowledge tools. Unlike the extensive literature of organizational learning, there are fewer references that provide a detailed look at organizational knowledge. Much of the literature associated with understanding organizational knowledge focuses on specific

ontological perspectives of organizational knowledge. This is evidenced by research work on the culture of organizations (Sackmann, 1992), benchmarking as a means to understand and evaluate an organization's knowledge capital (Hiebeler, 1996), and social processes and environmental influences on organizational knowledge (Lyles and Schwenk, 1992; Gummer, 1993; Brown and Duguid, 1998). Lyles and Schwenk (1992) also explore organizational knowledge from a top management-level perspective, presenting the organizational knowledge patterns as organizational knowledge structures (Lyles & Schwenk, 1992). While Lyles's and Schwenk's (1992) work represents movement forward in the understanding of organizational knowledge, it is limited in its depth and scope because their theory is developed and explained based on statements from business executives from international consulting firms. A recognized leader in the study of knowledge creation is Nonaka. The reference list of relatively all research work concerning organizational knowledge draws heavily on the foundations of tacit and explicit knowledge in the creation of organizational knowledge developed by Nonaka (1991; 1994). The foundational perspective of tacit knowledge was developed by Polanyi (1967). Polanyi (1967) explains that tacit knowledge is that we know more than we can tell. Essentially there is knowledge that individuals, and by extension organizations, implicitly know and understand (tacit knowledge) that cannot easily be put into words or is known at such a fundamental level it is never espoused openly. Finally, much of the literature on knowledge-based tools relates to specific computer-based expert technologies designed to help organizations automate relationships, develop digital repositories, or automate decision-making processes. The focus of this literature is primarily concerned with applying information technology innovations to spawn a cohesive and

comprehensive organizational knowledge environment and knowledge management strategy. Yoon and Guimaraes (1991) present an object-oriented knowledge-based expert system that enables an organization to develop and maintain their knowledge database. An implicit assumption in developing an object-oriented organizational knowledge-based system is that the organization can explicitly explain their knowledge objects and their diverse inter-relationships. This is a difficult task for any organization and even more so if the objective is to capture the informal organizational knowledge objects as well as the formal objects. Bose (1995) explains the development of a knowledge-based tool designed to aid organizational members in their collaborative process. The goal is to code the organizational members and their relationships with other members. This is a laudatory goal, but does not take into consideration the dynamic nature of the many inter-relationships organizational members engage in based on different tasks and responsibilities. Gaines (1993) addresses dissemination of journal knowledge using computer and telecommunications technology. The discussion provides a balanced perspective of the social and technological considerations concerning information dissemination, but does not holistically address acquisition, storage, and interpretation along with dissemination which are all part of an organization's knowledge system. Although these knowledge-based tools are important and provide benefit to organizations, they do not create knowledge and only address organizational knowledge from a limited and narrow perspective. Polanyi (1967) stressed that it is essential to look at issues in their entirety before we analyze a phenomenon in pieces. This perspective ensures that organizational knowledge is placed in the proper contextual frame of the organization.

SYNTHESIS OF ORGANIZATIONAL LEARNING AND KNOWLEDGE

As alluded to earlier, the literature of organizational learning and organizational knowledge by themselves lack the fullness of perspective in organizational research and study. However, when the concepts of organizational learning and organizational knowledge are linked they provide a continuity of thought that more correctly depicts the relationship of the concepts in organizations. This research fuses these two powerful organization concepts as the organizational knowledge system; thereby adding a significant contribution to the body of knowledge through the extension of the literature, where thoughts and perspectives of organizational learning and organizational knowledge intersect forming the intellectual bridge between organizational learning and knowledge. Figure 2 provides a graphical depiction of the current literature. The synthesis of the literature provides a holistic perspective of organizational learning and organizational knowledge and for the first time portrays the relationship of these concepts. Likewise, it gives researchers an opportunity to study the organizational dynamics of learning and knowledge as a whole. Thus, starting with the perspectives and thoughts on organizational learning, four major themes were identified: the ways in which organizations learn, the process of organizational change, the elements of organizational learning, and the perspectives on organizational learning.

Perspectives & Thoughts on Organizational Learning

Ways Org Learn

Process of Org Change

Organizational Learning

Elements and Perspectives of Org Learn

Knowledge Creation

Organizational Knowledge

Knowledge Tools

Understanding Org Knowledge

Perspectives & Thoughts on Organizational Knowledge
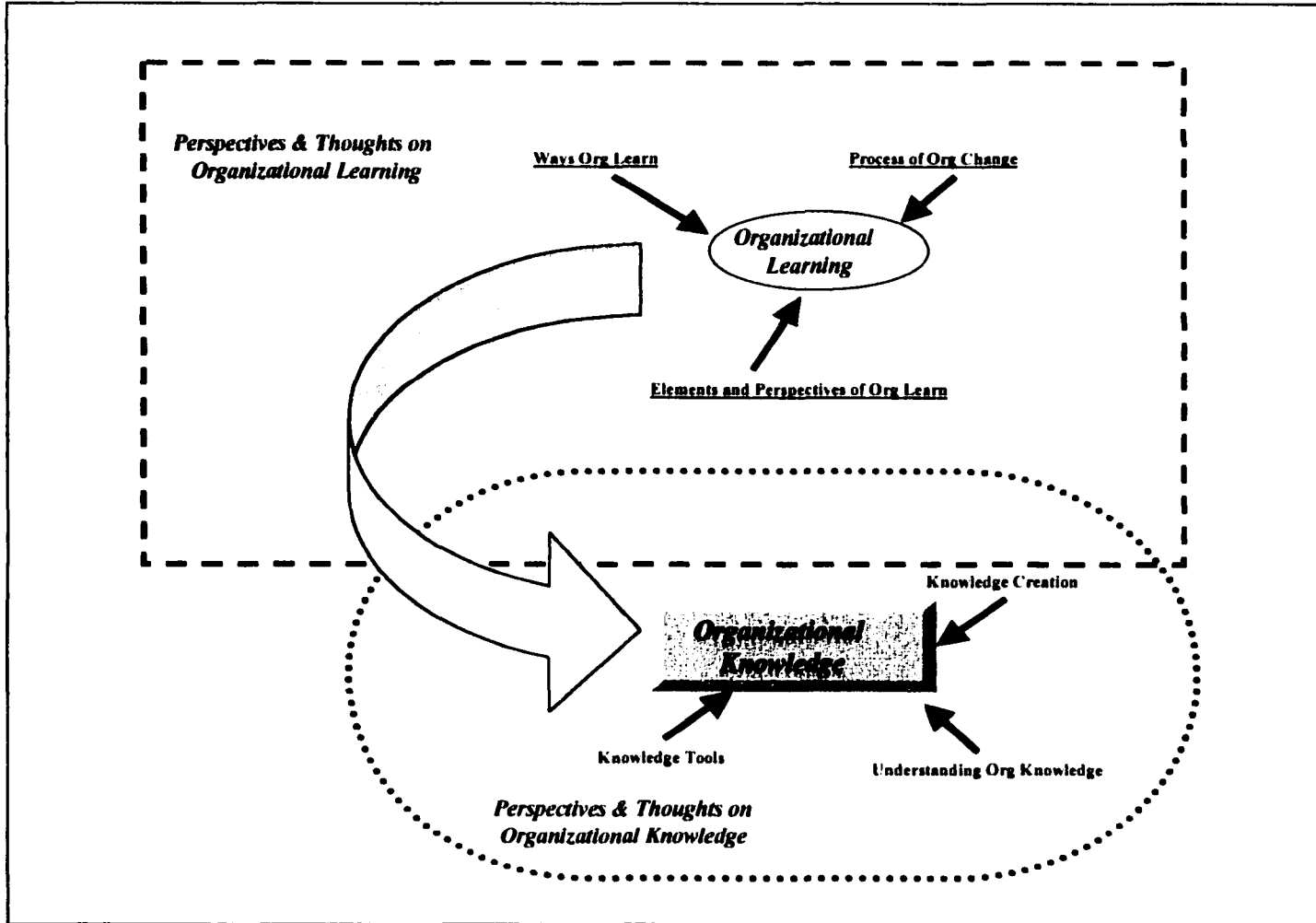
Figure 2.   Organizational Knowledge System Synthesis of Literature

Ways Organizations Learn

The ways in which organizations learn is a central theme, found in the organizational learning literature. This theme is focused on the individual and collective learning aspects of organizations. The literature highlighted in this section and the following sections identifies the prevailing thoughts and perspectives that support the research perspective and categorization of the organizational learning and knowledge literature. Argyris and Schön rightly highlight a paradoxical dilemma concerning organizational learning.

> Organizations are not merely collections of individuals, yet there is no organization without such collections. Similarly, organizational learning is not merely individual learning, yet organizations learn only through the experience and actions of individuals (Argyris and Schön (1978).

McGee and Prusak (1993) go into detail addressing individual skill development and how organizations leverage individual learning to meet corporate goals. The thrust of their analysis is that "...learning is about acquiring new skills and perspectives, not about acquiring new facts" (McGee & Prusak, 1993, p. 207). From this individual perspective of learning they form two levels of learning at the organizational level. First, organizations learn by supporting and encouraging the learning of individual members (McGee & Prusak, 1993). Second, organizations create systems and relationships to leverage individual learning, meet organizational goals, and vicariously learn from these systems and relationships that have been established (McGee & Prusak, 1993). Likewise, Argyris and Schön (1978) go on to explain organizational learning in two different ways -- single-loop and double-loop learning. Organizations experience single-loop learning when members of the organization identify internal and external environmental stimuli as

problems and then correct the problems to re-establish the defined system order (Argyris & Schön, 1978). Double-loop learning goes one step farther. When a problem arises, it is not resolved to re-establish the existing organizational practice of theory-in-use, where theory-in-use are patterns defining decision and action. On the contrary, the solution to the problem requires change beyond organizational strategies, processes, and basic norms and values of the organization. Thus, the double-loop learning solution to the problem challenges basic norms and the incompatibility of the organization's existing theory-in-use. Issacs (1993) addresses the concept of double-loop learning in his discussion of dialogue and collective thinking. Issacs argues that dialogue is the means to attain what he terms as triple-loop learning. "Triple-loop learning is the learning that opens inquiry into the underlying 'why' (Issacs, 1993, p. 46)." It permits insight and inspection of not only the nature of the paradigm, but also what assumptions led to using this paradigm, the paradigm selection process, and the goals that precipitated the paradigm development. Two other important perspectives concerning the way organizations learn are organizational behavior development and unlearning. Schein's (1983) organizational behavior development evolved into what is commonly referred to as the culture of the organization, where the underlying norms, beliefs, and values form the basis of organizational behavior. Schein defines organizational culture in this way:

> A (organizational) culture is a set of basic tacit assumptions about how the world is and ought to be, that a group of people share and that determines their perceptions, thoughts, feelings, and, to some degree, their overt behavior its individuals. (Schein, 1996, p. 11).

Schein's framework, Figure 3, of organizational culture has three basic levels.

CULTURE   **COMPLEXITY**

Artifacts   Surface

Espoused
Values & Beliefs   DEPTH

Basic Assumptions   Fundamental

(Values &
Beliefs in Use)
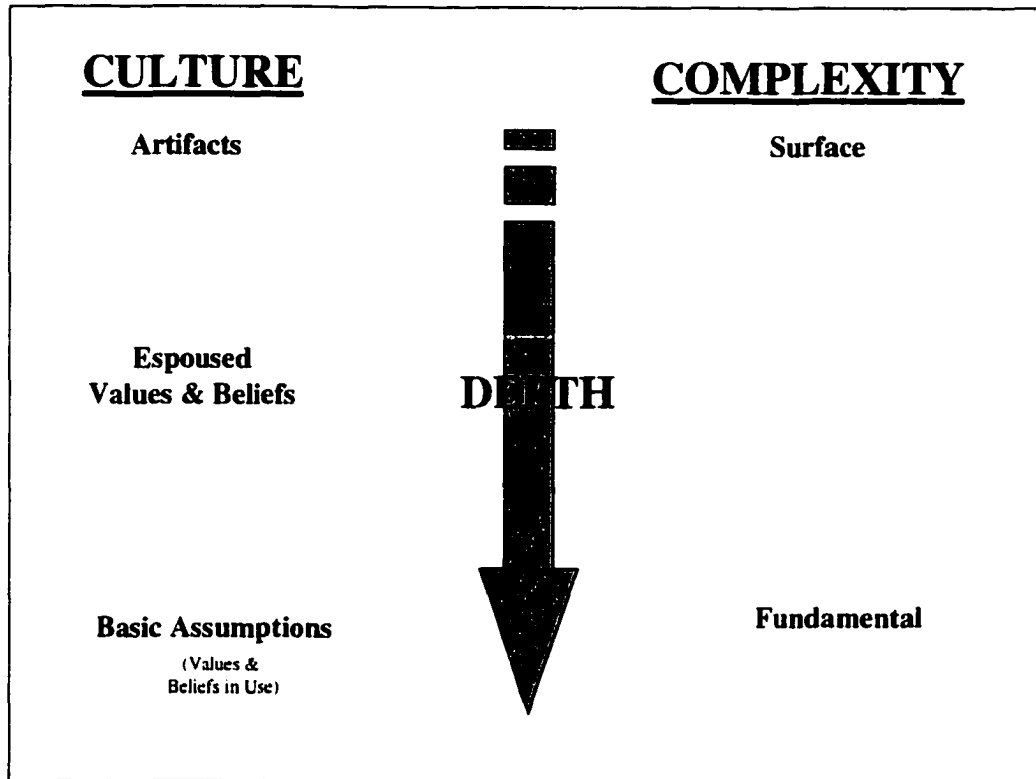
FIGURE 3. Schein's Framework of Organizational Culture (Schein, 1992)

As one inquires deeper into an organization's culture, the values, norms, and beliefs that truly govern actions and decisions are manifest. However, the order of complexity of these norms and values also increases. Oftentimes, they are obscured by processes and perceived values and beliefs from the espoused values and beliefs level of organizational culture. Usually, they are quite entrenched and hidden in the organization. Organizational cultural dynamics are an every day part of the organization's structure, human resources, and politics. The theory and practice of dialogue is emerging, in industry and government, as a means to bridge communication and cultural differences, enabling organizations to more clearly formulate problems and issues for resolution (Schein, 1997). Dialogue's main objective is to get at the underlying assumptions of an issue or problem. It goes to the heart of understanding individual mental models and

group or organizational culture. Thus, dialogue develops a process to build common understanding. By understanding the meanings and representations individuals in the organization use and hold close, a common experience base is developed that allows the group or organization to learn collectively (Schein, 1997). The collective learning of the organization is then processed and may be used as knowledge, thus increasing shared corporate understanding and potentially enhancing organizational performance. The second is unlearning. McGill and Slocum (1994) present unlearning as a concept that organizations must learn so that the organization can make room for new ways of thinking. Ultimately, managers will need to unlearn primitive ways of thinking and begin to use new mental patterns that provide a unifying focus toward attaining new organizational learning. "Unlearning is a process that shows people they should no longer rely on their current beliefs and methods" (Starbuck, W., 1996, p. 726). Also, management, oftentimes, makes learning difficult by simply overlaying new initiatives and policies over existing ones. This only adds to employee confusion as to what the organization's true priorities, beliefs and values are. An important step towards successful organizational learning and knowledge creation is to unlearn old ways and patterns of thought for new ways designed to support the evolving organization. This is by no means an easy task, but is just as important as creating a climate of innovation within the organization. As organizations understand and begin to learn, they must now embark on the process of organizational change to ensure they incorporate the new learning into their organizational system.

Process of Organizational Change

The Process of Organizational Change finds some of its roots in the work by Simon. Simon's work (1969) theorized that learning is the means to influence organizational change. Foil and Lyles noted that Simon defined organizational learning as "the growing insights and successful restructuring of organizational problems by individuals reflected in the structural elements and outcomes of the organization itself" (Foil and Lyles, 1985, p. 803). As observed earlier, Simon's work has added to the lack of a clear distinction between organizational learning and organizational knowledge. However, Simon's work does provide interesting and perceptive thought on the process of organizational change. The discussion of organizational change goes on as Foil and Lyles (1985) discuss how organizations improve their actions through knowledge and understanding. Their discussion is centered around what they term the concept of learning. The concept of learning is the organization's interpretive processes, shared understanding, and conceptual schemes (Foil and Lyles, 1985). These elements lead to Foil and Lyles's (1985) lower-level and higher-level learning, where lower-level learning is "focused learning that may be mere repetition of past behaviors" and higher-level learning is the "development of complex rules and associations regarding new actions and the development of understanding of causation" (Foil and Lyles, 1985). Dixon (1992) adds to the process of organizational change as she links organizational knowledge about action outcomes to relationships between the organization and its environment. Likewise, McGee and Prusak (1993) also contribute to the process of organizational change through their work, which attempts to close the gap between business practices and an ever dynamic environment. Senge's (1999) discussion of

organizational change focuses on the challenges of learning organizations. Senge (1999) presents three major areas of emphasis: challenges of redesigning and rethinking in the organization, the challenges of initiating organizational learning, and the challenges of sustaining new learning initiatives. Each of these areas provide organizations with a comprehensive set of principles to foster learning that will bring about organizational change and prevent limitations that will inhibit true organizational transformation. From the process of organizational change the literature diverges into the elements and perspectives of organizational learning. It is here that the organizational learning literature begins to address its copula to organizational knowledge.

Elements and Perspectives of Organizational Learning

The Elements and Perspectives of Organizational Learning section represents the initial links of the learning literature to organizational knowledge. As outlined in the preceding sections on organizational learning and knowledge, Daft, Huber, and Weick contribute heavily to the delineation between organizational learning and organizational knowledge. Likewise, the following list of literature topics is purported to be organizational learning literature, but it clearly has threads of understanding that lead to organizational knowledge development processes.

◆ Organizational learning insights into knowledge (Argyris & Schön, 1978; Hedberg, 1981)

◆ Perspective development (McGee & Prusak, 1993)

◆ Cognition development (Nonaka, 1988)

◆ Innovation (Mohrman & Mohrman, 1993; Bohen & Fry, 1992)

Intuitively, many researchers seem to make the connection between organizational learning and organizational knowledge without clearly establishing a distinction between the two. However, Daft and Huber's (1987) work on a system's structural perspective of organizational learning, along with Huber's (1991) work categorizing the constructs of organizational learning, lay the foundation for the bridge connecting organizational learning and knowledge. Daft and Huber (1987) also address the interpretive process that organizations must conduct and characterize this as a cognitive process. Estes (1988) surmised that organizations construct events through perceptual and cognitive operations that are then preserved in organizational memory. Weick (1991), in a later work, showed that the events are perceived and interpreted by learners within the organization. The link to organizational knowledge is that the cognitive process, which resides in humans, leads to knowledge. An important issue of interest to organizations is how they capture that knowledge and recall it to capitalize on its benefits. Another important issue is how a kernel of knowledge manifests itself at the organizational level. Moreover, because the concepts of organizational learning and knowledge are separate but intrinsically linked, it allows for them to be studied from a systems perspective.

The substantive work on organizational knowledge can be divided into three areas: knowledge creation, understanding organizational knowledge, and knowledge tools, all of which were explained in the Organizational Knowledge section. However, it is important to note that the current organizational knowledge literature provides diverse viewpoints from which to examine the organizational knowledge system, where,

> ...knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in

the minds of knowers. In organizations, it often becomes
embedded not only in documents and repositories but also
in organizational routines, processes, practices, and norms
(Davenport & Prusak, 1998, p. 5).

This statement explains part of what seems to be the confusion in defining

organizational knowledge, but it also highlights the richness and depth of knowledge and

the need for continued investigation. Further investigation will endeavor to explain how

knowledge is embedded into organizational routines, processes, and practices and why

the understanding of "how" is important to the organization. The emergent

understanding of organizational knowledge is made more complete by linking

organizational learning in its proper context to knowledge. This fosters a shared

perspective describing knowledge that can be stored and share a dominant organizational

knowledge logic (Lyles & Schwenk, 1992).

Thus, the organizational knowledge system is a fully linked and holistic perspective

that encompasses the concepts of organizational learning and organizational knowledge.

The concepts, taken individually, are powerful and provide tremendous insights into

organizations that cannot be gained by their separate study. However, the substantive

study of both concepts together provides the contextual understanding and richness that

researchers must endeavor to achieve if we are to fully unlock the mysteries, power, and

riches of the organizational system.

LITERATURE REVIEW SUMMARY

A summary of the literature review highlights the intellectual foundation for the

development of the organizational knowledge system. The literature review started with

a summary and synthesis of organizational learning. In this section we discovered that

there are multiple definitions for organizational learning and that there is a plethora of

research concerning organizational learning. The literature review in this area also developed four areas of learning that impact the organizational knowledge system: ways organizations learn, the process of organizational change, the elements of organizational learning, and the perspectives of organizational learning. The major theme of the organizational learning literature is that learning is the process for organizational change.

The literature review ends with an exploration of organizational knowledge. Here we found that the literature was not as abundant when compared to organizational learning. However, the richness of the perspectives concerning organizational knowledge is evident in this section. The major theme identified was that organizational knowledge is composed of many components. Experience, insight, values, and contextual information are but a few of the important aspects that aid organizations in framing and evaluating experiences and information that lead to organizational knowledge. Here a gap in the literature was identified. The literature does not clearly articulate the relationship of learning to knowledge, where learning is the process that informs and leads knowledge. The literature also does not establish how the relationship of learning and knowledge works. However, by extending the literature through the development of the organizational knowledge system, a relationship between organizational learning and organizational knowledge is established. Furthermore, the concept of the organizational knowledge system provides a more holistic interpretation of an organization's learning and knowledge processes.

ORGANIZATIONAL KNOWLEDGE SYSTEM & MODEL

This chapter is devoted to providing an in-depth explanation of the organizational knowledge system (OKS). The first section builds the relationship between knowledge and organizational learning from the perspective of the cognitive hierarchy. The second section of this chapter applies the open systems theory to the dynamic interrelationship between knowledge and learning. The next section identifies the literature which supports the development of the organizational knowledge system. This section also addresses in detail the four upper-level organizational knowledge system subsystems: information acquisition, information storage, information interpretation, and information dissemination. This last section establishes the organizational knowledge system model which serves as the link between theory and reality and explains the important relationships within the systems-based organizational knowledge model. The chapter concludes with a summary of the key points concerning the organizational knowledge system methodology and model.

A COGNITIVE PROCESS

The organizational knowledge system includes a cognitive process concerning the relationship between organizational learning and knowledge. The process of combining the two concepts yields an organizational cognition that is a representation of how knowledge is attained (Figure 4). It starts with data, which is transformed into information, where that information is interpreted within a particular frame of reference and then becomes knowledge. This migration will be discussed in more detail later in

this section. However, first it is important to understand that an organizational knowledge system is distributed and incorporates the

Organizational Cognition

DECISION/ACTION
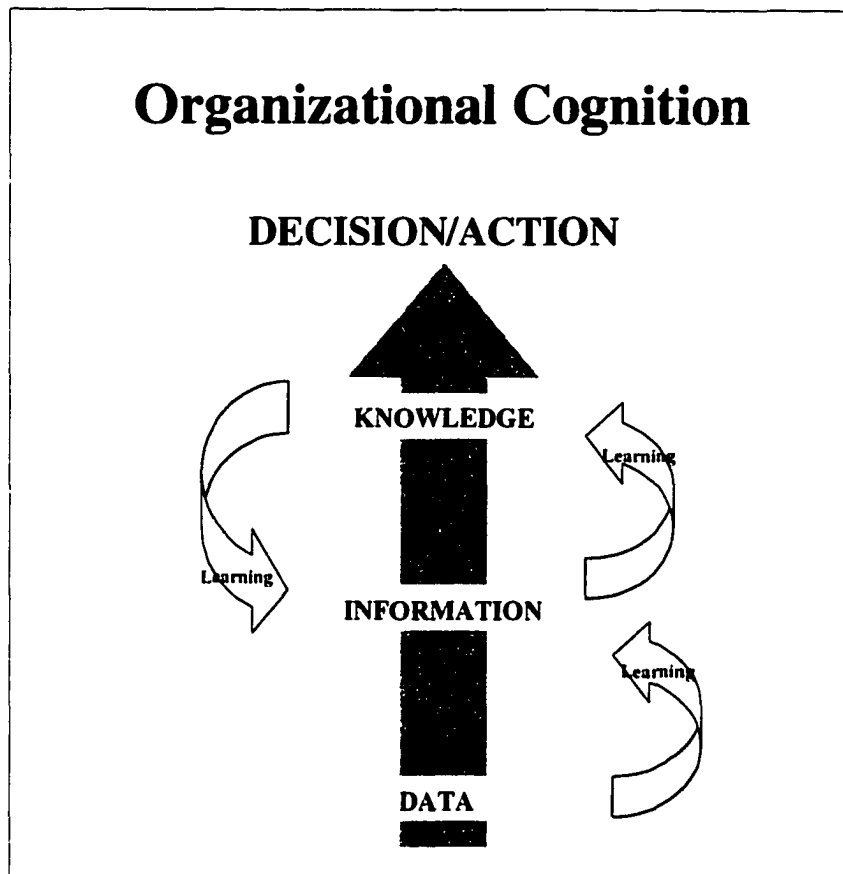
FIGURE 4. Organizational Cognition

individual's experience and judgement, along with various information technologies, into a collective relational system. Organizational standard procedures, policies, tools, equipment, personnel, information systems architecture, information requirements, and strategic focus all support the acquiring, interpretation, and dissemination of relevant data and information. The process by which an organization transforms data into information and information into knowledge and back is organizational learning. Thus, the ability of an organization to promote and manage learning is integral to the effective and efficient

development and management of knowledge. Figure 4 provides a framework of the cognitive hierarchy. The lowest level of the hierarchy is data. Data is characterized as raw facts and figures. There has been considerable emphasis associated with the data processing capability of computers and management tools because of the tremendous leaps in processing speeds, data storage, and retrieval capability. These tools allow organizations the capability to access, generate, and store large amounts of data for use by individuals and sub-elements within an organization. Examples include data repositories, data mining, data search engines (e.g., internet-based search engines), and data modeling. The data is then analyzed and organized into useable information (aggregated data) (Dutta, 1997). Information is the categorizing and combining of the data into a format that provides meaning to the organization. This can take many explicit forms, such as quarterly financial reports, organizational status reports, monthly production schedules, and organizational personnel rosters. The flow of information, again, aggregated data, conveys a message or has meaning which might create, restructure, or change the organizational knowledge base. Dretske (1981) refers to this with some useful insights:

> Information is that commodity capable of yielding knowledge, and what information a signal carries is what we can learn from it (Dretske, 1981, p. 44). Knowledge is identified with information-produced (or sustained) belief, but the information a person receives is relative to what he or she already knows about the possibilities at the source (Dretske, 1981, p. 86).

"In short, information is a flow of messages, while knowledge is created and organized by the flow of information, anchored on the commitment and beliefs of its holder"

(Nonaka, 1994, p. 15). The next step in the hierarchy moves organizations towards focusing on knowledge as opposed to information (Dutta, 1997).

Organizations create, store, retrieve, interpret, and disseminate information. That information is composed of aggregated data which has meaning and conveys a message. Transitioning this information into knowledge is a human cognitive process which contextualizes and interprets the information for its relevance and significance to an organizational sub-element or the organization as a whole. How the information is interpreted is based on unique patterns of knowledge embodied within each particular organization. The knowledge pattern constructed by the organization not only affirms the validity and veracity of the information, but provides the basis for organizational interpretation, understanding, and representation of that information. This in turn leads to specific decision and action or inaction which may be undertaken by the organization based on certain information. Karl Weick refers to the phenomena of knowledge patterns as "satisficing within context" (Weick, 1995). The construction or existence of organizational patterns of knowledge may be beneficial or not beneficial to an organization. This is dependent on the particular organization, the context in which the organization operates and perceives information, and the resultant interpretation of that information. This notion partly explains some of the dysfunction in organizations, where it is not unlikely that various organizational sub-elements will be operating off of differing knowledge patterns while analyzing the same piece of information. This can lead to certain knowledge patterns becoming dominant over others. The idea of knowledge patterns being dominant and pervasive and on a tacit level in an organization is consistent with Schein's (1992) discussion of organizational beliefs and values located

at the basic assumptions level of an organization's culture. What is new and important with this research is making these knowledge patterns explicit at the organizational level to determine if the knowledge pattern is in alignment with the organization at a particular time, within a particular environment, and within the context of organizational operations.

Thus, another significant gap in the literature is the understanding of organizational knowledge patterns and making them explicit to the organization. Explicit knowledge patterns can provide for decisions concerning the efficacy of the patterns and their appropriateness in the context of dynamic and changing organizations and environments. The essence of organizational knowledge is the ability to represent and interpret information through the understanding and management of these organizational knowledge patterns. Consequently, this research adds to the body of knowledge by extending the current literature through the explicit construction and representation of organizational knowledge patterns that lead to organization decision, action, and interpretation.

SYSTEMS THEORY

This research relies on open systems theory as one of its foundational underpinnings. Open systems theory is a comprehensive model that describes the elements of an organization and their dynamic interrelationships (Hanna, 1988). It states that organizations are an arrangement of elements that have an interdependence on one another. Pasmore (1978) describes systems thinking in the following quote:

> Systems' thinking provides guidance and direction for exploration of an organization and goals for change. It describes the complex relationships between people, tasks,

and technologies and helps us to see how these can be used to
enhance organizational performance (Pasmore, 1978, p. 4).

Open systems theory provides an important perspective for this research, particularly as

one looks at organizational learning and knowledge and their dynamic interrelationship.

The underlying foundation of this research takes into consideration the organization's

learning and knowledge systems and looks at them as a whole -- the organizational

knowledge system. This is a significant departure from the literature on organizational

learning and organizational knowledge to date. All organizations can be defined as

systems, where the system consists of entities, a system boundary, pattern of relationships

between entities, and the environment. Short explanations of a system's components are

found in Table 1.

Entity	A system entity can be an individual, group, technology, or a combination that comprises the organizational system.
System boundary	The system boundary is the border that delineates it from other systems and the environment. It is permeable allowing interaction between the system and its environment. The proper identification of the boundary will determine the scope and span of the organization's knowledge system. This boundary provides the contextual atmosphere in which resides the knowledge system.
Pattern of relationships between entities	The pattern of relationships between entities interconnects all entities within the system together, but all entities do not have to be connected to each other. The connection or relationship does not have to be two-way. (See Figure 5)
Environment	The system environment is subdivided into the knowledge system contextual atmosphere and global environment. The knowledge system contextual atmosphere has immediate and substantial effect on how the knowledge system functions. This environment is defined as entities or systems that have a habitual association and critical effect on the system in question. The global environment is the larger encompassing environment within which the system exists. This environment includes those systems that are outside the parent organization. Care must be taken by organizational managers when defining the boundaries of the local and global environments, so as not to invite unwarranted complexity or overlook important interactions with the system.

TABLE 1.   System Theory Components (adapted from Hanna, 1988)

Systems theory also states that a system must have a purpose (Hanna, 1988). This is critically important to understand, because without a purpose the system has no reason for being. The purpose for the system provides focus and direction for the organization and provides the impetus for the entities to develop the mission and goals that accomplish the organization's purpose. The purpose of this system is to achieve organizational action, decision, and interpretation through the alignment of knowledge patterns. This
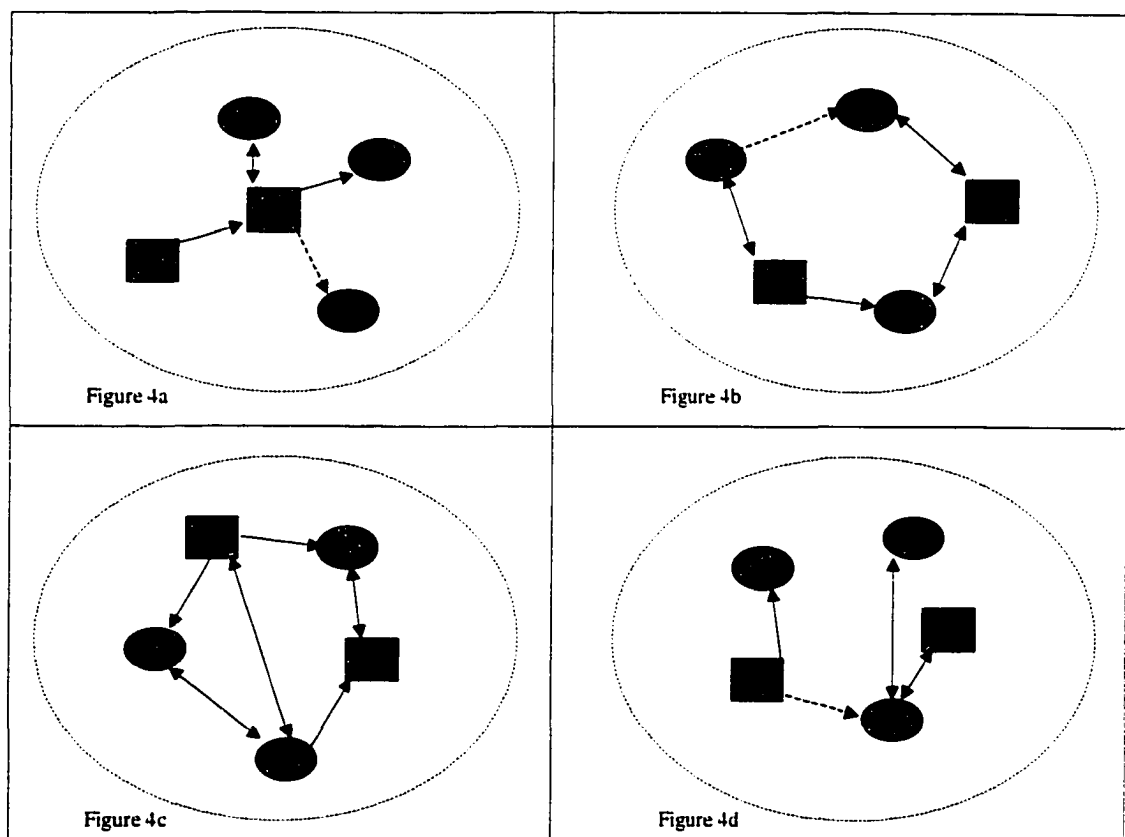
FIGURE 5.   Pattern of Relationships Between System Entities

Figures 5a-d represent correct relationships between entities. All entities within each system are interconnected either directly, indirectly, or with a temporary (virtual) connection (represented by the dotted lines) (Hanna, 1988).

purposeful system transforms data into information, information into knowledge, and knowledge into action and decisions. This is not unlike a production facility that

transforms raw materials into finished products for consumers. The significance is that the knowledge system not only underlies the production facility and all other elements within the organization, but is responsible for the construction and reconstruction of knowledge by the elements of the system (organization). Consequently, this informs and guides action, decision, and interpretation in the sub-elements of the system.

Open systems theory provides a framework from which to view organizational learning and organizational knowledge as a whole. The systems perspective helps to explain the relational richness between learning and knowledge, but also establishes the foundation for assessing the relationships between the entities associated with the organizational knowledge system methodology. Systems theory underpins the organizational knowledge system methodology and provides the theoretical basis for development of the organizational knowledge system and knowledge system model.

ORGANIZATIONAL KNOWLEDGE SYSTEM

The organizational knowledge system is a holistic synthesis of the organizational learning and organizational knowledge literature. Currently, there is no theory or perspective in the literature that combines the organizational learning and organizational knowledge concepts as a unified systematic view of organizational dynamics. This research has developed this methodological way of thinking (the organizational knowledge system) to fill the gap in the literature between organizational learning and organizational knowledge. The organizational knowledge system methodology provides the literature-based framework required for this research to construct and represent an organization's knowledge system.

The organizational knowledge system is composed of four subsystems. These subsystems are information acquisition, information storage, interpretation, and information dissemination. Huber's synthesis of the organizational learning literature provides the substantive basis for the development of the organizational knowledge system. Huber (1991) refers to the subsystems as constructs (knowledge acquisition, information distribution, information interpretation, and organizational memory) related to organizational learning. The constructs represent a synthesis of organizational learning as shown in Figure 6. Huber (1991) also identifies where considerable work has been conducted and highlights where future research can have a substantial impact on the body of knowledge. Huber(1991) explains that there is a considerable amount of work relating to knowledge acquisition and information dissemination. However, the literature on information interpretation focuses mainly on individual interpretation and not on organizational interpretation, while the literature on organizational memory is in need of systematic investigation (Huber, 1991). What neither Huber nor the other research literature addresses is where this understanding of organizational learning will lead researchers next or whether this is the culmination of organizational learning. This research extends Huber's constructs and creates a bridge between organizational learning and organizational knowledge.
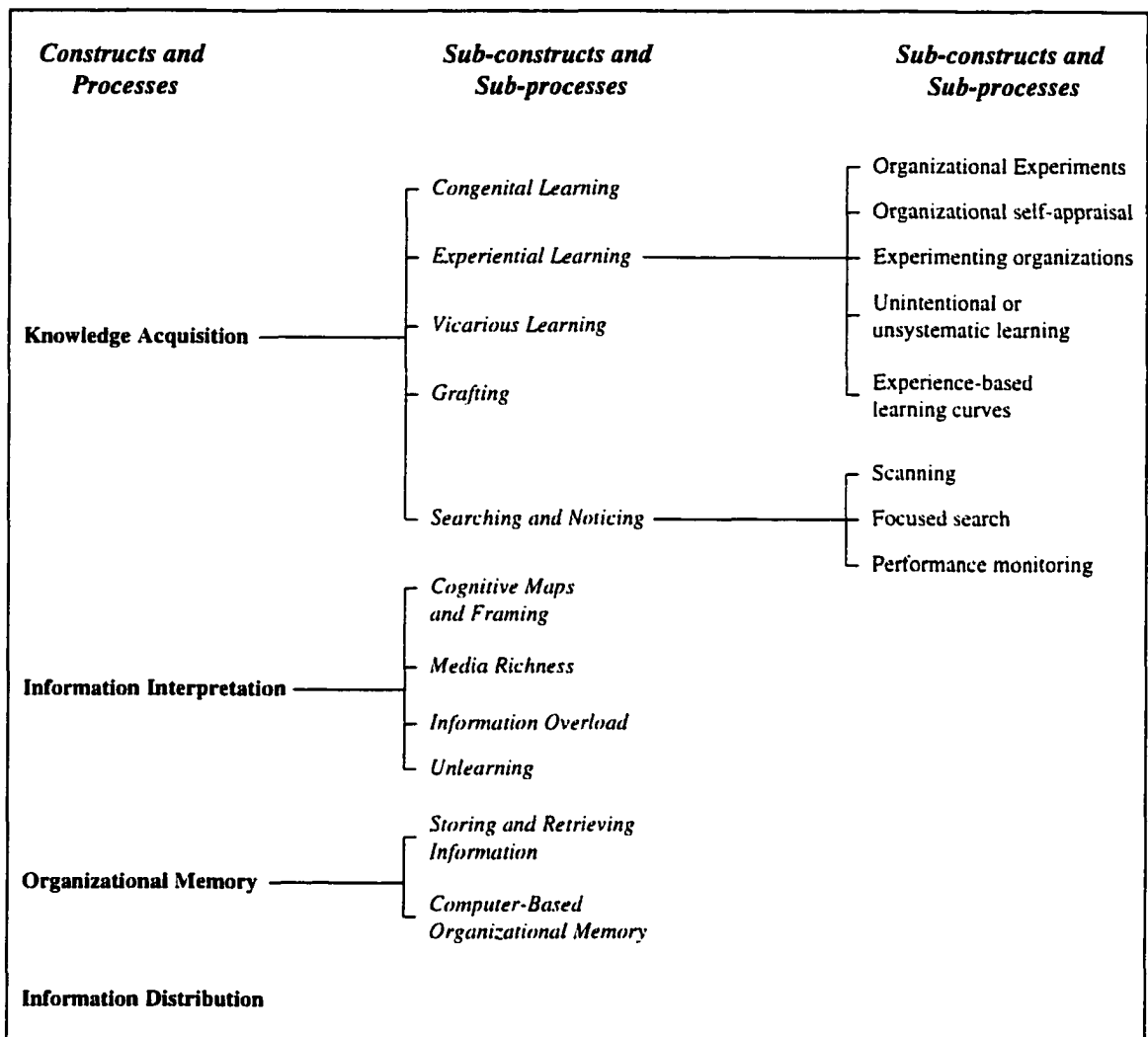
Figure 6. Constructs and Processes Associated with Organizational Learning (adapted from Huber, 1991)

There are some important exceptions and additions to the constructs of learning presented by Huber that appear in the framework of the organizational knowledge system. Huber's synthesis of organizational learning does not identify the rich relationship of his constructs. This study will provide a full explanation of each of the organizational knowledge subsystems (stemming form Huber's work) and also establish and explore the important and vital relationships between the subsystems. The explanation of the knowledge subsystems will begin with information acquisition, then discuss information

storage, interpretation and dissemination. The explanation of each subsystem will highlight the departure from Huber's work and the extension of the literature contributed by this research. The explanation will also present the detailed understanding of the four knowledge subsystems that comprise the organizational knowledge system.

Information Acquisition

Huber refers to the information acquisition process as knowledge acquisition. This assumes that organizations are able to acquire knowledge, which is a rather tenuous assumption. For this assumption to be true, the transfer of the information must include the interpretive framework and contextualization assigned to it from its source. But, information alone does not constitute knowledge. There is a great deal of confusion and misinformation in the business community in relation to what knowledge transfer and knowledge databases are. When information is acquired from knowledge repositories, it is devoid of the circumstances from which it was created. Why, how, and when the information was created, and even who put it together, all play an important role in the context of the information. How one interprets the information, or for that matter, the interpretive framework used, plays a part in the knowledge drawn from bits and pieces of information. Thus, for organizations to acquire knowledge, the acquiring organization, collectively and individually, must share norms, experiences, and mental models necessary to transfer the intact knowledge in its original form. This assumes that individual cognitive processes (mental models) are not unique, which we know is not true (Senge, 1990), but also that organizational understanding and interpretation are very similar, if not the same. For this reason, this research assumes that organizations do not acquire or store knowledge, but more precisely stated, acquire and store information.

The ability of an organization to acquire information is crucial to its short-term and long-term viability in its chosen industry. The acquiring of information is both an internal and external function, where internally, organizational entities acquire information from sources within the system and externally, entities within the system acquire information from sources outside the system. For instance, a manufacturing firm may be composed of the following entities (Figure 7):

Figure 7. Manufacturing Firm

Upper-level management may view their organization as a three entity system. However, the advertising section manager may view the organization as a sixteen entity system. Neither viewpoint is wrong, but understanding the various viewpoints provides a perspective of the system that is of concern to the organizational manager. Simply put, the key issue is the bounding of the system (the articulation of the entities that comprise the system) is arbitrary and the bounding is critical for analyzing the system. This research calls this bounded system the *system in focus*. The system in focus is defined as the " identified bounded system" under investigation. Thus, does the organization's information acquisition process consist of three internal sources or sixteen (refer to Figure 7)? What are the tradeoffs between the two perspectives? These are important

questions that establish the organizational holistic perspective of their information acquisition subsystem. This relates to the internal and external acquisition of information since it is relative to the entity of the system. Likewise, organizations may gather information by reviewing the business practices of their competitors or organizations that have achieved heralded success as a means to inform their internal operations. Clarity of what is internal and external information to the organization is important because this helps to identify and establish knowledge system boundaries in the organizational culture. The internal and external understanding of information acquisition is an important aspect of defining system boundaries, which in turn help to define and establish the organizational knowledge system.

An organization acquires information in two ways: creation and obtainment. This is a further clarification of Huber's constructs. The creation of information is essentially the organization learning from experience, while the obtainment of information can be the purchasing, depredation, alliances, and or cooperative agreements organizations engage in to acquire knowledge. Organizations may also purchase information through the hiring of specialists in certain fields of study or expertise. These specialists bring with them vast amounts of information that can be assimilated by the organization to improve operations. Also, the acquisition or merger of rival companies provides an organization with an infusion of information, which if managed properly, will enhance the capabilities of the organization. This obtainment of information also creates new information that the organization assesses, which may result in modifications or changes in business processes to ensure that the organization remains competitive in their industry environment. The dynamic nature of our environment portends that the creation of

information is a vital organizational function, which if not nurtured, will wither and ultimately prevent the organization from changing to keep pace with its environment. The above discussion represents an extension of the literature pertinent to the information acquisition organizational knowledge subsystem. The research then draws upon Huber's taxonomy of the types of information acquisition.

Huber further subdivides these two types of information acquisition into five categories: congenital learning, experiential learning, vicarious learning, grafting, and searching and noticing (Huber, 1991). Congenital learning is defined as knowledge inherited at an organization's conception and additional knowledge acquired prior to its birth (Huber, 1991). Experiential learning is organizational knowledge acquired through direct experience (Huber, 1991). Vicarious learning is the acquiring of knowledge through mimicry or the borrowing of ideas and practices from other corporations. Grafting refers to acquiring knowledge by adding new members who possess knowledge not previously available to the organization (Huber, 1991). Finally, searching and noticing is the process of active and passive scanning and the monitoring of the organization's internal and external environments which leads to acquiring additional knowledge (Huber, 1991). This research agrees with Huber's five foundational sub-constructs to knowledge acquisition, with one primary exception. That exception is that organizations do not acquire or store knowledge. Organizations acquire information, which they may process into knowledge. A synopsis of the information acquisition differences of this research and Huber's constructs are shown in Figure 8. This does not change Huber's work, but extends his work with additional structure and organization of the literature.

Information Acquisition

Information Creation
— Congenital Learning
— Searching and Noticing
  — Scanning
  — Focused search
  — Performance monitoring

Information Obtainment
— Vicarious Learning
— Grafting
— Experiential Learning
  — Organizational Experiments
  — Organizational self-appraisal
  — Experimenting organizations
  — Unintentional or unsystematic learning
  — Experience-based learning curves
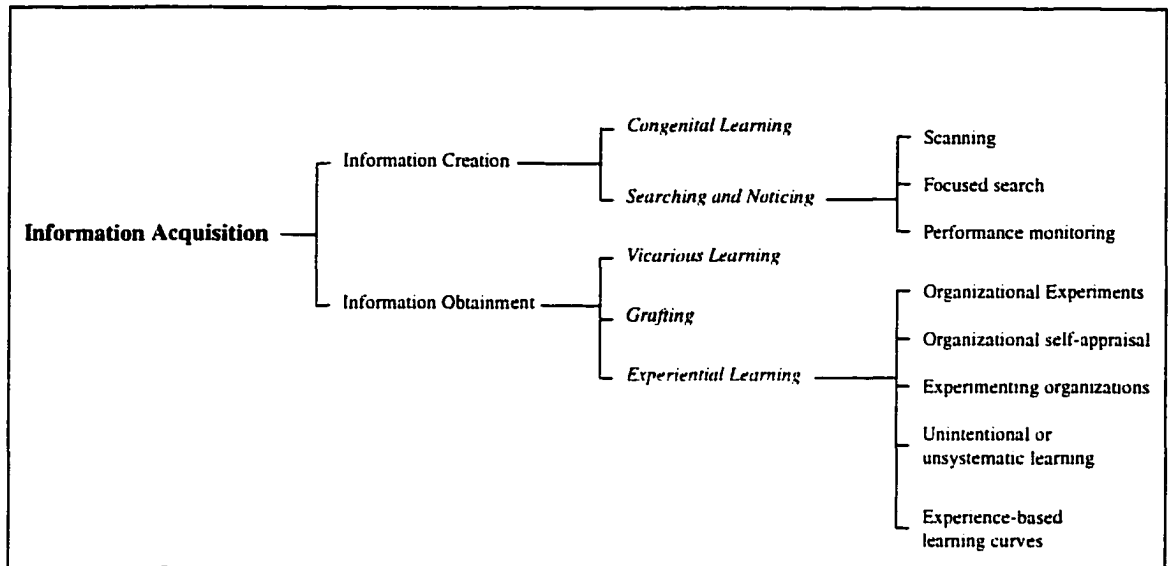
Figure 8. Information Acquisition

Information Storage

The organizational storage of information has two basic components: repositories and categorizing. He refers to this construct as organizational memory and further categorizes organizational repositories as containing "hard" and "soft" information (Huber, 1991). "Hard" information is characterized by such examples as organizational reports, standard operating procedures, process routines, and scripts. Also, computer-based information residing in flat files and/or relational databases is considered to be hard information. Likewise, expert systems that capture information from humans and provide a means to store and access that information via computer technology is becoming a common occurrence within organizations (Huber, 1991) and is also considered "hard" information. "Soft" information is stored in the minds of the individual members of the organization (Huber, 1991). This information is much more difficult to quantify, access, and disseminate.

Huber does not discuss the important aspect of information categorization or timeliness. Information categorization is concerned with *how* an organization stores its information. There is little argument, however, that organizations need the right information at the correct time for that information to be relevant to any organization decisions or actions. Timeliness will be more completely discussed in the section on information dissemination. Most organizations store tremendous amounts of data and information. Also, there are many more storage repositories that organizations can access from external sources. But, how to look for that information is important to an organization. The method of categorizing information not only influences how an organization accesses information, but also how an organization thinks. Planning the categorization of information for efficient use and ease of searching and retrieval can and will make access to the information more effective and focused for the information seeker. This, in turn, reduces the amount of required search time and may encourage the increased use of an information repository by organizational members. This seemingly simple act of categorizing information provides insights concerning organization memory, whether an organization uses computer databases to store information or a file cabinet provides critical insights to how the organizations perceive information sharing, as well as the power of information. Also, an organization's categorization method and methodology speaks to the organization's understanding of the complexity and dynamic nature of information, where the sharing or merging of diverse information opens the door to new ideas and potentially to the creation or modification of existing organizational knowledge patterns.

Huber alludes to organizational memory as the retention of tacit knowledge stored within the organization (Huber, 1991). This study departs from Huber's perspective in that organizational memory is not the retention of tacit knowledge, but rather the retention of information. However, this research extends Huber's perspective on organizational memory by identifying the impact or effect categorizing information has on an organization's knowledge system. Figure 9 depicts the addition of categorizing to information storage.
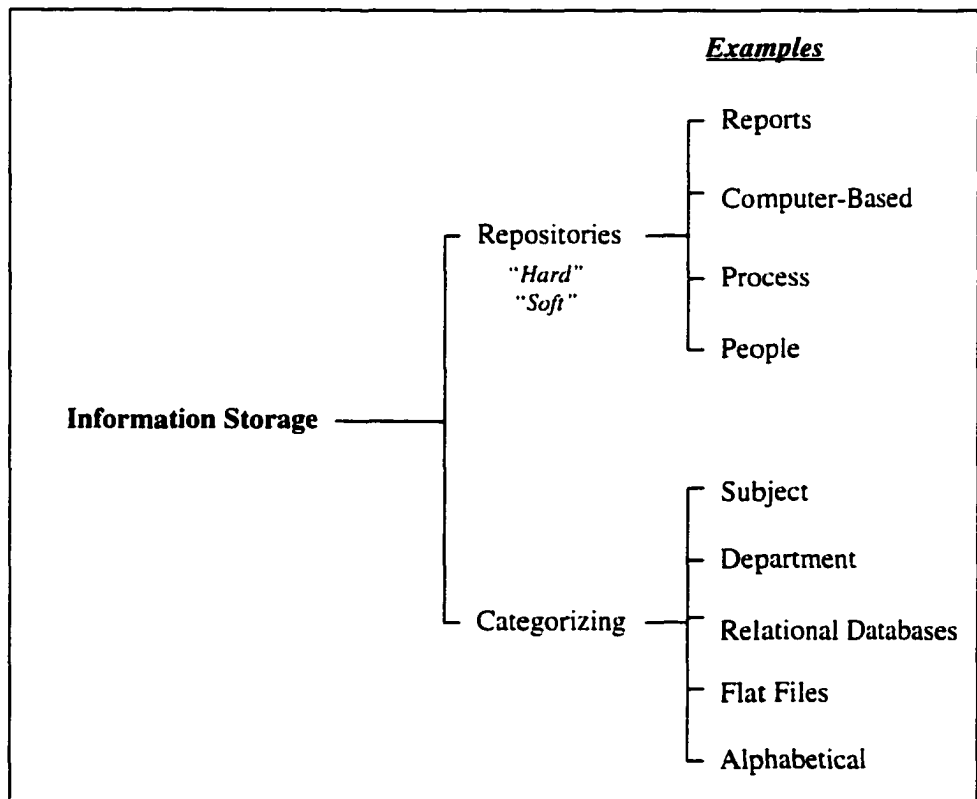
Figure 9. Information Storage

Interpretation

As stated earlier, stored information is static and must go through an interpretive process to become knowledge. This is an important point because much of the current focus and initiatives concerning knowledge management assumes that knowledge can be stored. That presupposes that the contextual nature surrounding information, as well as the experience and understanding of individuals or the group that interpreted the information, is put into a repository as an intact object. To some degree this can be accomplished in a "soft" repository, but is extremely difficult in a "hard" repository. Information interpretation is possibly the most significant aspect of an organization's knowledge system; however, it is normally not the primary focus of an organization's time, resources, or intellectual energy. Daft and Weick (1984) define information interpretation as " the process through which information is given meaning" (p. 294), and also as "the process of translating events and developing shared understandings and conceptual schemes" (p. 286). This, however, does not imply that all organizational members develop a common understanding (Huber, 1991). Moreover, these multiple individual interpretations lead to patterns of interpretation or understanding at a collective level. Organizational learning is the process that leads to the creation, modification, or reinforcement of core patterns of interpretation and understanding. The interpretive process is governed by the core patterns of organizational understanding that contextualizes the information for use by the organization. At the individual level, mental models interpret and contextualize the information into knowledge. However, at the organizational level, patterns of understanding transform information into knowledge. These patterns are developed over time and by negotiation and dialogue through the

interaction of individuals to achieve group goals and objectives. Most individuals in an organization cannot put these patterns into words, but merely understand that this is the way the organization works. Thus, organizational knowledge is expressed as these core patterns of interpretation and understanding that uniquely define an organization. The patterns also influence and shape an organization's belief and value systems. These patterns form the basis for how an organization (1) makes decisions, (2) determines what actions to undertake in support of those decisions, and (3) interprets the decision and action outcome relationships. Knowing this implies that we as researchers can begin to understand why organizations do what they do. Thus it follows that the creation and reconstruction of knowledge influences, and has an immediate and profoundly lasting effect on, an organization's decisions and actions. The essence of organizational knowledge is the organization's ability to piece together information through some interpretive process or representation that provides meaning to the organization. This "meaning", newly created or modified knowledge, may then be used by the organization to drive decisions and or actions, as well as provide a common interpretive framework..

Huber addresses the above points in his discussion of cognitive maps, framing, and media richness. Cognitive maps and framing refer to the belief structure, mental representation, or frame of reference that shapes an individuals interpretation of information (Huber, 1991). This is consistent with the "framing" perspective of Fairhurst and Sarr (1996) and Bolman and Deal (1997) and "sense-making" as described by Weick (1995). As stated earlier, the cognitive process resides within individuals. However, in organizations, the interpretation process is a social endeavor (Huber, 1991). The interpretation process takes individuals and invites them to develop a group belief

structure and organizational representation when conducting information interpretation. This is a give-and-take process which is dynamic and may change based on the individuals involved and/or the information provided. What is important to understand, is as organizational knowledge is created or modified, it enhances or refutes the already existing patterns of knowledge developed by the organization. These existing patterns have an ingrained inertia may be difficult to overcome. The intransigence of organizations to change even when the indicators dictate change is necessary can be explained based on this struggle. It is difficult to question dominant tacit patterns which define what is the comfortable and familiar range of decision, action, and interpretation. Just as the cognitive process resides in individuals, the organizational interpretive process is likewise subject to the collective of individuals, as well as the emergence of dynamics stemming from their interaction.

Media richness is the communication "...medium's capacity to change mental representations within a specific time interval" (Daft & Huber, 1987, p. 14). This is what the organization uses to facilitate its interpretive process. The communication medium can take many forms, including for example: face to face, video teleconferencing, audio-only exchange, or e-mail to name a few. But, whatever the type of media, it plays a significant role in the information interpretive process. The medium not only determines the number and type of cues organization members receive, but also the speed of the interpretive feedback to the members (Huber, 1991).

By applying a systems perspective to Huber's organizational learning constructs it is possible to see the interconnectedness of the components which form system relationships. This viewpoint provides a means to connect organizational learning and

organizational knowledge. Learning is the transition process organizations use to create knowledge allowing organizational knowledge to be expressed as core patterns of interpretation and understanding that uniquely define the organization. Figure 10 provides a depiction of this discussion and will be explained later in this section. This concept extends Huber's discussion of interpretation through the development of the core patterns of interpretation and understanding which represents the knowledge patterns inherent in organizations. This is consistent with Myers' suggestion that organizational knowledge is embedded within the organization (Myers, 1996). Likewise, it is also consistent with Nonaka's discussion of tacit to explicit knowledge, where an organization's knowledge patterns are deeply held and not easily made explicit.
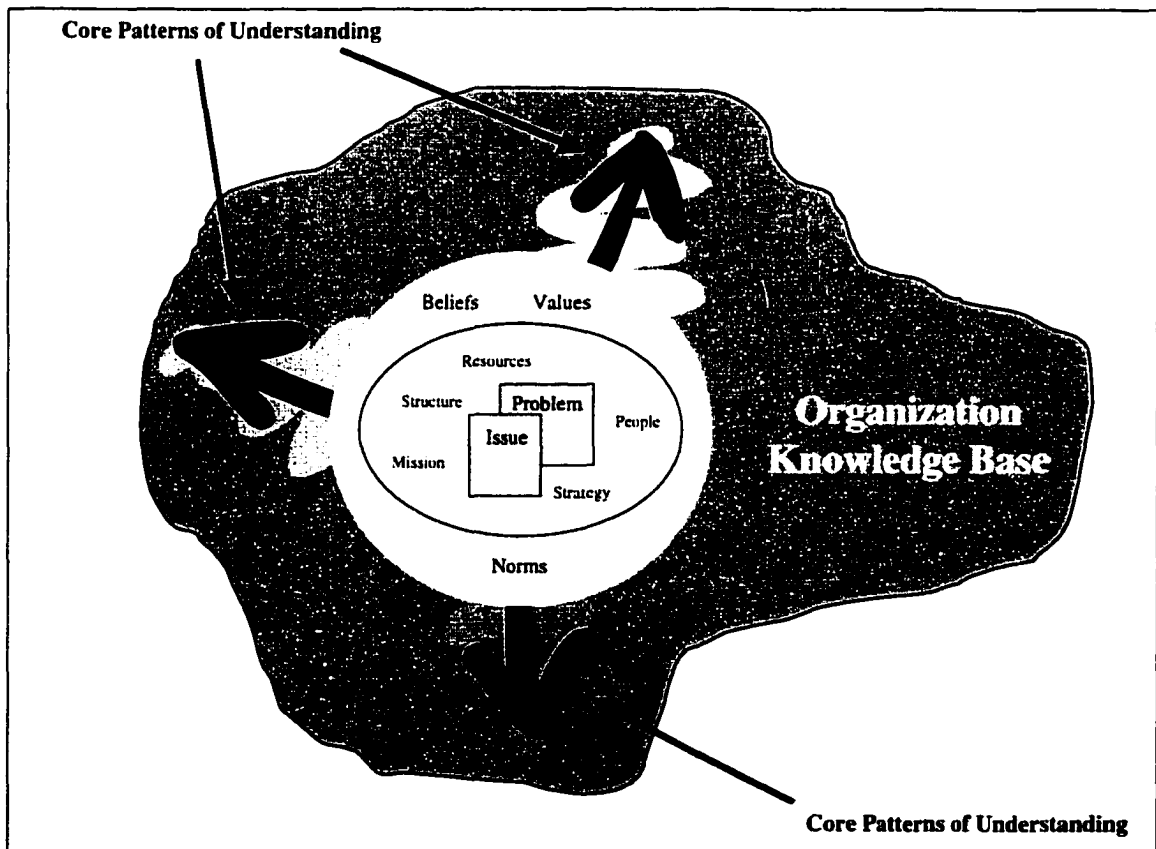
Figure 10. Organizational Core Patterns of Interpretation

The organizational learning process starts with an organizational problem or issue that needs to be resolved (Weick, 1995). The organizational learning process is affected by the contextual nature surrounding the issue or problem. Some of the contextual factors (also information) may include resources, people, mission, long and short range strategies, and structure. The context surrounding the issue is presumed by the organization and represents a filter that provides understanding of the information developed to inform the subsequent decisions and/or actions undertaken to address the problem. This contextual filter also includes the embedded cultural beliefs, values, and norms of the organization. It is important to note that the organization's underlying beliefs, norms, and values effect how the patterns of interpretation change and develop. Organizational culture arises from the shared beliefs, experiences, and histories of its individuals (Schein, 1992). If the organization has deeply embedded, unshakable beliefs and values, new or modified patterns of interpretation and understanding may not become part of the organization's knowledge base. This may lead to inefficient organizational core patterns of interpretation and understanding. Again, as the learning process unfolds, organizational knowledge is created, modified, or reinforced, where the organizational learning occurs through individuals but represents collective learning. This is consistent with Argyris's and Schön's notion of organizational learning occurring through individuals (Argyris and Schön, 1996). Patterns of interpretation and understanding of the information (knowledge) drives, changes, and directs the organizations core patterns of interpretation toward organization action and decision. These core patterns of interpretation are tacit and before the organization can determine whether the patterns remain applicable to the organization they must be made explicit.

However, the influence of these core patterns on the organization may not always be positive. Core patterns that stifle new ideas, ignore opposing concepts, or are mired in ritualistic and outdated modes of operation can also be part of an organization's knowledge framework. Whether the core patterns become a positive or negative influence on the organization lies in the uncertainty of the organization's processes, relationships, and leadership. It needs to be understood that organizational knowledge core patterns are present at all systems in focus of the organization. Core patterns of interpretation exist in an organization's engineering department, human resources department, within the mid-level management structure, within the senior management and leadership, and theoretically will be found in various ethnic, religious, and professional groups. As stated earlier, the bounding of the system in focus is an important task for the organizational manager. It determines the patterns of interpretation that will be manifest by the system under study.

Another important issue is the understanding that an organization's core patterns of understanding and interpretation can be found in the organization's formal and informal structure. Within the formal structure of the organization, the organization's core knowledge patterns develop based on the beliefs, norms, perceptions, and interpretive processes and framework established by the organization. Likewise, the informal structure of the organization develops core knowledge patterns. Together these patterns form the basis from which organizations interpret information, make decisions, and determine organizational actions. This study addresses the organization and its formal and informal structure to provide an explicit understanding of its core knowledge patterns.

In summary, the following are the main points of this section. First, learning is the transition process organizations use to create knowledge allowing organizational knowledge to be expressed as core patterns of interpretation and understanding. Second, the essence of knowledge is the organization's ability to bring together information through some interpretive process or representation that provides meaning to the organization. Thus, the core patterns of interpretation and understanding uniquely define an organization while influencing the organization's system of beliefs, values, and goals.

Information Dissemination

The last element of the knowledge system is information dissemination. This is the capacity of information to flow through the organization for use by all organizational entities. Huber's synthesis of the literature is relatively silent on information dissemination. This study provides a look at information dissemination from four aspects (Figure 11). In general, there is a formal information dissemination process and an
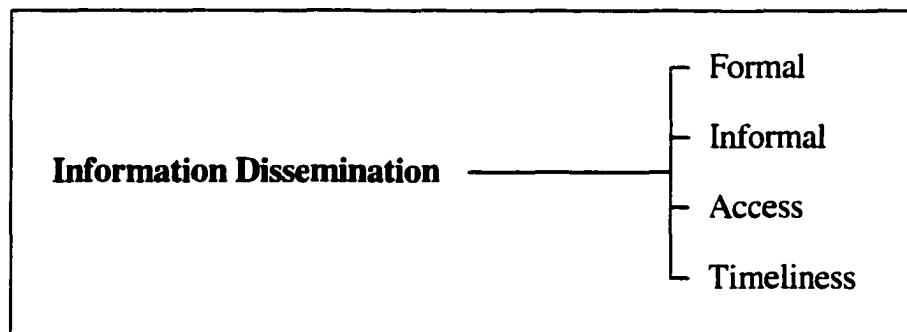
Figure 11. Information Dissemination

informal information dissemination process. Both of these can be further identified by examples like quarterly reports and e-mail messages, respectively. However, all organizationally disseminated information can be categorized as either formal or

informal. Formal information can usually be found in an organization's written documentation and follows the organization's physical structure. The formal process also includes scheduled meetings and briefings. Formal information dissemination represents the established processes, routines, and structures used by organizations to disseminate information internally and externally. In contrast, the informal process disseminates information via unstructured or non-mandated information exchange mediums. For example, these might include informal discussions or e-mails. This method of information exchange is more fluid and much more difficult to capture and manage. However, there is a real richness in these informal information exchanges. The spontaneity and diversity of shared ideas is unencumbered by the usual structured, rule-based exchanges of formal information dissemination. This allows individuals to speak more freely and openly with less regard for position, political correctness, or personal agendas. Thus, informal information dissemination can be understood to be information the organization exchanges which is important to the operations of the organization, but happen outside the established organizational information exchange process structure or routine.

However, there are two other important aspects of information dissemination, access and timeliness. Often overlooked, access and timeliness of information storage are critically important concepts. In this instance, access to information does not refer to members having access to sensitive or proprietary information. The goal is ensuring organizational members have access to information that is relevant. Argyris and Schön (1996) identify access as a critical element which distinguishes limited learning systems from advanced learning systems. The organization or individual must have connectivity

to the correct information source for that information to be used effectively. This requires that the information repositories not only be categorized efficiently for member understanding and use, but implicitly requires that organizational members have the ability to establish connectivity to these repositories when desired. Access to the World Wide Web is achievable by anyone who has an Internet connection. But access alone is not sufficient. The vast amount of information contained in the Internet can and does cause information overload. But access is not confined to "hard" information. A more deleterious effect on organizational information storage is the inability to obtain access to "soft" information. This study attempts to capture these "soft" information repositories and make them explicitly known to the organization.

Timeliness of information is also an important issue to information access and retrieval. Timeliness of information addresses the idea of the temporal nature of information. The window for action and decision is not forever open. If information is to have an impact it must be captured when and where needed. The turnaround time for most organizational action is not fast and some would say that the turnaround time for a decision is directly proportional to the size of the organizational bureaucracy (Senge, 1990). This concept is no different for information creation or exchange. The review process for information dissemination oftentimes is longer than the effective benefit life of the particular information. As business becomes increasingly more and more tied to the timeliness and relevance of information, new processes and methods will need to be discovered by business entities to ensure that information gets to the right place at the right time. Quinn, Baruch, and Zien (1997) talk about organizations extending their time horizons to ensure that they meet critical goals and objectives. Their discussion is

focused on capital investments, but this idea is easily extended to information as it becomes more and more a capital investment. The deliberate planning and continuous monitoring of an organization's knowledge system will help organizations determine their information requirements, and as part of the planning process the important aspect of timeliness can and will be addressed. Similarly, organization's can continuously monitor and manage their knowledge system through the concept of the organizational knowledge system. The organizational knowledge system provides the organization the holistic perspective of their organizational dynamic, where the organization's learning and knowledge processes are viewed as separate but integral concepts that have a rich symbiotic relationship.

ORGANIZATIONAL KNOWLEDGE SYSTEM SUMMARY

Organizational knowledge manifests itself as cognitive patterns that uniquely define the organization. This is an extension of the cognitive process of individuals, where individual assumptions, beliefs, values and perspectives most often drive decision and action (Schein 1985; Sackmann, 1992). Likewise, Brown and Duguid (1998) also assert that knowledge is not confined to individuals, although this is often the prevailing thought. On the contrary, organizational knowledge is best rationalized when we know that:

> ...organizations are purposive, the manifestations of ideas in practices are important. Comparing expressed ideas and actual practices as perceived by others can provide valuable information about the world view of organizational members and its degree of overlap with reality as perceived or experienced by others (Sackmann, 1992, p. 140).

Hence, true organizational knowledge comes from clearly manifesting and understanding the underlying organizational patterns of interpretation and understanding of the

knowledge system. This is developed from the literature on organizational learning and organizational knowledge. It is then tied to together with the cognitive understanding of the relationship between organizational learning and knowledge and open systems theory.

Organizational cognition explains that learning provides the impetus to move from data to information to knowledge. This cognitive process supports the idea of knowledge patterns being dominant and pervasive in an organization, even if they are at the tacit level. This research extends the literature through the understanding of knowledge patterns and making them explicit to the organization, so that informed decisions concerning the efficacy of the patterns can be evaluated in the context of a changing organization in a changing environment. The essence of organizational knowledge is the ability to represent and interpret information through the understanding and management of organizational knowledge patterns. This perspective leads to the explicit construction and representation of organizational knowledge patterns that underpin organizational decision, action, and interpretation.

Open systems theory provides the critically important foundational relationship required to develop the organizational knowledge system methodology and model. It is the lens from which to understand the organizational knowledge system.

This research distinctly establishes a hierarchy in that organizational knowledge is a product of learning. Furthermore, organizational knowledge patterns are what informs action and decision. Additionally, organizational learning is the process by which an organization transitions information into knowledge. The perspective of an organizational knowledge system developed for this research is a holistic perspective of the learning processes and knowledge creation within an organization. This viewpoint

bridges the gap in the literature between organizational learning and organizational knowledge and establishes the research perspective for what constitutes and organizational knowledge system.

Also, an organization's knowledge system uniquely defines an organization. For an organization to benefit from its knowledge system, it must have the ability to clearly and effectively manage its knowledge system. This requires that the organization make the tacit nature of knowledge explicit at each sub-element level. A synthesis of Nonaka's research work on tacit and explicit knowledge provides a foundation for this research study. Explicit knowledge refers to knowledge that is understood through formal systematic language, where tacit knowledge is personal in nature, making it difficult to articulate and formalize (Nonaka, 1994). This research is designed to take an organization's knowledge system which is organizationally intuitive and systematically display the knowledge system graphically for everyone in the organization to understand. The development of the organizational knowledge system provides an approach for the construction and representation of a knowledge system. The next step is to develop the organizational knowledge system model required to employ the concept of the organizational knowledge system.

ORGANIZATIONAL KNOWLEDGE SYSTEM MODEL

The preceding discussion has accomplished the first part of the purpose of this study, investigating "what is the organizational knowledge system?". Development of the organizational knowledge system has provided a framework that is drawn from and extends the scholarly literature. The next objective was to design a model of this theoretical perspective to use in the construction and representation of an organization's

knowledge system. Figure 12 is presented as the study methodology's model of the organizational knowledge system. This section is devoted to explaining the organizational knowledge system model. The section begins by presenting the organizational knowledge system model and discussing the significance of the upper and lower levels of the model. The discussion of the organizational knowledge system model continues with an explanation of the recursive nature of the knowledge system within organizations and the importance of the organization's mechanisms. Lastly, the explanation of the model addresses the relationships and strength of relationships between the organization knowledge system entities. Figure 12 represents a viable knowledge system. This systems-based view of the organizational knowledge system demonstrates the complexity of knowledge as an organizational system. The complexity of the organizational knowledge system also meets the requirements of a complex system as characterized by Flood and Jackson.
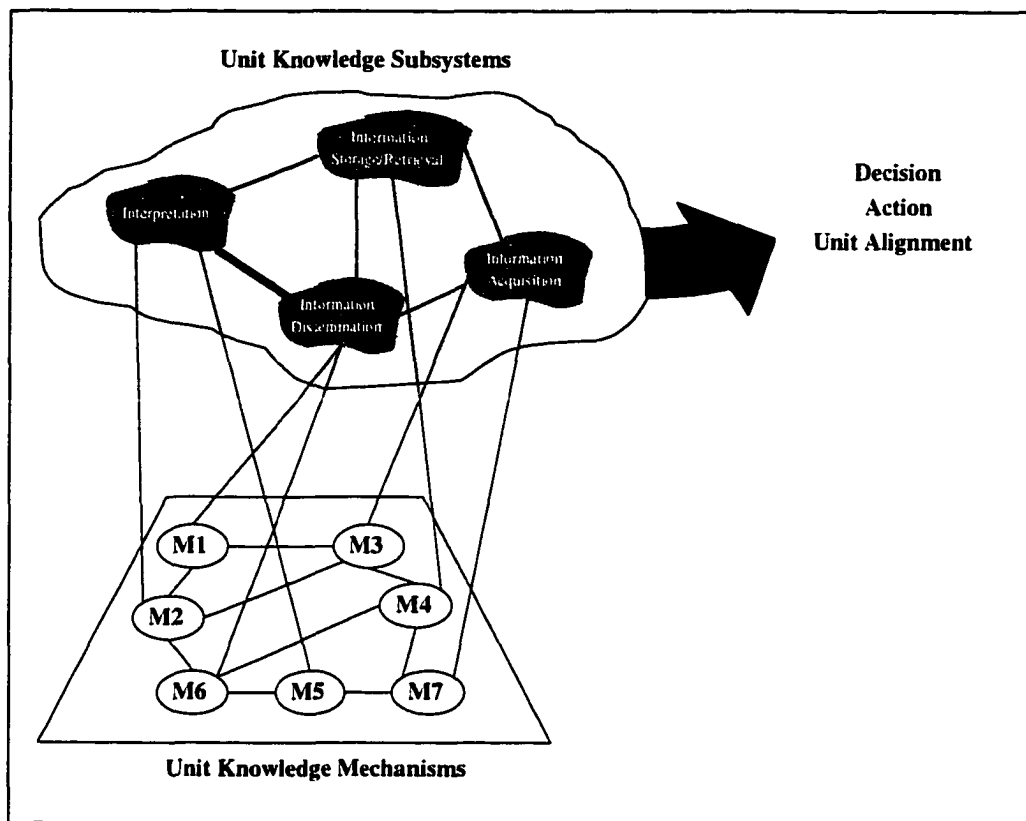
FIGURE 12. Organizational Knowledge System Model

These characteristics of a complex system are presented in the following list (Flood and Jackson, 1991):

♦ a large number of elements,

♦ many interactions between the elements,

♦ attributes of the elements are not predetermined,

♦ interaction between elements is loosely organized,

♦ they are probabilistic in their behavior,

♦ the system evolves over time,

♦ subsystems are purposeful and generate their own goals,

♦ the system is subject to behavioral influences, and

♦ the system is largely open to the environment.

This is in contrast to a configuration of the four subsystems connected linearly, where the simple portrayal of the knowledge system connected linearly ignores the rich interaction and interchange of the elements in an organization. A more appropriate representation of the interconnectivity of the knowledge subsystems shows a richer relationship (Figure 12). However, this represents an example of a snapshot in time of the possible connectivity and strength of relationships between the knowledge subsystems. This connectivity is dynamic and changes depending on the organization. Needless to say, the strength of relationship of the connections between subsystems can differ. The dynamic nature of the connectivity is also evident over time. As the organization changes, we accept that the knowledge system within the organization, as a complex system, will change also. Likewise, we except that the subsystem relationships and strength of relationships will also change over time. The linear portrayal of organizational knowledge also ignores the recursive effect that is inherent in the structure of the knowledge system. The recursive structure of the knowledge system starts with the individual and continues to manifest itself at each successive organizational level. At each level the organizational knowledge system relationships and strength of relationships is unique to that system in focus. The uniqueness is indicative of the individuals, mechanisms, and system in focus culture. Each of these knowledge systems is also richly interconnected, informing and being informed by other knowledge systems (Figure 13). This structure highlights the complexity of the knowledge system within an organization. It also follows the pattern established with the cognitive hierarchy. What is passed between knowledge systems is information. At each recursive level the knowledge system is defined by its system boundary. The system boundary is the buffer

that bounds the core patterns of interpretation and contextualization at each particular organizational level. The organizational knowledge system represents the upper-level of the organizational knowledge model. It provides the intellectual connection to the literature, but this is only half of the model. The second half of the model, which is just
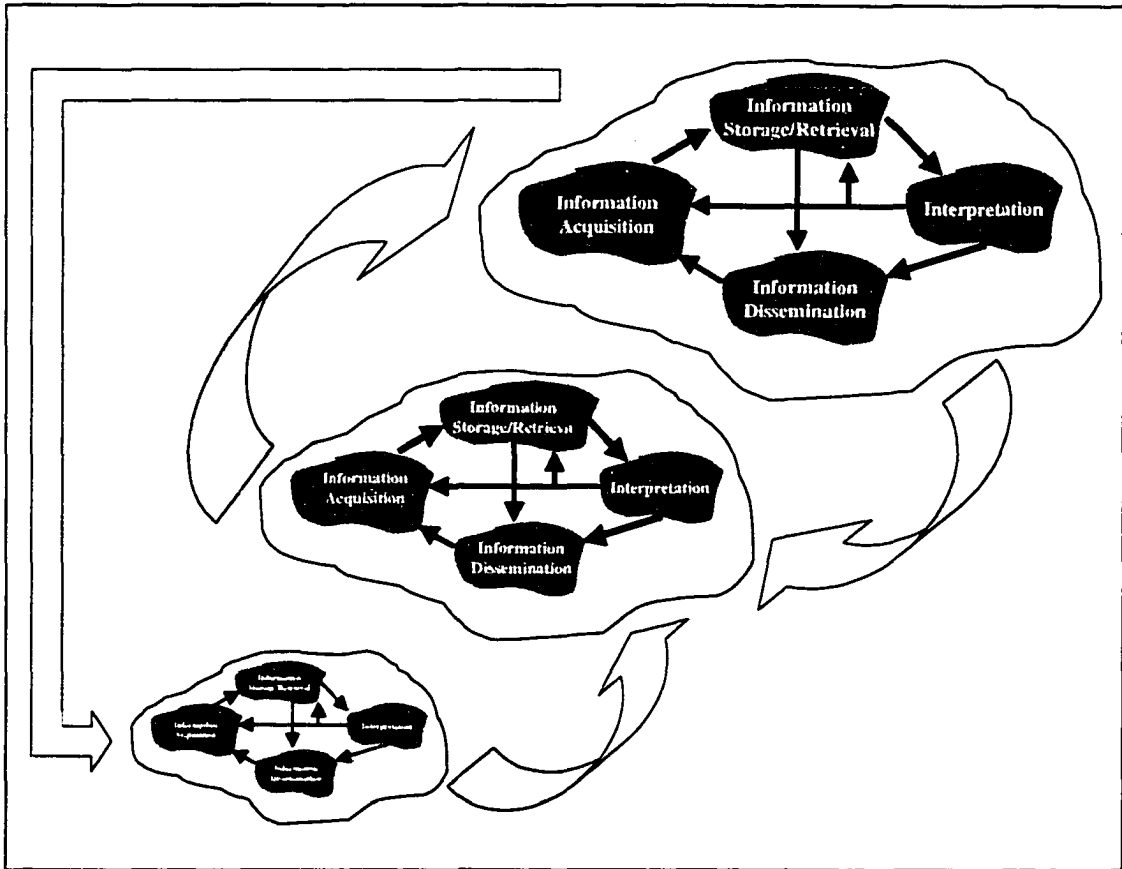
Figure 13. Recursive Nature of Organizational Knowledge

as important, is the organizational knowledge system mechanisms. The organizational knowledge system mechanisms provide the substantive link to the particular organization that is required to construct and represent the organization's knowledge system.

Organization Knowledge Mechanisms

The second part of the model is the organizational knowledge mechanisms (Figure 14). These mechanisms are the actual vehicles, identified by the organization,

used to facilitate the knowledge subsystems. For instance, one organization may use trade manuals, quarterly reports, formal staff meetings, and informal staff discussions as their major mechanisms to facilitate information acquisition. Another organization may use these mechanisms and others. The mechanisms are the vehicles the organization uses
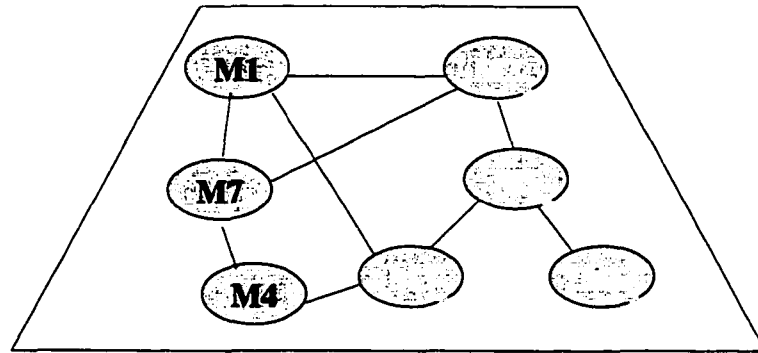
Figure 14. Organization Knowledge Mechanisms

to inform and facilitate accomplishing the functions of the organizational knowledge subsystems. For example, mechanisms M1, M7, and M4 may be directly associated with information interpretation, while mechanisms M2, M3, M5, and M6 may be directly associated with information dissemination. Thus there is a hypertext quality to the mechanisms. The mechanisms can be organized into connected associations to the knowledge subsystems and each other based on participant input. The relationships established between the mechanisms and the subsystems provide the means that transforms the tacit nature of individual knowledge into a knowledge system that can be portrayed explicitly at the organizational level.

ORGANIZATIONAL KNOWLEDGE SYSTEM & MODEL SUMMARY

The research has established the upper-level (organization knowledge subsystems) and lower-level (organization knowledge mechanisms) of the organizational knowledge system model and identifies the strength of relationships between mechanism to mechanism, mechanism to knowledge subsystem, and knowledge subsystem to knowledge subsystem. Thus far, the following has been presented (1) examination of organization knowledge, (2) a literature based derivation resulting in the organizational knowledge system, and (3) a resultant system-based model of organizational knowledge system for application. The final area presented is the organizational knowledge system methodology. The organizational knowledge system perspective is the literature-based conceptual understanding of the organizational knowledge system and organizational knowledge system model. Also, the organizational knowledge system and the organizational knowledge system model are essential elements in the construction and representation of an organization's knowledge system. From here, we now shift focus from the organizational knowledge system and organizational knowledge system model to examine the research methodology used for the analysis of the organizational knowledge system.

RESEARCH METHODOLOGY

The research methodology used for this study is the mixed methodology design. This research methodology uses both quantitative and qualitative analysis methods to achieve the study purpose and respond to the research questions. The design is characterized by the mixing of the qualitative and quantitative approaches, data collection methods, and/or data sources. The thrust of this chapter is intended to establish the appropriateness of the mixed methodology design for this research. To this end, the following issues concerning the research methodology will be addressed: (1) research rigor; (2) the positivist and naturalistic paradigms; (3) development of a research perspective and design; (4) appropriateness of the mixed methodology design for this organizational knowledge researcher; (5) influence of the researcher; and (6) efficacy of the research.

RIGOROUS RESEARCH

The development of a research perspective and design methodology does not ensure that the research will have substance. Critical to this research, as with any research effort, is ensuring that the research is rigorous. "Rigorous research is to the researcher what efficiency is to an executive: an ideal state that is always aspired to, never reached, and continually revered" (Argyris, 1968, p. 290). One will find that military leaders consistently agree that the more rigorous the training, the more capable and effective the unit. Likewise, if the organization is not effective it is because organization members are not adhering to the strict training standards developed over the years. In the same fashion, researchers are confronted with developing a research study that adheres to a strict set of scientific principles designed to make the research believable and consistent.

So as to ensure a common understanding of past thoughts on research rigor, I will start by first providing a historical perspective of rigorous research. Argyris (1968) provides a set of three early assumptions to guide understanding of what research rigor is and what the researcher should strive to achieve in his or her studies. The first assumption is that rigorousness in research is an ideal state. Although researchers continually strive to achieve this state, they can only approximate it (Argyris, 1979). Rigor is a subjective standard, which resides in the mind of the researcher or critic. It may be true that a qualitative study on the homeless receives laudatory comments on its rigorousness from behavioral scientists, but this same study is met with limited enthusiasm on its scientific merits from researchers who espouse the positivist perspective. The second assumption is that rigorousness is more closely achieved when the problem and relevant variables are well-defined. However, there is an unintended consequence to this assumption. As the problem and variables are more stringently defined, the more controlled the inquiry and the greater loss of context within which the problem exists. This is supported by Poplin (1987, p. 33) when she proposes that "this, in essence, strips the problem from its context by narrowing the range of variables to be studied." The third assumption is that the more control the researcher has over the research variables, the greater the rigor in the research. This assumption suffers from the same consequence as the second assumption.

Based on the above assumptions, it would be difficult for any qualitative study or a mixed methodology study, because it employs some principles of the naturalistic perspective to be called rigorous research. The difficulty arises when the research questions that must be answered involve the study of people within their contextual

environment. To better understand why this is the case, Edwards (1954) presents a list of qualities required for rigorous research to occur.

1. The research is deliberately undertaken to satisfy the needs of the researcher and where the pace of activity is controlled by the researcher to give him maximum possible control over the subjects' behavior.

2. The setting is designed by the researcher to achieve his objectives and to minimize any of the subjects' desires from contaminating the experiment.

3. The researcher is responsible for making accurate observations, recording them, analyzing them, and eventually reporting them.

4. The researcher has the conditions so rigorously defined that he or others can replicate them.

5. The researcher can systematically vary the conditions and note the concomitant variation among the variables.

On closer inspection, the five qualities of rigorous research align with the four principles of scientific inquiry: verifiable observation, experimental separation, replicability, and control, as developed by Poplin (1987) and Leedy (1997). Verifiable observations are judgments based on the observable data (Poplin, 1987). However, the principle of verifiable observations does not always answer the important social science question of why. The gathering and recording of observed frequencies, times, and events are quite often the domain of quantitative analysis. Although qualitative analysis may gather and record the above data, it is also interested in the internal realities that may be driving the observed data or behavior (Poplin, 1987). Experimental separation has two components. The first component is the creation of a barrier between the researcher and the research (Poplin, 1987). The second part is the separation, which causes the researcher to focus on a specific situation apart from its broader context (Poplin, 1987). Experimental

separation does not take into account the rich interactions associated with human subjects and discounts the effect of the subjects on the researcher. Replicability refers to the research being repeatable. The standard is that any competent researcher can take the problem and collect data under the same conditions and parameters and achieve comparable results (Leedy, 1997). Also associated with replicability is the principle of universality. This principle is such that any competent researcher could come in and complete the study with similar results without prejudicing the study or the efficacy of the research. The principle of control requires strict researcher oversight of the parameters, variables, and other factors critical to the research. As stated earlier, the greater the control over the research the greater loss of context in which the problem exists.

From the above discussion, one can see that quantitative analysis provides the researcher with some level of scientific inquiry that is capable of answering many issues and questions associated with a particular research study. However, it does not answer all the issues or questions for all studies. To deal with only quantitative data would ignore the rich relationships between system entities and discard their importance to organizational dynamics. Likewise, the use of only quantitative analysis in this study would elude to a sense of orderliness and predictability of an organization's knowledge system (Poplin, 1987). This would be in violation of characteristics of a complex system. In this study, the research purpose and questions are such that quantitative analysis will only satisfy part of the research goals. Thus, it is critical to include qualitative analysis in this study. It is not possible or pragmatic to reduce living entities of an organization to mathematical equations or define organizational knowledge as a simple or complex

mathematical expression. To effectively analyze an organization's knowledge system qualitative analysis must be incorporated. The inclusion of qualitative analysis provides the remaining and necessary inquiry needed to answer the research questions and achieve the research purpose for this study. To better understand the benefits of both quantitative and qualitative analysis, the following section provides an explanation of the two research analysis paradigms.

POSITIVIST AND NATURALISTIC PARADIGMS

Currently, quantitative and qualitative inquiries represent the two dominant research study methods used by researchers. A quantitative study is "an inquiry into a social or human problem, based on testing a theory composed of variables, measured with numbers, and analyzed with statistical procedures, in order to determine whether the predictive generalizations of the theory hold true" (Creswell, 1994, p. 2). A qualitative study is an "inquiry process of understanding a social or human problem based on building a complex, holistic picture, formed with words, reporting detailed views of informants, and conducted in a natural setting" (Creswell, 1994, p. 1). These methodologies go by other names as well. Quantitative analysis is also referred to as the traditional, the positivist, the experimental, or the empiricist approach (Leedy, 1997). Qualitative analysis is often referred to as the interpretive, the naturalistic, the constructivist, or the postpositivist approach (Leedy, 1997). Both of these methodologies have philosophical underpinnings that represent a paradigmatic perspective of assumptions, theories, and methods that explain a particular worldview on how to conduct research science (Cook & Reichardt, 1979; Creswell, 1994). Patton (1986, p. 203) defines a paradigm as:

> A world view, a general perspective, a way of breaking down the complexity of the real world. As such, paradigms are deeply embedded in the socialization of adherents and practitioners: paradigms tell them what is important, legitimate, and reasonable. Paradigms are also normative, telling the practitioner what to do without the necessity of long existential or epistemological considerations.

Naturalistic inquiry is concerned with the humanistic aspect of research, and as such naturalistic researchers have come to realize that:

> [The] inquirer is himself the instrument. Changes resulting from fatigue, shifts in knowledge, and cooperation, as well as, variations resulting from differences in training, skill, and experience among different "instruments," easily occur. But this loss in rigor is more than offset by the flexibility, insight, and ability to build on tacit knowledge that is the peculiar province of the human instrument (Guba and Lincoln, 1981, p. 113).

Naturalism has taken on many different, but related, definitions and precepts. It is defined by Lincoln and Guba (1985) as a belief in multiple realities where the researcher and researched are inseparable. Marshall and Rossman (1989) explain naturalism as a belief that the world should be studied in its natural state, undisturbed by the researcher as in an experiment. "The goal of naturalistic inquiry is to provide idiographic knowledge, rather than generalizable principles" (Potter, 1996, p. 8). Idiographic knowledge represents the particulars about how an individual produces meaning (Potter, 1996). The naturalistic perspective provides this research a method of analyzing the particulars of an organization's knowledge system, where the analysis is wrapped in the contextualization of an organization's environment. However, the analysis of an organization's knowledge system from the positivist paradigm provides a different perspective.

Positivism is primarily concerned with the physical sciences, but makes no distinction between the objects of the social sciences and the physical sciences (Potter, 1996). The positivist paradigm holds to a strict form of empiricism and it also requires that claims for truth must be verified empirically; philosophy and mentalism are not acceptable (Potter, 1996). The goal of the positivist paradigm is to explain behavior, make predictions, and improve society by changing social conditions through the discovery of general laws that govern real world processes (Potter, 1996).

As stated earlier, the quantitative and qualitative research methodologies are directly associated with the philosophical underpinnings which explain the positivist and naturalistic paradigms, respectively. Although the perspectives of research inquiry are different for the two paradigms, the goal of the paradigms is the same--the rigorous and accurate inquiry into some phenomena. This is highlighted by the following terms synthesized from the two paradigms which describe the principles behind the two research methodologies (Table 2).

Quantitative Research	Qualitative Research
Objectivity - reality is outside of the of the researcher's attitudes, biases, beliefs, and perceptions (Kerlinger, 1992)	**Confirmability** - attention to sound methodological concerns, quality in data, explanation of bias, and audit trail of analysis (Lincoln & Guba, 1985)
Reliability - consistency (accuracy & precision) of the performance of a measuring instrument (Leedy, 1997; Kerlinger, 1992)	**Dependability** - consistency in the data over time (Lincoln & Guba, 1985)
Internal Validity - freedom from bias forming conclusions from the data (Leedy, 1997)	**Credibility** -congruence of explanation and methods used to form conclusions (Lincoln & Guba, 1985)
External Validity - can the conclusions drawn be generalized to other cases (Leedy, 1997)	**Transferability** - conclusions applicable to other cases than in original study (Lincoln & Guba, 1985)

Table 2. Elements of Quantitative and Qualitative Research

Moreover, each paradigm brings its own unique qualities and biases to the research. However, it is incumbent upon the researcher to adhere to the principles of each chosen research method to ensure that rigorous research is conducted in the manner consistent with the particular methodology. This is also true, but more difficult, when the research employs the mixed methodology research design. Under the mixed methodology, conducting rigorous research must not only follow both research methodologies, but at the same time it cannot violate them when mixing what in some instances are diametrically opposed views of research analysis.

Too often the merits of qualitative research are minimized because they are measured against the principles of scientific inquiry which have foundational underpinnings rooted in the positivist perspective. Likewise, quantitative research is deemed to be incomplete and limited in value and understanding because it is removed from the contextual environment in which the problem exists and thus, loses the richness and depth associated with that environment. The problem is that researchers of either paradigm are judging the research not of that ilk, but based upon their paradigmatic perspective. As early as 1975, Polanyi expresses his frustration with this dilemma.

> The ideal of science remains what it was in the time of Laplace: to replace all human knowledge by a complete knowledge of atoms in motion. In spite of much that is said to the contrary, quantum mechanics makes no difference in this respect. A quantum-mechanical theory of the universe is just as empty of meaning as a Laplacean mechanical theory.... It is simply this sort of mechanical reductionism that, is the heart of the matter. It is this that is the origin of the whole system of scientific obscurantism under which we are suffering today. This is the cause of our conception of man, reducing him either to an insentient automaton or to a bundle of appetites. This is why science

denies us the possibility of acknowledging personal responsibility. This is why science can be invoked so easily in support of totalitarian violence, why science has become the greatest source of dangerous fallacies (Polanyi, 1975, p. 25).

By adhering a higher level set of research principles, researchers from either paradigm striving to meet these principles will ultimately arrive at reasoned conclusions based on rigorous research. Strauss and Corbin (1990) agree with this premise, suggesting that

...the usual canons of 'good science' should be retained, but require redefinition in order to fit the realities of qualitative research, and the complexities of social phenomenon that we seek to understand (Strauss & Corbin, 1990, p. 250).

The following table (Table 3) presents the canons of science and the relationship of the qualitative and quantitative methodologies to them. The principles of the canons of science have been synthesized from research design methodology literature.

Canons of Science	Quantitative Research	Qualitative Research
Neutrality	Objectivity	Confirmability
Consistency	Reliability	Dependability
Truth Value	Internal Validity	Credibility
Applicability	External Validity	Transferability

Table 3. Canons of Science

Neutrality is understood to be a research environment free of bias or overt researcher influence, but seeks supportable evidence or data leading to convincing research results or conclusions (Lincoln & Guba, 1985). Consistency concerns a logical coherence of data gathering sources, methods and analysis techniques and their congruence with research problem, design, and questions (Lincoln & Guba, 1985). Truth value refers to the plausibility of the research findings as they relate to the causal relationships of the research factors and concepts (Lincoln & Guba, 1985). Finally, applicability refers to the

research processes and consistency of conclusions in relation to one's experience, the congruence or connection with prior theory, and the generic nature of findings enough to be applicable to other settings (Lincoln & Guba, 1985).

The canons of science provide a universal scientific standard which applies to all research. The auspices of the positivist and naturalistic paradigms are stripped from the canons of science and replaced with a set of ideals to which all research should aspire. This new perspective will allow researchers the freedom of tailoring their inquiries to meet a common set of higher level standards of research. The judgement of qualitative research from the perspective of positivism and vice versa is gone. The merits and rigorousness of the research will be judged based on how completely and effectively the researcher adheres to the foundations of his or her paradigm to meet the standards of the canons of science.

The discussions on research rigor and the positivist and naturalistic paradigms provide the important understanding of why this research study chose to use the mixed methodology research design. The following section continues the discussion of why and also how the mixed methodology was chosen for this research.

RESEARCH PERSPECTIVE AND DESIGN

The central issues of concern a researcher must address in developing an appropriate research perspective and design are the researcher's worldview, training and experience, researcher's psychological attributes, nature of the problem, and audience of the study (Creswell, 1994; Leedy, 1997). The researcher's worldview refers to his or her outlook on whether they prefer a qualitative and quantitative perspective regarding ontological and epistemological assumptions (Creswell, 1994). There can also be a mix of these

assumptions which may give the researcher greater insight and flexibility and consequently increase the research complexity. The researcher's worldview also encompasses the beliefs and feelings of the researcher concerning the research design as they relate to his or her comfort with the skills, training, and experience they bring to the study. Creswell confirms this when he states, "undoubtedly this worldview may be affected by a second factor -- training or experiences" (p. 8). The researcher's training and experience relates to his or her skills set, such as writing, computer, mathematical, and library skills. The researcher's psychological attributes refer to his or her comfort level with a particular type of research, research methodology, data collection methods, and data analysis tools. The ability or comfort of the researcher to embrace the requirements, assumptions and procedures inherent in the chosen research design addresses the psychological perspective. The nature of the problem is an important issue. It is concerned with answering the study purpose with the available literature and data on hand. It is also concerned with the type of research employed to answer the research questions, such as exploratory research, evaluation research, case study research, and participatory action research. Lastly, the audience for the research must be taken into account (Creswell, 1994; Leedy, 1997). Creswell goes on to provide a table that represents reasons a researcher may select either a quantitative or qualitative paradigm (Table 4).

This list of research issues provides a good starting point for understanding a researcher's concerns when developing a research design. However, it does not provide a thoroughly reasoned perspective of the framework of thought that the researcher must

address when developing his or her research study. A framework of thought provides a rich and substantive perspective on how the issues influence the researcher's actions.

Criteria	Quantitative Paradigm	Qualitative Paradigm
Researcher's Worldview	A researcher's comfort with the ontological, epistemological, axiological, rhetorical, and methodological assumptions of the quantitative paradigm	A researcher's comfort with the ontological, epistemological, axiological, rhetorical, and methodological assumptions of the qualitative paradigm
Training and Experience of the Researcher	Technical writing skills; computer statistical skills; library skills	Literary writing skills; computer text-analysis skills; library skills
Researcher's Psychological Attributes	Comfort with rules and guidelines for conducting research; low tolerance for ambiguity; time for a study of short duration	Comfort with lack of specific rules and procedures for conducting research; high tolerance for ambiguity; time for lengthy study
Nature of the Problem	Previously studied by other researchers so that body of literature exists; known variables; existing theories	Exploratory research; variables unknown; context important; may lack theory base for study
Audience for the Study	Individuals accustomed to/supportive of quantitative studies	Individuals accustomed to/supportive of qualitative studies

Table 4. Reasons for Selecting a Paradigm (adapted from Creswell, 1994 p. 9)

Also, this researcher contends that these issues fall along two lines of prevailing thought (Figure 15). The first line of thought is the researcher's worldview and the second is the nature of the problem. The first deals with the more personal aspects associated with the researcher; aspects such as how comfortable the researcher is with the research design, his or her familiarity with the principles and assumptions of the design, and the skills the researcher brings to the research perspective. The second line of thought addresses the particulars of the research focus. It is concerned with the requirements to answer the research question(s) and the facts and assumptions surrounding the research problem.
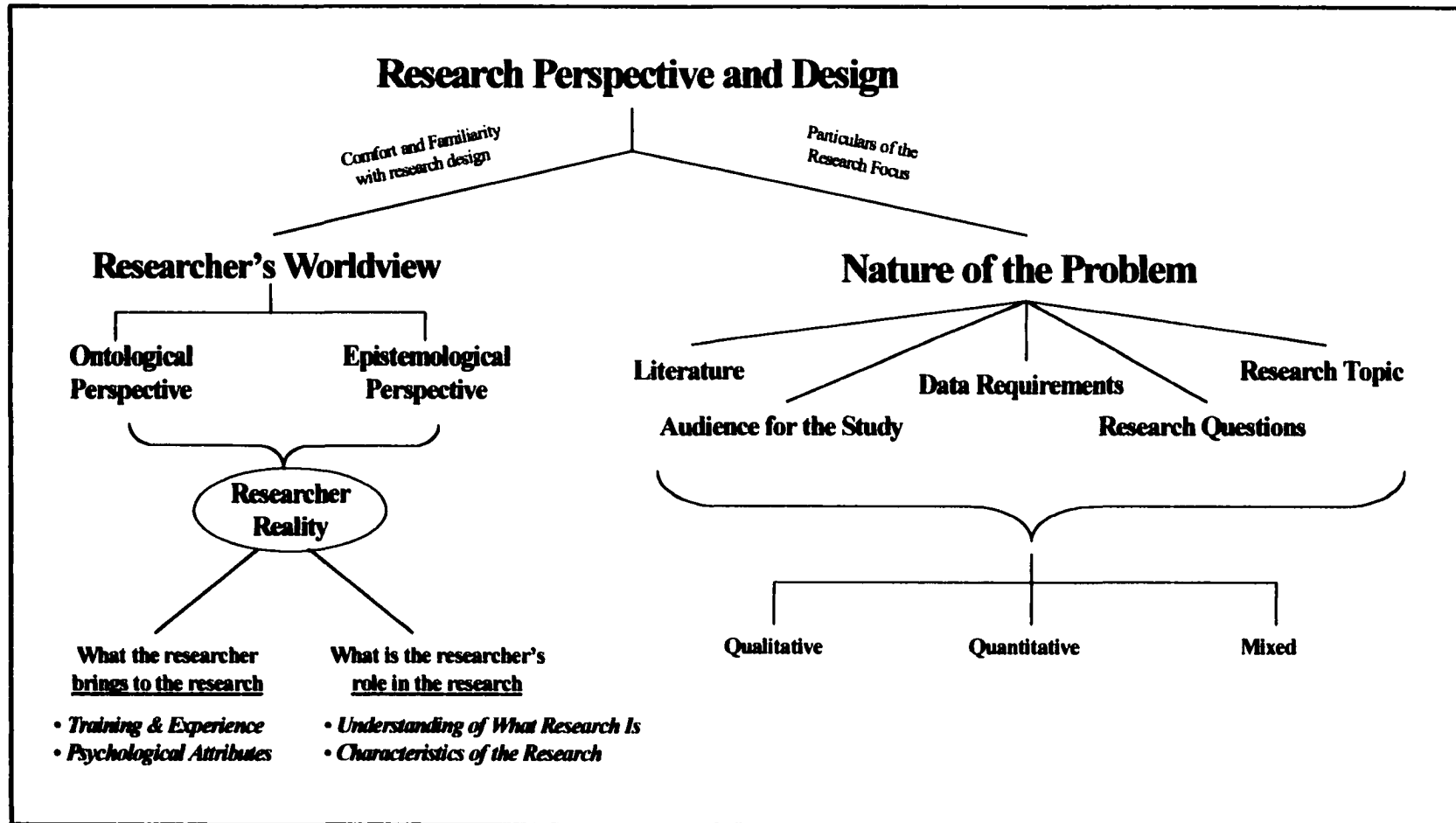
Figure 15. Framework of Thought Surrounding Central Issues Pertinent to Research Perspective and Design

There is a sliding balance between the lines of thought. The balance is not always equal and is not always weighted to one side or the other. However, the researcher does consider, either tacitly or explicitly, his or her worldview and the nature of the problem when developing the research perspective and design. Ultimately these considerations drive the selection of a research methodology for the study. Researcher skills, comfort, facts, assumptions, and requirements are all factors determining the shape and development of the research design and overall study. Thus the researcher's view of the world of research is important to the selection of a research methodology.

Researcher's Worldview

The researcher's worldview is developed based upon his or her beliefs, norms, and values. Just as the organizational culture arises from the shared beliefs, experiences, and histories of its individuals (Schein, 1996), the researcher's worldview is shaped by his or her personally embedded beliefs, values, and norms. The two perspectives that influence the nature of the researcher's work are the ontological and epistemological assumptions.

Ontological Perspective

Ontology is concerned with the nature of reality and how the researcher perceives the construction of reality. Is the reality of the problem or research focus distinctly separate from the researcher, or is the reality of the study within the mind of the researcher and/or study participants? In the former reality, the researcher is only able to observe, analyze, and report on the problem. In the latter reality, the researcher is part of the reality of the study. Potter supports this view of reality with a more in-depth explanation of ontology. He states,

> With the question of ontology, the central distinction seems
> to be on the matter of materialism versus idealism.

> Materialism is the belief that there is a fixed material reality
> that is external to people. In contrast, idealism is the belief
> that reality is in one's mind; nothing exists apart from the
> mind knowing it (Potter, 1996, p. 37)

Using this perspective, one is able to more effectively understand Creswell's quantitative and qualitative ontological assumptions. The quantitative assumption is expressed where "reality is objective and singular, apart from the researcher" (Creswell, 1994, p. 5). The researcher who takes on this view believes that there is one objective reality from which the researcher can assess from an unbiased perspective because he or she is set apart from the problem. The qualitative assumption is expectedly a stark opposite of the quantitative assumption. "Reality is subjective and multiple as seen by participants in a study" (Creswell, 1994, p. 5), where the researcher is also a participant in the study. Potter (1996) refers to this position as the reality which exists in a person's mind about the research, not the research itself. The incorporation of the ontological perspective as an active influence in the researcher's worldview starts to shape the researcher's design perspective concerning the nature of the research.

Epistemological Perspective

Epistemology is concerned with the relationship of the researcher to that which is being researched (Creswell, 1994). Under the qualitative approach, the researcher interacts with the participants of the research, while in the quantitative approach the researcher is independent of the research (Creswell, 1994). In the qualitative assumption the researcher tries to minimize his or her impact on the research environment. The goal is to become part of the research environment to capture the rich, personal interactions and observations that provide an in-depth understanding of the system under study. In the quantitative approach, the researcher is viewed as

independent of the research. This researcher separation is intended to provide objectivity and eliminate researcher bias in the study. Potter (1996) views epistemology as it concerns the quantitative and qualitative paradigms in much the same fashion as Creswell (1994). Those that hold the quantitative perspective believe in observing the world from an objective viewpoint; whereas researchers who subscribe to the qualitative perspective view the world from within the context they use to interpret their research (Potter, 1996).

The Researcher's Reality

It must be understood that ontology and epistemology are two separate philosophical issues. The ontological and epistemological perspectives help to shape the researcher's reality and provide a lens through which the researcher can more easily know his or her reality. However, this reality is at a personal level and in this context pertains to the compatibility of a particular research design and perspective to the researcher's reality. These philosophical issues can be diverse and oftentimes complex, but they go towards supporting the researcher's understanding of his or her abilities to comprehend, develop, and execute a particular research design. Therefore, the effect of actively applying the ontological and epistemological perspectives within the researcher's worldview provides a shaping and synthesis of the framework of thought for the researcher concerning the research. This thought process follows along the line of Creswell's (1994) and Leedy's (1997) reasons for selecting a paradigm, but provides a more contextual structure to the central issues and their relation and effect on the selection of the research design and perspective. One notable aspect of this framework is the researcher's training, experience, and psychological attributes are distinct from the researcher's worldview. This distinction is not readily evident from a simple sequential

list. From this two questions arise. What does the researcher bring to the research? What is the researcher's role in the research?

Under "what the researcher brings to the research", one finds the researcher's training and experience and his or her psychological attributes. The researcher's writing, technical and research skills, along with his or her propensity to work closely with others, mathematical aptitude, and perseverance are all contributing factors to the researcher's comfort with the evolution of the research design and perspective. Likewise, the skills and abilities the researcher brings to the research impact the determination of whether he or she will rely on quantitative or qualitative techniques in their research design. Obviously, whether a quantitative, qualitative, or mixed research design methodology is employed should be determined by the nature of the problem. However, the perspective of the research (study purpose and research questions) can be framed in a manner, based on the researcher's worldview, to leave the researcher comfortable and familiar with a particular research methodology.

The researcher's relationship to the research has two issues: the understanding of what constitutes research and the characteristics of the research. The researcher's understanding of what constitutes research provides a substantive basis for him or her to determine how he or she fits in the research schema. Leedy (1997) suggests that research is a process -- where we answer questions, explore a phenomenon, or resolve a problem by gathering and analyzing data through a systemic process all for the purpose of increasing understanding and knowledge. Leedy (1997) also presents a list of research characteristics:

- originates with a question or problem

- requires a clear articulation of a goal

- follows a specific plan of procedure

- usually divides the principal problem into more manageable sub-problems

- is guided by the specific research problem, question, or hypothesis

- accepts certain critical assumptions

- requires the collection and interpretation of data in attempting to resolve the problem that initiated the research

- is, by its nature, cyclical; or more exactly, helical

These research characteristics help the researcher to plan and manage the development and structure of his or her research study. The characteristics also help the researcher determine his or her role in the research design, as well as providing a transition to the nature of the problem. Just as a researcher's training, experience, and psychology influence his or her worldview, the researcher's understanding of what is research and the characteristics of research play an important role in developing his or her worldview. As the researcher addresses the characteristics, he or she begins to develop the nature of the problem.

Nature of the Problem

The second line of thought addresses the particulars of the research focus. It is concerned with the requirements to answer the research question(s) and the facts and assumptions surrounding the research problem. These can be termed as the particulars of the nature of the problem (Creswell, 1994). The nature of the problem encompasses the research topic, literature availability, audience for the study, time to complete the study, research questions, and required data. The detailed scrutiny of these areas is important because it leads to the reasoned decision to employ either a quantitative, qualitative, or

mixed research methodology. Just as with the researcher's training, experience, and psychological attributes, the audience of the study is put into context and becomes a component of the larger more encompassing issue -- nature of the problem. Also, as mentioned earlier, the researcher's worldview aids in the decision of which research methodology should be employed. Leedy (1994) provides a list of considerations from the researcher's worldview (personal) and from the nature of the problem (research problem) (Table 5) that the researcher should consider when deciding which methodology is best for the developed research design. There is a link or transition from the researcher's worldview and the nature of the problem. This is not a one-way transfer, but follows a helical logic presented by Leedy concerning the research cycle process. Thus, as the researcher progresses in his or her research, the above issues may be revisited as necessary.

Use this Methodology if	Quantitative	Qualitative
Your audience is	Familiar with and supportive of quantitative studies	Familiar with and supportive of qualitative studies
Your research question is	Confirmatory, predictive	Exploratory, interpretive
Your available literature is	Relatively large	Limited or missing
Your time available is	Relatively short	Relatively long
Data required	Statistical, Experimental	Documentary, Interview, Observations
Your research focus	Covers a lot of breadth	Involves in-depth study
Your ability/desire to work with people is	*Medium to low*	*High*
Your desire for structure is	*High*	*Low*
You have skills in the area(s) of	*Statistics and deductive reasoning*	*Attention to detail and inductive reasoning*
Your writing skills are strong in the area of	*Technical, scientific writing*	*Literary, narrative writing*

Research Problem (rows 1–6), **Personal** (rows 7–10)

Table 5. Which Methodology to Use? (adapted from Leedy, 1997, p. 109)

At first glance, it may appear that the determination of whether to use a quantitative or qualitative methodology in the research design is a relatively straightforward and easy decision. In some research situations this is the case, in others, situations may arise that prompt the researcher to modify the research design to incorporate both qualitative and quantitative research techniques. Considerations for the use of a mixed methodology are not as well-defined as for the qualitative and quantitative paradigms. However, Cook and Reichardt (1979) provide three reasons for using the two methods together which can yield potential benefits. The first reason is to adequately and completely assess a research problem that has multiple purposes that must be accomplished under demanding circumstances. The second reason is the two methods could provide insights that build off of each other (Cook and Reichardt, 1979). Finally, the two methods could be used to check each other and provide a more in-depth learning by offsetting the biases inherent in each method (Cook and Reichardt, 1979). The nature of the problem looks at the facts and assumptions surrounding the research and provides the researcher with the information needed to select an appropriate research methodology to support the research design and perspective.

In summary, a structured framework of thought was used in the development of a research perspective and design for this study. The first step was to identify the research's central issues of concern and apply the issues along the two lines of prevailing thought. Next, the researcher had to consider his worldview and the nature of the problem when determining what would be the appropriate research methodology for the study.

APPROPRIATENESS OF THE MIXED METHODOLOGY DESIGN

As earlier illustrated, one's worldview and the nature of this research problem play a

significant role in the selection of a research design methodology. An additional aid

designed to help determine the appropriate methodology to use is found in Table 6.

Question	*Quantitative*	*Qualitative*
What is the purpose of the research?	**To explain and predict** **To confirm and validate** To test theory Outcome-oriented	**To describe and explain** **To explore and interpret** To build theory Process-oriented
What is the nature of the research process?	**Focused** Known variables Established guidelines Static design Context-free Detached view	Holistic **Unknown variables** **Flexible guidelines** **Emergent design** **Context-bound** **Personal view**
What are the methods of data collection?	Representative, large sample **Standardized instruments**	**Informative, small sample** **Observations, interviews**
What is the form of reasoning used in analysis?	**Deductive analysis**	**Inductive analysis**
How are the findings communicated?	**Numbers** **Statistics, aggregated data** **Graphical representation** Formal voice, scientific style	**Words** **Narratives, individual quotes** Personal voice, literary style

Table 6. Characteristics of Quantitative and Qualitative Approaches (adapted from Leedy, 1997, p. 106)

The emboldened characteristics apply to this research study. By answering each question

I was able to determine that this research required the use of both the qualitative and

quantitative research analysis methods. To effectively apply and analyze the

organizational knowledge system methodology it was evident that using one or the other

research method would not adequately answer my four research questions. Thus, from

the totality of this detailed analysis it was determined that a mixed methodology design

best accomplished the goals of this research.

The rigorousness of this research is in part dependent on the researcher's ability to follow the standards of quality represented by the canons of science as they relate to the combined principles of the mixed methodology design. By using the mixed methodology design, it is possible to objectively gather research data while preserving the contextual nature of the data. Likewise, it is possible to present graphical and statistical interpretations that are supported by the qualitative richness of personal and participant insight. The mixed methodology design is complex and difficult to execute, but the benefits of incorporating quantitative measures while maintaining the contextual nature of the problem has the potential to increase the research significance; thus, adding to the body of knowledge. One particular issue, the researcher's influence on the research, is present in the mixed methodology research design just as it is associated with qualitative research. This issue will be discussed in more detail in the next section.

INFLUENCE OF THE RESEARCHER

Another issue associated with the mixed methodology design is the role of the researcher. In a qualitative study the researcher is meant to be an integral part of the study. However, in a quantitative study the perceptions of the researcher are strictly guarded against, creating an artificial boundary between the researcher and the research. The dichotomy of these two paradigms presents itself as a significant obstacle to this research. It is arguable that the researcher is never detached or able to achieve experimental separation. The interpretation and written explanation of data analysis, as well as hypothesis generation, interjects the biases, experiences, and perceptions of the researcher into all research. As a matter of fact, this research employs the researcher in a role as an active participant. This is necessary to allow the researcher to not only gather

the appropriate data, but assess whether the construction and representation of the organizational knowledge system is sufficient to the organization under study. However, the research employs a few methods designed to address this issue. First, the structured research strategy, data collection, and data analysis provide the discipline, which will limit subjectivity in the research. The research strategy also provides a feedback loop between the researcher and the participants to ensure that the resulting organizational knowledge representation is sufficient and correct. Likewise, triangulation of the gathered quantitative and qualitative data and analysis will provide meaningful cross-checking throughout the research process. It should be understood that there is not a fusion of qualitative and quantitative methods, but rather an examination of data collection efforts uniquely using one method or the other then cross-referencing the data to determine consistency or potential contradictions. Thus, there is a conformation or corroboration element between the quantitative and qualitative collected data and subsequent analysis. The research also includes an articulated reflection by the researcher on the research process and researcher decisions and interpretations as the research progresses. This is referred to as critical subjectivity (Reason, 1994). This reflection allows the reader to actively understand the researcher's perspective and biases and know that the researcher is aware of them. Through the use of critical subjectivity, the researcher questions his or her assumptions and perceptions, testing them to ensure efficacy and accuracy in relation to the collected data and its analysis.

There is always the concern of research bias associated with the researcher. The above methods are intended to address many of those issues associated with the researcher's influence in this study. By making the influence of the researcher on the

research clear, the reader is provided with an important insight as to the context of research, process of the research, and frame-of-reference of the researcher. The last area of discussion is focused on the efficacy of the research methodology.

EFFICACY OF THE RESEARCH METHODOLOGY

"Validity focuses on the meaning and meaningfulness of data; reliability focuses on the consistency of results" (Patton, 1986, p. 223), where internal validity "is the freedom from bias in forming conclusions in view of the data" (Leedy, 1997, p. 34), and external validity "is concerned with the generalizability of the conclusions reached through observation of a sample of the universe" (Leedy, 1997, p. 34). However, from the qualitative perspective we are talking about credibility and transferability, respectively. The real issue here is one's worldview of scientific inquiry. This research attains internal efficacy by providing a detailed record or audit trail of the research, ensuring that any conclusions are linked to the data, investigates alternative conclusions, and honestly presents researcher biases, assumptions, and values which may effect the research. External efficacy is achieved through the combination of two components. First, the organization must agree that through the research process they were able to construct and represent their knowledge system. Secondly, the literature clearly supports the notion that all organizations possess knowledge. Thus, by conducting the research in two different organizational settings, it is possible to imply that the organizational knowledge system methodology is able to construct and represent an organization's unique knowledge system. This would indicate that the organizational knowledge system methodology is transferable.

RESEARCH METHODOLOGY SUMMARY

In summary, this chapter explains why the mixed methodology design was utilized for this research. A thoroughly reasoned perspective of what research inquiry should be used by the researcher was addressed when developing this research study design. This framework of thought provides a rich and substantive perspective on how the issues influence the researcher's actions and fall along two lines of prevailing thought -- the researcher's worldview and the nature of the problem. This study, like all others, will strive to be rigorous, where the canons of science provide a universal scientific standard by which to judge research. The problematic judgement of qualitative research from the perspective of positivism and vice versa is disregarded, and the merits and rigorousness of the research will be judged on how effectively the researcher accomplishes the standards of the canons of science. The quantitative and qualitative research methodologies are directly associated with the philosophical underpinnings that explain the positivist and naturalistic paradigms, respectively. Each paradigm brings its own unique qualities and biases to the research. However, it is incumbent upon the researcher to adhere to the principles of each chosen research method to ensure that rigorous research is conducted in the manner of that particular methodology. The nature of this research dictates that the mixed methodology design is appropriate because it provides a substantive analysis of an organization by using both the positivist and naturalistic perspectives. This study addresses the influence of the researcher to ensure that researcher participation is not an adverse element of the research. By making the influence of the researcher on the research process clear to the reader, he or she is

provided an important context from which to understand the research. Finally, the efficacy of the research is addressed to highlight how internal and external efficacy will be achieved within a mixed methodology design.

RESEARCH DESIGN METHOD AND PROCEDURE

This study will employ the mixed methodology design. The design is characterized by the mixing of the qualitative and quantitative analysis approaches, data collection methods, and/or data sources. The mixed design will help to develop a better understanding of the organizational knowledge system by allowing the use of inductive and deductive models in the research process. One important advantage of using the mixed methodology research design is its ability to strengthen the study through triangulation (Patton, 1990). In this study there is triangulation of theory (organization and systems), research methodology (qualitative and quantitative), and method (interview and statistical). This provides for a more robust design for investigating the research questions. The logic of triangulation is based on the following premise:

> no single method ever adequately solves the problem of rival causal factors....Because each method reveals different aspects of empirical reality, multiple methods of observations must be employed. This is termed triangulation. I now offer as a final methodological rule the principle that multiple methods should be used in every investigation (Denzin, 1978, p 28).

It means: (1) comparing observational data with interview data; (2) comparing what people say in private to what they espouse in public; (3) checking the consistency of interview data with survey data; and (4) comparing the perspectives of people with different points of view into a homogeneous whole (Patton, 1990). The nature of this research requires the gathering of contextual data (qualitative assessment) to support data gathered using quantitative methods and vice versa. Thus, the mixed methodology design provides a more substantive analysis of an organization by using both the

positivist and naturalistic perspectives. The *Research Methodology* chapter provided a detailed discussion of issues and concerns surrounding the use of either the positivist or naturalistic methodologies and the appropriateness of the mixed methodology for this research.

For ease of explanation and understanding, the research is divided into two broad phases with the following components in each phase (Figure 16). I will discuss each phase in more detail in the following sections.
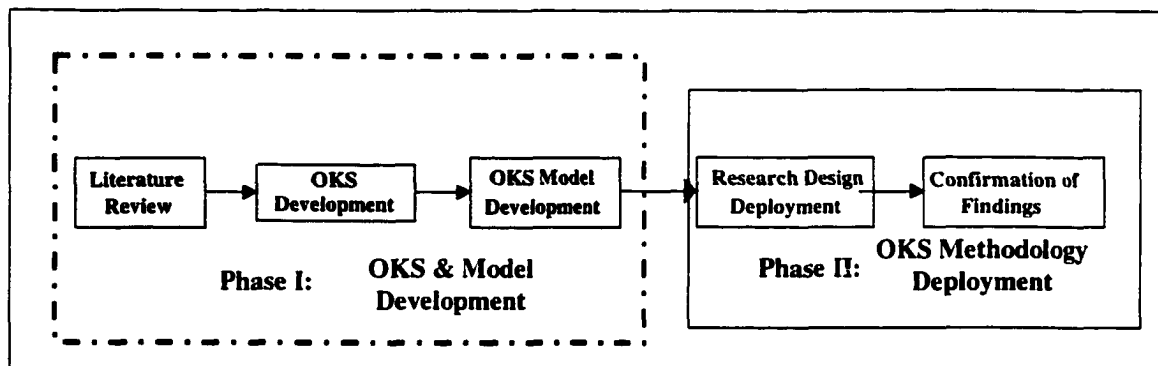
Figure 16.   Research Study Phases

PHASE I (OKS & MODEL DEVELOPMENT)

Phase I of the research has three components: (1) the literature review; (2) organizational knowledge system development; and (3) the organizational knowledge system model development (Figure 16). Phase I answers the first research objective identified in the *Introduction* chapter of this study. The research objective was to "develop a literature-based methodology perspective and model of the organizational knowledge system" (see Figure 1). This was accomplished in the *Literature Review* and *Organizational Knowledge System and Model* chapters. This phase is the essence of this research study and is the real contribution to the body of knowledge and engineering

management practice. The following sections provide a recap of the above mentioned chapters.

Literature Review

The literature review was focused toward synthesizing, categorizing, and interpreting the applicable organizational learning and organizational knowledge literatures. The review highlighted the definitions of organizational learning and addressed the inconsistencies that exist between and within the organizational learning literature and the inaccurate interchange of the concepts of organizational knowledge and organizational learning. The review provided structure to the literature and convergence in the organizational learning literature showing where some scholars suggest a clearly defined difference between organizational learning and organizational knowledge. However, the culmination of the review identified the absence of literature that links organizational learning as the process that produces organizational knowledge. Ultimately, this is where this research fills a gap in the body of knowledge concerning organizational knowledge. From the literature review evolved the concept of the organizational knowledge system. This concept was synthesized from and supported by the existing organizational learning and knowledge literatures. The major themes supporting the organizational knowledge system perspective are:

♦ organizational learning is the process for organizational change,

♦ organizational knowledge and learning are two separate concepts,

♦ an organization's knowledge system is unique,

♦ organizational knowledge is a product of organizational learning, and

♦ the organizational learning and knowledge concepts are interconnected.

The organizational knowledge system perspective is a holistic understanding and explanation of the relationship between the organizational learning and knowledge concepts.

Organizational Knowledge System and Model

The organizational knowledge system and model are essential elements in the construction and representation of an organization's knowledge system. This is the centerpiece of this research. It is in this section that the organizational knowledge system is presented and explained. The literature provided the foundation for the development of the organizational knowledge system based on the migration of thought concerning organizational learning culminating largely on Huber's constructs of organizational learning. As presented in the *Organizational Knowledge System and Model* chapter, these constructs are knowledge acquisition, information interpretation, organizational memory, and information distribution (Huber, 1991). The organizational knowledge system also encompasses the precepts and thoughts contained in the current organizational knowledge literature. The development process of the knowledge system binds Huber's constructs into a modified set of knowledge system subsystems. The glue in this binding process is systems theory. Systems theory provides the literature-based perspective from which to evaluate the elements of organizational knowledge and their rich interaction as a system, and it also addresses the holistic perspective of the relationship between organizational learning and organizational knowledge as a system. The final element of the methodology was the development and explanation of the system model, which serves as the framework for the application of the organizational knowledge system in an organization. The product is a refined organizational knowledge

system and model that represents the knowledge system at an upper-level (Organization Knowledge Subsystems) and the associated model at a lower-level (Organization Knowledge Mechanisms), which are linked to allow the representation of an organization's unique knowledge system.

PHASE II (DEPLOYMENT & CONFIRMATION)

The second phase of the research design is the deployment of the organizational knowledge system model and confirmation of the research findings (Figure 17). Phase II addresses the second objective of the research, which was to "deploy the organizational knowledge system for application in selected organizations" (see Figure 1). The research design deployment completes what will now be called the Organizational Knowledge System Methodology (OKSM). Thus far, the research has developed the organizational knowledge system, which is composed of the literature-based perspective, organizational cognition, and systems theory. These perspectives and theory form the framework, foundation, and understanding of the organizational knowledge system. The second component of the organizational knowledge system methodology is the organizational knowledge system model. The OKS model explains the rich and complex relationships that exist between the knowledge subsystems of the organizational knowledge system. It also establishes and explains the importance of the mechanisms organizations use to inform their knowledge system. Like the knowledge subsystems, the mechanisms are linked through relationships of various strengths. Relationships between the knowledge subsystems and mechanisms also exist. The final step is the deployment and confirmation of the model. This is accomplished by the research design method. The research design methodology takes the OKS and OKS model and fashions a research

design deployment and confirmation strategy, thereby completing all the necessary components required to construct and represent an organization's knowledge system. The thought process and development of the OKSM is complex and represents a significant addition to organization theory and the practice of organization management. The construction and representation of an organization's knowledge system was accomplished by developing or supporting each element of the methodology from the literature. This was an extensive process and has brought us to this point. Now the research is at the maturity to deploy the model to selected organizations.
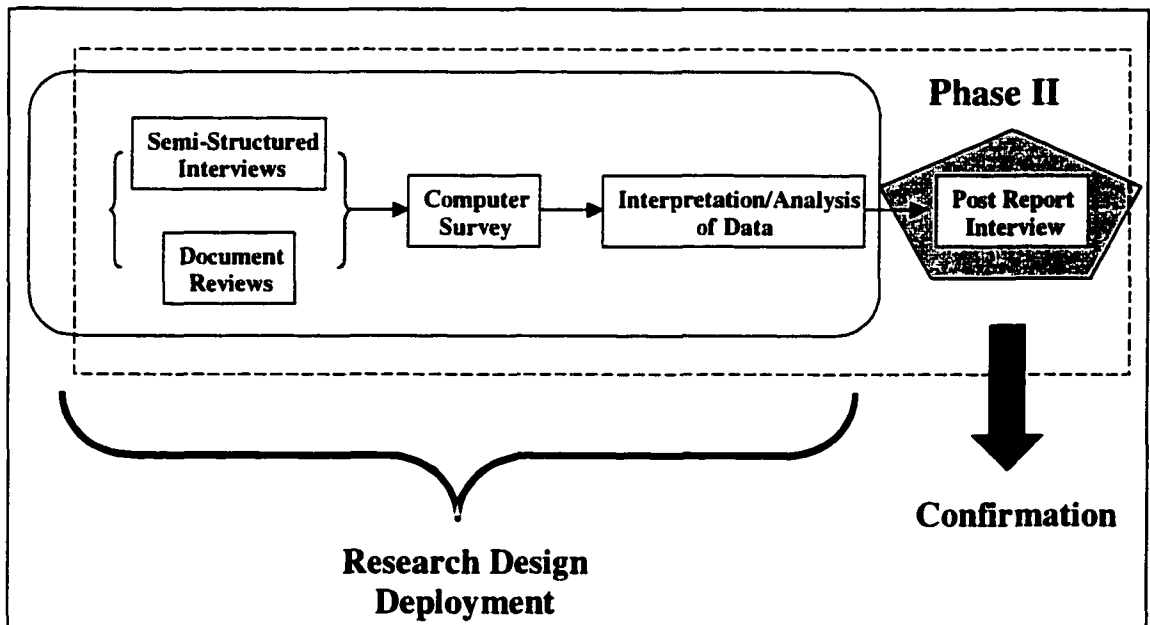
Figure 17. Phase II of Research Study

Research Design Deployment

The research design deployment is segmented into the above-mentioned research sections in Figure 17. The components were developed as part of the research method and procedure to promote an orderly, effective, and efficient procedure of employing the organizational knowledge system methodology and facilitate the traceability of the

research process. The components include semi-structured interviews, document reviews, computerized surveys, and interpretation and analysis of the gathered data. The major purpose of the semi-structured interviews and document reviews were to provide the researcher the specific formal and informal mechanisms each organization used to inform their knowledge system subsystems. The document reviews and interviews also elicited the substantive contextual information required to develop the knowledge system construction for each organization. It also provided the researcher or investigator a foundation or framework from which to understand the organization's unique knowledge system. The construction of the knowledge system is bounded by the system in focus where, as stated earlier, the system in focus is understood to be the identified bounded system under investigation. The computer survey was a critical component in the process, as it provides the quantitative data for the research. This data came from the research participants responses to the web-based Likert scale survey. The quantitative and qualitative data obtained was then triangulated and analyzed using the mixed methodology design to provide each organization a representation of their knowledge system. This representation was based on their current structure and present environment. The post-report interview provided the means to determine the occurrence of new learning and/or knowledge generated as a result of the implementation of this methodology and the efficacy of the main research product which is the representation of the organization's knowledge system.

Throughout the entire process there was constant coordination with the organization participants to ensure that the efficacy of the knowledge system is correct. This was a necessary aspect of the research, as it is impractical to think that an independent, outside

investigator could come into an organization and with a high degree of accuracy represent the organization's knowledge system without extensive coordination and feedback. Much of the reason why this is not possible is rooted in understanding an organization's social component (people) along with the organization's technical component. Knowledge patterns are socially derived understandings and interpretations, which govern the content of the information, as well as the context for which the information is pertinent, all of which leads to the creation of knowledge and ultimately organization action and decision. Schwandt and Marquardt (1999, p. 132) reinforce this point when they say that "they (organization knowledge structures) provide the organizational reference point for... the learning and performance of the organization." Thus, constant and substantive coordination between the researcher and organizations were conducted to identify and explain each organization's knowledge system.

To accomplish the research purpose two organizations were assessed. These organizations accomplish the second objective of this research by applying the OKSM to functioning organizations. The deployment objective was met by demonstrating the capability of the OKSM to accurately construct and represent an organization's knowledge system. However, by using two organizations as research subjects, the research design was purposely projected to various work environments, which were focused on very different goals, tasks, and responsibilities. The deployment phase also included the data collection effort, which was necessary to fulfill the purpose of the research study. The research assumptions, selection of the organization and participants, methods of data collection and structure, and analysis methods were all identified to

facilitate an orderly and efficient research effort. They will all be discussed in the following sections.

Research Assumptions

The research deployment strategy also addressed the research assumptions and organizations that participated in the study. One research assumption was that the organizational participants understand the organization's vision, mission, and objectives. This was an important assumption because it rules out the ambiguity of individual understanding and interpretation of an organization's vision and mission. This does not assume that there is a unitary understanding of these critical unifying and focusing perspectives of the organization. However, it is assumed that the organization's vision, mission, and objectives are understood well enough by the research participants, thereby providing an alignment of thought and effort towards their achievement. The second research assumption is that all organizations have a knowledge system. This assumption is confirmed based on the organizational knowledge literature. Huber (1991), Daft and Weick (1984), Nonaka (1991, 1994), and Lyles and Schwenk (1992) all agree that every organization possesses a knowledge system.

Research Sites and Participants

Within the research design deployment, is the selection process of the participating organizations and organizational members. The two organizations participating in this research are the Thomas Jefferson National Accelerator Facility (hereafter referred to as Jefferson Laboratory (JLAB)) in Newport News, Virginia, and the Office of the Under Secretary of Defense (Acquisition and Technology) for Development Test and Evaluation (Strategic and Tactical Systems), Washington, DC.

The first organization consisted of civilian personnel and the latter of military and civilian personnel.

The specific sub-elements studied in these two organizations were the Accelerator Development Department of the Jefferson Laboratory and the Analysis and Baseline Development Integrated Process Team (IPT) of the Joint Warfighter Joint Test and Evaluation (JWF JT&E). The mission of Jefferson Laboratory is to conduct research that builds a comprehensive understanding of the atom's nucleus and use the Free Electron Lasers developed by the lab to conduct its physics experiments. The Accelerator Development Department is more accurately characterized as a part of the Jefferson Lab Accelerator Division. The mission of the department is two-fold, research and development and production of accelerator components. The department consists of 40 individuals, ten of which were selected as a representative group who possessed an understanding of the organization's history, functions, and procedures. Of these ten individuals, all but one had over ten years of experience with Jefferson Labs, most if not all of those years with the Accelerator Development Department. The ten individuals were selected using the participant selection criteria developed in this section. Likewise, the Analysis and Baseline Development IPT was selected using the participant selection criteria developed in this section. The JWF JT&E is chartered to investigate, evaluate, and improve the operational effectiveness of joint operations against time-sensitive surface targets focusing on the work process of the joint targeting cycle system. It is a military analysis organization that is formed to respond to issues and problems in the military requiring detailed experimentation and/or testing to provide empirical evidence to support decision and actions. The primary responsibility of the Analysis and Baseline

IPT is reconstructing the time sensitive surface target missions from the data collected at various exercises. The IPT consists of four personnel, all of whom participate in the research. These organizations were selected based on the selection criteria established in the organization section of this chapter. The diversity of these organizations provides the research with uniquely different organizational foci. Each organization provides a different perspective for understanding the organizational knowledge system. This is due to the uniqueness of the knowledge system in each organization. The time required for completion of an organizational study ranged between one and one-half to two months. However, this was dependent on the number of organizational participants and the relative size of the resultant mapping of the organization's knowledge system. The length of the intervention is broken down into an on-site time of one to three weeks to gather data, with the remaining time devoted towards analyzing the gathered data and preparing a organization report and out-briefing. The development of participant consent forms were completed and reviewed by the Old Dominion University (ODU) approving agency. The consent forms outlined the major research goals to the participating organizations, as well as served as a coordinating vehicle between the researcher, participants, and organization as to how the gathered data and final report would be used (APPENDIX B). Also to ensure participant confidentiality, all names in this research are omitted and substituted with unique user identification numbers.

Both organizations provide substantive insight into the concept of an organizational knowledge system, but the question remains, why pick these organizations? This led to the selection criteria for the organizations, as well as the selection criteria for the participants.

Organization Selection Criteria

Determining whether an organization should participate in any research is a subjective judgment. However, the selected organization should be capable of providing the data necessary to accomplish the research purpose. Again, the purpose of this research is to develop and apply a system-based analysis methodology, which constructs and represents an organization's knowledge system. The criteria can range from a few specific areas to many, all of which can be assessed differently by individual researchers. In an attempt to provide a modicum of objectivity in choosing organizations to participate in this study, the selection was tied to the collection of data. The data collection for this research has three basic selection criteria:

1. Relation of data to research questions (gathered data must answer the research questions),

2. Data needed for analysis of the organizational knowledge system, and

3. Data collection requirements.

Inherently, it is understood that any organization selected to participate in this research must be capable of generating the data required to meet the three selection criteria. The OKS model developed to explain and represent the organizational knowledge system was designed to be robust enough for use in all manner and types of organizations. This includes organizations that are issue, problem, project, structure, product, individual, industry, or geographically focused, as well as organizations that exist in public and private domains. Thus, this research is able to cast a wide net in determining which organizations should be included in this study.

However, the narrowing of the potential research pool of candidates is accomplished by the second and third data collection criteria. The data needed for the analysis of an organizational knowledge system addresses the availability, quality, and type of data required (Figure 18) while the data collection requirements address the

	Availability	Quality of Data	Data Required
Organization A			
Organization B			
Organization C			
Organization D			
Organization E			
Organization F			
Organization G			

Figure 18. Organization Selection Matrix

collection plan, method of collection, and data confidence assurance. The second data collection criterion deals with issues of researcher access to the organization and the cost of that access to the researcher and organization. Organizations selected for participation in the study came from the Tidewater area, as stated earlier, to facilitate ease of researcher access. The type of data required (document review, semi-structured interviews, and survey) led the research to again focus on organizations in the Tidewater area. The proximity of the organizations to the researcher facilitates the conduct of the research work and any follow-up actions that may be necessary.

The third data collection criterion is concerned with confidence in the gathered data. The assurance that the gathered data deserves researcher, participating organization, and reader confidence is a quality issue, as well as trust in the researcher's ability to eliminate bias and provide traceability. The assurance of data confidence and quality can be established by the selected organizations and by the researcher through adherence to the positivist and naturalist research perspective against not each other, but the canons of science. Also, confidence in the gathered data was engendered by selecting organizations that understood research. Both organizations are involved with research and analysis on a daily basis and ensured that their participation in this research would provide the substantive and necessary data to answer the research questions.

Participant Selection Criteria

The selection criteria for the organizational participants are a more fluid set of criteria which are based on the organization and organizational focus. The problem, issue, and identified bounded system under investigation contextually bind the representation of the knowledge system. In this fashion, the selection criteria for the organizational participants must mirror the span of the knowledge system for the system in focus. If the organization desires to represent their knowledge system at the top management levels, breadth of analysis is required and participants will span the horizontal dimension of this segment of the organization. Likewise, if the organization desires to represent their knowledge system within a particular department, breadth and depth of analysis is required and participants will span the horizontal and vertical dimensions of the organization. The ultimate result is to have participants that are knowledgeable about the inquiry (Figure 19). The guide for participant selection is

availability, an understanding of the system in focus, and an understanding of the research inquiry. The system in focus is defined as the identified bounded system under investigation, such as upper management, a department, or section. Furthermore, the understanding of the research inquiry is the participant's grasp or understanding of the research goals, the process of the research inquiry, and their particular role in the research.

	Understanding of the System in Focus	Availability	Understanding of the research inquiry
Participant 1			
Participant 2			
Participant 3			
Participant 4			
Participant 5			
Participant 6			
Participant 7			

Figure 19. Participant Selection Matrix

Because the research is focused on constructing and representing an organization's knowledge system, it is not necessary to have a large pool or sample size of participants. On the contrary, it would prove detrimental to the research to have large numbers of individuals, where the majority of them did not fully understand the system in focus or have an adequate working knowledge of the organization's vision, goals, and objectives. Not all members of an organization contribute to the creation of knowledge

or foster intellectual capital. Clearly, some members merely exist and function in the organizational environment. This does not impugn them, as they do contribute to the viability of the organization. Moreover, it is by design that this methodology allows the organizational manager to focus on the organizational knowledge system he or she chooses. Thus, statistical significance through the use of the law of large numbers, as it relates to the number of research participants, does not apply here.

Similarly, there is no requirement to have a large number of organizations in this research, as the purpose of this research is to construct and represent an organization's knowledge system and little is gained from providing a statistical significance between the failure and success rate of the methodology and model. There is little argument that all organizations possess some type of knowledge system (Nonaka, 1994; Quinn, Baruch, & Zien, 1997). This is usually at the tacit level. The OKSM provides a means of making that tacit organizational knowledge system explicit for the entire organization to see, understand, and potentially act upon. However, to provide the organizations an explicit representation of their knowledge system, data must be collected and analyzed.

Data Collection

The data required for the study is guided by the requirement to satisfy the dendritic structure (Table 7). The dendritic structure is a branch structure designed to correlate the issues with the measures of effectiveness identified to resolve them. This ensured that data collection was conducted in a manner that was effective and efficient to respond to the research questions. The data collected for the dendritic included both qualitative and quantitative forms. The dendritic structure in Table 7 represents the data

flow required to assess each knowledge subsystem. The identification of the data requirements then led to a determination of the proper data collection method and the appropriate corresponding data analysis strategies. The mechanisms associated with each knowledge subsystem were identified through both document reviews and

	Knowledge System	Questions Assessing	Mechanisms (Examples)
I	Information Acquisition	Importance Effectiveness Strength of Relationships	1.1 Trade Manuals
			1.2 Quarterly Report
			1.3 Formal Staff Meetings
			1.4 Informal Staff Discussions
II	Information Storage/Retrie val	Importance Effectiveness Strength of Relationships	2.1 Experts
			2.2 Reports
			2.3 Computer Databases
			2.4 Filing Cabinets
III	Interpretation	Importance Effectiveness Strength of Relationships	3.1 Brainstorming Sessions
			3.2 Offsite Meetings
			3.3 Framing Sessions
			3.4 Reflective Thought
IV	Information Dissemination	Importance Effectiveness Strength of Relationships	4.1 Formal Meetings
			4.2 Briefings
			4.3 E-mail
			4.4 Informal Staff Discussions

TABLE 7. Dendritic Structure

semi-structured interviews (Table 8). The assessment of the mechanisms was accomplished through a computerized survey which assessed the strength of the relationship between mechanisms and their associated knowledge subsystems, the strength of relationship between knowledge subsystems, as well as the importance and effectiveness of the mechanisms to the organization's knowledge system. The survey was a web-based application utilizing the Inquisite 2.0 and Microsoft Excel software packages (Inquisite, 1999 & Microsoft, 1997). Inquisite is an electronic survey system built by Catapult Systems. Although Inquisite is an admirable software package, it did

not have the flexibility to meet the diverse requirements necessary for the research survey

objectives. This inadequacy led to the use of Microsoft Excel, a spreadsheet software

package, for one part of the research survey. The product of the computer survey would

be a graphical representation of the mechanisms and strength of relationships for the

studied

| Data Collection Method	Reference	Data Analysis Method	Reference	Expected Outcomes/Products
Semi-structured Interviews	◆ Kerlinger, F., (1992), *Foundations of Behavioral Research,* New York, NY: Harcourt Brace College Publishers. ◆ Creswell, W., (1998), *Qualitative Inquiry and Research Design,* London: Sage Publications. ◆ Leedy, P. (1997), *Practical Research,* Columbus, OH: Prentice Hall.	Coding, Themes, Triangulation, Patterns.	◆ Creswell, W., (1998), *Qualitative Inquiry and Research Design,* London: Sage Publications. ◆ Miles & Huberman, (1994), *Qualitative Data Analysis,* London: Sage Publications. ◆ Corbin, J., (1991), *Basics of Qualitative Research,* London: Sage Publications.	● Contextual information concerning knowledge system. ● Identification of organization knowledge mechanisms
Document Reviews	◆ Kerlinger, F., (1992), *Foundations of Behavioral Research,* New York, NY: Harcourt Brace College Publishers. ◆ Creswell, W., (1998), *Qualitative Inquiry and Research Design,* London: Sage Publications. ◆ Leedy, P. (1997), *Practical Research,* Columbus, OH: Prentice Hall.	Coding, Themes, Triangulation, Patterns.	◆ Creswell, W., (1998), *Qualitative Inquiry and Research Design,* London: Sage Publications. ◆ Corbin, J., (1991), *Basics of Qualitative Research,* London: Sage Publications. ◆ Miles & Huberman, (1994), *Qualitative Data Analysis,* London: Sage Publications.	● Contextual information concerning knowledge system. ● Identification of organization knowledge mechanisms
Computerized questionnaire	◆ Kerlinger, F., (1992), *Foundations of Behavioral Research,* New York, NY: Harcourt Brace College Publishers. ◆ Creswell, W., (1998), *Qualitative Inquiry and Research Design,* London: Sage Publications. ◆ Leedy, P. (1997), *Practical Research,* Columbus, OH: Prentice Hall.	Statistical and Graphical Analysis (Microsoft Excel)	◆ Kerlinger, F., (1992), *Foundations of Behavioral Research,* New York, NY: Harcourt Brace College Publishers. ◆ Chambers, Cleveland, Kleiner, & Tukey, (1983), Graphical Methods for Data Analysis, Pacific Grove, CA: Wadsworth & Brooks/Cole Publishing.	● Graphic representation of relatedness and complexity between organization knowledge system entities ● Assess relationship/linkage of knowledge mechanisms.

TABLE 8. Data Collection Methods

organizations. The computer survey used a Likert-type scale. The Likert scale falls in the family of summated scales, where subjects respond to questions in varying degrees of agreement or disagreement (Kerlinger, 1992). A characteristic of Likert scales that made their use appropriate for this study is their ability to quantitatively measure the intensity of a participant's expression. This aided the research by numerically quantifying the goodness and effect the knowledge system mechanisms had on the knowledge system subsystems themselves, and the strength of relationships between system entities. Additionally, Table 8 provides the detailed audit trail of the research data collection, analysis, and expected outcomes. This audit trail is further detailed in APPENDIX C, which explains the researcher's on-site actions to complete the research design deployment. The on-site actions provide the step-by-step data collection process for this research. However, within the on-site actions many important and diverse acts were being conducted. For instance, a complete and thorough briefing was given to all the participants in the research to provide a common understanding of the research methodology and model. This is a key point as it is the initial introduction of the organizational knowledge system and starts the contextual data collection, as well as establishes a baseline of understanding for the research. When the semi-structured interviews were conducted on each research participant, they were afforded the opportunity to read the research interview guide (APPENDIX D). The research interview guide was designed to educate the research participants on the goals of the research and give them an understanding of the organizational knowledge system. However, at a minimum the research guide was paraphrased by the researcher at each interview. The same research interview guide was provided on a web site (APPENDIX E) providing

access to the research information to the participants for use on their own schedules. For each participant interview notes were taken and the interview was recorded. Appendix F provides an example of the recorded notes and transcript obtained from the interviews. The research web site provided more information on the research than just the research interview guide. One very important element of the web site was it provided the research participants the Internet link to the computerized survey (APPENDIX G). Appendix G provides the front-end instructions and introduction for the three research modules. The participant responses were gathered and electronically stored in established files for later analysis. This ended the data collection process of the research and started the analysis phase.

Research Analysis

The analysis of the interviews and document reviews consisted of identifying themes and patterns through coding the research notes and transcripts (Creswell, 1998; Miles and Huberman, 1994; and Corbin, 1991). The themes and patterns developed for the qualitative data provides the contextual richness to the analysis required to adequately represent each organization's knowledge system. It is important to remember that this is not a test for the organization's personnel, but rather an exploration into their knowledge work process to elicit the particular mechanisms each individual uses to inform a particular knowledge subsystem. This is one reason why the interviews are semi-structured. The other reason is to foster discussion to learn more about each mechanism and the organization overall. Within each of the subsystems, probing questions were developed to ascertain the mechanisms, which is the main goal of the interviews, and then to help foster discussion. Each interview was taped and transcribed, providing not

only a record of the mechanisms and discussion, but also providing a manuscript for analysis using various qualitative techniques such as coding, pattern recognition, and theme generation. Once the mechanisms were gathered from the organization the research then developed a taxonomy of the mechanisms. The taxonomy was important because it reduced the complexity of the organization's knowledge system by creating a hierarchy, which could be dealt with more readily by the research participants. This taxonomy provided the organization with a method of examining their information mechanisms in a hierarchical fashion. This viewpoint in many cases is done intuitively or tacitly from a knowledge perspective. The value of explicitly showing the organization their taxonomy induced the organization to evaluate the ordering of the mechanisms, as well as to determine the organizational necessity of a mechanism. The analysis of the computer survey data was conducted using the statistical package available in Microsoft Excel (1997). It is important to remember that the knowledge system representation is dependent on the computerized survey supplying the quantitative data, which will be triangulated with the qualitative data. Figure 20 provides a graphic depiction of the research analysis and each analysis element will be explained later in this section. This was accomplished by allowing the research participants to assess the mechanisms and the strength of the various relationship links that have been established or developed. These relationships were established either by the research participants or are based on the
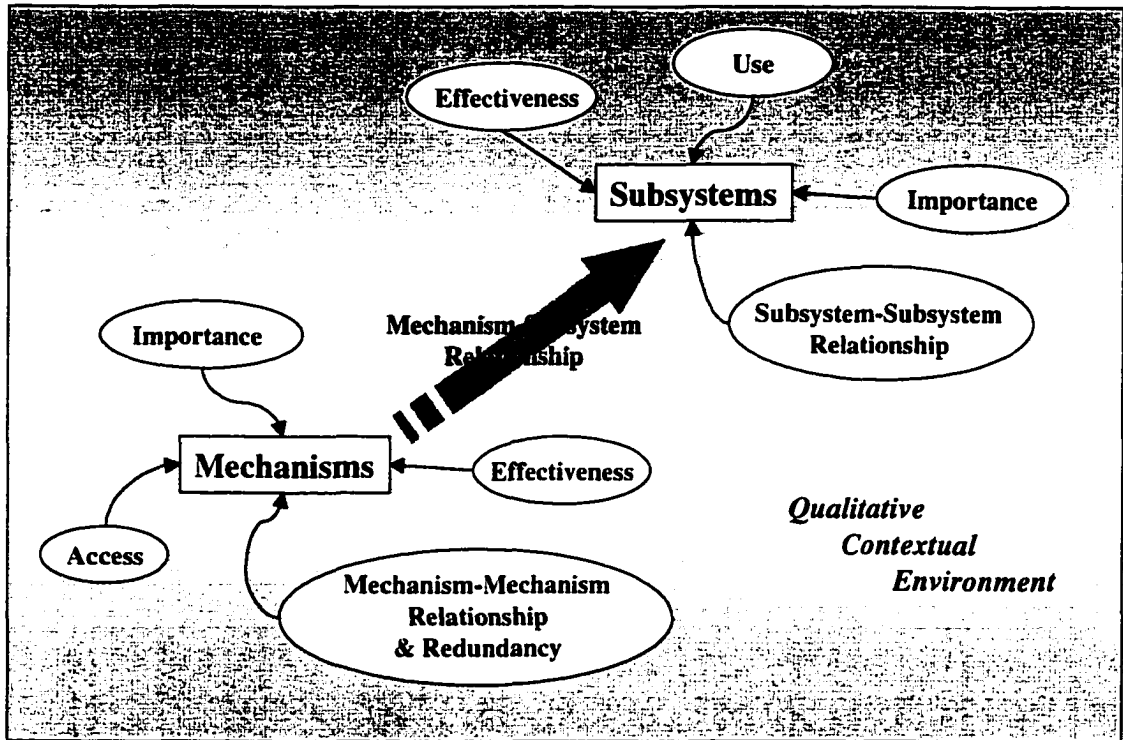
Figure 20. Mixed Methodology Analysis and Interpretation

theoretical underpinnings of systems theory. The research survey was subdivided into six

areas for analysis:

1. Mechanism Assessment

2. Mechanism to Mechanism Relationships

3. Mechanism Redundancies

4. Mechanism to Subsystem Relationships

5. Subsystem Assessment

6. Subsystems to Subsystem Relationships.

Mechanism Assessment

The mechanism assessment portion of the survey was designed to have the

research participants evaluate each mechanism along three axes: importance,

effectiveness, and access. The importance of the mechanism relates to its significance to

the particular subsystem and the organization under study. Because a mechanism can belong to multiple knowledge subsystems, it would not be unusual for a mechanism to have different importance ratings when looking across all the subsystems to which it belongs. This phenomenon provides insight into how the research participants view a particular mechanism. Similarly, this relationship extends to the participant ratings for effectiveness and access. The effectiveness of the mechanism is addressed along three sub-axes, the first being relevance, where relevance is concerned with the suitability of the information provided by the mechanism. Next, usefulness addresses the utility of the mechanism being able to provide information that is required to accomplish organizational tasks and responsibilities. The last sub-mechanism evaluation of effectiveness is accuracy. It is concerned with the correctness of information provided by the mechanism. Finally, access addresses the ability of the organization members getting timely access to the required mechanism and the overall organization personnel accessibility to the mechanism.

Each mechanism is rated along these three axes by means of a Likert scale ranging from one to seven. The statistics gathered in this research are limited to the mean, standard deviation, and range. Graphical analysis was also used as a visual aid to assist in understanding the results of the quantitative analysis. Distributions and analyses using the traditional forms of parametric and non-parametric statistics were not employed because of the small sample and population sizes in the research. This by no means lessens the significance of the research study. On the contrary, the gathered data provided a very substantive and thorough analysis of the organizational knowledge system. More importantly, the construction and representation of the organizational

knowledge system is not dependent on sample size, but rather, is dependent on the knowledge system of interest, which requires the organizational proponent to identify those members that provide substance to the inquiry of an organization's knowledge system. Thus, the construction and representation process is flexible and adept enough to be employed within a small organization, as well as a large organization. The key point is to determine the knowledge system of interest and define the scope of the inquiry by adequately bounding the system in focus.

Mechanism-to-Mechanism Relationships

The research participants continued their assessment by rating the strength of the relationship between the principle mechanisms within a knowledge subsystem. This, like the other assessments, was based on a Likert scale. This assessment was accomplished by using Microsoft Excel, due to its spreadsheet capability. The limitations of the Inquisite software prevented the building of an assessment tool that could effectively and efficiently collect this data. The graphical depiction provided to the organization is in the form of a modified correlation diagram. The graphical analysis of the modified correlation diagram is enhanced by adjusting the relationship line widths based on four equally divided bands from zero to three. By taking the mean of the responses and graphing only those that attained a value of 1.51 or greater, the research participants were able to visualize the most important mechanism-to-mechanism relationships based on their collective organization judgement.

Mechanism Redundancy

Next, the research participants were required to assess the mechanism redundancies within a particular knowledge system. This assessment was to only identify

the redundancies that did not enhance the organization's ability to accomplish its tasks or responsibilities. The assessment tool was built using Inquisite. However, when employed in the Accelerator Development Department, the size of the matrix (27x27) was too cumbersome for the respondents to navigate. This was due to the inability to scroll within the matrix. Thus, the data recorded was incomplete and disjointed, rendering it unusable. The researcher believes that the redundancy assessment would provide the organization with useful information about its knowledge system. However, the information is not critical to the representation process. Subsequently, it was dropped from the assessment for the Analysis and Baseline Development IPT. The loss of this analysis does not have an adverse effect on the research. The redundancy analysis is not part of the construction and representation of an organization's knowledge system, but provides background information to the research organizations about the utilization of scarce and oftentimes costly resources. This area of assessment will therefore be recommended for inclusion in any follow-up research or new organizational research.

Mechanism-to-Subsystem Relationships

Like the mechanism-to-mechanism relationships, the mechanism-to-subsystem relationships are assessed based on the strength of the relationships. The research participants rate the strength of relationship from a particular mechanism to a particular subsystem. For example, each research participant evaluates the strength of relationship between the e-mail mechanism and the information dissemination knowledge subsystem. These are the individual evaluations of how important a mechanism is to its associated knowledge subsystem. From the Likert scale responses, the mean is used to determine the line thickness of the relationship. The line widths are based on four

equally divided bands from one to seven. Unlike the mechanism-to-mechanism relationship, there is no zero value. This is because the organizational participants have established a relationship between the mechanism and subsystem within the construction phase of the research inquiry process. The graphic depiction provided to the organization resembles a grouped pin wheel where the thicker the line indicates the stronger the relationship and therefore, the more important one. This allows the organization to visualize and graphically determine the most important mechanism-to-subsystem relationships based on the data from their collective judgements.

Subsystem Assessment

The assessment of the knowledge subsystems is based on their importance to the organization, how effectively they are utilized in the organization, and how extensively the subsystem is utilized by the organization. The data for this assessment is presented on an axis diagram, where the four knowledge subsystems represent the axes. The means of each subsystem's importance and effectiveness ratings are then graphed and bounded by the range values of the participant responses. Also, a straight line is drawn connecting the means for all importance and effectiveness data points. This assessment provides essential information to organization managers as to where to place scarce resources and what type of resources should be employed. It also alerts the organization to potential deficiencies within a particular knowledge subsystem.

Subsystem-to-Subsystem Relationships

The subsystem-to-subsystem relationships were the last assessment in the computerized survey. The research participants were required to rate the relationships between all the knowledge subsystems. Like the other assessments, the subsystem-to-

subsystem assessment used a Likert scale with a range of one to seven. This assessment provided valuable information to the organization about the organizational perspective of the relationships between the knowledge subsystems.

The analysis of the gathered data completes the research design deployment. To this point a large amount of data and information has been generated, all focused towards the analysis and interpretation of the organization's knowledge system. The final element of the research is the confirmation of research findings.

Confirmation of Findings

Within Phase II, it is incumbent on this researcher to validate the research findings. The confirmation process is concerned with determining the veracity of the organizational knowledge system representation. To ensure that the purpose of the research is fulfilled, it is paramount that the research effectively validates the ability of the methodology and model to represent the organization's knowledge system. The research converted what is oftentimes the implicit nature of organizational knowledge, which resides at both the individual and collective levels, to knowledge that was explicit at the collective organizational level. Thus, post-research study interviews were conducted on selected research participants to assess how the organization rated the methodology and model's ability to represent the organization's knowledge system. The outcome was a confirmation that the OKSM represented each organization's knowledge system. This does not imply that the confirmation of the generated organization reports was unimportant or minimized. On the contrary, great care and a significant amount of time and rigor was applied to ensure that the data gathered not only met a high degree of quality, but was also reliable. As addressed earlier in this chapter, this was accomplished

by following a comprehensive work plan that detailed all on-site research actions (APPENDIX C).

RESEARCH DESIGN METHOD & PROCEDURE SUMMARY

This chapter provides the complete organizational knowledge system methodology. The OKS perspective was theorized from the organizational learning and knowledge literatures. The organizational knowledge system was developed by applying the theory of organizational cognition and systems theory to the OKS perspective. Next, the OKS model was developed that established the linkage between theory and practice. Lastly, the research design deployment and confirmation of results was developed to apply to two organizations. Within the research design deployment the research assumption, selection of research organizations and participants, data collection, and analysis were discussed. Finally, the chapter ends with a discussion of the confirmation of the findings. What follows is the presentation of the research results.

RESEARCH RESULTS

This chapter presents the results of this research and is subdivided into two major sections. The first section is the *Knowledge System Construction*. This section explains the results of the knowledge system construction. The second section is the *Knowledge System Representation*. This section addresses the analysis of the research organizations using the mixed methodology design and interprets the analysis to develop each organization's knowledge system representation.

KNOWLEDGE SYSTEM CONSTRUCTION

Accelerator Development Department

The construction process began with a meeting that outlines the purpose, benefits, and scope of the research inquiry. This was followed by an agreement between the researcher and the director of the Accelerator Development Department on what is the proper system in focus, along with a determination of who will participate in the research.

Next, the researcher conducted an independent review of the applicable policy letters, manuals, electronic media, and other documents, all of which help to shed light on the governance and organizational structure of the system in focus. This allowed the researcher to acquire a general sense of how the organization espouses its knowledge structure and management. However, the primary purpose of the document review is to determine what mechanisms the organization says it uses to inform its knowledge subsystems. Interestingly enough, the Accelerator Development Department did not provide any policy documents or manuals that were strictly related to the functions or procedures of the department. They did provide manuals and policy guidance that

supported the entire Jefferson Labs organization. Some of these include: the environmental health and safety manual, administrative manual, and Jefferson Lab web site. Although these parent organization information mechanisms are important and quite comprehensive, they did not specifically target the organization specific knowledge system intricacies and issues present in the Accelerator Development Department.

The construction process continued with the semi-structured interviews of each research participant. As noted earlier, the Accelerator Development Department has 40 personnel, ten of which participated in this research. These ten respondents represented a cross-section of the entire department, spanning the depth and breadth of the organization, thus establishing the research conditions from which to make results from the data that describe the whole department. The interviews were conducted over the course of a week with the primary goal of attaining the particular individual mechanisms that the respondent and organization use to inform each knowledge subsystem. Appendix G, Tab 1 provides an example of the form used to capture the mechanisms presented by each research participant along with their insights, comments, and observations concerning the mechanisms. This is the qualitative in-depth and rich information that provides a framework of understanding about the organization's knowledge system that cannot be obtained through the use of only quantitative data.

The next step in the construction process is to adequately transform the responses of the participants into a taxonomy of mechanisms and establish their relationship to the subsystems. The taxonomy is derived from the notes and interviews done by the researcher. The data reduction technique utilized was ordering of the participant responses (Miles and Huberman, 1994). However, for the taxonomy of mechanisms to

be accurate, they had to be affirmed by the organizational participants. The Accelerator Development Department's taxonomy has two levels. The upper-level is the principle mechanism that was tracked throughout the research study. A principle mechanism represents a grouping of sub-mechanisms or it can be a mechanism that is important enough to the organization to stand on its own. The sub-mechanisms under a particular principle mechanism (lower-level) are specific examples of information sources the research respondents use to inform a knowledge subsystem. When listing the mechanisms presented by the Accelerator Development Department, we see that the list is long and lacking meaningful structure (Figure 21). There are also many mechanism duplications between subsystems. The enormity of attempting to understand their knowledge system from this list becomes a daunting and potentially fruitless task. However, the taxonomy provides order, where oftentimes order has never been explicitly portrayed. Through the use of the taxonomy, the Accelerator Development Department was able to see their principle mechanisms, as well as determine which mechanisms span one or more knowledge subsystems.

Information Acquisition	Information Storage	Information Interpretation	Information Dissemination
Organization Internal	Internet	E-mail	Ad Hoc Meetings
Organization External	Technical Notes	Brainstorming	Face to Face Coordination
Rolodex	Electronic Logbooks	Reflective Thought	Formal Meetings
Formal Meetings	Document Control Office	Progress Reviews	Accelerator Logbook
Daily Accelerator Meeting	E-mail	Flowcharting	Software Logbook
Weekly Staff Meeting	Travelers	Schematic Process Diagrams	Maintenance Database
Software Group Meeting	Web Sites (JLAB, Manufacturers, Dept.)	Quantitative Analysis	Spare Parts Database
Weekly Engineering Meeting	Searches on specific subjects or projects		Free Electron Laser
Horizontal Test bed Meeting	Accelerator Logbook		Electronic Logbooks
Development Engineering Dept Meeting	Software Logbook		Publications
People/Experts	Maintenance Database		User Guides
Web Sites (JLAB, Manufacturers, Dept.)	Spare Parts Database		Design/Requirements Documents
Searches on specific subjects or projects	Free Electron Laser		Engineering Drawings
Ad Hoc Meetings	Personal/Individual Notebooks		Papers (journal, conference, workshop)
Face to Face Coordination	Computer Files (individual)		Briefings
Informal Meetings	Spreadsheets		Specification Development 12
E-mail	Text Files		Phone
Conferences/Workshops	Shared Folders		Memos
Travelers	Public Folders		Daily Accelerator Meeting
Internet	Digital Archive		Weekly Staff Meeting
Literature	Publications		Software Group Meeting
Journals	User Guides		Weekly Engineering Meeting
Trade Manuals	Design/Requirements Documents		Horizontal Test bed Meeting
Textbooks	Engineering Drawings		Development Engineering Dept Meeting
Administration Manual	Papers (journal, conference, workshop)		Informal Meetings
EH&S Manual	Briefings		E-mail
Conference Proceedings	Specification Development 12		Conferences/Workshops
Technical Notes	Personal/Individual Files (office hard copy)		Technical Notes
JLAB Library			
Training Assets			
University Courses			
Professional Exchange			
Seminars			
Vendor Training			
AVS Courses			
Professional Organizations/Societies			
Personal Experience			
Electronic Logbooks			
Accelerator Logbook			
Software Logbook			
Maintenance Database			
Spare Parts Database			
Free Electron Laser			
Document Control Office			

Figure 21. JLAB Accelerator Development Department Mechanism List

The researcher, based on interviews and the document review data, developed the initial taxonomy. By aggregating the participant responses, a clearer picture of the organization's knowledge system was established from each knowledge subsystem list of mechanisms (Figure 22). Miles and Huberman (1994) refer to this aggregation as clustering. Care was taken to ensure that mechanisms stressed by the organizational members were presented as principle mechanisms. For instance, under information acquisition, literature became the eighth principle mechanism, with various sub-

mechanisms. However, publication appears as the organization's seventeenth mechanism under information storage and information dissemination. This researcher could argue for combining these two mechanisms, and some research participants did actually argue this position. Through the discussion and collaboration process, the
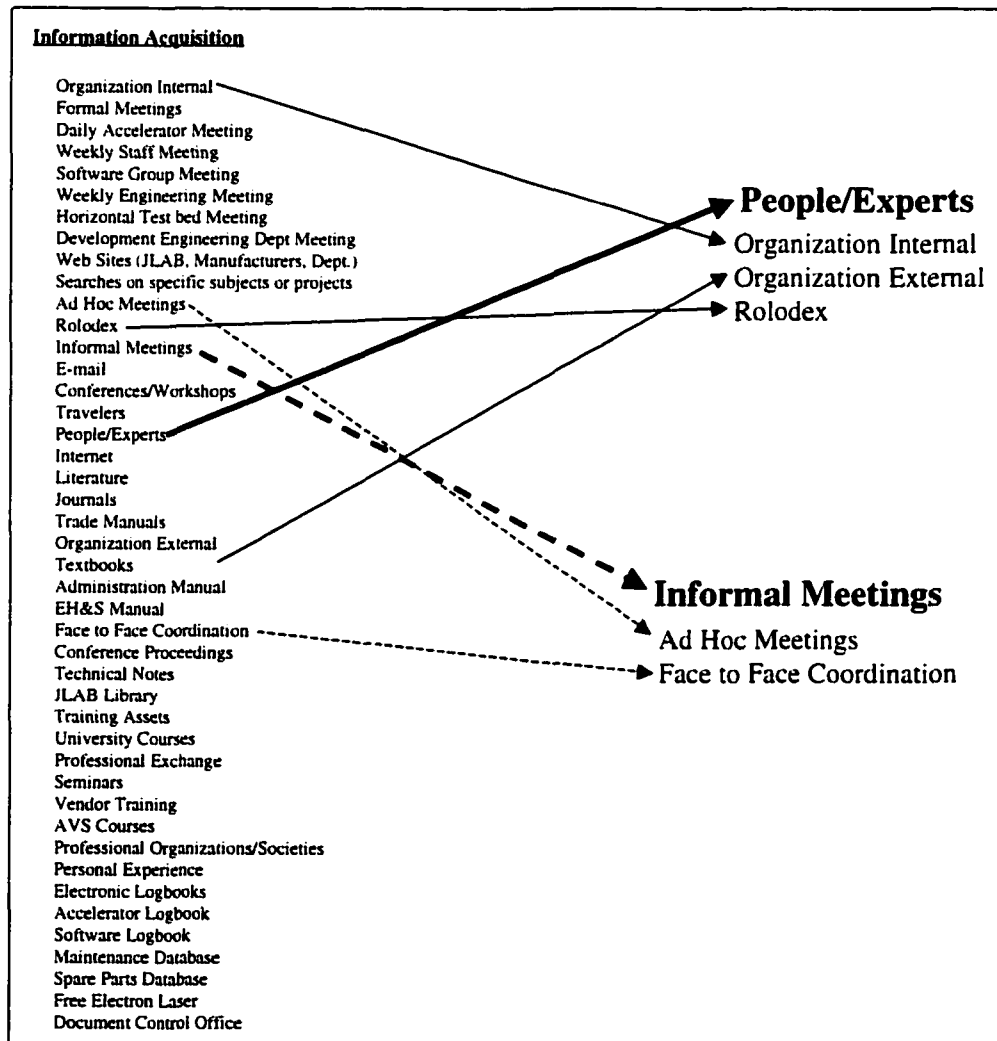
Figure 22. Taxonomy Development

Accelerator Development Department concluded that literature and publication were two distinct mechanisms uniquely informing their overall knowledge system. Similarly, the organization members challenged and refined other elements of the taxonomy, such as:

- adding briefings as a sub-mechanism of publications;

- adding the maintenance database, spare parts database, and free electron laser as sub-mechanisms of electronic logbooks;

- adding the weekly engineering meeting, development department and engineering department bi-weekly meeting, and horizontal test bed meeting as sub-mechanisms of formal meetings;

- adding shared folders, public folders, and digital archive as sub-mechanisms of computer files;

- deleting operations logbook as a sub-mechanism of electronic logbooks, because it and the accelerator logbook are the same;

- establishing that quantitative analysis as a principle mechanism under information interpretation;

- establishing a new information acquisition principle mechanism (Training Assets) that incorporates university courses, professional exchange, and seminars, then add vendor training, AVS courses, and professional organizations and societies as sub-mechanisms;

- indicating that the progress reviews are also conducted in the organization's formal meetings.

Through this collaborative process, the Accelerator Development Department was able to develop a collective organization knowledge system taxonomy (Figure 23). Thus, the organizational knowledge system methodology deployment took what was normally not known or understood in an organization and made it explicit at the organizational level.

Information Acquisition

M1: Informal Meetings

Ad Hoc Meetings
Face to Face Coordination

M2: Formal Meetings

Daily Accelerator Meeting
Weekly Staff Meeting
Software Group Meeting
Weekly Engineering Meeting
Horizontal Test Bed Meeting
Development Engineering Dept Meeting

M3: People/Experts

Organization Internal
Organization External
Rolodex

M4: E-mail

M5: Conferences/Workshops

M6: Travelers

M7: Internet

Web Sites (JLAB, Manufacturers, Dept.)
Searches on specific subjects or projects

M8: Literature

Journals
Trade Manuals
Textbooks
Administration Manual
JLAB Manual
Conference Proceedings

M9: Technical Notes

M10: JLAB Library

M11: Training Assets

University Courses
Professional Exchange
Seminars
Vendor Training
AVS Courses
Professional Organization Sessions

M12: Personal Experience

M13: Electronic Logbooks

Accelerator Logbook
Software Logbook
Maintenance Database
Spare Parts Database
Free Electron Laser

M14: Document Control Office

Information Storage

M4: E-mail

M6: Travelers

M7: Internet

Web Sites (JLAB, Manufacturers, Dept.)
Searches on specific subjects or projects

M9: Technical Notes

M13: Electronic Logbooks

Accelerator Logbook
Software Logbook
Maintenance Database
Spare Parts Database
Free Electron Laser

M14: Document Control Office

M15: Personal/Individual Notebooks

M16: Computer Files (individual)

Spreadsheets
Text Files
Shared Folders
Public Folders
Digital Archive

M17: Publications

User Guides
Design Requirements Documents
Engineering Drawings
Papers (journal, conference, workshop)
Briefings

M18: Specification Development 12

M19: Personal/Individual Files (office hard copy)

Information Interpretation

M4: E-mail *Collaborative Internet*

M20: Brainstorming *Informal Formal Meetings Conferences Workshops*

M21: Reflective Thought

M22: Progress Reviews *Informal Formal Meetings*

M23: Flowcharting *Informal Meetings*

M24: Schematic Process Diagrams *Informal Meetings*

M25: Quantitative Analysis *Informal Meetings*

Information Dissemination

M1: Informal Meetings

Ad Hoc Meetings
Face to Face Coordination

M2: Formal Meetings

Daily Accelerator Meeting
Weekly Staff Meeting
Software Group Meeting
Weekly Engineering Meeting
Horizontal Test Bed Meeting
Development Engineering Dept Meeting

M4: E-mail

M5: Conferences/Workshops

M9: Technical Notes

M13: Electronic Logbooks

Accelerator Logbook
Software Logbook
Maintenance Database
Spare Parts Database
Free Electron Laser

M17: Publications

User Guides
Design Requirements Documents
Engineering Drawings
Papers (journal, conference, workshop)
Briefings

M18: Specification Development 12

M26: Phone

M27: Memos

Figure 23. Accelerator Development Department KS Taxonomy

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The taxonomy then leads to the construction of the organization's knowledge system (Figure 24). The department's constructed knowledge system displays the mechanisms and knowledge subsystem relational links. These links were established based on the data from the semi-structured interviews. In the same collaborative nature as the knowledge system taxonomy, the knowledge system construction was refined and validated by the organization. The modifications included:

- establishing a relationship between electronic logbooks and the information dissemination knowledge subsystem;

- establishing a relationship between internet and the information dissemination knowledge subsystem;

- identifying that the document control office is also an information acquisition mechanism;

- understanding that formal meetings link to information interpretation through the organization's interpretive process in the same manner as informal meetings.

By addressing each knowledge subsystem independently, the methodology takes each individual organization member's tacit knowledge into account. Thereby, the resultant construction provides a depiction of the organization's knowledge system explicitly.

When looking at the Accelerator Development Department's taxonomy of the four knowledge subsystems and their associated mechanisms, one sees an extremely robust knowledge system. There are a requisite number of principle mechanisms within each knowledge subsystem, with many having supporting sub-mechanisms. However, the graphical knowledge system construction provides a richer analysis perspective. First, there are eleven mechanisms that span more than one knowledge subsystem out of 27 total principle mechanisms. This is less than 50%. Further stratification of the spanning
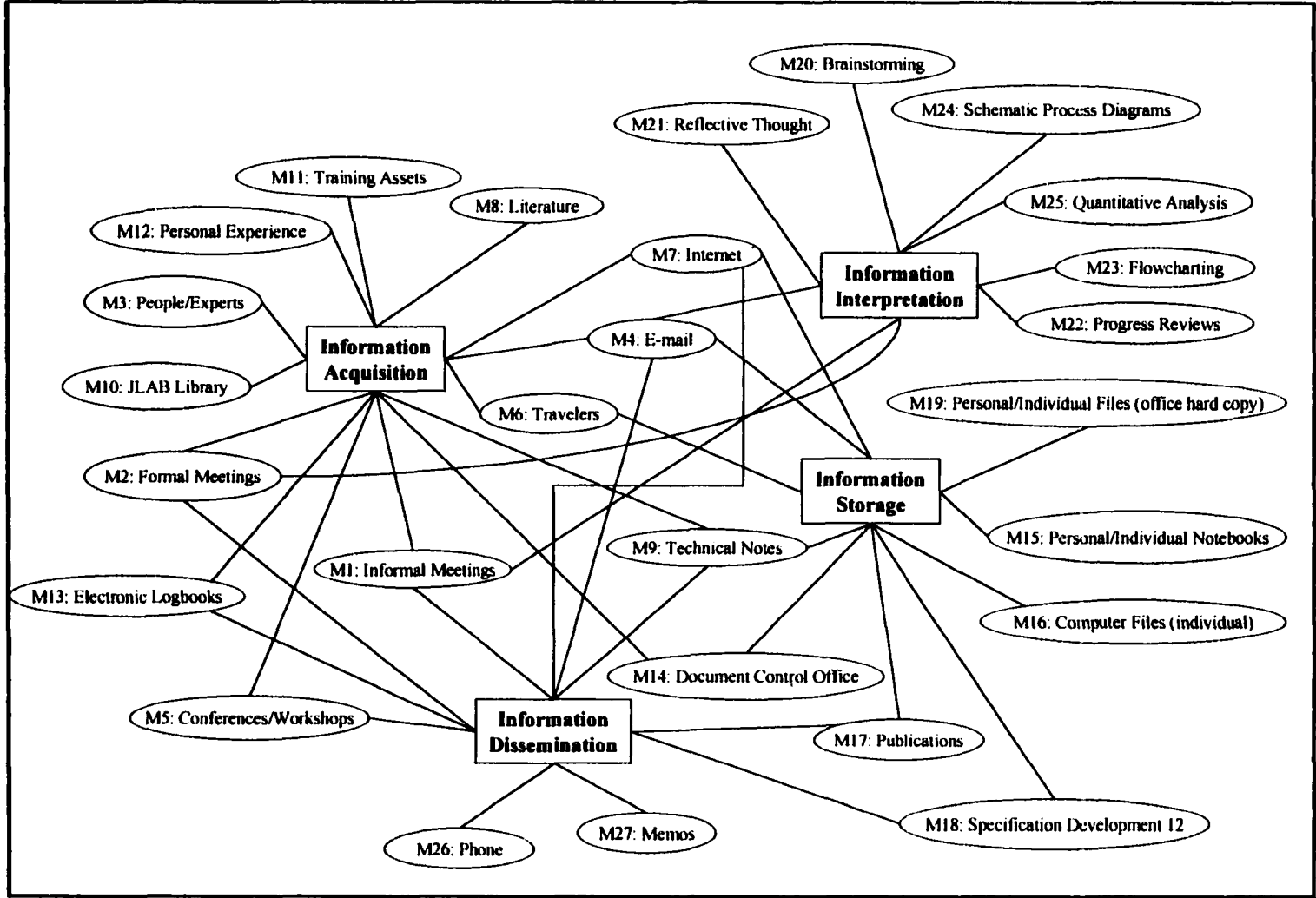
Figure 24. Accelerator Development Department KS Construction

mechanisms show that only one mechanism, e-mail, interconnects with all the knowledge subsystems. From the remaining ten, six interconnect (electronic logbooks, travelers, specification development 12, document control office, conferences/workshops, and publications) with two knowledge subsystems and four mechanisms interconnect (technical notes, informal meetings, formal meetings, and internet) with three knowledge subsystems. Correspondingly, the remaining mechanisms only interconnect with one knowledge subsystem. Further graphical analysis indicates that only one mechanism with multiple interconnections to knowledge subsystems, e-mail, is associated with the organization's information interpretive processes. The development of the information interpretation knowledge subsystem tells us that the organization's interpretive mechanisms and processes are where information is transformed into knowledge. An organization's knowledge creation, knowledge modification, and knowledge confirmation are rooted in its interpretive processes (Daft and Weick, 1984; Nonaka, 1991). What's more, all of the organization's storage mechanisms are individual or personal in nature or are external to the Accelerator Development Department except one, specification development 12. Specification development 12 is the only organizationally designated information storage repository, and from the interviews, is not widely used or highly regarded by the organization. "I stopped using it [specification development 12] because there wasn't enough contribution to it" (Respondent mn5wg4). This issue accentuated the need for a comprehensive information and database repository. The organization saw this deficiency and has begun the planning and initial development stages of a new repository.

Thus far, the methodology has constructed the Accelerator Development Department's knowledge system, from which it was possible to conduct a graphical analysis of the construction. The next phase of the research was a more detailed analysis through which the organization completes the system focused survey and the quantitative and qualitative data can be triangulated to produce the organization's knowledge system representation. However, the knowledge system construction continues, but with a new organization.
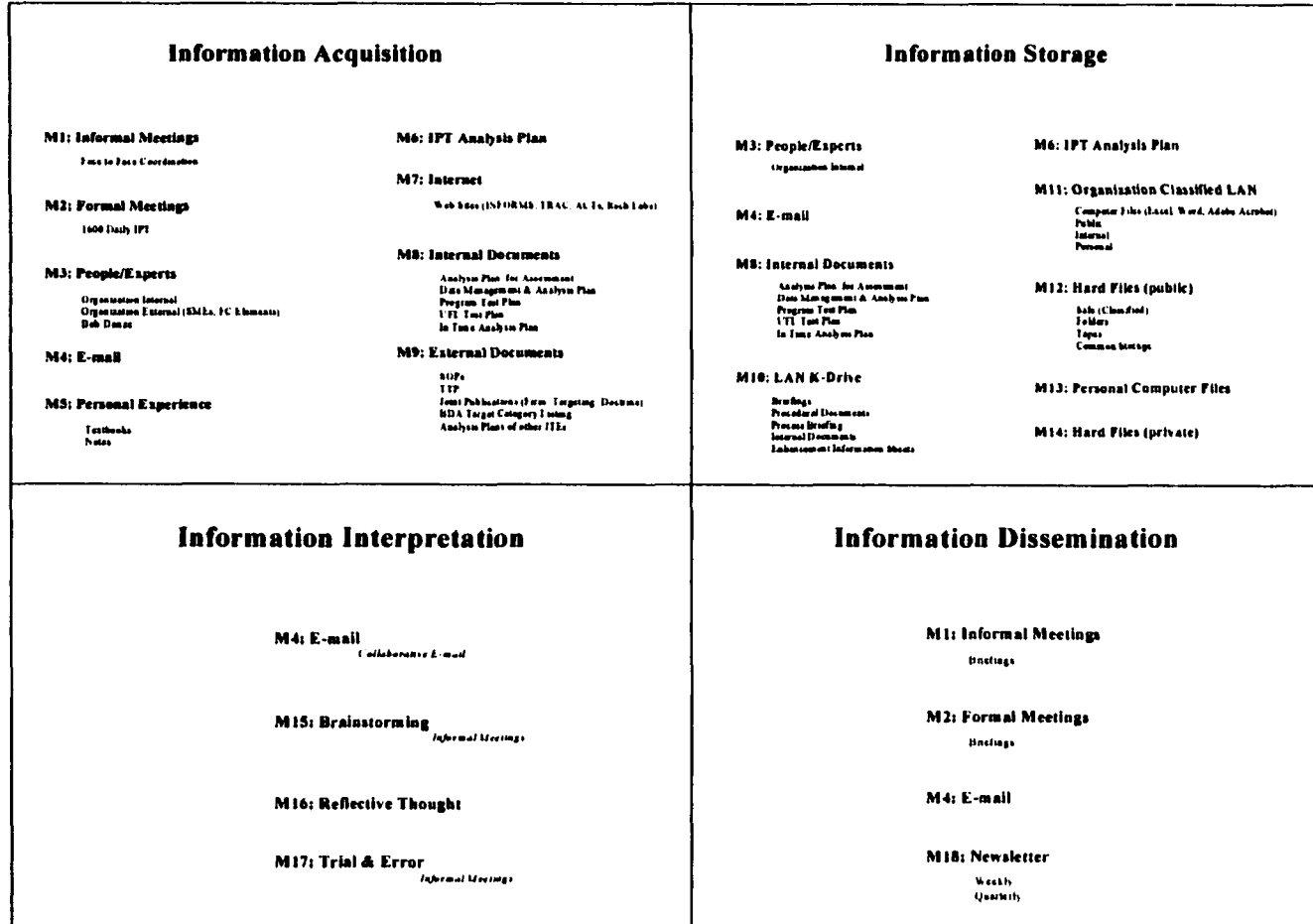
Analysis and Baseline Development IPT

The knowledge system construction process was successful at accomplishing its purpose when deployed on the Accelerator Development Department of Jefferson Labs. However, since the organizational knowledge system methodology was designed to construct and represent an organization's knowledge system. it was important to apply the development to more than a single organizational work system. For this reason, the research was implemented on the Analysis and Baseline Development IPT to further demonstrate the application of the methodology.

The construction process begins in the same fashion as the Accelerator Development Department. A meeting was held with the Joint Warfighter (JWF) leadership to outline the research purpose, its scope and benefits, and agree upon the system in focus. Once the system in focus was established, a comprehensive and detailed briefing was administered to the research participants. This briefing was followed by the researcher conducting independent document reviews and semi-structured interviews with each IPT member (see APPENDICES C, D, and G).

The document review found many documents that the IPT uses as mechanisms to inform their knowledge system. However, only one document, the IPT data analysis plan, specifically impacts the functioning of the IPT. "It's an informational document that I go to figure out my direction and my objective' (Respondent, hd3na5). Other program documents like the analysis plan for assessment, data management and analysis plan, and the program test plan are all focused on the mission, goals, and objectives of the larger JWF organization. However, like the Accelerator Development Department, these higher level documents and policy guidance do affect the JWF Analysis and Baseline Development IPT and are important mechanisms. Still, it is important to note that the IPT is a temporary organizational entity. Although none of the IPT members could say how long their team would exist, they made it clear that their existence was temporal. The temporal quality of the IPT does have an impact on the types of documents and policy guidance developed to influence the IPT's tasks and responsibilities. Ultimately, this affects their knowledge system.

The construction process continued with the semi-structured interviews. As noted earlier, the Analysis and Baseline Development IPT has four members, all of which participated in the research study. Because the four research participants represent the population of the IPT, conclusions can be made about the IPT from the collected data. The semi-structured interviews were conducted with the primary goal of eliciting the mechanisms used by the IPT members to inform their individual knowledge systems. A secondary goal of the interviews was to gather the richness of perspectives concerning the IPT's knowledge system mechanisms. The interview guides used to gather the mechanisms can be found in Appendix D.

At the completion of the interviews and document review processes, the task of building the taxonomy was next. Again, the initial building of the taxonomy falls to the researcher and was based on the data gathered in the construction process. The very important coordination and collaboration process between the researcher and the IPT serves the functions of refinement and confirmation, generating the taxonomy in Figure 25.

Figure 25. Analysis & Baseline Development IPT KS Taxonomy

As explained earlier, the taxonomy is derived from the list of mechanisms that the research participants identified in their interviews. The following explanation is provided to help the reader fully understand the collaborative effort undertaken by the researcher and the IPT to generate the taxonomy. The essence of the joint collaboration is rolled up into a detailed briefing and collaboration session. At this session each subsystem was presented independently. This was followed by the presentation of a principle mechanism and then each subsequent sub-mechanism, if applicable (Figure 26).
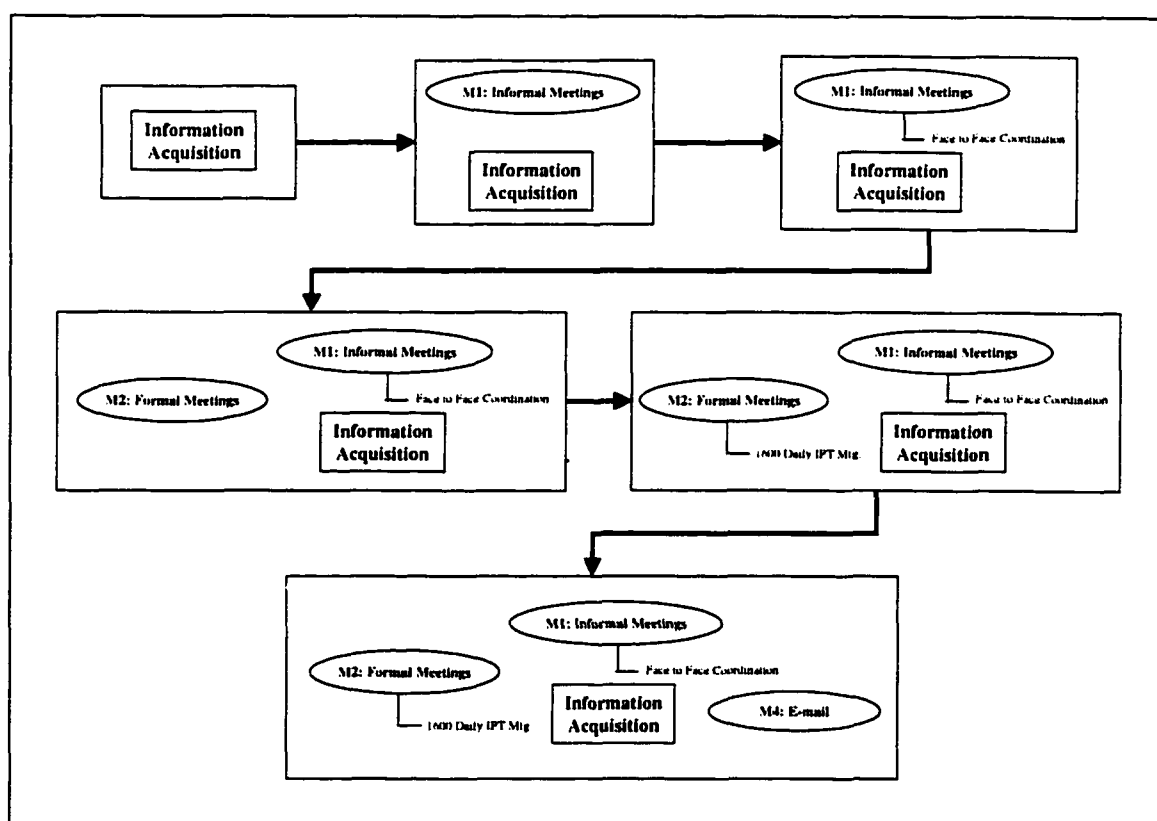
Figure 26. IPT Taxonomy Refinement and Confirmation

This presentation and collaborative forum allowed the discussion to focus on each knowledge subsystem and then guide the exchange of thoughts, ideas, and issues with respect to each particular principle mechanism and sub-mechanism. Once all the

mechanisms within a knowledge subsystem were presented, the discussion then turned toward addressing the subsystem in total. Through this procedure the taxonomy evolved to more accurately portray the IPT's knowledge system mechanisms within their proper context. This identical strategy and process was used in the Accelerator Development Department study of this research work. The following is the list of changes that resulted from the collaboration process:

- eliminate phone, mail, and intercom as principle mechanisms under information dissemination,

- eliminate textbooks as a principle mechanism and add it as a sub-mechanism of personal experience in the information acquisition knowledge subsystem,

- elevate IPT analysis plan from a sub-mechanism of internal documents to a stand alone principle document because of its importance to the IPT as an information acquisition source,

- add lead analyst as a specific sub-mechanism of people and experts, because of his position and the frequent and necessary interactions the IPT must have with this individual,

- add private hard files as a principle mechanism under information storage, and

- delete in-time analysis plan as a sub-mechanism of internal documents.

Once these changes were made to the Analysis and Baseline Development IPT's knowledge system taxonomy, the collaboration effort transitioned to their knowledge system construction. As part of the collaboration process to ensure that the IPT's knowledge system construction depicted their perspective, the following modifications were made:

- establish an interconnection between IPT analysis plan and the information storage knowledge subsystem,

- establish a relationship between people and experts with information interpretation -- this relationship is implicit in the same manner as informal meetings,

- establish an interconnection between internal documents and the information storage knowledge subsystem, and

- establish an interconnection between organization classified LAN and the information dissemination knowledge subsystem.

Thus, the resultant changes constructed the Analysis and Baseline Development IPT knowledge system (Figure 27).

Like the knowledge system construction for the Accelerator Development Department, the explicit knowledge system construction provides a richer analysis perspective. There are seven principle mechanisms that span more than one knowledge subsystem (formal meetings, informal meetings, internal documents, people/experts, e-mail, organization classified LAN, and IPT analysis plan). This is approximately a third of the total number of mechanisms for this organization. Further stratification of the spanning mechanisms show one mechanism, e-mail, interconnects with all the knowledge subsystems. From the remaining six, two (informal meetings and people/experts) interconnect with three knowledge subsystems and four principle mechanisms (formal meetings, internal documents, organization classified LAN, and IPT analysis plan) interconnect with two knowledge subsystems. The remaining eleven principle mechanisms only interconnect with one knowledge subsystem. Continued graphical
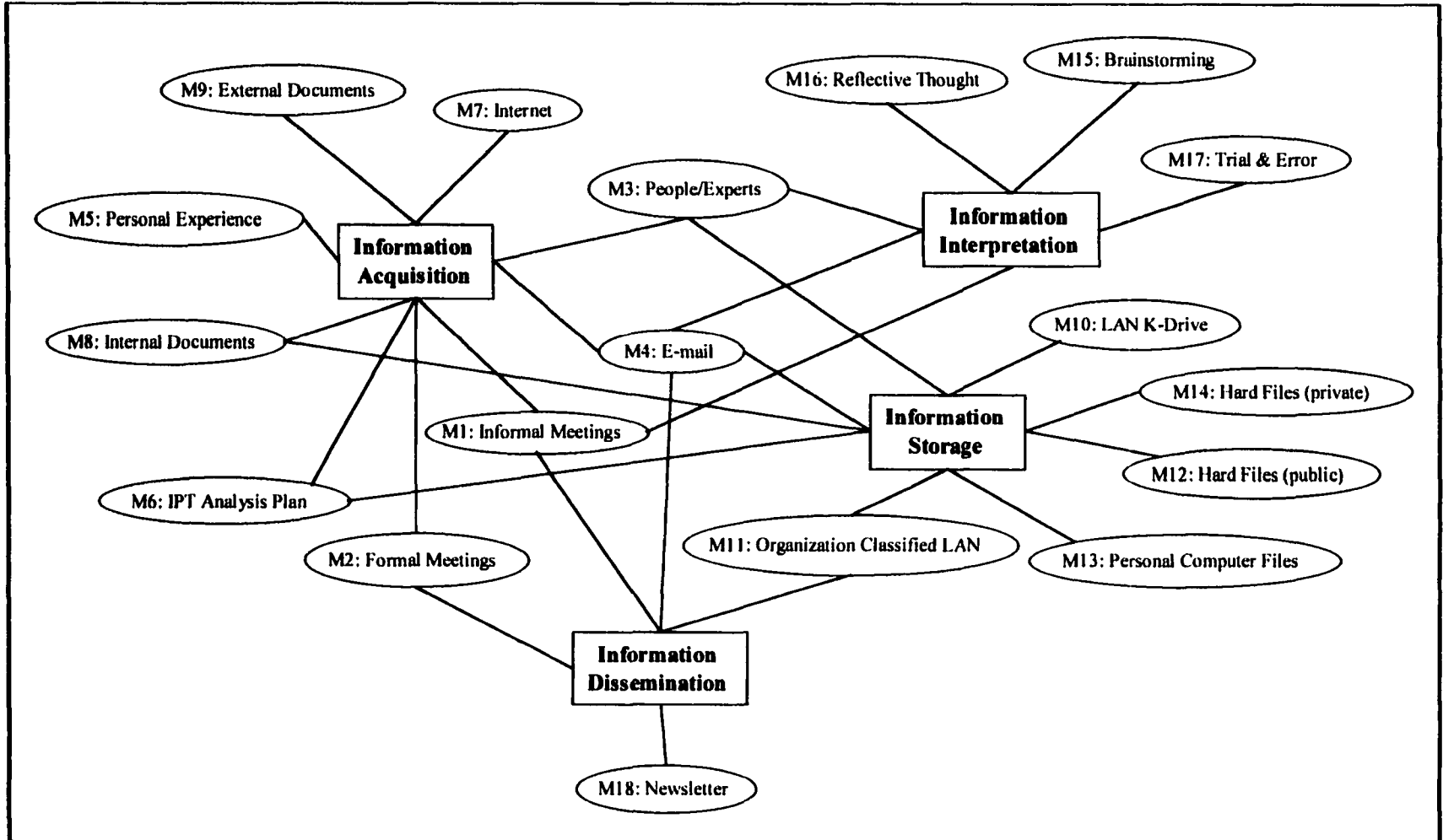
Figure 27. Analysis & Baseline Development IPT KS Construction

analysis shows two mechanisms (e-mail and people/experts) interconnecting with information interpretation also connecting with information storage. It suggests that as the IPT transforms information into knowledge, it is storing the knowledge as some form of information for use by the IPT and JWF organization. However, a closer inspection indicates that the two mechanisms, e-mail and people/experts, are not explicit information storage repository mechanisms. People and experts are tacit storage repositories. While e-mail can be an explicit information storage repository, the IPT members use it to store information important to them personally and access to their stored e-mail is not readily available to all. Additionally, two major forums where information interpretation happens, formal and informal meetings, are not linked to the organization's storage subsystem. One issue identified by the IPT lead analyst, which was conspicuous to say the least, was the absence of quantitative and qualitative analysis as interpretive tools for an IPT that is charged with analysis. This was an issue that each IPT member reinforced, and then pointed to the absence of a database as an information acquisition source and information storage repository. While their knowledge system does not have to include these mechanisms, it was suggested as a knowledge issue in the larger JWF organization.

SUMMARY OF KNOWLEDGE SYSTEM CONSTRUCTION

The application of the organizational knowledge system methodology for the construction phase of the research demonstrated the capability to construct each organization's knowledge system. Additionally, the confirmation of their respective constructed knowledge systems by the participating organizations adds credibility to the assertion that the OKSM was capable of constructing an organization's knowledge

system. It must be noted that changes to the organization's knowledge system taxonomy and construction were not automatic. Each issue raised was challenged to ensure that the constructed knowledge system captured the organization's perspective of their knowledge system. As important as it is to know that the research methodology and model are capable of constructing an organization's knowledge system, addressing the benefits of the process is also crucial. The application of the methodology and model demonstrated the uniqueness of each organization's knowledge system. This research study purposely avoids comparing and contrasting knowledge systems because (1) it is not part of the research focus and (2) each knowledge system is unique. Moreover, a comparison and contrast assumes that the corporate vision, mission, goals, objectives, and ultimately, work systems are immaterial to the make-up of each organization's knowledge system. The organizational knowledge system methodology implicitly incorporated organizational context through the identification of the unique mechanisms each organization uses in the construction of their knowledge system. It was critical to build this flexibility into the methodology and model from the beginning as research participants from each organization digressed to focusing on the differing perspectives of the vision and mission within their organization. The uniqueness of each organization's constructed knowledge system comes into play when one is able to see the different mechanisms and their relationship to the knowledge subsystems. The products generated through the construction process are: (1) a taxonomy of the organizational mechanisms, (2) the relationship of these mechanisms to the knowledge subsystems, and (3) a graphical depiction of the organization's knowledge system. The OKSM was capable of producing these products for both of the participating organizations.

The construction process provides only one aspect of the OKS. The second aspect is the representation. The next section develops the representation phase of the research results.

KNOWLEDGE SYSTEM REPRESENTATION

The knowledge system representation is the final phase in the research process. The representation process begins with the research participants completing the research survey. Continuity between the knowledge system construction and representation was achieved by maintaining the generated mechanisms and their relational links established in the construction phase of the organization's knowledge system. However, the knowledge system representation was dependent on the computerized survey supplying the quantitative data, which was triangulated with the qualitative data gathered during the construction phase. The completion of the computerized surveys ushered in the analysis and interpretation of all the collected data. Up to this point the research effort has been focused towards the representation of the organization's knowledge system.

At this time, one may discern why the mixed methodology design strategy was chosen for this research. The construction process was based on qualitative analysis. Now armed with substantive quantitative data, the knowledge system representation can be developed by jointly analyzing and interpreting the quantitative data within the qualitative contextual environment of the organization. The analysis and interpretation of qualitative and quantitative data provides a balance that is crucial to performing substantive analysis of the organizational knowledge systems. The quantitative and qualitative analysis methods performed in isolation would not have provided the robustness gained by a combination of both methods. The representation of the two

research organizations is based on the synergetic interplay of the quantitative and qualitative generated data.

Accelerator Development Department

The analysis and interpretation of the Jefferson Labs Accelerator Development Department indicated that the organization considered certain mechanisms to be more critical to their organizational knowledge system than others. Throughout this phase, the quantitative data was analyzed and then contextualized with the qualitative data to determine the essence of the organization's knowledge system. This is not to say that the quantitative data was incorrect, but merely to highlight that the joint analysis inherent in the mixed methodology design provided somewhat different results than would have been concluded by otherwise. The assessment process begins by analyzing the knowledge subsystems.

Information Acquisition

The analysis and interpretation begins by first evaluating the importance the organizational members place on the subsystems mechanisms. Table 9 provides a rank ordered list of the importance ranking of the information acquisition mechanisms. From the table, it is easy to determine that informal meetings, people/experts, literature, and personal experience are considered to be the most important mechanisms of the information acquisition subsystem from the organization's perspective.

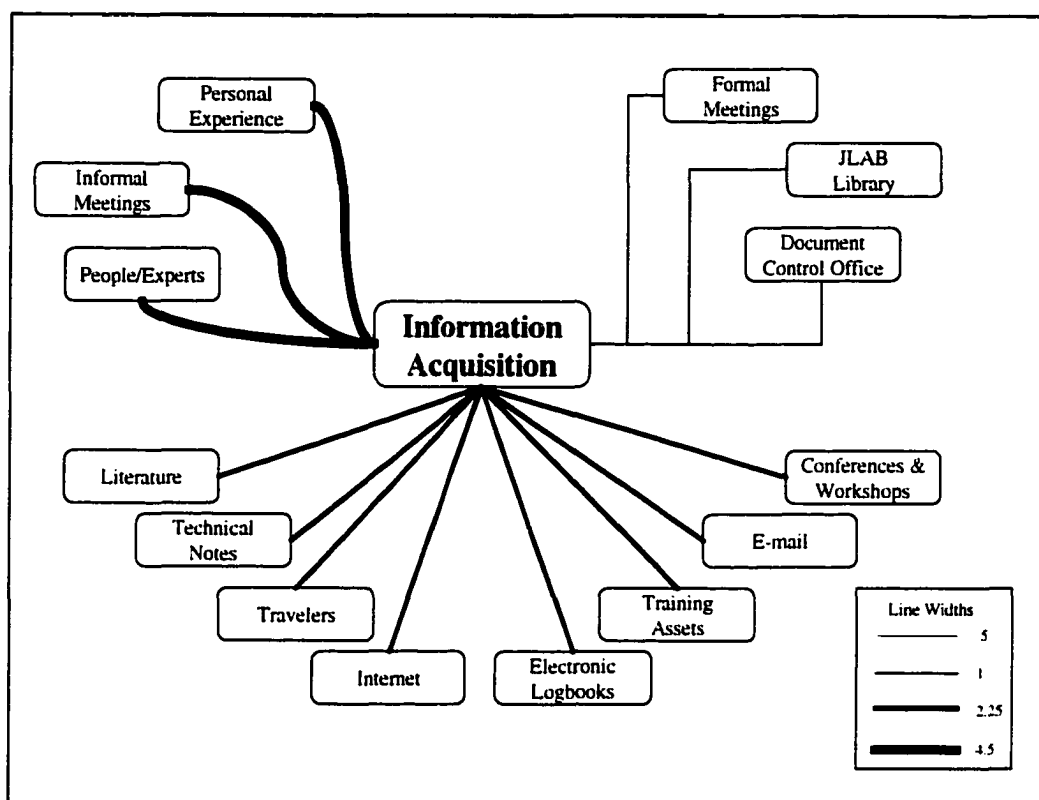| Mechanism	Importance Means
Personal Experience	6.50
Informal Meetings	6.30
People/Experts	6.30
Literature	6.20
Electronic Logbooks	5.60
E-mail	5.40
Conferences/Workshops	5.40
Internet	5.20
Technical Notes	5.20
Training Assets	5.20
Travelers	5.10
JLAB Library	4.90
Formal Meetings	4.50
Document Control Office	4.40

Table 9. IA Mechanism Importance

In like manner, each mechanism was evaluated for its effectiveness and access. Although these evaluations do not play a role in the organization's knowledge system representation, they do provide the organization substantive information concerning each mechanism. Further analysis that assesses the strength of the relationship between the mechanisms in the information acquisition subsystem shows that personal experience, informal meetings, people and experts, literature, technical notes, and conferences and workshops have the greatest relational links within the subsystem (Figure 28).
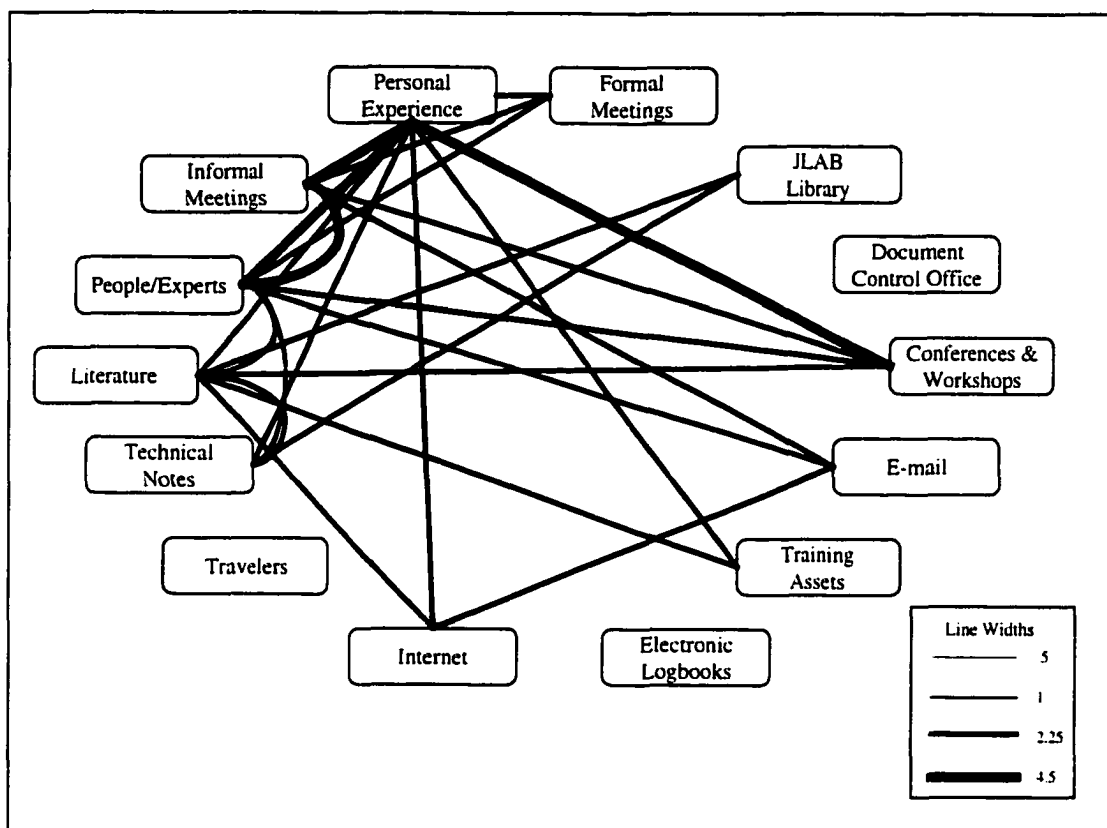
Figure 28. IA Mechanism Relationship

It must be remembered that there are relational links with all the mechanisms. However, the links displayed are limited to those relationships, which were evaluated by the research participants as moderately strong or strong (database provided in APPENDIX H). The mechanism-to-subsystem evaluation indicated that there was a strong relationship between the organization's information acquisition activity and personal experience, informal meetings, and people and experts mechanisms (Figure 29). In the mechanism-to-subsystem assessment, literature was rated as moderately strong and has extensive relational links when analyzed from the mechanism-to-mechanism perspective. Literature was a created principle mechanism that has as its sub-mechanisms journals, trade manuals, textbooks, conference proceedings, the environment health & safety

Figure 29. IA Mechanism-to-Subsystem Relationships

manual, and the administrative manual. It received a high rating for mechanism

importance. The assessment of this data in combination with the following research

participant quotes and themes:

- "people sources represent 80% of my information acquisition sources", Respondent PQ4DF4,

- collaboration within the organization is mainly informal,

- ad hoc meetings and face-to-face communication are important to organizational task accomplishment, and

- formal meetings not used or welcomed

developed a contextual picture where informal face-to-face communication is the preferred method of information acquisition in the Accelerator Development Department. Likewise, the theme of informal and personal collaboration as the means of information exchange is supported by the data. The quantitative analysis provided a set of mechanisms that were rated most important, had the greatest mechanism-to-mechanism relationships, and were evaluated to have the highest mechanism-to-information acquisition subsystem strength of relationships (Table 10).

Mechanism Importance	Mechanism Relationships	SS-Mech Relationships
Personal Experience	Personal Experience	Personal Experience
Informal Meetings	Informal Meetings	Informal Meetings
People/Experts	People/Experts	People/Experts
Literature	Literature	Literature
	Technical Notes	Technical Notes
	Conferences/Workshops	Conferences/Workshops

Table 10. IA Subsystem Synthesis

The qualitative analysis is the contextual filter from which to further analyze the results of the quantitative data. Using this contextual filter, the joint analysis of the two methods suggests that personal experience, informal meetings, people/experts, literature, conferences/workshops, and technical notes are all essential mechanisms to the Accelerator Development Department's information knowledge subsystem. The mixed methodology analysis suggests that the organization's information knowledge system is predominantly based on personal and informal means of acquiring information. The process of analysis presented above is repeated for the Accelerator Development Department's remaining knowledge subsystems, thereby building the organization's knowledge system representation.

Information Storage

As with information acquisition, the assessment of the Accelerator Development Department's information storage mechanism began by evaluating the importance the organizational members place on the subsystem's mechanisms. Table 11 provides a the list of the mechanisms the Accelerator Development Department

| Mechanism	Importance Means
Computer Files (individual)	6.20
Travelers	6.00
Technical Notes	6.00
Personal/Individual Notebooks	5.90
Publications	5.50
Electronic Logbooks	5.30
E-mail	5.10
Personal/Individual Files (office hard copy)	5.00
Internet	4.60
Specification Development 12	4.50
Document Control Office	4.30

Table 11. IS Mechanism Importance

rated were the most important to their information storage knowledge subsystem. From the table individual computer files, travelers, technical notes, and personal/individual notebooks, rise to the top as important in the information storage knowledge subsystem. The analysis of the mechanism-to-mechanism strength of relationship data (to view data refer to APENDIX H) indicated that there are but a few moderately strong links. This suggests that many of the organization's storage mechanisms (repositories) are disparate, stand-alone mechanisms. Thus, from the quantitative analysis, it is difficult to determine what the essential organizational storage mechanisms are. However, when contextualized using the qualitative data, a central theme identified by the research participants was that "tribal knowledge" is the organization's main information storage mechanism. Tribal knowledge refers to the collective understanding the organization has

developed over time, through experiences and interactions, to accomplish organizational tasks and responsibilities. The bulk of this knowledge and information is stored as conceptual information by the organization's members. Likewise, individual and personal storage mechanisms are used to file information deemed important, noteworthy, or essential to a particular organization member. The following participant comments and researcher observations help to better understand the context of the organization's storage knowledge subsystem.

- The organization relies too much on "soft" information (Respondent EF7PR4).

- Filing system is not good (Respondent JK2AD4).

- The organization does not capture knowledge well (Respondent MN5WG).

- There is no department-level storage mechanism (repository).

- Personal logbooks are kept, but information is not shared.

- Categorization of information is not adequate (Respondent VX3EG4).

- The updating of digital repositories is slow if done at all.

- Technical notes are not searchable; to be useful, one must have knowledge of what is there.

The data supports that individual computer files, personal/individual notebooks, personal/individual files, and publications are the principal storage mechanisms used by the Accelerator Development Department when assessing their mechanism-to-mechanism relationship (Figure 30). The assessment of the organization's information knowledge subsystem continues with the mechanism-to-subsystem relationships.
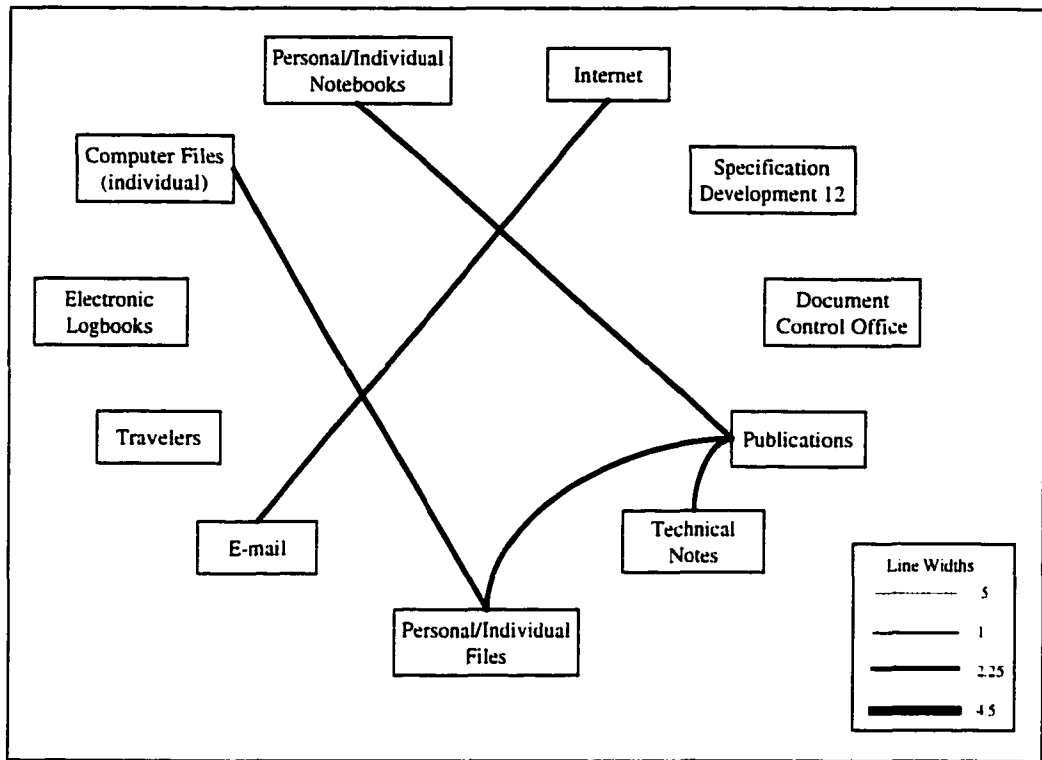
Figure 30. IS Mechanism Relationship

This assessment indicated that the organization members considered individual computer files and personal/individual notebooks as strongly linked to information storage (Figure 31). Publications, personal/individual files, technical notes, document control office, e-mail, electronic logbooks, and travelers were rated to have a moderately strong relationship. However, based on the qualitative contextualization for the information storage knowledge subsystem, the organizationally essential mechanisms within the
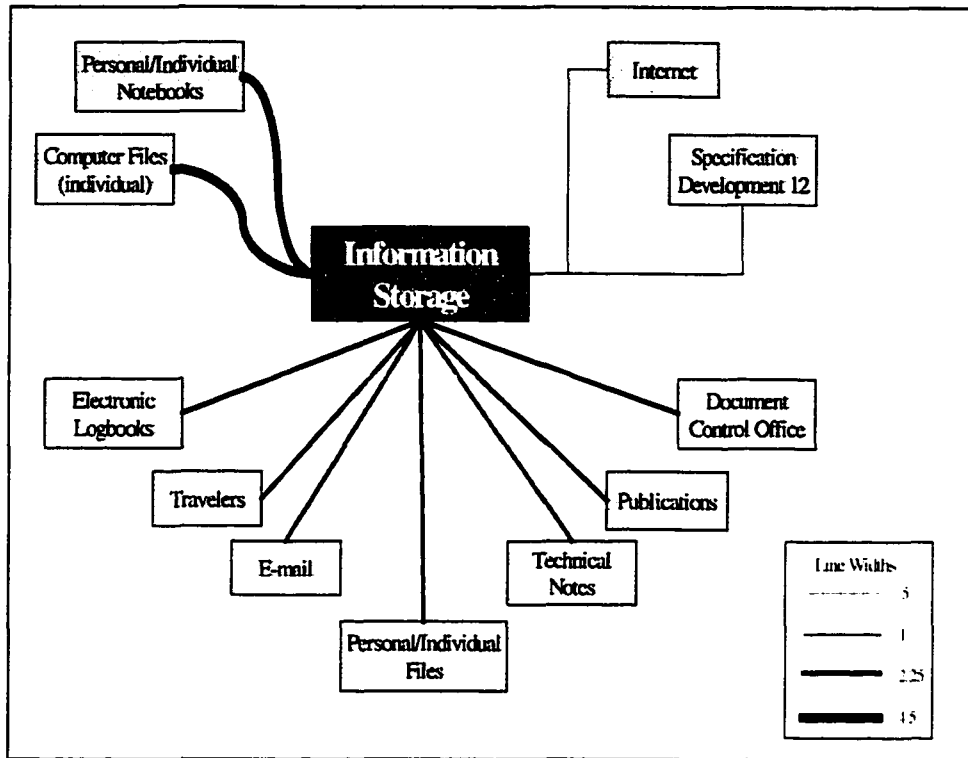
Figure 31. Mechanism-to-Subsystem Relationships

mechanism-to-subsystem relationships are computer files, personal/individual notebooks, publications, and personal/individual files. Table 12 provides the list of mechanisms that were evaluated to be essential to the Accelerator Development Department's information storage knowledge subsystem.

Mechanism Importance	Mechanism Relationships	SS-Mech Relationships
Computer Files	Computer Files	Computer Files
Per/Indiv Notebooks	Per/Indiv Notebooks	Per/Indiv Notebooks
Technical Notes	Publications	Publications
Travelers	Per/Individual Files	Per/Individual Files

Table 12 IS Subsystem Synthesis

An additional review of the qualitative data indicated that technical notes and travelers, although not considered essential in the relationship perspective of the information

storage knowledge subsystem, were obviously rated as important and are mentioned extensively by the research participants as storage mechanisms.

Information Interpretation

The analysis and interpretation continues with the evaluation of the mechanisms in the information interpretation knowledge subsystem. In Table 13, brainstorming, reflective thought, and quantitative analysis represent the most important interpretive mechanisms for the Accelerator Development Department.

| Mechanism	Importance Means
Reflective Thought	6.20
Quantitative Analysis	5.90
Brainstorming	5.80
Progress Reviews	5.10
Flowcharting	4.70
Schematic Process Diagrams	4.70
E-mail	4.50

Table 13. II Mechanism Importance

Within this knowledge subsystem the dominant contextual theme for the organization was that it relied heavily on individual and personal interpretation of information. Researcher observations of the interpretation knowledge subsystem are as follows:

- no formal organization interpretive process,

- no organizationally established information interpretation media, and

- the organization depends on individual interpretation to augment the lack of an organizational interpretive process.

The researcher's perception from the interviews was that the organization had never taken into consideration that they could manage or influence the way the organization interprets information. Although quantitative analysis appears as an organizational interpretive

process it was not mentioned in any of the interviews. During the organization and researcher collaboration of the Accelerator Development Department's knowledge system construction it was identified by the researcher that the organization's interpretive mechanisms were mainly individual and personal. It was here that quantitative analysis was introduced as an information interpretation mechanism and strongly agreed to by the rest of the research participants. However, when analyzing the qualitative data for the information interpretation knowledge subsystem with the mechanism-to-mechanism relationships (refer to APPENDIX H for data) and the mechanism-to-subsystem relationships (Figures 32 and 33, respectively), the data indicated that brainstorming, reflective thought, and quantitative analysis represent the organization's key information interpretation mechanisms.
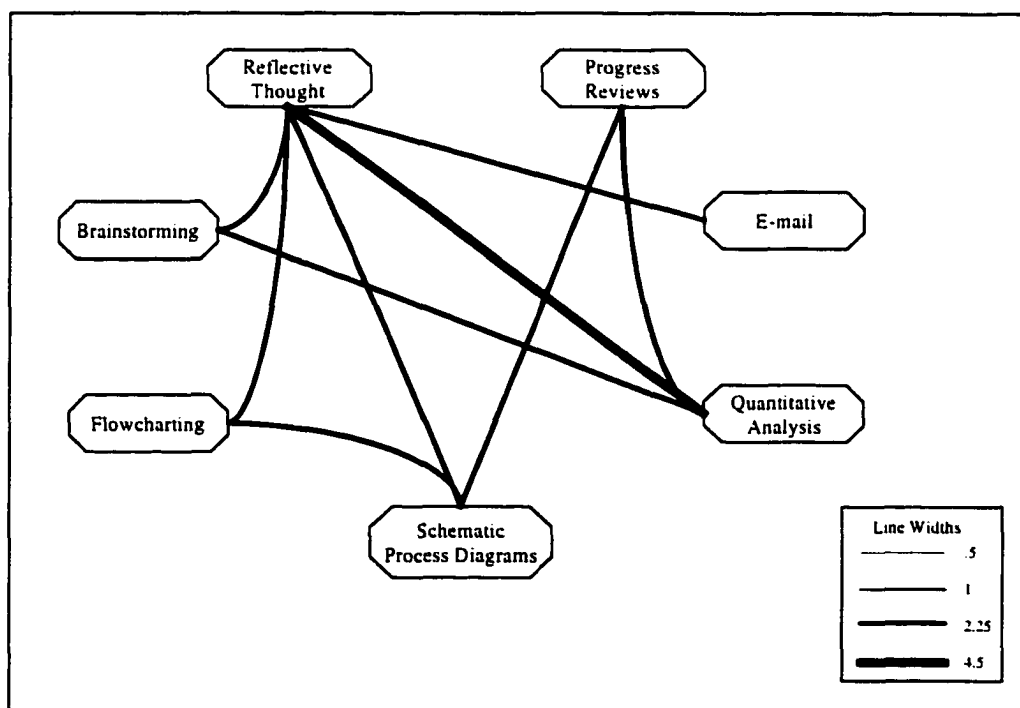
Figure 32. II Mechanism Relationship
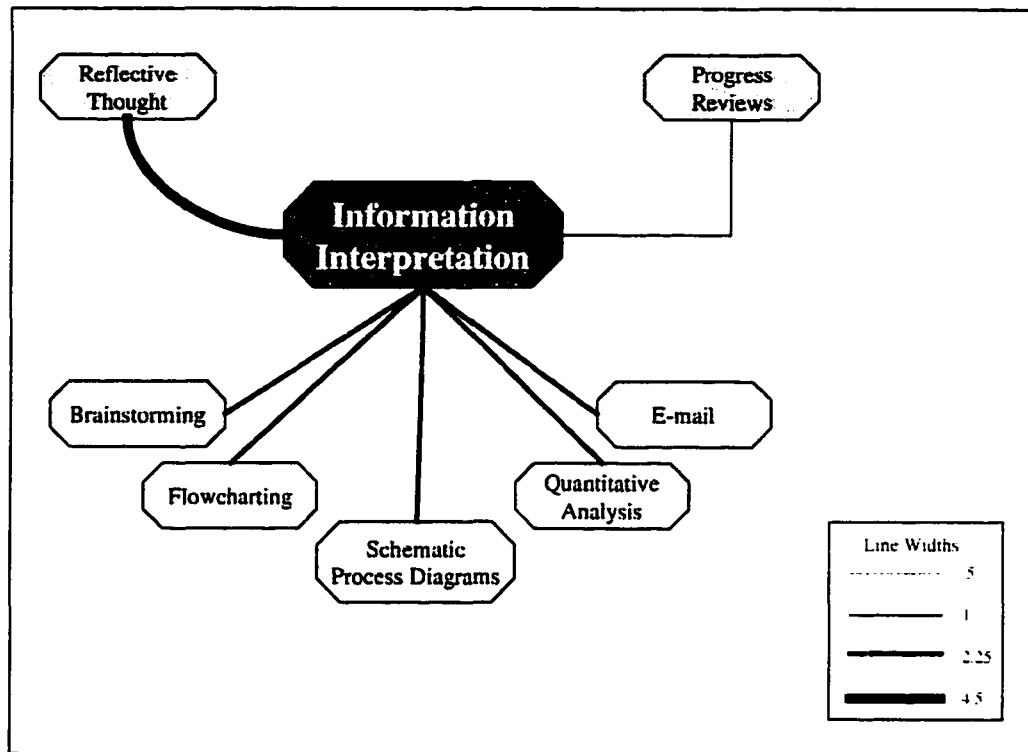
Figure 33.   Mechanism-to-Subsystem Relationships

The qualitative data supports the conclusion that brainstorming and reflective thought are the organization's primary interpretive mechanisms. The dependence on individual and personal knowledge and information, as well as a lack of an established department-level interpretive processes or mediums, inferred that information interpretation is mainly an informal activity. However, experimentation is a major function of the Accelerator Development Department. Therefore, logically it is consistent to add quantitative analysis as an interpretive mechanism to this knowledge subsystem. Consequently, Table 14 identifies the key and essential mechanisms which comprise the organization's information interpretation activity.

Mechanism Importance	Mechanism Relationships	SS-Mech Relationships
Reflective Thought Brainstorming Quantitative Analysis	Reflective Thought Brainstorming Quantitative Analysis	Reflective Thought Brainstorming Quantitative Analysis

Table 14. II Subsystem Synthesis

Up to this point, the organizational knowledge system methodology has identified the Accelerator Development Department's essential knowledge system mechanisms. This was, in a large part, accomplished by using the mixed methodology analysis. The representation process continues with the information dissemination knowledge subsystem and then provides the organization's knowledge system representation.
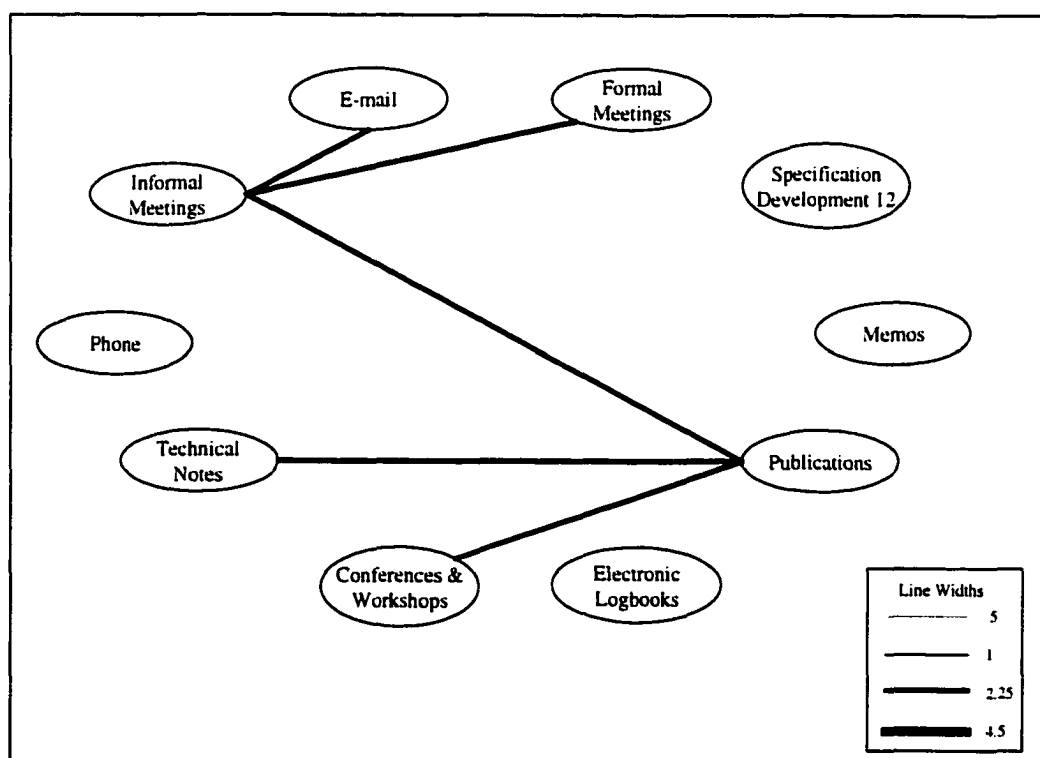
Information Dissemination

The last subsystem to analyze was information interpretation. Analysis of the Table 15 indicated that informal meetings, e-mail, and technical notes rank as the most highly thought of information dissemination mechanisms from a collective organization standpoint.

Mechanism	Importance Means
Informal Meetings	6.00
E-mail	5.80
Technical Notes	5.60
Phone	5.40
Electronic Logbooks	5.20
Conference/Workshops	5.10
Publications	4.60
Specification Development 12	4.60
Formal Meetings	4.40
Memos	3.70

**Table 15. ID Mechanism Importance**

Further analysis of this subsystem showed that informal meetings and publications represent the most interconnected mechanisms (Figure 34) (refer to APPENDIX H for data). Again, it must be remembered that there are relational links with all the mechanisms. However, the links displayed were limited to those relationships which were rated as moderately strong or strong. The final analysis showed that the organization's strength of relationship ratings between the mechanisms and the knowledge subsystem indicated a strong relationship between the organization's

Figure 34. ID Mechanism Relationship (refer to APPENDIX H for data)

information dissemination activity and the e-mail and informal meetings mechanisms (Figure 35). Likewise, publications, phone, electronic logbook, conferences/workshops, and technical notes are rated as having moderately strong links to this knowledge

subsystem. Interpreting the quantitative analysis with respect to the qualitative

contextual data provided the key mechanisms that comprise the organization's

information dissemination knowledge subsystem. This is supported based on the already
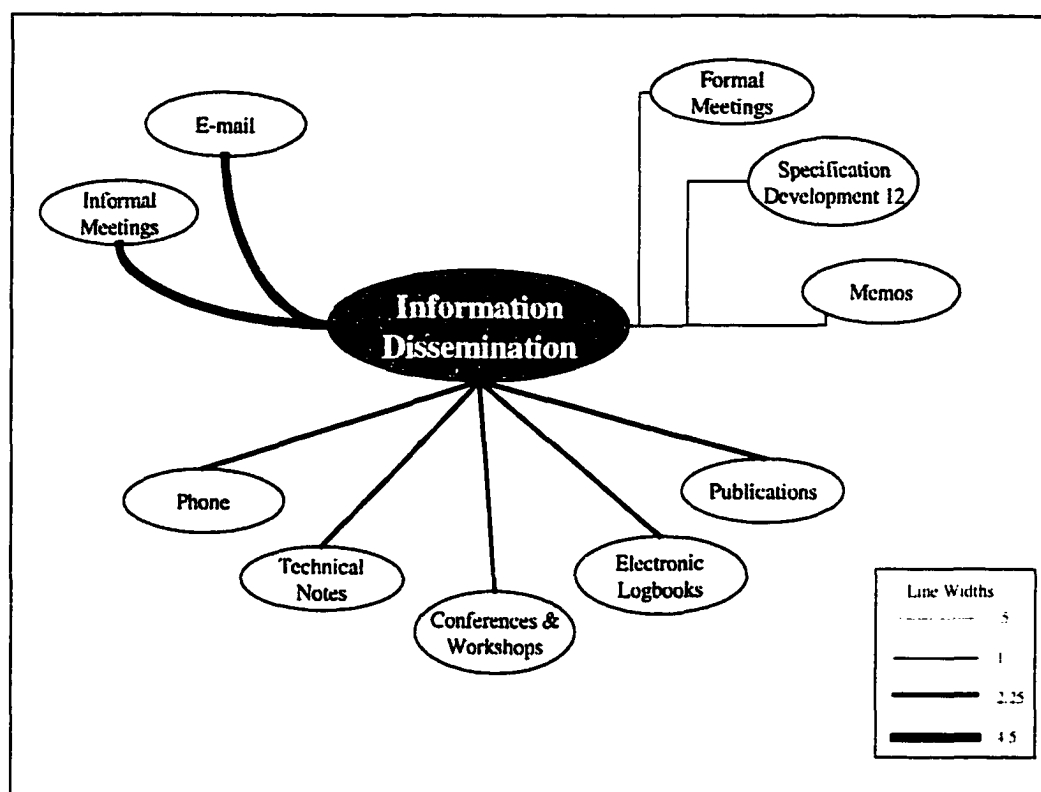
Figure 35. Mechanism-to-Subsystem Relationships

presented qualitative analysis, as well as the following themes which emerged from the

qualitative data analysis:

- formal dissemination mechanisms are cumbersome and are not perceived to be useful

- information dissemination is accomplished predominantly by organizational participants going out and finding the required information

As before, the data supports the perspective that technical notes is a mechanism that was

discussed by all the research participants in a favorable manner. Thus, Table 16 lists the

key mechanisms that comprise the Accelerator Development Department's information dissemination knowledge subsystem.

Mechanism Importance E-mail Informal Meetings Technical Notes	Mechanism Relationships Informal Meetings Publications	SS-Mech Relationships E-mail Informal Meetings Publications Technical Notes

Table 16. ID Subsystem Synthesis

After the analysis and interpretation of the qualitative and quantitative data, what remained to be built was the Accelerator Development Department's knowledge system representation. This representation (Figure 36) provides the organization with a visual perspective of their current organizational knowledge system. It is different from the constructed knowledge system because the representation is composed of the essential mechanisms the organization relies on to create knowledge. This was due to the organizational knowledge system methodology using the mixed methodology analysis to interpret the organizational quantitative data within the context of its environment. Thus the representation is supported by qualitative, as well as quantitative data.

In general, the representation appears to be robust. However, closer inspection reveals that a significant amount of information is stored in personal and/or individual type mechanisms. This information is shared only through publications, informal meetings, and technical notes. The qualitative data indicates that publications generated by Accelerator Development Department members are not readily known to the rest of the department personnel. Likewise, the previously mentioned storage issue was recognized by the organization and steps were being taken to correct it. However, even
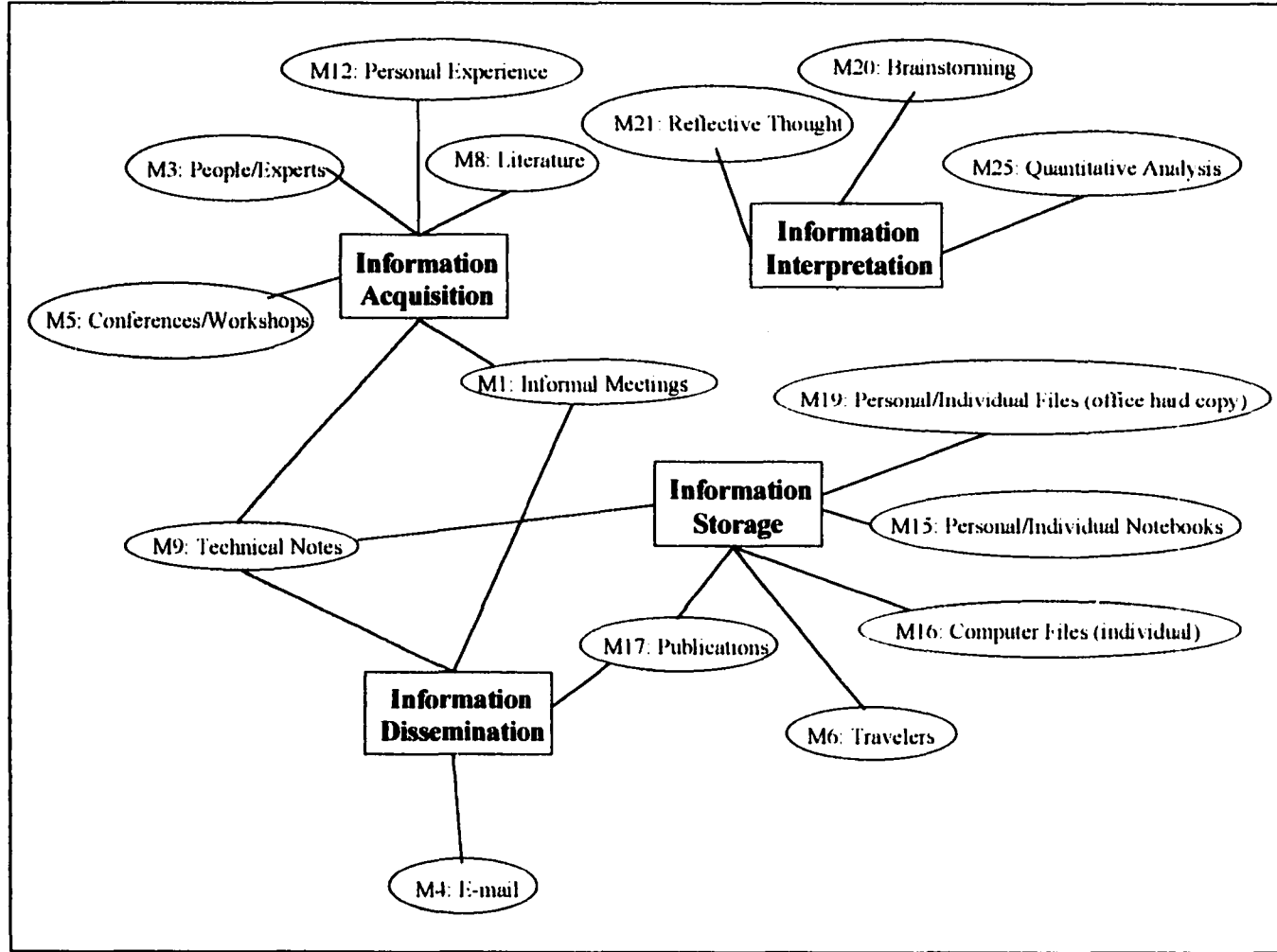
Figure 36. Accelerator Development Department Knowledge System Representation

though the storage issue was recognized the OKS methodology was able to ascertain the same issue. What the methodology was able to add to the organization's storage issue perspective was an explanation of why the problem exists. The contextual analysis provided by the qualitative data discloses an organization culture that relies heavily on personal relationships. The Accelerator Development Department's culture strongly leans toward an informal and loosely structured work-system environment. Standard operating procedures, policy guidance, and information and data storage repositories are limited or not developed to govern the Accelerator Development Department. The organization can be described by the following characteristics supported by the qualitative and quantitative data:

- Self-organized Knowledge System

- "Tribal Knowledge" represents a major form of information storage

- Informal/Ad hoc coordination is the preferred method of Information exchange

- Information Exchange is primarily a pull activity
  - right question must be asked
  - correct source must be ascertained
  - viscosity of information flow is moderate to high

The organizational knowledge system methodology constructed and represented the Accelerator Development Department's knowledge system. The representation is quite different from the Accelerator Development Department's knowledge system construction. This is due to the organizational knowledge system methodology's employment of the mixed methodology analysis. The representation of the organization's knowledge system is developed within the contextual environment of the organization. This is important as it takes into consideration the socialized work environment which

exists in all human organizations. Although the OKSM has constructed and represented an organization's knowledge system, the robustness of the methodology will be demonstrated as the OKSM is applied to the Analysis and Baseline Development IPT.

Analysis & Baseline Development IPT

Like the Accelerator Development Department, the Analysis and Baseline Development IPT's knowledge system was represented using the organizational knowledge system methodology. Throughout this phase, the quantitative data was analyzed and then contextualized with the qualitative data. Again, this is not to say that the quantitative data was incorrect, but is meant to highlight that the mixed methodology design provides a somewhat different conclusion or set of results than either analysis method independently. The representation development began with the organization's information acquisition knowledge subsystem.
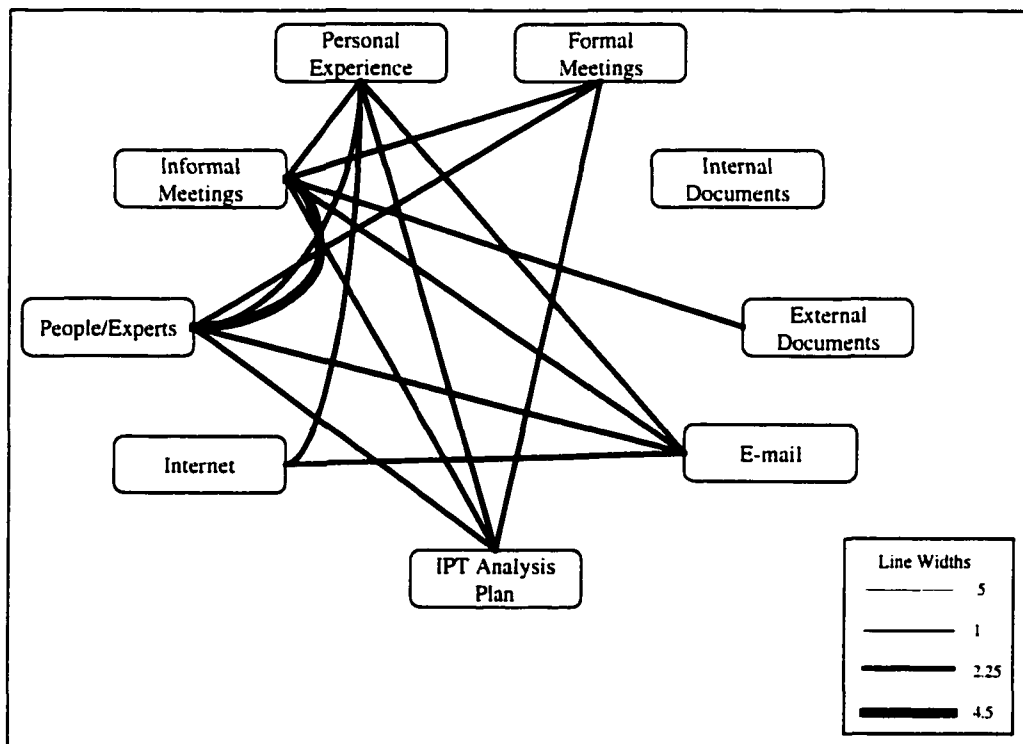
Information Acquisition

The analysis and interpretation of the information acquisition mechanism importance started the representation process of the IPT's knowledge system. Table 17 provides a list of mechanisms the Analysis and Baseline Development IPT identified as the most important. From the table, informal meetings, people/experts, personal

Mechanism	Importance Means
Personal Experience	6.50
Informal Meetings	6.00
People/Experts	5.75
IPT Analysis Plan	5.75
Formal Meetings	5.50
Internet	5.50
E-mail	5.25
Internal Documents	5.25
External Documents	5.25

**Table 17. IPT IA Mechanism Importance**

experience, and the IPT analysis plan were the most highly rated information acquisition mechanisms from the organization's perspective. The analysis of the strength of the relationship between the mechanisms in the information acquisition subsystem showed that personal experience, informal meetings, people/experts, the IPT analysis plan, e-mail, and formal meetings had the greatest number of relationship links (Figure 37) (refer to APPENDIX H, Tab 2 for data). However, it must be remembered that there are relational links with all the mechanisms. The links displayed are limited to those relationships which are judged as moderately strong or strong.

Figure 37. IPT IA Mechanism Relationship

The third analysis perspective indicated that there was a strong relationship between the organization's information acquisition activity and the personal experience, informal meetings, and people/experts mechanisms (Figure 38). All other mechanisms in the

information acquisition subsystem were rated as having moderately strong relationships. The contextualization of the interpretation is accomplished by triangulating both the qualitative and quantitative data. This helps to impart more substantive meaning to the quantitative data by putting it in the context of the Analysis and Baseline Development IPT's environment.
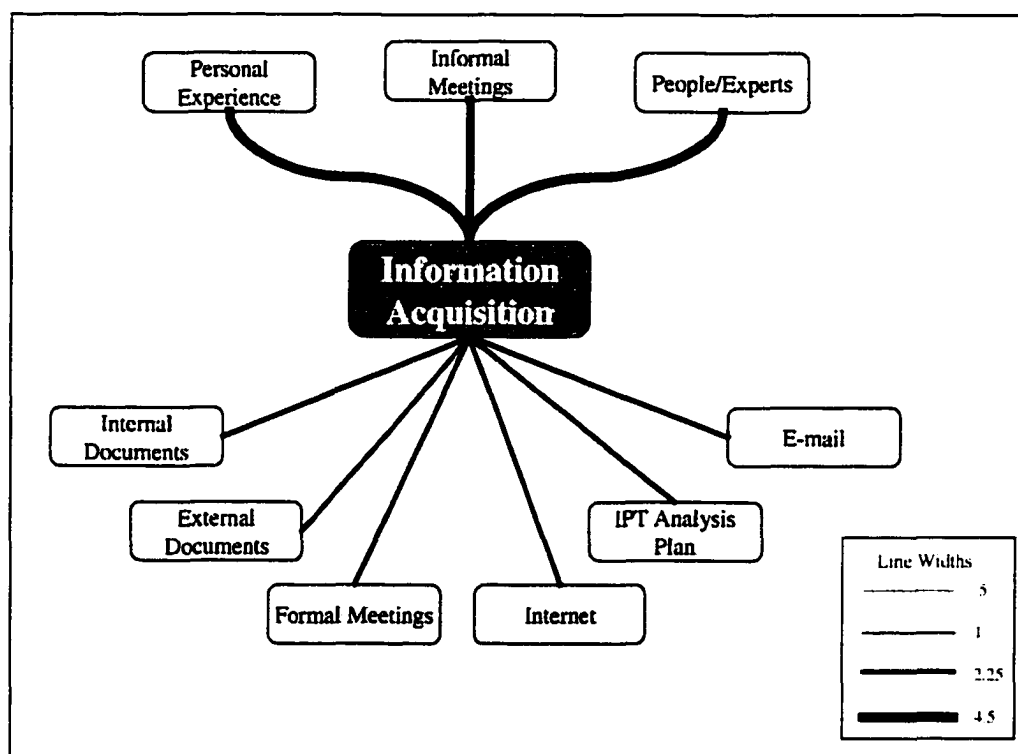
Figure 38. IPT Mechanism-to-Subsystem Relationships

Thus, when interpreting the quantitative data in conjunction with statements from the research respondents and observations from the researcher such as:

- "there is limited guidance from management" (Respondent, HD3NA5),

- there are no formal IPT internal meetings,

- "the IPT analysis plan is a living document, but is being written after the fact" (Respondent, HD3NA5),

- there is no analytic database,

- the 1600 IPT meeting is considered to be useful, and

- information exchange is a pull activity

a contextual picture emerged of a knowledge system self-organizing toward using personal and informal mechanisms to acquire information. This is supported by the data from the limited guidance provided to the IPT from their leadership and the reliance of the IPT members on acquiring information from primarily human sources. Table 18 lists the mechanisms that were the most highly rated based on the quantitative analysis.

Mechanism Importance	Mechanism Relationships	SS-Mech Relationships
Informal Meetings	Informal Meetings	Informal Meetings
People/Experts	People/Experts	People/Experts
Personal Experience	Personal Experience	Personal Experience
IPT Analysis Plan	IPT Analysis Plan	
	E-mail	
	Formal Meetings	

Table 18. IA Subsystem Synthesis

However, the qualitative analysis provides the contextual understanding from which to further analyze the results of the quantitative data. Thus, informal meetings, people/ experts, and personal experience are mechanisms the IPT members strongly rely upon based upon the data analysis. Moreover, the analysis of the two methods suggested that e-mail and formal meetings were not significant information acquisition mechanisms. Likewise, the IPT analysis plan was determined to be a key information acquisition mechanism to the organization.
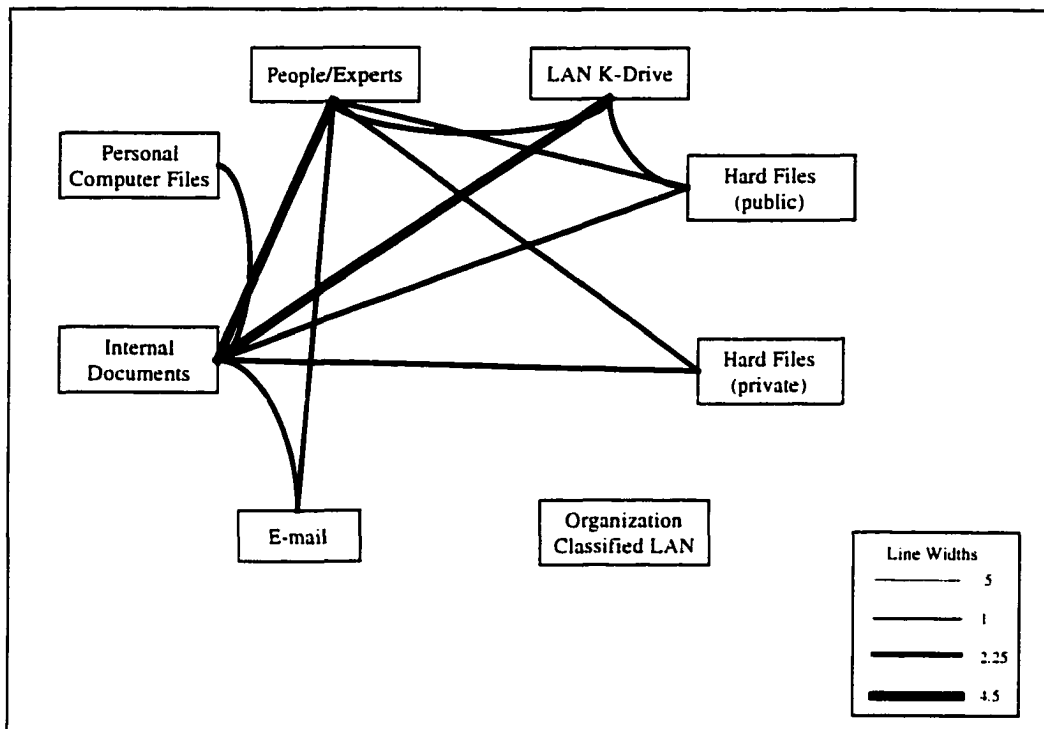
Information Storage

As with information acquisition, the analysis of the IPT's information storage mechanism began by evaluating the importance the organizational members place on the

subsystem's mechanisms. Table 19 provides the ranked list of mechanisms the IPT members considered to be the most important. From the table, people and experts,

| Mechanism	Importance Means
People/Experts	6.25
LAN K-Drive	5.75
Organization Classified LAN	5.75
Hard Files (private)	5.75
Personal Computer Files	5.75
E-mail	5.50
Hard Files (public)	5.25
Internal Documents	4.75

Table 19. IPT IS Mechanism Importance

LAN K-drive, organization classified LAN, private hard files, and personal computer files rise to the top as important in the information storage knowledge subsystem. The analysis of the mechanism-to-mechanism relationships indicated that people/experts, the LAN K-drive, internal documents, and public hard files mechanisms have the greatest relational links (Figure 39) (refer to APPENDIX H, Tab 2 for data). The interview contextual data for their information storage subsystem was primarily focused on the lack of an analytic database and the inadequate categorization of information in existing repositories. The data also supports the deduction that "soft" storage repositories are where the bulk of the organization's useful information is stored. In contrast, the mechanism-to-subsystem relationship shows that the

Figure 39. IPT IS Mechanism Relationship

organization members consider personal computer files, internal documents, and people/experts as strongly linked to information storage (Figure 40). Private hard files,
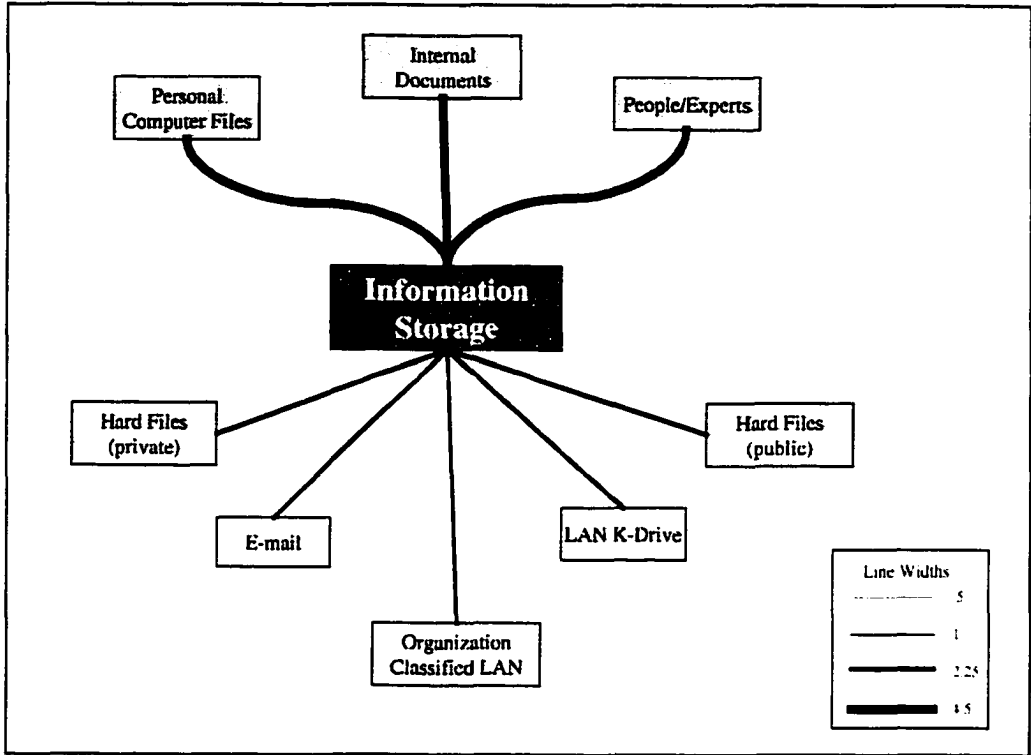
Figure 40. IPT Mechanism-to-Subsystem Relationships

e-mail, the LAN K-drive, public hard files, and the organization classified LAN were

rated to have a moderately strong relationship. Table 20 lists the mechanisms the

research participants rated as the most highly in the quantitative analysis.

Mechanism Importance	Mechanism Relationships	SS-Mech Relationships
People/Experts	People/Experts	People/Experts
LAN K-Drive	LAN K-Drive	Internal Documents
Organization Classified LAN	Internal Documents	Personal Computer Files
Hard Files (private)	Hard Files (public)	
Personal Computer Files		

Table 20. IS Subsystem Synthesis

As stated earlier, a central theme drawn from the research participants is that "soft"

repositories are the major organizational information storage mechanisms. This theme,

along with comments and observations such as:

- "information is used as power in the organization" (Respondent KN1VZ5),

- "categorization of information is okay" (Respondents HD3NA5 and CF2ZX5),

- there is no centralized database from which data can be extracted for analysis, and

- current information storage is not useful for analysis

persuade this researcher to conclude that people/experts, personal computer files, internal documents, and the LAN K-drive are the predominate storage mechanisms used by the IPT to inform its information storage knowledge subsystem.
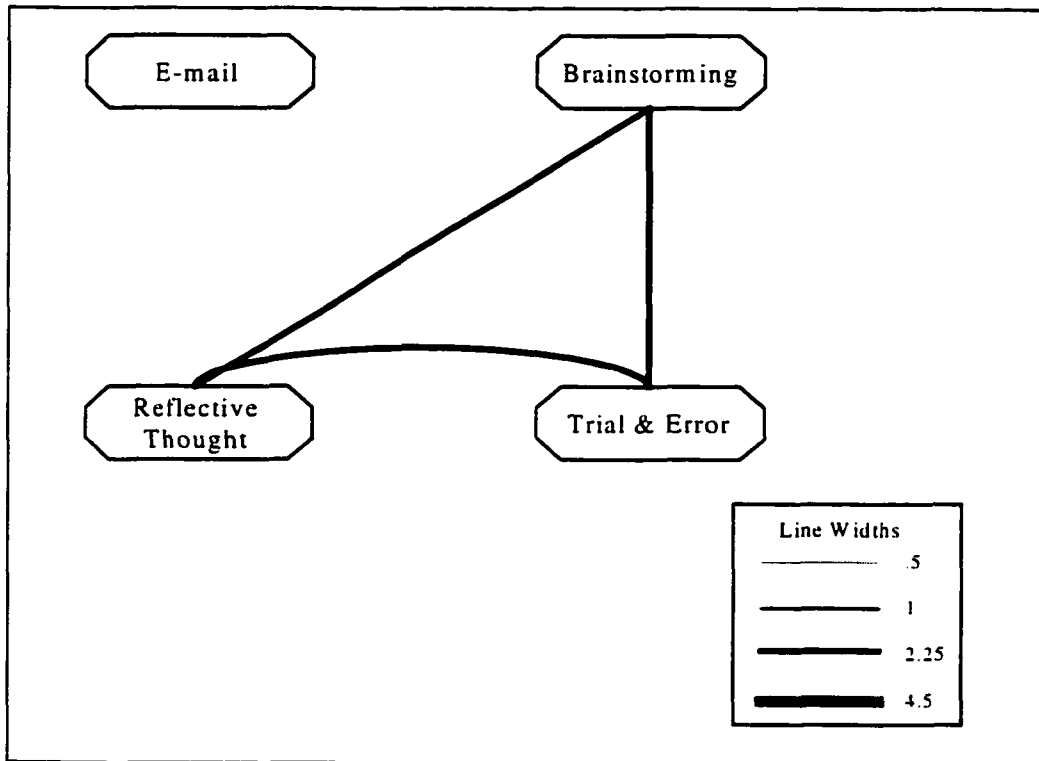
Information Interpretation

The analysis and interpretation continues with the evaluation of the mechanisms in the information interpretation knowledge subsystem. In Table 21 brainstorming represents the most important interpretive mechanism for the Analysis and Baseline Development IPT.

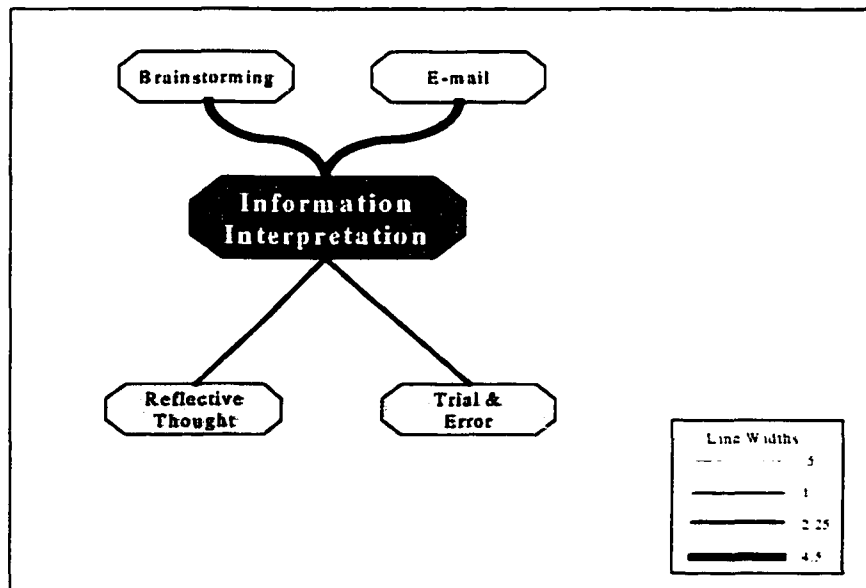| Mechanism	Importance Means
Brainstorming	6.50
E-mail	5.75
Reflective Thought	5.50
Trial & Error	4.75

Table 21. IPT II Mechanism Importance

However, when analyzing the mechanism-to-mechanism relationships, (Figure 41) brainstorming, reflective thought, and trial and error represent the organization's most interconnected information interpretation mechanisms.

Figure 41. IPT II Mechanism Relationship

The analysis of the mechanism-to-subsystem relationships indicated that brainstorming

and e-mail are strongly related to information interpretation (Figure 42) (refer to

Figure 42. IPT Mechanism to Subsystem Relationships

APPENDIX H for data). Consequently, Table 22 shows the quantitative list of the most highly rated information interpretation mechanisms.

Mechanism Importance Brainstorming	Mechanism Relationships Brainstorming Reflective Thought Trial & Error	SS-Mech Relationships Brainstorming E-mail

Table 22.   II Subsystem Synthesis

But, the qualitative data supports the conclusion that brainstorming is the only organizational interpretive tool. The research respondents in the semi-structured interviews indicated that they draw on their knowledge and experience of military operations concerning their study. As a matter of fact, many of the JWF organization personnel are hired because of their military technical experience, operational experience, strategic experience, and military personnel contacts. The organizational collective of experience is used as an interpretive concept referred by the IPT members as "expert military judgement." "Expert military judgement" is considered by the profession of arms to be a contextual analysis tool that applies military common sense and experience to data and information in the analytic process. This, along with observations such as:

- structured analysis is not used as a interpretive tool,

- knowledge capture and re-depositing it into information storage repositories is not done well, and

- there has been very limited structured qualitative or quantitative analysis thus far in the organization's study

illustrate the dependence on individual and personal knowledge and information, as well as a lack of an established department level interpretive process or medium. This infers

that information interpretation is mainly an informal activity. However, in the semi-structured interviews the IPT members indicated that analysis should be a key function of their work, but the consensus of the IPT was that no structured analysis is being conducted. This continual emphasis on analysis by the IPT implied that there is a misinterpretation of what the IPT members see as their roles and responsibilities compared to the way the JWF leadership comprehends the IPT's roles and responsibilities (Respondent HD3NA5). Thus, the joint analysis concludes that brainstorming represents the only mechanism for the organization's information interpretation knowledge subsystem.

Information Dissemination

The last subsystem to analyze is information dissemination. Analysis of Table 23 indicates that the informal meetings mechanism is the most important of the information dissemination mechanisms. Further analysis of this knowledge subsystem

Mechanism	Importance Means
Informal Meetings	6.50
Formal Meetings	5.25
Organization Classified LAN	5.25
E-mail	5.00
Newsletter	3.75

Table 23. IPT ID Mechanism Importance

shows that informal meetings represent the most interconnected mechanism (Figure 43) (refer to APPENDIX H for data). Again, it must be remembered that there are relational
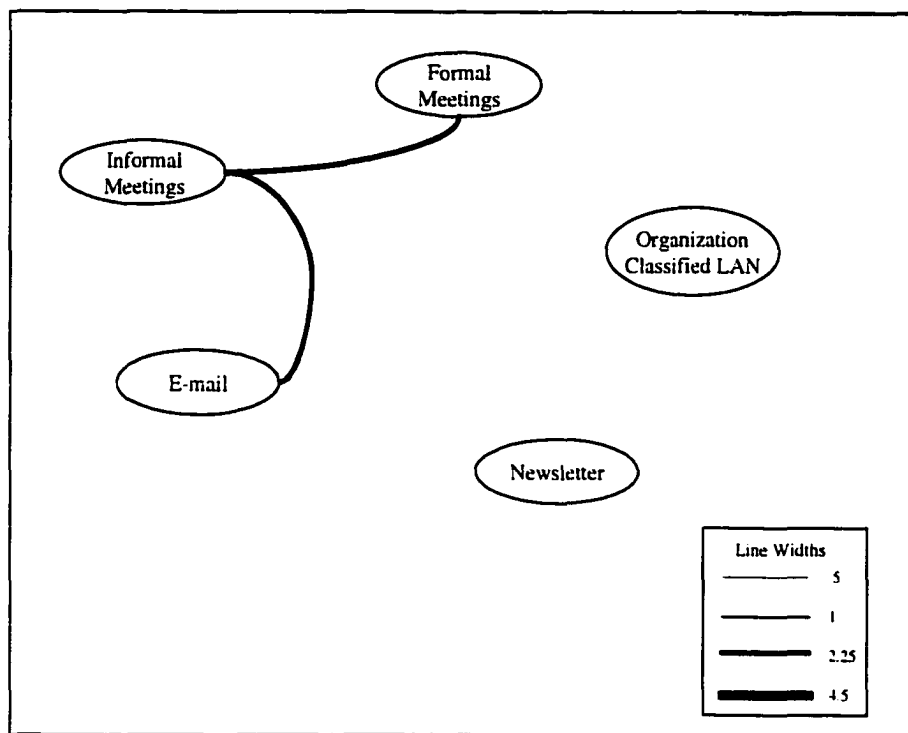
Figure 43. IPT ID Mechanism Relationship

links with all the mechanisms. However, the links displayed are limited to those

relationships which were rated as moderately strong or strong. Moreover, this indicated

that the IPT relies most heavily on informal discussions to disseminate information.

Lastly, the organization's strength of relationship ratings suggested that there was a

strong relationship between the IPT's information dissemination activity and e-mail,

formal meetings, and the informal meetings mechanisms (Figure 44). Table 24 provides
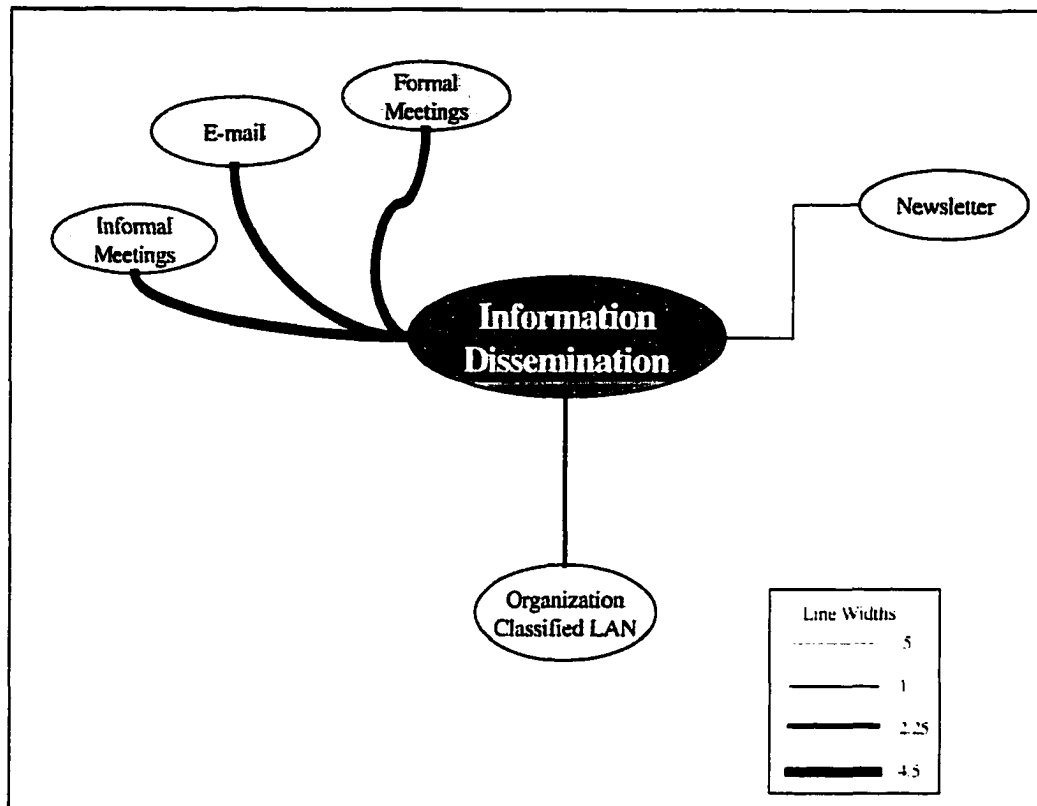
Figure 44. IPT Mechanism to Subsystem Relationships

the roll up of the graphical analysis. Interpreting the quantitative analysis from

Mechanism Importance Informal Meetings	Mechanism Relationships Informal Meetings	SS-Mech Relationships Informal Meetings Formal Meetings E-mail

Table 24. ID Subsystem Synthesis

a qualitative contextual nature concluded that the informal meetings represent the key

dissemination mechanism for the Analysis and Baseline Development IPT. This is

supported by the already presented qualitative analysis, as well as the following:

- informal meetings are more useful than formal meetings

- information dissemination requires the organizational member to first know what he or she is seeking and how can provide the information

- dissemination of information when provided to the IPT is focused toward specific individuals.

The methodology and model deployment has now constructed and represented the knowledge system of the Analysis and Baseline Development IPT. This representation (Figure 45) provides the organization with a graphic portrayal of the essence of their current organizational knowledge system. The representation is what the organization relies on to create knowledge. The other knowledge mechanisms are used, but not to the extent of those mechanisms portrayed in the representation. The representation is supported by both quantitative and qualitative data.

The representation graphically portrays the strengths and weaknesses of the IPT's knowledge system. For instance, it appears that the IPT lacks sufficient information dissemination mechanisms. Still, based on their current information exchange environment that is focused largely internal to the JWF organization, informal meetings
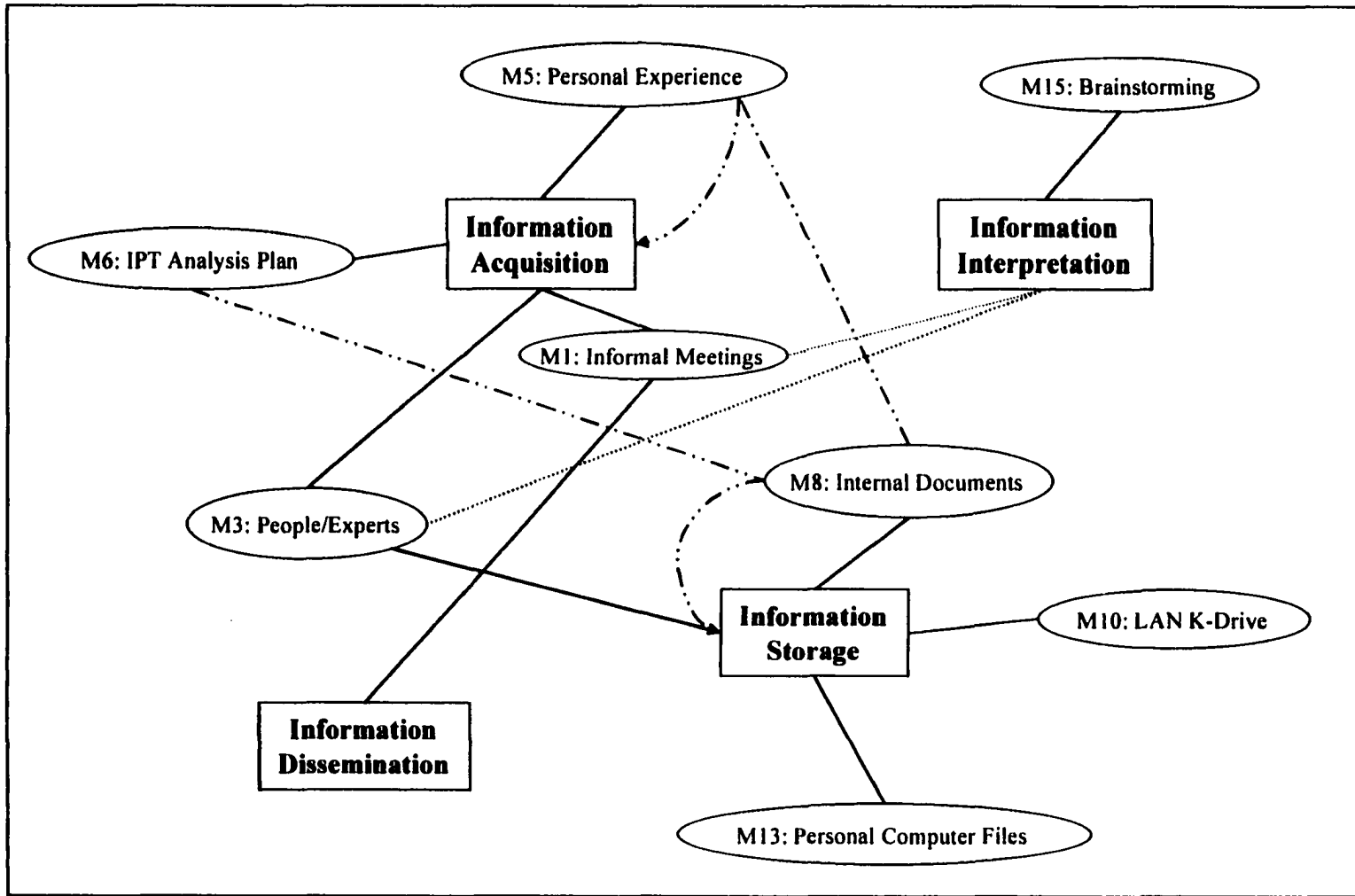
Figure 45. IPT Knowledge System Representation

may be sufficient at this time. This is an issue that can only be adequately addressed by the IPT. Continued analysis of this issue indicates that in a dynamically changing environment, the IPT's information dissemination knowledge subsystem is not developed enough to meet future requirements which may call for increased information dissemination outside the JWF organization. The analysis of the IPT's information acquisition subsystem suggests a closed information acquisition activity. All the information acquisition mechanisms come from within the organization, except for some external personnel. To accomplish today's mission this may be adequate. However, it eliminates the infusion of new information, perspectives, and most importantly, interpretation into the IPT's knowledge system. Likewise, the organization's interpretive component rests squarely on the experience, intellect, and knowledge of individuals. This seems to be a strong point for the IPT. The research participants are all highly intelligent and conscience about providing a good product. Nevertheless, the absence of structured analysis, as an interpretive mechanism for an organization charged with analysis, is troubling. From a systems perspective, the IPT's knowledge system is held together by its people and their informal information exchange sessions. This is definitely a system weakness. However, through discussions with the IPT members they presented and defended two notional linkages (represented by dotted lines) that are understood by the system members, but are not explicit in there relationship.

It should not be forgotten that there are other mechanisms used by the organization. Nonetheless, it should be remembered that the exhaustive list of mechanisms that comprises the knowledge system construction is based on qualitative data only. Thus, the quantitative data provides some statistical underpinning to support

the research conclusions and results. The contextual analysis provided by the qualitative data captures the mechanisms and discloses an organization culture that relies heavily on personal relationships. This has resulted in the IPT's knowledge system self-organizing due to the limited or lack of planning in the work system design. Thus, based on the comments and themes generated from the qualitative data and supported by the quantitative inquiry, the organization's knowledge system is characterized as:

- Top down directed organizational structure, but the IPT's knowledge system has self-organized

- "Tribal Knowledge" and "Expert Military Judgement" represent the major forms of information interpretation

- "Tribal Knowledge" is a major form of information storage

- Informal/Ad hoc coordination forms the IPT's foundational method of information exchange

- Information exchange within the IPT & IPT to external entities is primarily a pull activity
  - right question must be asked
  - correct source must be ascertained
  - viscosity of information flow is moderately low to moderately high

These characteristics help to explain the organization's knowledge system and establish the contextual framework for their knowledge system.

SUMMARY OF KNOWLEDGE SYSTEM REPRESENTATION

As in the construction phase, the organizational knowledge system methodology demonstrated its capability to represent each organization's knowledge system. Additionally, the confirmation of the respective represented knowledge system by the participating organizations adds credibility to each organization's knowledge system representation. The confirmation of each organization's knowledge system was planned into the research design. This was accomplished through systemic critique and

assessment sessions with the organizational to determine the efficacy of the representation. A key element of the representation phase was the mixed methodology design. This was also noted by both research organizations. The mixed methodology analysis allowed for hard data to be evaluated within the contextual environment of the organizations. This provided for a more full and substantive research evaluation of each organization's knowledge system that took into consideration each organization's reality and perceived reality of their knowledge system. Also, the triangulation of the quantitative and qualitative data provided the organizations the understanding and knowledge of what mechanisms and relationships within their knowledge system were critical to their organizational knowledge dynamic. However, it must be noted that all the mechanisms identified in the construction phase were utilized by the organizations. The products of the representation were: (1) a graphical representation of the organization's knowledge system, (2) the strength of the relationships within the knowledge system, and (3) an understanding of which knowledge mechanisms are critical to the organization's knowledge system.

It is here that significant learning occurred in the research. The research organizations saw for the first time a graphical representation of their knowledge system, which could be supported by quantitative and qualitative data analysis. The knowledge system representations clearly portrayed the mechanisms that reside at the espoused and basic levels (Schein, 1992) of each organization's cultural framework. These mechanisms represent the foundation of each organization's knowledge system. This understanding/new knowledge provided the organizations with a common collectively known zero state from which to apply focused transformation or reengineering strategies

and/or where to allocate scarce resources. The successful application of the organizational knowledge system methodology to the two research organizations has resulted in the construction, representation, and confirmation of two unique organizational knowledge systems. The final chapter of this study will highlight the major findings, implications, and future research opportunities.

CONCLUSION

A major confirmation of the research is that organizational knowledge systems are unique. This has been one of the major premises throughout the search. The uniqueness of an organization's knowledge system is derived from the particular mechanisms, relationships, and values organizational members place upon themselves and their system entities. Although there may be commonality in some of the mechanisms for both of the research organizations, the importance and use of the common mechanisms is dependent on the organizational members. A second significant finding of the research is the relatively few mechanisms the organizations rely upon to conduct the vast amount of their organizational business. This can clearly be seen when comparing the organizational knowledge system construction to the representation (Figure 46). Each organization's constructed knowledge system displays the mechanisms and relationships gathered in the semi-structured interviews. Both organizations made a concerted effort to include all the mechanisms that they use to accomplish their organizational tasks and responsibilities. This provided the researcher and reader with a preliminary robust and well connected organizational knowledge system. However, when the qualitative construction was triangulated with the quantitative assessment, the mixed methodological analysis indicated that the both organizations relied on a subset of the mechanisms they identified in the construction process. This follows Schein's (1992) premises on the
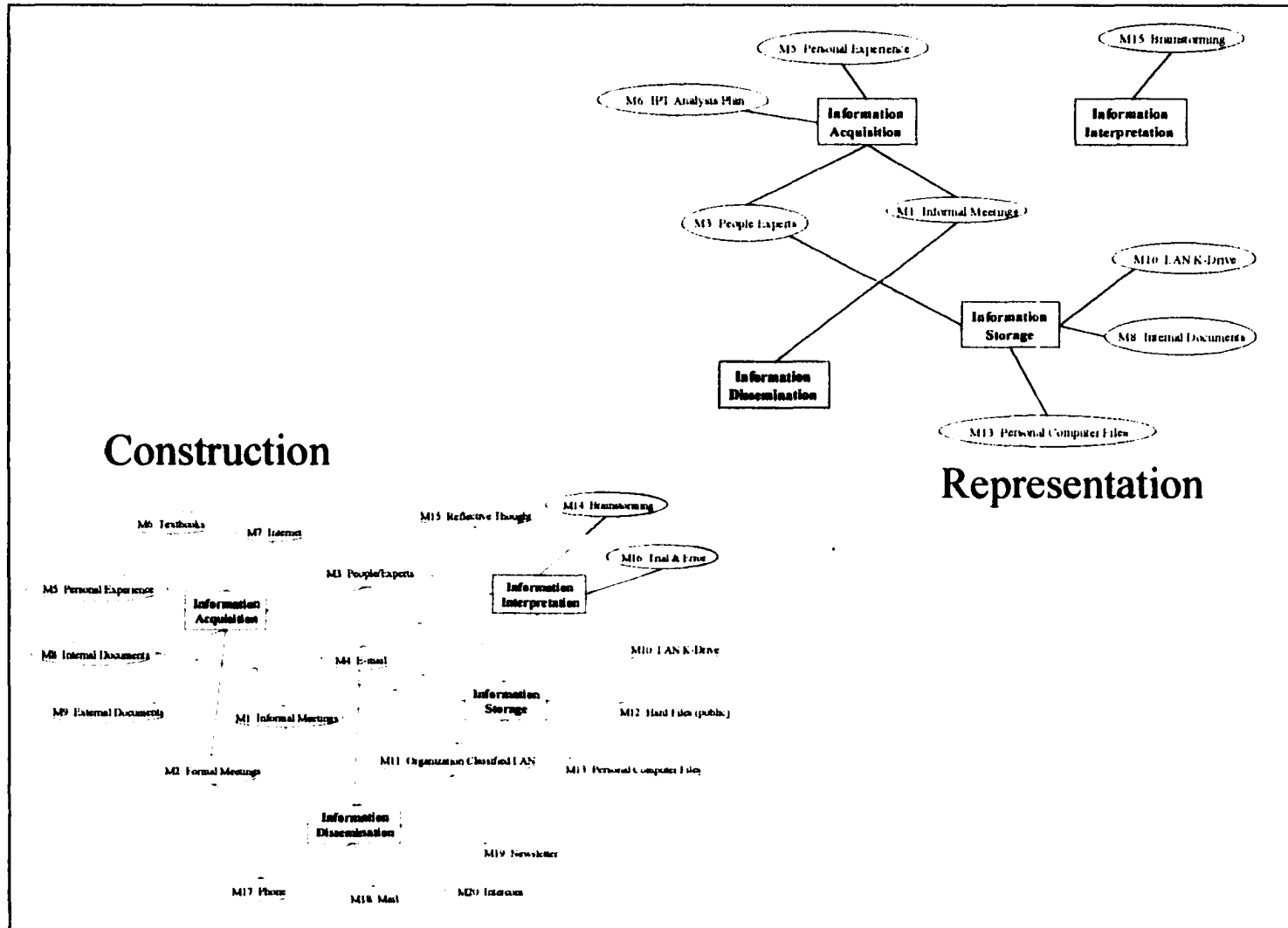
Figure 46. Constructed and Represented Knowledge System

framework of organizational culture. The implications of this particular finding can provide organizations with the ability to determine the most important components of their organizational knowledge system. This can then lead to organizations applying resources to specific areas of their organizational knowledge system to improve knowledge creation and knowledge management or dissemination, storage, interpretation, and acquisition of information. The research findings also suggest that the organization's mechanisms can be grouped. Here, I provide two simple groupings; those mechanisms that are critical or important to organizational tasks accomplishment and those mechanisms that are used on an as needed basis. These simple groupings provide organizations a way of stratifying the many and diverse mechanisms used when required from the mechanisms which form the true basis of their organizational knowledge system. Likewise, the organizational knowledge system methodology was able to combine individual knowledge systems into an aggregate knowledge system. The system was then validated through the basic cultural norms, beliefs, values, and social interactions that are always evident in any decision making process of an organization.

> The interwoven pattern of beliefs, values, practices, and
> artifacts that define for members who they are and how
> they are to do things. Culture is both a product and a
> process. As a product, it embodies accumulated wisdom....
> As a process, it is continually renewed and re-
> created...(Bolman and Deal, 1997, p. 217).

The research also found that e-mail was not an important element to either organization's knowledge system. Within the construction of each organization's knowledge system, e-mail was the only mechanism interconnected to all the knowledge subsystems, but e-mail was not prominently visible in the representation process. This indicates that e-mail is not critical to either organization's knowledge system. This is an important point as

organizations migrate to greater use of virtual offices and other connective relationships through e-mail. This research suggests that an organization's knowledge system may suffer if e-mail is the main relationship link between virtual offices and other organizational members. Lastly, the research found that the weakest aspect of each organization's knowledge system was information interpretation. Within each organization there was no organizational-level process or forum established for information interpretation. This meant that information interpretation was not part of the formal structure of the organization, but was by default relegated to the organization's informal structure. Although, the organization's informal structure is a real and viable part of the organization ,capturing and incorporating the interpretive processes, understandings, and products from the informal side of the organization is difficult. This is due to much of the organization's informal structure existing at a tacit level (Nonaka, 1991; Schein, 1992). Also, there was a lack of understanding by the organizational members of what information interpretive processes are and how they can be used. The above discussion presents the major findings of the research, except whether the research was able to construct and represent each organization's knowledge system.

Simply put, the organizational knowledge system, organizational knowledge system, and research design process (all of which form The Organizational Knowledge System Methodology) successfully constructed and represented both research organizational knowledge systems. The development of the organizational knowledge system methodology is a holistically linked perspective of the current learning processes and knowledge creation within an organization. This viewpoint bridges the gap in the literature between organizational learning and organizational knowledge and also extends

the literature through the development of the organizational knowledge system. Alternatively, this study established a distinct hierarchy in that organizational knowledge is a product of organizational learning. Furthermore, the study established that organizational knowledge informs action and decision, and organizational learning is the process by which an organization transforms information into knowledge. The methodology incorporates the organizational knowledge system model and implementation process, which analyzed each organization's knowledge within the context of the organizational environment via the mixed methodology analysis. The construction and representation of the each organization's knowledge system conforms to the systems nature of the entity under study, as well as the systems nature of the developed methodology (Hanna, 1988). Systems theory is a foundation of this research.

The purpose of the research, to develop and apply a systems-based analysis methodology which constructs and represents an organization's knowledge system, was accomplished. The major findings of the research have been presented, but there are additional implications of this research and this research inquiry has generated areas for future research.

IMPLICATIONS

The implications of this research fall along three distinct axes: methodology, theory, and practice. The methodological implications of this research are concerned with the organizational knowledge system methodology. The success of the research begs the issues of methodology transferability and efficient implementation platform. Because the research findings clearly indicate that an organization's knowledge system is unique, the results of the research are not generalizable to other organizations. However, the

research supports the transferability of the organizational knowledge system methodology to other organizations. This is accomplished by the assessment of each organization as an independent entity with its own unique knowledge system and contextual environment. This subtle understanding foretells the powerful implications this methodology, because the methodology was designed to be robust enough to assess an individual's knowledge system, as well as a large organization's knowledge system. Inherent in the research methodology is the ability to take what is tacit and make it explicit. "To convert tacit knowledge into explicit knowledge means finding a way to express the inexpressible" (Harvard, 1998, p. 31).

This research was able to capture an individual's tacit knowledge system and make that system explicit at the collective organization level. This portends to allow organizations the ability to clearly manifest and understand their underlying patterns of interpretation and understanding, enabling them to more effectively manage their knowledge system. The second methodological implication is the development of an efficient and effective research methodology platform. Although computer software was used to conduct surveys and analyze the data, much of the work was done by hand. This slowed the process of researcher-to-organization feedback and analysis of data. The development of an integrated software system is required to leverage the power of computers and e-business when employing the methodology. This would provide knowledge engineers, business managers, and researchers a simple and effective computer-based reusable tool to assess the status and welfare of their organizational knowledge systems. This would free these individuals to concentrate on employing

effective work design strategies which focus specifically at knowledge areas needing attention.

The second implications area is theory. This research extends the current organizational learning and knowledge literature by showing that the two important concepts are distinct and separate and then by developing the hierarchical relationship structure between the concepts. Likewise, theory is advanced through the development of the organizational knowledge system. The systems perspective creates a holistic understanding of the learning and the knowledge within organizations and represents a significant new literature-based perspective of organizational knowledge dynamics and processes. This research is responsible for refining the theories of organizational learning and organizational knowledge and for providing a new theory that addresses the holistic perspective and relationship of the two.

The final implications area is to the engineering management practice. Through the successful accomplishment of the research purpose this research provides organizations the capability to assess their knowledge systems and focus scarce organizational resources to improve the effectiveness and efficiency of the their knowledge system processes and mechanisms. The result of this research provides engineering managers, researchers, and architects of organizational knowledge systems a practical methodology of evaluating their organization's knowledge system. Now these individuals can more effectively conduct the business of determining organizational knowledge requirements analysis, determination of essential organizational information requirements, plan and implement purposeful knowledge work system designs, and focus on knowledge creation to identify organizational deficiencies and correct them at any organizational level. This

research has added much to theory and the engineering management practice, but it has raised some questions that are significant enough to warrant additional research inquiry.

FUTURE RESEARCH

This research has filled critical gaps in the literature and extends the existing intellectual knowledge base. However, this research has generated areas of research needing focused study. One such area is a need to conduct this research on a large scale to determine if organizational knowledge systems can be categorized by industry or profession, for example. This could lead to the development of truly noteworthy best practices or a super-set of organizational knowledge system mechanisms that transcend organization and exist within an industrial context. Another logical continuation to this research is the development and implementation of the transformation or change strategy required to move an organization from their current state to the next state in their envisioned evolution. Senge (1999) noted that most change initiatives fail. This research would provide organizations with a different starting point from which to implement a change initiative. Organizations would effectively know what composes their knowledge system and explicitly understand their knowledge system before implementing a change initiative. Organizations would know what their knowledge system currently looks like, thus enabling organizational managers to more effectively plan and implement change initiatives designed to achieve the desired organizational results (Beer, 1990). Likewise, this concept could also be used to develop organizational frameworks on thought and action for strategizing and planning their idealized knowledge system. Lastly, future research should also focus on employing more robust analytic tools such as optimization

and mathematical models to explain relationships in a concrete fashion to be used as decision support tools for managers and leaders.

This research study's major contribution is the development of the organizational knowledge system methodology. This is a new, robust, and holistic perspective of an organization's learning and knowledge processes and dynamics. The methodology offers organizational managers and researchers a significant literature-based concept for understand the complexity of their organization's knowledge system and enables them to explicitly represent their knowledge systems. This clearly goes beyond the current theory and practice available today and has implications which could shape organizational thinking on knowledge and knowledge management.

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APPENDIX A
Glossary of Terms

This glossary of terms is provided to reinforce with the reader some of the key provisos of this research. Where wording in this glossary differs from that in the main body of this study, both wordings are intended to convey the same meaning. This glossary of terms does not represent a set of definitions for these terms, but rather explains the perspective from which these terms are used in this research. The explanation of these terms is meant to establish a base-level of understanding of important elements concerning this research.

Contextualization refers to the circumstances in which information is presented, interpreted, and eventually understood.

Organizational Knowledge System (OKS) is a holistic perspective and understanding of the connection between the learning processes and knowledge creation within an organization. It represents a synthesis of thought respecting organizational learning and knowledge. In the context of this research the term "knowledge system" is synonymous with the term "organizational knowledge system."

Organizational Knowledge Subsystems are the of four elements that make up the organizational knowledge system. These elements are information acquisition, information storage, interpretation, and information dissemination. They form the upper-level portion of the OKS model.

Organizational Knowledge Mechanisms are the actual mediums, identified by the organization, which are used to facilitate the knowledge subsystems. They can be both part of the formal or informal structure of the organization.

Organizational Knowledge System Methodology is the unification of the organizational knowledge system perspective and understanding, organizational knowledge system model, and research design method and procedures which enables the research to construct and represent an organization's knowledge system.

Systems-Based Methodology is a comprehensive perspective and model that applies the precepts of the Open Systems Theory (Hanna, 1988) to describe the elements of an organization and their dynamic interrelationships. Organizations are an arrangement of entities that have an interdependence on one another, are bounded by an arbitrary boundary, and exist in a larger environment.

System in Focus is defined as the identified bounded system under investigation.

Traceability refers to tracking and confirming the steps and procedures used by the researcher in developing the research concepts and administering the research design strategy. Traceability strives to ensure credibility and fidelity in the research explanation, data collection, analysis, and findings (Erlandson, Harris, Skipper, & Allen, 1993).

Transferability examines whether the research findings are confirmatory of presented concepts and theories and can be subsequently applied to persons and places other than those in the original study (Lincoln & Guba, 1985; Miles & Huberman, 1994).

Triangulation is the process of using multiple data collection methods, data sources, or theories to validate the findings of a research study. This study will triangulate data collection and analysis methods from both quantitative and qualitative paradigms to validate the findings of this research (Erlandson, Harris, Skipper, & Allen, 1993).

APPENDIX B
Participant Consent Form

The participant consent form is the formal contract between the research participants and the researcher. Each research participant was required to read and sign a consent form. The following consent form provides each research participant an overview of the research, the approximate length of the research inquiry, and explains that their confidentiality will be maintained. The original signed copy of each research participant consent form is on record with the researcher and each participant was provided a copy for their records. The consent form also satisfies the requirements and guidelines for human subjects research as set forth by Old Dominion's Human Subjects Institutional Review Board (IRB). The process implementation, filing, and content of this research consent form was reviewed and approved by the Department of Engineering Management's representative of the University's IRB

Participant Consent Form

Protocol: Semi-Structured Interview and Computerized Survey
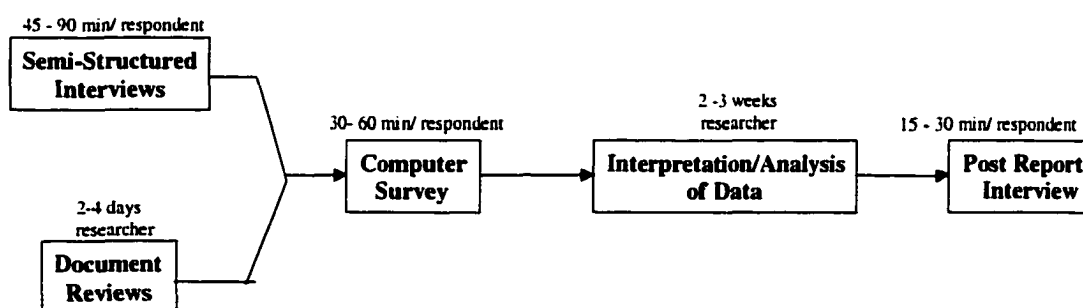**Subject:** Organizational Knowledge System (Doctoral Dissertation)
Interviewer: Willie J. McFadden, Doctoral Candidate
Study Sponsor: Engineering Management Department, Old Dominion University

You are invited to participate in a semi-structured interview and computerized survey to discuss the concept of the Organizational Knowledge System. You were selected as a possible participant because of your position in the organization and expertise in organization operations. The purpose of the survey and interview is to gather information about your organization concerning what mechanisms you and your organization use to:

♦ acquire information

♦ store and retrieve information

♦ interpret information

♦ disseminate information.

The general data collection structure for this study is depicted as follows:

If you decide to participate, I will analyze your responses from the survey and interview to provide your organization with a representation of your organizational knowledge system. This will be accomplished by mapping the mechanisms your

organization transmits to me to the four areas above and assessing the value, effectiveness, and potentiality of the mechanisms. Standard analytic techniques will be applied to the gathered data resulting in a graphical representation of how your organization members view their organizational knowledge system. The interview and survey process should not take any longer than 2-3 hours per selected participant within an overall 5 to 7 day organizational assessment. The interviews will be conducted at your place of business and the computerized survey will be web-based so that the selected participants can complete the survey at home or from their office to avoid any risks or inconveniences to anyone involved in this research.

Individual confidentiality will be strictly maintained. Also, information at the organization collective level that is obtained in connection with this research will remain confidential, but will be disclosed as needed to this researcher's dissertation advisory committee in the Engineering Management Department, Old Dominion University. Organization confidentiality will be meticulously maintained and the final dissertation research report will be devoid of individual, personal, or organizational reference unless prior approval has been obtained. At the completion of my study, an out-briefing will be provided to your organization. If you decide to participate, you are free to discontinue participation at any time without prejudice.

If you have any questions, please feel free to contact me by phone at 877-6582 or e-mail willemcfadden@mindspring.com.

You are making a decision whether or not to participate. Your signature indicates that you have read the information provided above and have decided to participate. You may

withdraw at any time without prejudice after signing this form should you choose to discontinue participation in this research interview.

_____   _____

Signature of Participant   Date

_____   _____

Signature of Investigator   Date

*You are under no obligation to participate in this study. Your completing and returning of this consent form will be regarded as your willingness to participate in this research. It also serves as your consent to have the information obtained used for purposes of this research.

APPENDIX C
Research On-Site Actions

The following list of on-site action actions represents the detailed steps required to conduct a thorough, complete, and professional research plan of action. The action plan begins with the first contact of the selected organization and is finalized with a briefing of results and findings to the organization. The action plan serves as a checklist for the researcher, guiding him through the research and data collection process in an orderly and efficient manner. These action plan steps are also provided for those researchers interested in duplicating this research in other organizational settings. The list of actions outlined in this appendix is not provided as an explanation of the rich interaction details that occurred between the research participants and the researcher. The detailed discussion of these actions can be found in the Research Design Method and Procedure Chapter of this study.

Research On-Site Actions

1. Scheduled meeting with organization point of contact to discuss research purpose, goals, organization's participation in the study, and arrange starting date.

Points of discussion:
- Study Purpose
- Importance of the research
- Why your organization was selected
- Organizational benefits of the research
- Research process flow
- On site time to complete research and total time to complete organizational study
- Number of personnel needed to conduct research
- Products provided to the organization (if applicable)

2. Provided a briefing on the research purpose, goals, plan of action, and organizational knowledge system methodology to organization participants.

3. Had organization participants read and fill out participant consent forms and schedule times to conduct individual interviews.

4. Conducted interviews as scheduled and conduct document reviews to identify the mechanisms. Triangulate data from both sources to determine mechanisms used to inform organization knowledge system.

5. Had interviews transcribed for analysis.

6. Scheduled a date and time to conduct a focus group interview. At this meeting the researcher presented the organizational knowledge system *construction* derived from the participant interviews and organization documents.

7. Administered computerized survey to study participants. Explained to the participants the function of the computer survey and the mechanics of the Likert scale. The survey will identify the following critical points:

- Effectiveness and importance of a particular mechanism
- Relationship of a mechanism to other mechanisms
- Redundancy of a particular mechanism to other mechanisms
- The importance of a subsystem to the organization
- The adequacy of a subsystem to the organization
- Relationship of a subsystem to other subsystems
- Relationship of a mechanism to a particular subsystem

8. Conducted statistical and graphical analysis of computer survey responses.

9. Used appropriate qualitative data from semi-structured interviews to triangulate with computer survey quantitative data.

10. Scheduled a date and time to conduct a focus group interview. At this meeting the researcher presented the organizational knowledge system *representation* derived from the analysis of the data.

Points of discussion:

- Veracity of knowledge system representation
- Errors or corrections required in representation (based on participant input only)
- Understanding of what the organizational knowledge system representation means
- The benefits/disadvantages of the research to the organization
- What new understandings of the organization emerged
- Does the organizational knowledge system aid action and decision making in the organization? How?

11. Based on discussion, refined organizational knowledge system as appropriate.

12. Provided feedback to organizational participants.

13. Administered post report interview to selected participants. The interview will identify the following critical points:

- Do the subsystems and mechanisms capture the organizational knowledge system.
- Who is or should be responsible for managing the organizational knowledge system?
- Was the organizational knowledge system made explicit?
- Does the organizational knowledge system aid action and decision-making in the organization?

14. Write up findings and conclusions.

15. Present findings to advisor for review.

APPENDIX D
Research Interview Guide

The purpose the research interview guide was to identify the mechanisms organizational members use to inform their organizational knowledge system. The mechanisms elicited from the research participants can be either part of the organization's formal or informal structure. The interview guide was provided in hard copy and on the Internet as part of a web site (Appendix E), both designed to provide research participants the maximum amount of information on the organizational knowledge subsystems and how the organization's mechanisms inform the subsystems. As part of each semi-structured interview the major points of each organizational knowledge system was reviewed to ensure that the research participants understood the framework of the subsystem and could provide informed responses to the presented questions. The research participant responses were then captured and filed for analysis. Appendix G provides an example of the results of one research participant interview.

INTERVIEW GUIDE

PURPOSE

To identify the mechanisms organizational members use to inform the organizational
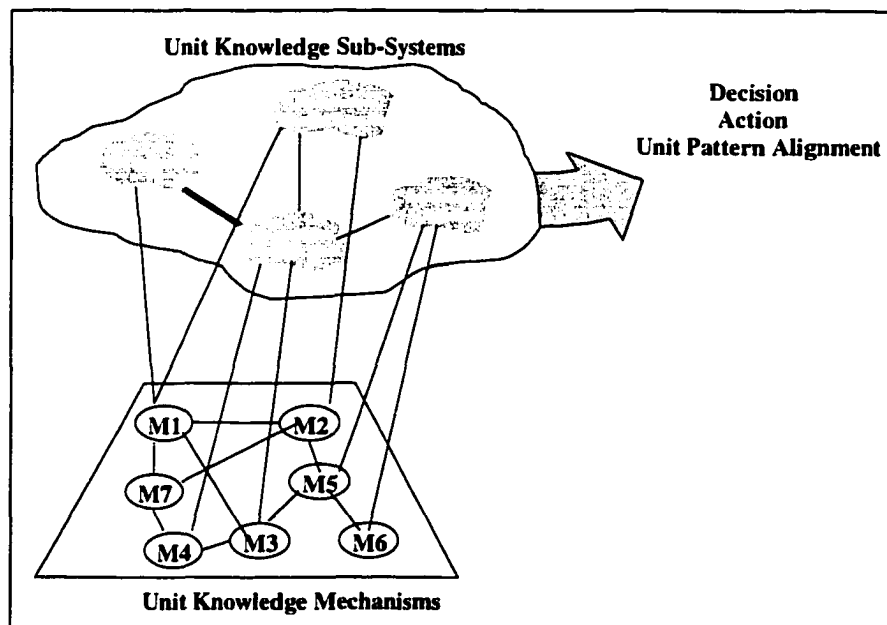
knowledge system.

ORGANIZATIONAL KNOWLEDGE SYSTEM AND MODEL

The organizational knowledge system is synthesized from the literature and further

develops Huber's constructs of organizational learning. The development process of the

knowledge system binds Huber's construct's into a modified set of knowledge subsystems

(Figure 1). The glue in this binding process is systems theory. Systems theory provides

the conduit for looking at not only the elements of the knowledge system and their rich

interaction, but also the holistic perspective of the relationship between organizational

learning and organizational
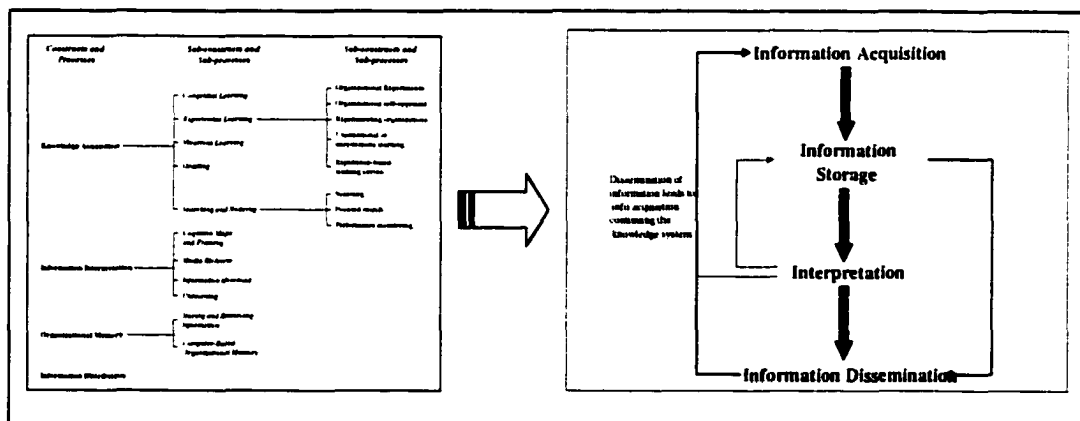
Figure 1. Constructs and Processes Associated with Organizational Learning (Huber, 1991) modified in to Become the Organizational Knowledge System Subsystems

knowledge. The final element of the methodology is the development and explanation of the system model which will serve as the framework for the application of the organizational knowledge system concept in an organization (Figure 2). The organizational knowledge system model consists of the knowledge subsystems and a distinct set of mechanisms. The unit knowledge mechanisms are the tools and processes the organization uses to inform and facilitate the unit knowledge subsystems.

FIGURE 2. Model of Organizational Knowledge System

Identification of the mechanisms provides the means to transform the tacit nature of individual knowledge into an explicit representation of an organizational knowledge system. Thus, the research establishes two major subsystems - upper level (unit knowledge subsystems) and lower level (unit knowledge mechanisms) systems both of which are required to facilitate the construction and representation of an organization's unique knowledge system.
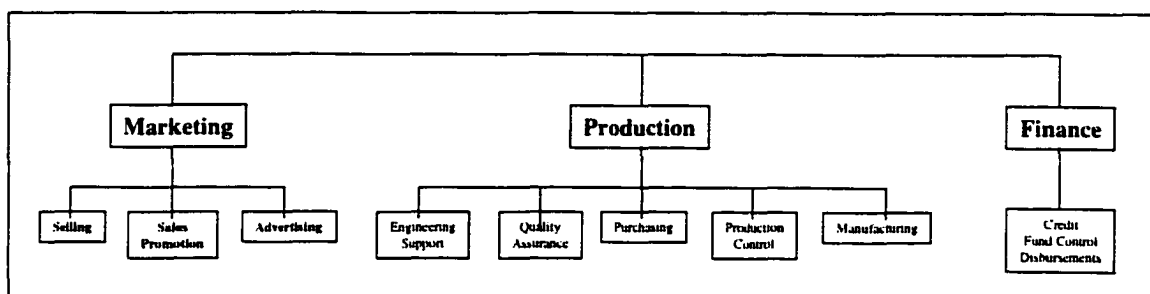
SYSTEM IN FOCUS

The system in focus is the identified bounded system under investigation. It may represent the entire organization, upper management, a particular department, or a section within a department. The final determination of the system in focus must be agreed upon by the researcher and the organization to facilitate the research inquiry.

INFORMATION ACQUISITION

Huber refers to the information acquisition process as knowledge acquisition. This assumes that organizations are able to acquire knowledge, which is a rather tenuous assumption. For this assumption to be true, the transfer of the information must include the interpretive framework and contextualization assigned to it from its source. But, information alone does not constitute knowledge. There is a great deal of confusion and misinformation in the business community in relation to what knowledge transfer and knowledge databases are. When information is acquired from knowledge repositories, it is devoid of the circumstances from which it was created. Why, how, and when the information was created, and even who put it together, all play an important role in the context of the information. How one interprets the information, or for that matter, the interpretive framework used, plays a part in the knowledge drawn from bits and pieces of information. Thus, for organizations to acquire knowledge, the acquiring organization, collectively and individually, must share norms, experiences, and mental models necessary to transfer the intact knowledge in its original form. This assumes that individual cognitive processes (mental models) are not unique, which we know is not true (Senge, 1990), but also that organizational understanding and interpretation are very similar, if not the same. For this reason, this research assumes that organizations do not acquire or store knowledge, but more precisely stated, acquire and store information.

The ability of an organization to acquire information is crucial to its short-term and long-term viability in its chosen industry. The acquiring of information is both an internal and external function, where internally, organizational entities acquire information from sources within the system and externally, entities within the system

acquire information from sources outside the system. For instance, a manufacturing firm

may be composed of the following entities (Figure 3):


Figure 3. Manufacturing Firm

Upper-level management may view their organization as a three entity system. However,

the advertising section manager may view the organization as a sixteen entity system.

Neither viewpoint is wrong, but understanding the various viewpoints provides a

perspective of the system that is of concern to the organizational manager. Simply put,

the key issue is the bounding of the system (the articulation of the entities that comprise

the system) is arbitrary and the bounding is critical for analyzing the system. This

research calls this bounded system the *system in focus*. The system in focus is defined as

the " identified bounded system" under investigation. Thus, does the organization's

information acquisition process consist of three internal sources or sixteen (refer to

Figure 7)? What are the tradeoffs between the two perspectives? These are important

questions that establish the organizational holistic perspective of their information

acquisition subsystem. This relates to the internal and external acquisition of information

since it is relative to the entity of the system. Likewise, organizations may gather

information by reviewing the business practices of their competitors or organizations that

have achieved heralded success as a means to inform their internal operations. Clarity of what is internal and external information to the organization is important because this helps to identify and establish knowledge system boundaries in the organizational culture. The internal and external understanding of information acquisition is an important aspect of defining system boundaries, which in turn help to define and establish the organizational knowledge system.

An organization acquires information in two ways: creation and obtainment. This is a further clarification of Huber's constructs. The creation of information is essentially the organization learning from experience, while the obtainment of information can be the purchasing, depredation, alliances, and or cooperative agreements organizations engage in to acquire knowledge. Organizations may also purchase information through the hiring of specialists in certain fields of study or expertise. These specialists bring with them vast amounts of information that can be assimilated by the organization to improve operations. Also, the acquisition or merger of rival companies provides an organization with an infusion of information, which if managed properly, will enhance the capabilities of the organization. This obtainment of information also creates new information that the organization assesses, which may result in modifications or changes in business processes to ensure that the organization remains competitive in their industry environment. The dynamic nature of our environment portends that the creation of information is a vital organizational function, which if not nurtured, will wither and ultimately prevent the organization from changing to keep pace with its environment. The above discussion represents an extension of the literature pertinent to the information acquisition

organizational knowledge subsystem. The research then draws upon Huber's taxonomy of the types of information acquisition.

Huber further subdivides these two types of information acquisition into five categories: congenital learning, experiential learning, vicarious learning, grafting, and searching and noticing (Huber, 1991). Congenital learning is defined as knowledge inherited at an organization's conception and additional knowledge acquired prior to its birth (Huber, 1991). Experiential learning is organizational knowledge acquired through direct experience (Huber, 1991). Vicarious learning is the acquiring of knowledge through mimicry or the borrowing of ideas and practices from other corporations. Grafting refers to acquiring knowledge by adding new members who possess knowledge not previously available to the organization (Huber, 1991). Finally, searching and noticing is the process of active and passive scanning and the monitoring of the organization's internal and external environments which leads to acquiring additional knowledge (Huber, 1991). This research agrees with Huber's five foundational sub-constructs to knowledge acquisition, with one primary exception. That exception is that organizations do not acquire or store knowledge. Organizations acquire information, which they may process into knowledge. A synopsis of the information acquisition differences of this research and Huber's constructs are shown in Figure 4. This does not change Huber's work, but extends his work with additional structure and organization of the literature.
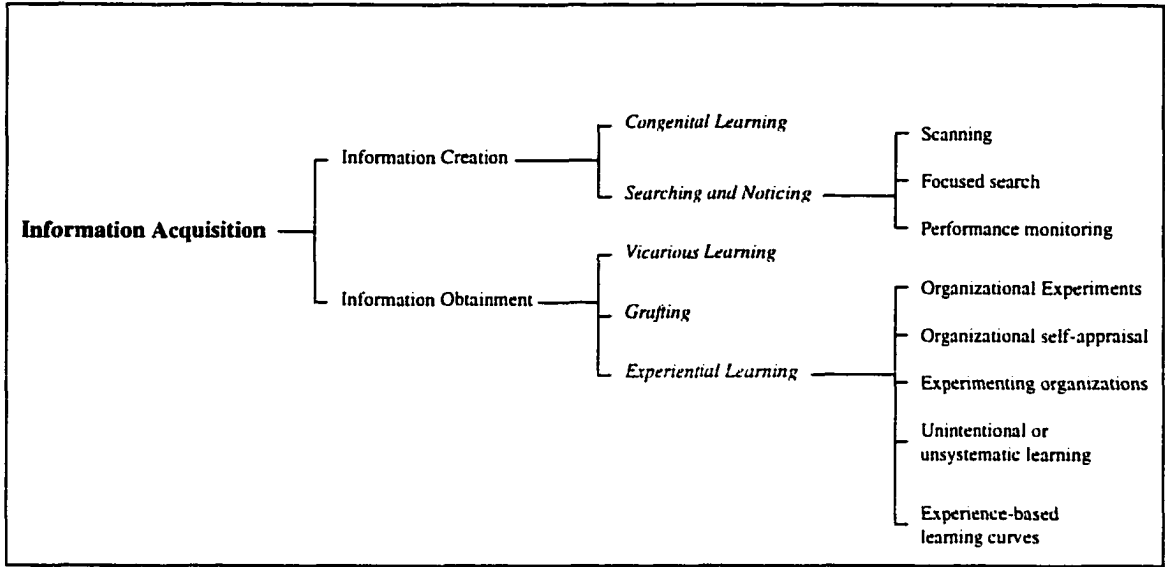
Figure 4. Information Acquisition

INFORMATION ACQUISITION

Organizations acquire and assess information to remain competitive in their industry environment.

    Determine if business processes, goals, vision, or strategies require modification, validation, or change

Organizations acquire information in two ways - creation and obtainment.

    Creation of information - organization learning from experience

    Obtainment of information - purchasing, stealing, alliances, and or cooperative agreements

What mechanisms do you and your organization use to acquire information to accomplish your assigned tasks and responsibilities?

        Do you go to any particular person?

        What about organizational SOPs? Are there other documents you use to acquire information?

        Is your personal experience and expertise all you rely on? If so, when do you feel you reached this level?

        What about organization meetings?

        Is there any other formal or informal information sources you use to accomplish your job?

Mechanisms

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*Do you have any other comments reference the list of mechanisms for information acquisition you have presented me?*

INFORMATION STORAGE

The organizational storage of information has two basic components: repositories and categorizing. He refers to this construct as organizational memory and further categorizes organizational repositories as containing "hard" and "soft" information (Huber, 1991). "Hard" information is characterized by such examples as organizational reports, standard operating procedures, process routines, and scripts. Also, computer-based information residing in flat files and/or relational databases is considered to be hard information. Likewise, expert systems that capture information from humans and provide a means to store and access that information via computer technology is becoming a common occurrence within organizations (Huber, 1991) and is also considered "hard" information. "Soft" information is stored in the minds of the individual members of the organization (Huber, 1991). This information is much more difficult to quantify, access, and disseminate.

Huber does not discuss the important aspect of information categorization or timeliness. Information categorization is concerned with *how* an organization stores its information. There is little argument, however, that organizations need the right information at the correct time for that information to be relevant to any organization decisions or actions. Timeliness will be more completely discussed in the section on information dissemination. Most organizations store tremendous amounts of data and information. Also, there are many more storage repositories that organizations can access from external sources. But, how to look for that information is important to an organization. The method of categorizing information not only influences how an organization accesses information, but also how an organization thinks. Planning the

categorization of information for efficient use and ease of searching and retrieval can and will make access to the information more effective and focused for the information seeker. This, in turn, reduces the amount of required search time and may encourage the increased use of an information repository by organizational members. This seemingly simple act of categorizing information provides insights concerning organization memory, whether an organization uses computer databases to store information or a file cabinet provides critical insights to how the organizations perceive information sharing, as well as the power of information. Also, an organization's categorization method and methodology speaks to the organization's understanding of the complexity and dynamic nature of information, where the sharing or merging of diverse information opens the door to new ideas and potentially to the creation or modification of existing organizational knowledge patterns.

Huber alludes to organizational memory as the retention of tacit knowledge stored within the organization (Huber, 1991). This study departs from Huber's perspective in that organizational memory is not the retention of tacit knowledge, but rather the retention of information. However, this research extends Huber's perspective on organizational memory by identifying the impact or effect categorizing information has on an organization's knowledge system. Figure 5 depicts the addition of categorizing to information storage.
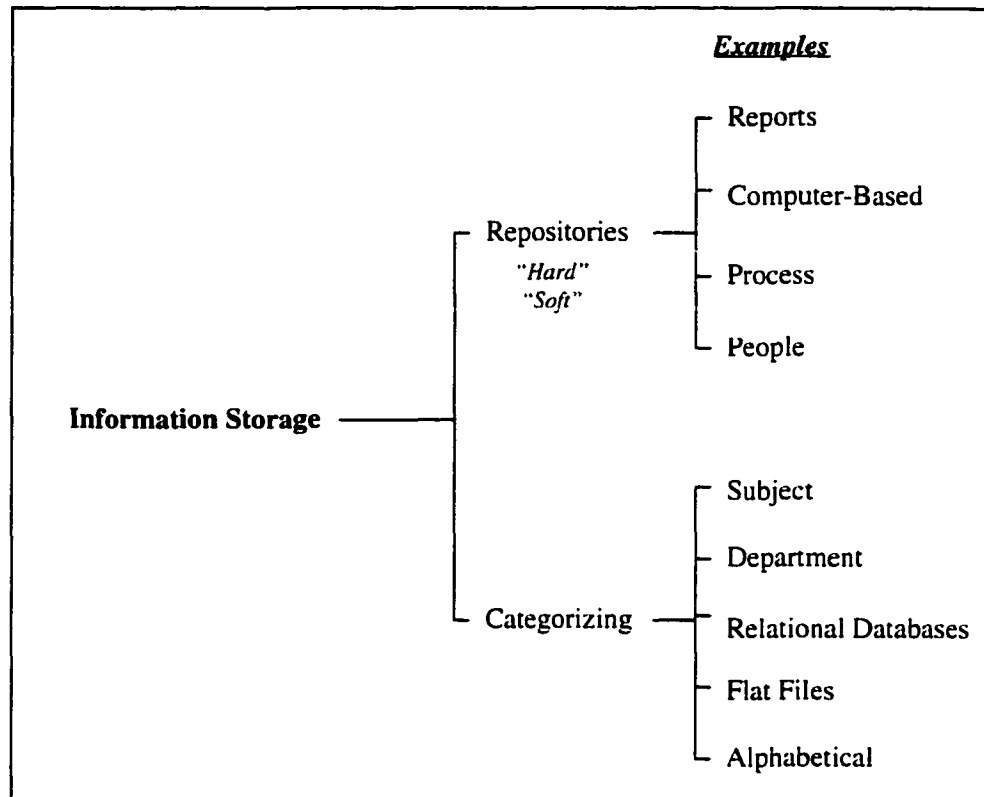
Figure 5. Information Storage

INFORMATION STORAGE

Two components of organizational storage - repositories and categorizing.

Repositories - where information is stored
    Examples: reports, people, computer-based filing, manual filing, and process files
    "Hard" information - explicit information composed of written rules and digital code
    "Soft" information - stored in the minds of the individual members of the organization

Categorizing - how information is stored
    Examples: subject, alphabetical, flat files, relational files, department
    Determines/influences how organizations search for information
    Gives insights to how an organization thinks

What mechanisms do you and your organization us to store information to accomplish your assigned tasks and responsibilities?

    Do you have access to your organizations storage mechanisms?
    How would characterize the usefulness of your organizations information
       categorization?
    Is there any other formal or informal information storage sources you use to
       accomplish in the conduct of your job?

Mechanisms

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Do you have any other comments reference the list of mechanisms for information storage you have presented me?

INTERPRETATION

As stated earlier, stored information is static and must go through an interpretive process to become knowledge. This is an important point because much of the current focus and initiatives concerning knowledge management assumes that knowledge can be stored. That presupposes that the contextual nature surrounding information, as well as the experience and understanding of individuals or the group that interpreted the information, is put into a repository as an intact object. To some degree this can be accomplished in a "soft" repository, but is extremely difficult in a "hard" repository. Information interpretation is possibly the most significant aspect of an organization's knowledge system; however, it is normally not the primary focus of an organization's time, resources, or intellectual energy. Daft and Weick (1984) define information interpretation as " the process through which information is given meaning" (p. 294), and also as "the process of translating events and developing shared understandings and conceptual schemes" (p. 286). This, however, does not imply that all organizational members develop a common understanding (Huber, 1991). Moreover, these multiple individual interpretations lead to patterns of interpretation or understanding at a collective level. Organizational learning is the process that leads to the creation, modification, or reinforcement of core patterns of interpretation and understanding. The interpretive process is governed by the core patterns of organizational understanding that contextualizes the information for use by the organization. At the individual level, mental models interpret and contextualize the information into knowledge. However, at the organizational level, patterns of understanding transform information into knowledge. These patterns are developed over time and by negotiation and dialogue through the

interaction of individuals to achieve group goals and objectives. Most individuals in an organization cannot put these patterns into words, but merely understand that this is the way the organization works. Thus, organizational knowledge is expressed as these core patterns of interpretation and understanding that uniquely define an organization. The patterns also influence and shape an organization's belief and value systems. These patterns form the basis for how an organization (1) makes decisions, (2) determines what actions to undertake in support of those decisions, and (3) interprets the decision and action outcome relationships. Knowing this implies that we as researchers can begin to understand why organizations do what they do. Thus it follows that the creation and reconstruction of knowledge influences, and has an immediate and profoundly lasting effect on, an organization's decisions and actions. The essence of organizational knowledge is the organization's ability to piece together information through some interpretive process or representation that provides meaning to the organization. This "meaning", newly created or modified knowledge, may then be used by the organization to drive decisions and or actions, as well as provide a common interpretive framework..

Huber addresses the above points in his discussion of cognitive maps, framing, and media richness. Cognitive maps and framing refer to the belief structure, mental representation, or frame of reference that shapes an individuals interpretation of information (Huber, 1991). This is consistent with the "framing" perspective of Fairhurst and Sarr (1996) and Bolman and Deal (1997) and "sense-making" as described by Weick (1995). As stated earlier, the cognitive process resides within individuals. However, in organizations, the interpretation process is a social endeavor (Huber, 1991). The interpretation process takes individuals and invites them to develop a group belief

structure and organizational representation when conducting information interpretation. This is a give-and-take process which is dynamic and may change based on the individuals involved and/or the information provided. What is important to understand, is as organizational knowledge is created or modified, it enhances or refutes the already existing patterns of knowledge developed by the organization. These existing patterns have an ingrained inertia may be difficult to overcome. The intransigence of organizations to change even when the indicators dictate change is necessary can be explained based on this struggle. It is difficult to question dominant tacit patterns which define what is the comfortable and familiar range of decision, action, and interpretation. Just as the cognitive process resides in individuals, the organizational interpretive process is likewise subject to the collective of individuals, as well as the emergence of dynamics stemming from their interaction.

Media richness is the communication "...medium's capacity to change mental representations within a specific time interval" (Daft & Huber, 1987, p. 14). This is what the organization uses to facilitate its interpretive process. The communication medium can take many forms, including for example: face to face, video teleconferencing, audio-only exchange, or e-mail to name a few. But, whatever the type of media, it plays a significant role in the information interpretive process. The medium not only determines the number and type of cues organization members receive, but also the speed of the interpretive feedback to the members (Huber, 1991).

By applying a systems perspective to Huber's organizational learning constructs it is possible to see the interconnectedness of the components which form system relationships. This viewpoint provides a means to connect organizational learning and

organizational knowledge. Learning is the transition process organizations use to create knowledge allowing organizational knowledge to be expressed as core patterns of interpretation and understanding that uniquely define the organization. Figure 6 provides a depiction of this discussion and will be explained later in this section. This concept extends Huber's discussion of interpretation through the development of the core patterns of interpretation and understanding which represents the knowledge patterns inherent in organizations. This is consistent with Myers' suggestion that organizational knowledge is embedded within the organization (Myers, 1996). Likewise, it is also consistent with Nonaka's discussion of tacit to explicit knowledge, where an organization's knowledge patterns are deeply held and not easily made explicit.
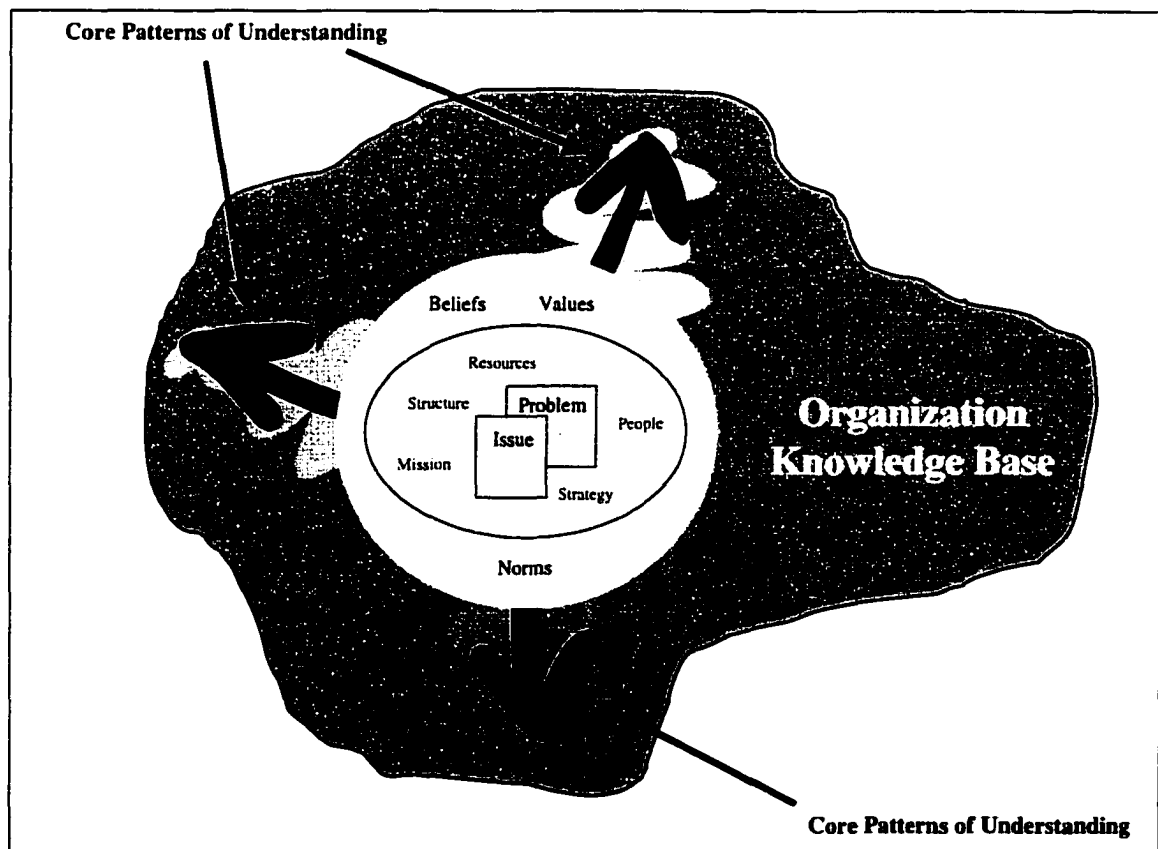
Figure 6.   Organizational Core Patterns of Interpretation

The organizational learning process starts with an organizational problem or issue that needs to be resolved (Weick, 1995). The organizational learning process is affected by the contextual nature surrounding the issue or problem. Some of the contextual factors (also information) may include resources, people, mission, long and short range strategies, and structure. The context surrounding the issue is presumed by the organization and represents a filter that provides understanding of the information developed to inform the subsequent decisions and/or actions undertaken to address the problem. This contextual filter also includes the embedded cultural beliefs, values, and norms of the organization. It is important to note that the organization's underlying beliefs, norms, and values effect how the patterns of interpretation change and develop. Organizational culture arises from the shared beliefs, experiences, and histories of its individuals (Schein, 1992). If the organization has deeply embedded, unshakable beliefs and values, new or modified patterns of interpretation and understanding may not become part of the organization's knowledge base. This may lead to inefficient organizational core patterns of interpretation and understanding. Again, as the learning process unfolds, organizational knowledge is created, modified, or reinforced, where the organizational learning occurs through individuals but represents collective learning. This is consistent with Argyris's and Schön's notion of organizational learning occurring through individuals (Argyris and Schön, 1996). Patterns of interpretation and understanding of the information (knowledge) drives, changes, and directs the organizations core patterns of interpretation toward organization action and decision. These core patterns of

interpretation are tacit and before the organization can determine whether the patterns remain applicable to the organization they must be made explicit.

However, the influence of these core patterns on the organization may not always be positive. Core patterns that stifle new ideas, ignore opposing concepts, or are mired in ritualistic and outdated modes of operation can also be part of an organization's knowledge framework. Whether the core patterns become a positive or negative influence on the organization lies in the uncertainty of the organization's processes, relationships, and leadership. It needs to be understood that organizational knowledge core patterns are present at all systems in focus of the organization. Core patterns of interpretation exist in an organization's engineering department, human resources department, within the mid-level management structure, within the senior management and leadership, and theoretically will be found in various ethnic, religious, and professional groups. As stated earlier, the bounding of the system in focus is an important task for the organizational manager. It determines the patterns of interpretation that will be manifest by the system under study.

Another important issue is the understanding that an organization's core patterns of understanding and interpretation can be found in the organization's formal and informal structure. Within the formal structure of the organization, the organization's core knowledge patterns develop based on the beliefs, norms, perceptions, and interpretive processes and framework established by the organization. Likewise, the informal structure of the organization develops core knowledge patterns. Together these patterns form the basis from which organizations interpret information, make decisions, and determine organizational actions. This study addresses the organization and its formal

and informal structure to provide an explicit understanding of its core knowledge patterns.

In summary, the following are the main points of this section. First, learning is the transition process organizations use to create knowledge allowing organizational knowledge to be expressed as core patterns of interpretation and understanding. Second, the essence of knowledge is the organization's ability to bring together information through some interpretive process or representation that provides meaning to the organization. Thus, the core patterns of interpretation and understanding uniquely define an organization while influencing the organization's system of beliefs, values, and goals.

INTERPRETATION

The interpretive process is governed by the core patterns of organizational understanding contextualizing the information for use by the unit.
> Individual level - mental models interpret information into knowledge, within a particular context that is appropriate and consistent with the type information, organization, and mental model of the individual
> Organizational level - patterns of interpretation and understanding process and frame the information transforming it into knowledge.

Essence of organizational knowledge - the unit's ability to piece together bits of information through interpretation and understanding.

Systems perspective provides a means to see the interconnectedness of the organizational knowledge system components which form system relationships.

What mechanisms do you and your organization use to interpret information to accomplish your assigned tasks and responsibilities?

> Do you have periodic meetings to discuss new information to determine how it effects the organization?
>> Offsites
>> Sensing Sessions
>> Brainstorming Sessions
>> Informal gatherings
>> Collaborative E-mail or computer related tools
> How do you capture the knowledge (understanding) within your meetings and make that available to the organization overall?
> Are there any other formal or informal information interpretation mechanisms you use in the conduct of your job?

Mechanisms

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Do you have any other comments reference the list of mechanisms for information interpretation you have presented me?

INFORMATION DISSEMINATION

The last element of the knowledge system is information dissemination. This is the capacity of information to flow through the organization for use by all organizational entities. Huber's synthesis of the literature is relatively silent on information dissemination. This study provides a look at information dissemination from four aspects (Figure 7). In general, there is a formal information dissemination process and an

Information Dissemination ──────┤ Formal / Informal / Access / Timeliness
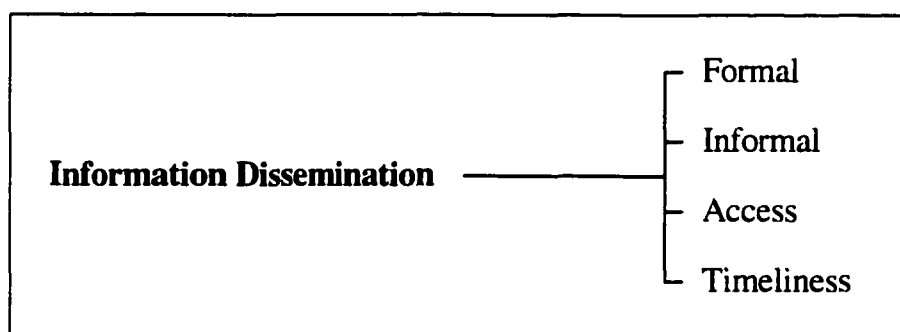
Figure 7. Information Dissemination

informal information dissemination process. Both of these can be further identified by examples like quarterly reports and e-mail messages, respectively. However, all organizationally disseminated information can be categorized as either formal or informal. Formal information can usually be found in an organization's written documentation and follows the organization's physical structure. The formal process also includes scheduled meetings and briefings. Formal information dissemination represents the established processes, routines, and structures used by organizations to disseminate information internally and externally. In contrast, the informal process disseminates information via unstructured or non-mandated information exchange mediums. For example, these might include informal discussions or e-mails. This method of

information exchange is more fluid and much more difficult to capture and manage. However, there is a real richness in these informal information exchanges. The spontaneity and diversity of shared ideas is unencumbered by the usual structured, rule-based exchanges of formal information dissemination. This allows individuals to speak more freely and openly with less regard for position, political correctness, or personal agendas. Thus, informal information dissemination can be understood to be information the organization exchanges which is important to the operations of the organization, but happen outside the established organizational information exchange process structure or routine.

However, there are two other important aspects of information dissemination, access and timeliness. Often overlooked, access and timeliness of information storage are critically important concepts. In this instance, access to information does not refer to members having access to sensitive or proprietary information. The goal is ensuring organizational members have access to information that is relevant. Argyris and Schön (1996) identify access as a critical element which distinguishes limited learning systems from advanced learning systems. The organization or individual must have connectivity to the correct information source for that information to be used effectively. This requires that the information repositories not only be categorized efficiently for member understanding and use, but implicitly requires that organizational members have the ability to establish connectivity to these repositories when desired. Access to the World Wide Web is achievable by anyone who has an Internet connection. But access alone is not sufficient. The vast amount of information contained in the Internet can and does cause information overload. But access is not confined to "hard" information. A more

deleterious effect on organizational information storage is the inability to obtain access to "soft" information. This study attempts to capture these "soft" information repositories and make them explicitly known to the organization.

Timeliness of information is also an important issue to information access and retrieval. Timeliness of information addresses the idea of the temporal nature of information. The window for action and decision is not forever open. If information is to have an impact it must be captured when and where needed. The turnaround time for most organizational action is not fast and some would say that the turnaround time for a decision is directly proportional to the size of the organizational bureaucracy (Senge, 1990). This concept is no different for information creation or exchange. The review process for information dissemination oftentimes is longer than the effective benefit life of the particular information. As business becomes increasingly more and more tied to the timeliness and relevance of information, new processes and methods will need to be discovered by business entities to ensure that information gets to the right place at the right time. Quinn, Baruch, and Zien (1997) talk about organizations extending their time horizons to ensure that they meet critical goals and objectives. Their discussion is focused on capital investments, but this idea is easily extended to information as it becomes more and more a capital investment. The deliberate planning and continuous monitoring of an organization's knowledge system will help organizations determine their information requirements, and as part of the planning process the important aspect of timeliness can and will be addressed. Similarly, organization's can continuously monitor and manage their knowledge system through the concept of the organizational knowledge system. The organizational knowledge system provides the organization the

holistic perspective of their organizational dynamic, where the organization's learning

and knowledge processes are viewed as separate but integral concepts that have a rich

symbiotic relationship.

INFORMATION DISSEMINATION

The capacity of information to flow within the unit and outside the unit for use by all organizational entities.

Four aspects of information dissemination:
   Formal - established processes, routines, and structures organizations use to disseminate information internally and externally
   Informal - information organization exchanges which is important to the operations of the organization, but happens outside established organizational information exchange processes.
   Access - organizational members can get to information that is *relevant*
   Timeliness - addresses temporal nature of information, it must be presented on time and on target

What mechanisms do you and your organization use to disseminate information to accomplish your assigned tasks and responsibilities?

   Do you have access to the necessary information which will facilitate you accomplishing your responsibilities and tasks?
   Is your access timely (when needed)?
   Are there any other formal or informal information interpretation mechanisms you use in the conduct of your job?

Mechanisms

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Do you have any other comments reference the list of mechanisms for information interpretation you have presented me?

APPENDIX E
Research Web Site

The research web site was primarily established to provide research participants the ability to complete the computerized surveys from home or office. However, it evolved into an information tool for the research, as well as the link to the computerized surveys. The web site provided the research participants an overview of the research goals, explanation of the organizational knowledge system and organizational knowledge system model, links to organizational knowledge and learning literature, the products of the research, and a link to the computerized surveys. As stated earlier, the computerized surveys were developed using the Inquisite software package and the front end of the surveys can be seen in Appendix F. The utility of the web site demonstrated to the participating research organizations that this research can effectively use the power of e-business to facilitate their organizational dynamics.

The Organizational Knowledge System

Providing organizations and individuals a graphical representation of their unique knowledge system.

Background

Organizational knowledge and knowledge management have been increasingly recognized as an underdeveloped aspect of technology based organizations (Nonaka, 1985; Brown & Duguid, 1998). Understanding and managing knowledge can improve the effectiveness and efficiency in an organization. Likewise, understanding the construction, and representation of knowledge have been identified by organizations as an important element to organization growth and viability. Thus, this research is devoted to the goal of providing organizations and individuals a graphical representation of their knowledge system.

Research Purpose

The purpose of this research is to develop and apply a system-based analysis methodology which constructs and represents an organizational knowledge system. The research focus is two-fold; first, to develop a systems theory based methodology for understanding the organizational knowledge system and; second, to apply the methodology in organizational settings.

Research Significance

Extends the existing scholarly literature by building the intellectual connection between organizational learning and organizational knowledge.

Develops the concept of an Organizational Knowledge System and provides a methodology that constructs and represents an Organizational Knowledge System.

Provides a computer-based robust reusable application method for organizations and individuals to identify and understand their knowledge system.

Gives organizations and individuals a practical method of evaluating their knowledge system to identify deficiencies and determine if its adequacy for current and future environments and conditions.

Researcher	Research Committee Members:
Willie J. McFadden II Doctoral Candidate Department of Engineering Management Old Dominion University	Dr. Charles Keating, Dissertation Advisor Dr. Derya Jacobs Dr. Paul Kauffman LTC Bruce Bowman, Ph.D.

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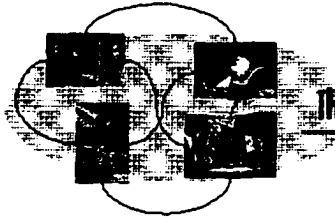
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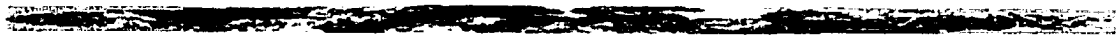
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Providing organizations and individuals a graphical representation of their unique knowledge system.

Construction & Representation

The Organizational Knowledge System

The Organizational Knowledge System is developed from the organizational learning and organizational knowledge literature. It uses as a basis Huber's constructs of organizational learning and combines systems theory and the cognitive hierarchy theory, which binds Huber's construct's into a modified set of knowledge subsystems.
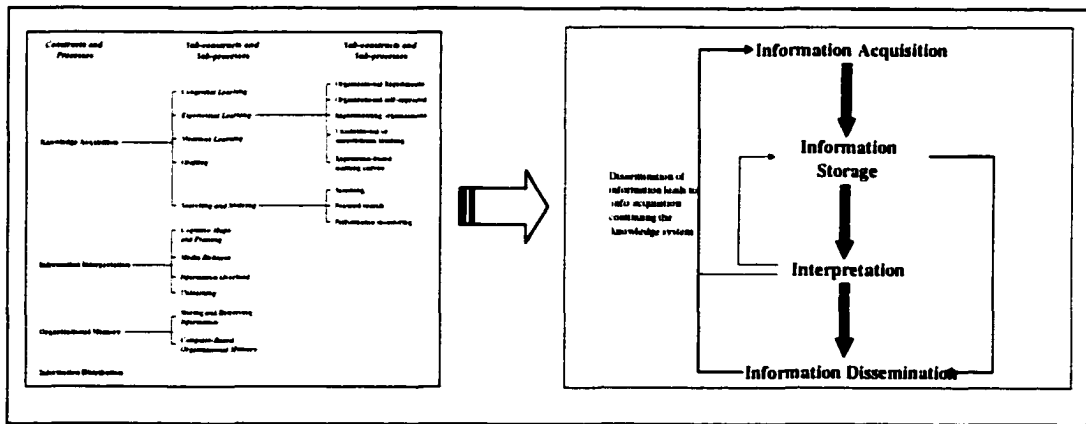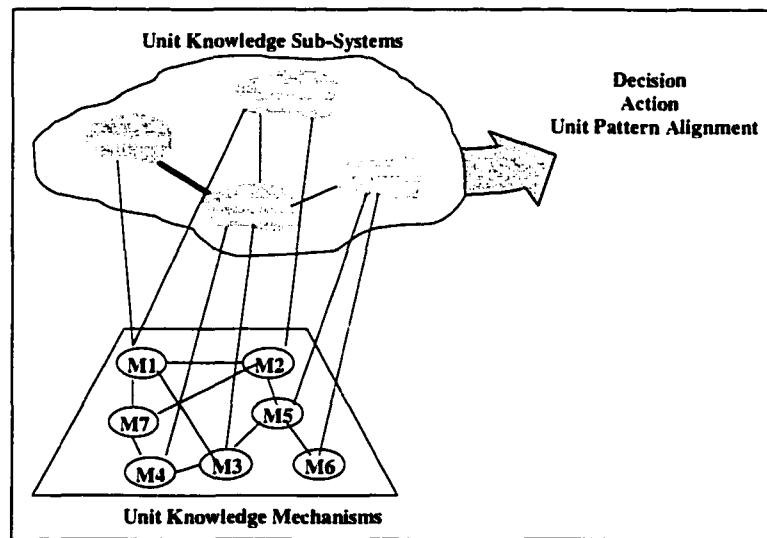

The glue in this binding process is systems theory. Systems theory provides the conduit for looking at not only the elements of the knowledge system, but their rich interaction. It also establishes a holistic perspective of the relationship which exists between organizational learning and organizational knowledge.

> *Information Acquisition*
> *Information Storage*
> *Interpretation*
> *Information Dissemination*

The Model

The system model serves as the framework for the application of the organizational knowledge system in an organization. The model consists of the four knowledge sub-systems and the organizational knowledge mechanisms (e-mail, reports, staff meetings, etc.) which serve as the vehicles organizational members use to inform their knowledge system.
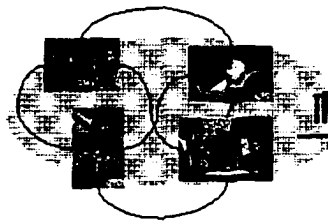

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Links to Organizational Learning & Knowledge

This research leans heavily on past and current work in the areas of organizational learning and organizational knowledge. A detailed review of the organizational learning and organizational knowledge literature gives one an understanding of these two areas leads to the concept of an organizational knowledge system. Provided are two substantive sources concerning these two important areas of interest to the business and academic communities. Also, provided is the bibliographic listing associated with this research.

Knowledge Management & Organizational Learning - Web resource on knowledge management and organizational learning

Selected References: Organizational Knowledge & Learning - The following list contains selected references on Knowledge Management compiled by Yogesh Malhotra from some of his working papers.

Research References - Research bibliography for the dissertation proposal, A Systems-based Methodology for the Construction and Representation of the Organizational Knowledge System. Submitted to the faculty of Old Dominion University for the fulfillment of the requirement for the degree of Doctor of Philosophy in Engineering Management.

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The Organizational Knowledge System

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Providing organizations and individuals a graphical representation of their unique knowledge system.

Products

All research must add to the academic body of knowledge and this research is no different. Some specific products of this research that will benefit organizations and individuals are listed below.

The list of products resulting from the interviews and document reviews are as follows:

> List of organizational mechanisms provided by organizational members that inform their knowledge subsystems.

> Qualitative and quantitative data to help provide insight on the strength of relationship between mechanism - mechanism, mechanisms - knowledge subsystem, and knowledge subsystem - knowledge subsystem.

> Articulation and understanding of the organization's knowledge system boundary.

> Identification of mechanisms found in document reviews and interviews to determine the correlation of the two and their implications on the organization's knowledge system.

The list of products resulting from the computer survey is as follows:

> Database of responses that quantitatively measure strength of relationships between mechanisms and subsystems

> Graphical representation of the organization's knowledge system.

The products resulting from the data analysis are as follows:

➤ Analysis and explanation of an organization's knowledge system

➤ Unit out-briefing.

The product resulting from the post report survey is the unit assessment of the organizational knowledge system methodology and model.

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The Organizational Knowledge System

Knowledge Requirements Analysis
Determination of Information Requirements
Purposeful Work System Knowledge Design
Knowledge Creation

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Providing organizations and individuals a graphical representation of their unique knowledge system.

Surveys

Welcome to the survey page. Here, you will find the links to the web based surveys that have been developed to assess your organizational or individual knowledge system. The surveys are developed to elicit participant responses which will enable the construction and representation of your organizational knowledge system. The surveys will give you an opportunity to confidentially share your opinions and ideas about your organizational knowledge system. It is not a test and since the survey items are concerning your opinions, there are no right or wrong answers. Under no circumstances will the information be used to identify you organizationally or in the research; all responses are kept completely confidential. Please complete each survey quickly, so as to speed the completion of the construction and representation of your organizational knowledge system.

There are three modules to the first survey. The first module allows you to provide your assessment of your organizational knowledge system mechanisms. The second and third modules are assessments of the strength of relationships and redundancies of the organizational knowledge system mechanisms and subsystems, respectively.

Thank you for your participation. It will not only benefit this research, but will also provide you and your organization a clear and unambiguous representation of your knowledge systems. This will provide you and your organization a starting point from which to purposefully design information systems, employ reengineering strategies, assess information flow within the organization, and manage knowledge.

Survey (Assessment of Mechanisms & Subsystems)

Module 1 Assessment of the Organizational Knowledge System Mechanisms
Pilot Module 1

First Research Organization Module 1 Information Acquisition
First Research Organization Module 1 Information Storage
First Research Organization Module 1 Information Interpretation
First Research Organization Module 1 Information Dissemination
Module 1 Information Acquisition
Module 1 Information Storage
Module 1 Information Interpretation
Module 1 Information Dissemination

Module 2 Mechanism Redundancy & Relationships
Pilot Module 2
First Research Organization Module 2
Module 2

Module 3 Subsystem Assessment and Strength of Relationships
Pilot Module 3
First Research Organization Module

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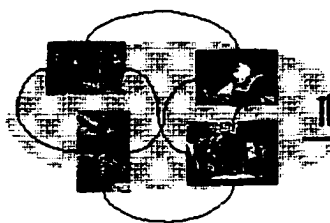
The Organizational Knowledge System

Knowledge Requirements Analysis
Determination of Information Requirements
Purposeful Work System Knowledge Design
Knowledge Creation

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Providing organizations and individuals a graphical representation of their unique knowledge system.

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APPENDIX F
Interview Notes and Transcripts
(An Example)

This appendix provides the reader with an example of the notes and transcripts obtained during the semi-structured interviews. The data obtained from these collection methods provided the qualitative substance and richness of their organizational knowledge system dynamics and context. This data was triangulated with the quantitative data obtained from the research surveys that resulted in the development of each organization's knowledge system representation.

TAB 1
Interview Notes (An Example)

Participant: ef7pr4

INFORMATION ACQUISITION

Organizations acquire and assess information to remain competitive in their industry environment.
    Determine if business processes, goals, vision, or strategies require modification, confirmation, or change

Organizations acquire information in two ways - creation and obtainment.
    Creation of information - organization learning from experience
    Obtainment of information - purchasing, stealing, alliances, and or cooperative agreements

What mechanisms do you and your organization use to acquire information to accomplish your assigned tasks and responsibilities?

Do you go to any particular person?
What about organizational SOPs? Are there other documents you use to acquire information?
Is your personal experience and expertise all you rely on? If so, when do you feel you reached this level?
What about organization meetings?
Are there any other formal or informal information sources you use to accomplish your job?

Mechanisms

AES Group
Operations Staff
E-mail
Web

Do you have any other comments in reference to the list of mechanisms for information acquisition you have presented me?

Notes:

+ Department does not place high value on learning outside of organization
+ Meetings are irregular and unstructured with no agenda (Respondent wishes dept. had meetings)
+ Communications from dept to external agencies are not good

+ Web site that provides information on department's cryovac construction and assembly operations, as well as other department functions, is under development

Participant: ef7pr4

INFORMATION STORAGE

Two components of organizational storage - repositories and categorizing.

Repositories - where information is stored
  Examples: reports, people, computer-based filing, manual filing, and process files
  "Hard" information - explicit information composed of written rules and digital code
  "Soft" information - stored in the minds of the individual members of the organization

Categorizing - how information is stored
  Examples: subject, alphabetical, flat files, relational files, department
  Determines/influences how organizations search for information
  Gives insights to how an organization thinks

What mechanisms do you and your organization use to store information to accomplish your assigned tasks and responsibilities?

   Do you have access to your organizations storage mechanisms?
   How would characterize the usefulness of your organizations information
     categorization?
   Are there any other formal or informal information storage sources you use to
     accomplish in the conduct of your job?

Mechanisms

Technical Notes
E-mail
Operations Log Book
Personal Computer Files

Do you have any other comments in reference to the list of mechanisms for information storage you have presented me?

Notes:

+ Tries to use hard repositories
+ E-mail messages are stored by topical subject
+ Internal dept. technical notes storage is loosely put together
+ Technical notes, analysis, and summary of results are stored only by date and title
+ Respondent does not feel that dept truly has organizational level storage repositories
+ Organization information categorization is good only if one knows if something is
stored, where it is stored, or can find the right person to tell them where to find the
information desired

Participant: ef7pr4

INTERPRETATION

The interpretive process is governed by the core patterns of organizational understanding contextualizing the information for use by the unit.
Individual level - mental models interpret information into knowledge, within a particular context that is appropriate and consistent with the type information, organization, and mental model of the individual
Organizational level - patterns of interpretation and understanding process and frame the information, transforming it into knowledge

Essence of organizational knowledge - the unit's ability to piece together bits of information through interpretation and understanding.

Systems perspective provides a means to see the interconnectedness of the organizational knowledge system components which form system relationships.

What mechanisms do you and your organization use to interpret information to accomplish your assigned tasks and responsibilities?

> Do you have periodic meetings to discuss new information to determine how it effects the organization?
>> Offsites
>> Sensing Sessions
>> Brainstorming Sessions
>> Informal gatherings
>> Collaborative E-mail or computer-related tools
> How do you capture the knowledge (understanding) within your meetings and make that available to the organization overall?
> Are there any other formal or informal information interpretation mechanisms you use in the conduct of your job?

Mechanisms

Brainstorming
Collaborative E-mail

Do you have any other comments in reference to the list of mechanisms for information interpretation you have presented me?

Notes:

+ "We need something"
+ Capture of knowledge within organization is done horribly
+ "Nothing is formally established"

+ Only by chance do dept. personnel see papers from conference proceedings presented by other dept. personnel

Participant: ef7pr4

INFORMATION DISSEMINATION

The capacity of information to flow within the unit and outside the unit for use by all organizational entities.

Four aspects of information dissemination:
Formal - established processes, routines, and structures organizations use to disseminate information internally and externally
Informal - information organization exchanges which is important to the operations of the organization, but happens outside established organizational information exchange processes.
Access - organizational members can get to information that is *relevant*
Timeliness - addresses temporal nature of information, it must be presented on-time and on-target

What mechanisms do you and your organization use to disseminate information to accomplish your assigned tasks and responsibilities?

Do you have access to the necessary information which will facilitate you accomplishing your responsibilities and tasks?
Is your access timely (when needed)?
Are there any other formal or informal information interpretation mechanisms you use in the conduct of your job?

Mechanisms

E-mail
Web Postings
Face to Face Meetings
Standard Operating Procedures (SOPs)
Formal Meetings

Do you have any other comments in reference to the list of mechanisms for information interpretation you have presented me?

Notes:

+ Information is a pull activity in the dept
+ Respondent feels that pushed information is an organizational weakness
+ SOPs were used as an information dissemination source previously
+ Web postings include technical notes and graphics

TAB 1
Transcribed Interview (An Example)

Researcher: O.K. today I am going to interview four people. The Joint Work Fighters, to do my research on organizational knowledge, on the analysis and base line development assessment, the IPT, for the Joint War Fighters. My first interviewee is HD3NA5 and HD3NA5 has signed the consent form and agreed to the consent form. I have given him a copy and we are going to go ahead and start the interview process.

Researcher: HD3NA5, when we talked at the beginning of my briefing, I presented four different subjects that were the major elements of the organizational knowledge system. And they were information acquisition, information storage, information interpretation, and information dissemination. And my goal here in this interview is to get from you what type of mechanisms the other important elements of the organizational knowledge system that you use to inform yourself about those different subjects. We'll start off first with information acquisition. And information acquisition is basically where organizations acquire and assess information to remain competitive in their industry or environment. They determine if their business profits, goals, visions, or goals strategies require modifications, validation, or change. And through the literature what I found is that there is two ways organizations acquire information basically. One is creation, and that creation is that information, organization learning from experience. And the other is obtainment. And the obtainment of information is like purchasing, alliances, cooperative agreements, but they get it from some other outside source, or internal source to the organization, or even to the system in focus that we are looking at here at IPT. Other organizations actually steal it too. And I don't believe you guys are going to do anything unethical. So we know that you guys don't do that. But that's basically the two ways, you can stratify them in any other type of way that you like. But they basically fall into creation and going out and getting it some how. So the basic question I have for you, is what mechanisms, what sources, what ways, what elements do you, or your organization use to acquire information to accomplish your assigned tasks on responsibility?

HD3NA5: OK, the Lead Analyst, first of all is the lead for analysis and the program. He would be preferably the primary source.

RESEARCHER: So, the Lead Analyst is the source for you to get information to do your job in this IPT?

HD3NA5: To help give us direction, to meet our objectives.

RESEARCHER: Are there any other particular people?

HD3NA5: No. I would say that he is about the only one. In addition to Lead Analyst we have a 4 o'clock meeting every afternoon, with Lead Analyst and the rest of the IPTs.

That is where the IPTs share information and we each brief what direction we are headed in, and what kind of progress we've made.

RESEARCHER: In that 4 o'clock meeting that you are talking about, is that just an overview or synthesis type meeting? Or is it just each IPT telling the other IPTs what they've done today? Or what some of their issues are, some of their successes?

HD3NA5: It's each IPT telling each other what they've done, the direction they are headed in, what kind of progress they've made, and then also discussing ideas for what direction we should go in. Because we don't have a lot of guidance at the program level.

RESEARCHER: When you say don't have a lot of guidance for the program level, who are you speaking of? What element? Or what level are you speaking at?

HD3NA5: Talking about the management level, we are the IPT for analysis for the data we collected at UFL '99. Management should be, in my opinion, giving us guidance as to how to conduct that analysis at that program level, guidance which basically I've never received. So what we do at the 4 o'clock meetings is we pretty much decide which direction we're going to go and so we discuss those kinds of things at that meeting.

RESEARCHER: Do you find this IPT meeting helpful? Does it work?

HD3NA5: Yes, absolutely.

RESEARCHER: Would it be a detriment to you guys if this meeting ended?

HD3NA5: Yeah.

RESEARCHER: What other type of meetings do you all use, to help you accomplish your tasks and responsibilities?

HD3NA5: That is probably the only regular formal meeting that we have. We have other informal meetings where we may decide that we need to discuss how we are going to do trial reconstruction. What kind of procedure we are going to use. And just then, informally me and maybe some of the other analysts will sit down and discuss that.

RESEARCHER: And when I put this together, I am looking at the 4 o'clock meeting being a formal meeting that you all are at?

HD3NA5: Yeah.

RESEARCHER: OK, was that established by management or established by the IPT or Lead Analyst?

HD3NA5: Initially it was informal, "Hey why don't we sit down at four and tell each other what is going on." And then we just decided that it was going to be a regular, everyday 4 o'clock meeting. And that was among the analysts.

RESEARCHER: Now you just started mentioning about the informal meetings that you have. Are there a lot of informal meetings, or a lot of "hey you" type of meetings? Which one is more predominate? The informal meetings where you send out email to talk about an issue, or you call someone up, or see someone in the hallway. And you kind of get together with a few folks and you do that kind of informal meeting? Or is it just like "hey I got an idea", a "hey you" type of deal?

HD3NA5: It's more, "hey we need to go in this direction, why don't we sit down and talk about it?" So it's not anybody in the chain of command or the management saying, "you guys need to sit down and discuss this." It's just among the analysts. One of us comes up with an idea, or figures some direction we need to head in, and we just say let's sit down and talk about it, before we jump in.

RESEARCHER: Are any of your IPT members there at any specific meetings that you have?

HD3NA5: No, I do most of my communication through email and then sitting down with the guys on a daily basis. I pretty much work with TD7BM5 side by side, day in and day out. So he has a much better idea of my thinking and my direction then the other guys do, but for the most part, it's just day to day working with them so there is really not a need to sit down and have a meeting.

RESEARCHER: What about specific documents? Or SOPs? Organizational SOPs or IPT SOPs? Do you go to through to acquire information?

HD3NA5: The main one is the UFL data analysis plan.

RESEARCHER: Is this a living document or static?

HD3NA5: It's a living document as we complete tasks, and then move on to the next phase, we.... It's a plan that should have been written before UFL, and before we conducted the analysis. But since it wasn't done, and we weren't given any guidance, its a living document that we as analysts sit down and said this is the direction we need to go in. And as we determine a direction, we sit down and write that section of the plan, and even though I've written a good portion of it, it's still an informational document that I go to, to figure out my direction and my objectives.

RESEARCHER: Are there any AR's, or DOD pamphlets, or other studies, or SOPs or other documents that you go to use?

HD3NA5: Sure, this would be the primary one, but of course I look at the analysis plans of other JT&E's that have been conducted. I look at joint doctrine pubs. Are you talking that I use to get gain information?

RESEARCHER: Yeah. When you said a joint publication, are these publications pertaining to fires?

HD3NA5: Not analysis, but of joint doctrine or joint targeting. I guess that I would include in there text books from school, from my masters program and notes.

RESEARCHER: Those text books are basically what types of text books?

HD3NA5: Engineering, management, operations research analysis, anything that seems to fit. And then my notes from those classes, and those programs as well. Web sites, such as INFORMS Web site, TRAC Web site, looking to see how some other organizations have done certain kinds of analysis.

RESEARCHER: Do you use those web sites on a regular basis, or just a one time shot, periodic?

HD3NA5: I would say pretty regularly, there are several that I go to at least once a week.

RESEARCHER: And mainly you go to INFORMS or TRAC?

HD3NA5: INFORMS is probably the main one. TRAC is next.

RESEARCHER: What about your personal experience? Do you rely on your personal expertise and experience a lot in this information source?

HD3NA5: Yes.

RESEARCHER: At what level are we talking? Military, artillery type experience? Or are we talking analyst type experience?

HD3NA5: More analyst, because even though I've got the artillery experience, I have actually never worked at the level that we are studying. We are looking at joint deep operations basically, and I never worked above division level. So even though I've got some artillery experience in targeting, and process in shooting targets, I never worked at that level in artillery. And so most of my experience that I draw from is from the analysis side.

RESEARCHER: Thus far what I have gathered these mechanisms, you talked about an individual, which I would term as an expert, or in this case Lead Analyst. You brought out formal meetings, the 1600 IPT formal meeting that everybody goes to. You talked about informal meetings, that you have among the analysts. And I understand that the

informal meeting among the analysts is one that doesn't necessarily reside just in your IPT, but it is outside your IPT as well.

HD3NA5: Right, we do a lot of cross IPT work. And we will just sit down and talk about an idea or direction we want to go in, and it is not necessarily limited to an IPT.

RESEARCHER: Some of the other things that you talked about, you said that you go to UFL Data Analysis Plan, that is a living document, that is kept by Lead Analyst. Analysis plans of other JT&E's, you look at those for ideas, on how to do things, or what you may be missing. Joint Publications, mainly those are Joint Targeting or Joint Fires. And you mentioned your text books, you go back to for basically statistics and OR type of issues. As well as your notes. And web sites, you said you go to web sites, INFORMS and TRAC, to also look at how to do analysis type operations. And then you said you rely on your personal experience, mainly the analytic experience that you have.

HD3NA5: Right.

RESEARCHER: Are there any other type of information sources?

HD3NA5: I have to add in, both TD7BM5 and Analyst 1 who have significant analytical experience. And even though TD7BM5 is part of my team, and Analyst 1 is in another IPT, I basically don't do anything without consulting the two of them first. They have a wealth of knowledge.

RESEARCHER: And the knowledge that you get from them is mainly, what type?

HD3NA5: Analytical expertise.

RESEARCHER: Anything else you would like to add?

HD3NA5: No, that's it.

RESEARCHER: OK, we will move on to storage. Information storage is a very important aspect. And basically what I found is there are two different components to information storage. One is the repositories themselves, where you store information. And the other is categorizing, how you store it? In the repositories, some examples could be, reports, computer filing, manual filing, process files. Where you have the hard information, that is explicit information that's composed of written rules, and digital codes. And then you have the soft information, which is stored in the minds of individuals, members of the organization, this case your IPT. So that would be the people. And categorizing that information is also critical and some examples of that could be, categorized by subject, alphabetically, in flat files, in relational files, by department, by project. And what I found is that how an organization categorizes the information, gives a lot of insights to determine how organizations search for information and let's you understand a lot about how that organization thinks. How important and

how complex the information relationships can actually be. So, do you have any questions on that? Do you understand?

HD3NA5: I think so.

RESEARCHER: Understanding that, what mechanisms do you or your organization use to store information to accomplish your assigned tasks and responsibilities?

HD3NA5: The main one would be the USFL data analysis plan. Like we discussed on the last question, it is a living document. So we'll determine which direction we what to go in, and how we're going to conduct certain procedures of the analysis. And then we'll write that, maybe after the fact. So that's why it becomes a storage facility, and we will decide how we are going to do it, we are going to determine the procedures, then we write it and goes it into the data analysis plan. So that is why I consider it probably the main storage facility.

RESEARCHER: What other storage repositories do you have in this organization that you all use?

HD3NA5: The K-Drive, is the common drive on the LAN.

RESEARCHER: Do you use that?

HD3NA5: I do. That's where shared information goes.

RESEARCHER: What type of information do you all put up there?

HD3NA5: Any documents that are created in the organization, briefings, procedural documents, if you want to put any change to the configuration in the data analysis, and if for example, you want a printer in there, you want certain software in there to do analysis you have to put in a change request. You go to the K-Drive to get that.

RESEARCHER: Are there any others, for instance any other repositories that you all have? That you use to store your information, of that you go to, to get information?

HD3NA5: We've got a classified LAN in the data analysis center. And on that LAN, we've got only certain people have access to it, and all of the analysts do. We've got a shared folder on that LAN, that any kind of analysis we do is classified, stays on that LAN, and we go to that. Also in there we have, and this may not apply, but you can tell me if it does or not, the data that we collected at USFL, right now, we're waiting for the data base to be constructed and the data entered, but in the mean time what we have done, is taken certain pieces of the data, and put it into an Excel spreadsheet, on that LAN, and that is what we do most of our analysis with right now.

RESEARCHER: What about any type of hard copy? You talked mainly about computer based type stuff. What about hard copies? Are there any type of hard copy or manual filing type repository that you use?

HD3NA5: No, I'd say the main two things are The K-Drive and the data analysis plans really are the only hard copies.

RESEARCHER: What about reports?

HD3NA5: No reports yet.

RESEARCHER: Process files?

HD3NA5: No.

RESEARCHER: Process documents?

HD3NA5: No, well I consider that data analysis part of a process document, how we are going to analyze procedures. I guess you can consider email, but again that's part of the LAN.

RESEARCHER: Is e-mail a major information storage repository for you? I mean I have noticed that you didn't say information acquisition for it.

HD3NA5: I didn't because, normally being the IPT lead, and one of the IPT leads any email I get reference, analysis, is after the fact. I create the empty mail, so to me it's not really information, it's information that I am passing on to somebody else. And when I get email, reference analysis, I normally already know it, so it's after the fact, and I don't consider it new information. But it could be stored information, because I may refer back to an email at some point, one that I sent out or one that I got, so it may be a storage.

RESEARCHER: Do you use these e-mails as like a storage repository for yourself?

HD3NA5: I do. I have an analysis folder in Outlook and I put everything in there.

RESEARCHER: Moving from the repositories, or are there any other repositories that you use?

HD3NA5: I can't think of any others.

RESEARCHER: OK, moving from that then, do you have access to your organization's storage mechanisms you've identified? You identified the UFL data analysis plan, the K-Drive, the classified LAN, and email. Do you have access to all of these?

HD3NA5: Yes.

RESEARCHER: How would you characterize the usefulness of your organization's information categorization? Not your email in this case, because you do that the way you would like to do it. But how do you store information on the LAN? How do you store it on the K-Drive? Or specifically since you said that the UFL data analysis plan is critical here, how is it laid out in that? Do you see the categorization usefulness for your organization to be good or bad? Or adequate?

HD3NA5: I would say the LANs are good, both of them classified, and the K-Drive. The data analysis plan is good, except that it shouldn't be a living document, to the extent that it is, it is something that should have been done well before this stage in the program, and it should be something that we can draw from and not something that we are creating as we go along.

RESEARCHER: So you are saying it should be a reference document, something that you can see that your procedures are correct, not something that you have to build, to track what you are doing?

HD3NA5: Right. Now I just thought of a couple of references that we go to as far as acquiring information. They are the main program documents, the Analysis Plan for Assessment, the APA. The data management and analysis plan, the D-map, the program test plan, the PTP, the UFL test plan how we conducted the test while we were in Korea in August.

RESEARCHER: Do you find yourself going back to these documents?

HD3NA5: I do. They are very general in nature for the most part. I find myself going back to those more to see what we said we were going to do as a program, and are not doing.

RESEARCHER: Now, when you say APA, what does that stand for?

HD3NA5: Analysis Plan for Assessment.

RESEARCHER: And the D Map?

HD3NA5: Data Management and Analysis Plan.

RESEARCHER: Now you said something interesting there to me that I want to explore, you said that you go to the D Map, the general document, to see what you're not doing. Are these documents basically definitive documents that really do outline what your goals, objectives are, and missions are?

HD3NA5: That is what they are supposed to do. And that's what we all assume that they did. But as time has gone on we have found that they seem to be more of a check the block type document. They're requirements that the program has to fulfill to continue on and that we are not following.

RESEARCHER: Has anybody ever gone back and take a look at the major objectives within these plans? Lined them up with your missions to determine if you are meeting those goals and objectives to accomplish the mission?

HD3NA5: Yes, and I guess it depends on your perspective when you think we're meeting those objectives, goals, procedures, or not. In my opinion, we are not.

RESEARCHER: Going back to information storage. Are there any other formal or informal? Because you have mentioned all formal, information storage, you use to accomplish your job?

HD3NA5: I guess you can consider some different people storage facilities, obviously Lead Analyst would be one, since he's the lead for analysis in the program. And then the different IPT leads, if I've got questions, or I need some information on data, data base, data entry, I would go to Analyst 2. And information on enhancements or how we are going to develop the enhancements, I go to Lead Analyst or Analyst 3 for example, is the Army SME. If I had a question on Apaches, or how they should be used, or how the Division operations coordination center should do a certain kind of operation, he's the one that I would go to. So subject matter experts I guess.

RESEARCHER: Anything else you would like to add to information storage?

HD3NA5: No, I can't think of anything else right now, except, that the data base that I mentioned earlier where data we collected should be stored and used for analysis. It is not developed yet, and that's a central problem, for conducting analysis right now. And that would be a main information storage facility, if we had it.

RESEARCHER: Just a note from me, I find it strange that there is no central data base, or no data basis that you use to do analysis.

HD3NA5: That is a big problem right now. The analysts are asking for that data base as quickly as possible. And asking for guidance in the level we need to go to in analyzing that data once it is available, and neither one of those are available right now. And as far as analysts are concerned, that's a show stopper.

RESEARCHER: Moving on to the interpretation. Information interpretation is the organization interpretative process which is governed by the core patterns of organizational understanding and contextualization. The interpretative process is governed on two different levels. One is the individual, where your mental models interpret information into knowledge. However, on the organizational side, it becomes patterns of interpretation and understanding that process and frame the information that transforms into some type of useable knowledge for the organization. What I would like to ask first is do you understand what I am talking about when I say information interpretation from an organizational point of view?

HD3NA5: You are asking how my IPT interprets the information that we acquire?

RESEARCHER: Yes, that's exactly what I'm asking. So, my basic question is the same format as the other two, what mechanism do you and your organization use to interpret information to accomplish you assigned tasks and responsibilities?

HD3NA5: Would our expertise and our education be a way of interpreting information?

RESEARCHER: That would be a process in the way that you do it, yeah. A forum would be, we have the 1600 meeting, to do it. Or we have an informal meeting, that could be a forum. A brainstorming session would be an example of a way to interpret information.

HD3NA5: I guess as an IPT, probably the main source would be after the 1600 meeting, immediately after or the next morning, some of us, TD7BM5 and I, Analyst 2, and Analyst 1 especially since we have been spending a lot of time together on that will discuss the direction, the procedures ( ).

RESEARCHER: So this is an informal meeting?

HD3NA5: It would be informal.

RESEARCHER: But this informal meeting that you just mentioned to me, that's not internal to your IPT?

HD3NA5: Sometimes it is, sometimes it isn't. Maybe just TD7BM5 and I. I would consider that an internal meeting to the IPT. I would say most of them probably are not, most of them include members from other IPTs. I guess the 1600 meeting would be a source of interpretation.

RESEARCHER: Do you use it in that manner? As an interpretative type of forum?

HD3NA5: As an IPT I am not sure. As an individual, the information is passed to me at that meeting and I interpret it one way or another. I can't say that we do that as an IPT.

RESEARCHER: So I would call that as reflected thought. As for you use the reflective thought as interpretative process. Are there any formalized type methods that you use to interpret information in organization?

HD3NA5: I really can't think of any unless after a meeting I may send out an email to the IPT telling them what I think. A post meeting email saying, "OK this is what we discussed, this is what we heard, and this what I think, and the direction we need to go in." If you want to call that an organizational interpretation.

RESEARCHER: Now, is that a collaborative type email, or is it basically your point of view, you're putting out....

HD3NA5: It would be my point of view. And I might get something back from someone else's point of view.

RESEARCHER: But that does happen?

HD3NA5: Yeah.

RESEARCHER: What other forms do you use? You said that you don't have any informal type system within your IPT to interpret the information. What about the organization at large? Does it have any formal type system?

HD3NA5: I really can't think of anything that would be formal.

RESEARCHER: What about influences?

HD3NA5: Again, it would just be discussion, informal discussion with us and the experts in a certain area with an individual's knowledge of all things in a certain area that we're working in.

RESEARCHER: What about once you've had these meetings, how do you capture the knowledge? These informal meetings, that you go to, to reflect the thought process individually. Or do you have some type of collaborate email? How do you capture the knowledge, the understanding and make that available to the organization overall?

HD3NA5: Normally it would go in the analysis plan, so we would have a discussion interpret the direction that we're heading and the procedure that we need to follow, and then I usually write as the lead of IPT I usually end up doing the writing so then I would put that into the analysis plan.

RESEARCHER: What if it is not at that level? How do you store it? How do you make it available to everyone, that you normally wouldn't come in contact with?

HD3NA5: I would say that it would just be face to face, if there is something that we interpret, and we decide it needs to be shared, that I would probably go tell that person. Normally it doesn't develop into something formal or written document and we probably don't do a very good job of that.

RESEARCHER: Are there any other formal or informal information interpretation mechanisms or forums that you use?

HD3NA5: I can't think of anything else because there are no other formal meetings in the organization. Management has one on Wed morning, but usually that is more of an administrative meeting. I can't think of any others.

RESEARCHER: And the last area is information dissemination. And it basically can be termed as the capacity of information to flow within the organization and outside the organization. And there are four aspects to it. One is there is a formal aspect. You have established processes, routine instructions, organizations use to disseminate the information. That could be externally or internally. Then you have informal, which is the organization exchange that is important to the operations of organization, but is outside the established organizational information exchange process. Then, there are also two others. Access, are the organizational members able to get to the information that is relevant? And timeliness, it addresses the temporal nature of the information. information must be presented on time, and on target. You and I both know if you are 20 minutes late, the information is no good. So you have four different aspects: the formal and informal and underneath formal and informal there are access and timeliness. What mechanisms do you and your organization use to disseminate information to accomplish your assigned tasks and responsibilities?

HD3NA5: OK, you want me to break it down within the IPT and then outside the IPT?

RESEARCHER: No, what do you use?

HD3NA5: We use email, as one. Informal face to face discussions. The 4 o'clock meeting would be the primary formal meeting, and again that's not internal for the IPT but internal to the JWF organization. I guess you could say briefings, recently we concluded the reconstruction of 30 trials and then we wanted to get some clarification from the data collectors who actually collect the data. We brought them in and gave them a briefing on how we establish the files. And what we wanted to do with them in their data collector reviews, was to set a briefing and to put them through the process that we use. That is really the only type of meeting or briefing that I know of at this point. And we brought in many people in the organization.

RESEARCHER: In your IPT, you mentioned some of the ones that I assume that you would know. Let me throw some ideas out about other ones. Do you have a web site that you put things up for your IPT?

HD3NA5: No.

RESEARCHER: What about a pamphlet or a published flier? Do you do anything like that?

HD3NA5: We've got both. We have a web site, not an IPT web site, but an organizational web site. It is for the entire organization, not for our use, but for anyone that wants information about us that is outside. We also have a periodic flier, a little mini magazine that goes out, and again that's the same thing for information for others telling them what we've done within the text and evaluation ( ). Internally we don't use those except that sometimes the articles that are written in there, there are people in our organization who don't know what is going on in the organization so that's news to them.

RESEARCHER: And I understand that when we are looking at the IPT, most of the information dissemination would do internally, and you would try to advertise outside. But what about advertising inside?

HD3NA5: Within the IPT?

RESEARCHER: No, within the organization. How do you disseminate information? Not just internally to the IPT, but also externally to the organization. Are there any other ways that you all do that? I want to make sure that I capture all the ways that you all do that.

HD3NA5: I guess another informal way would be just talking about it to some of the other members of the organization. Doing things like running, lifting weights, playing golf. A lot of the times the non-analysts don't really have a good idea of what we are doing and what we are trying...

(end of tape).

APPENDIX G
Research Surveys

The research surveys were a critical component to this study. The surveys provide the quantitative data used in the analysis to develop the organizational knowledge system representation. The entire survey was broken down into three modules: assessment of the organizational mechanisms within each knowledge subsystem, mechanism redundancy, and the knowledge subsystem assessment and relationships. The Inquisite software is designed to use the power of e-business providing researchers and organizational managers a tool to assess their respective organizations. The screen shots of the web-based survey show the front-end directions and information provided to each research participant. Research participants were able to scroll through the survey to change responses as desired and they were queried at the end of each module to ensure that they answered all questions. The web-based surveys, like the research web site, were essential to providing the research participants access to the research when it was convenient and timely for them.

Construction and Representation of the Organizational Knowledge System

This survey is developed to elicit participant's responses to enable the construction and representation their organizational knowledge system.

This survey will give you an opportunity to confidentially share your opinions and ideas about your organizational knowledge system. It is not a test. Since the survey concerns your opinions, there are no right or wrong answers. Under no circumstances will the information be used to identify you as an individual; all responses are kept completely confidential.

There are three modules to this survey. The first module consists of this introduction and explanation and has four parts which are associated with the Organizational Knowledge System Subsystems (Information Acquisition, Information Storage, Information Interpretation, and Information Dissemination). The first module is designed for you to assess each mechanism along three axes (importance, effectiveness, and access). The second and third modules are assessments of the strength of relationships and redundancies of the mechanisms and the strength of relationship between the organizational knowledge system subsystems, respectively. Throughout the course of this survey each research participant should respond to every question in each module.

This survey utilizes a Likert scale for many of the questions. The Likert scale falls in the family of summated scales, where research participants respond to questions in varying degrees of agreement or disagreement (Kerlinger, 1992). A characteristic of Likert scales that make there use appropriate for this study is their ability to quantitatively measure the intensity of a participant's expression. This will aid the research by numerically quantifying the relative goodness the knowledge system mechanisms have on the knowledge system subsystems, themselves, and the strength of relationships between system entities. The Likert scale is provided below.

1	2	3	4	5	6	7
Extremely Low	Low	Moderately Low	Niether Low or High	Moderately High	High	Extremely High

I thank you in advance for your participation and look forward to sharing the results of the survey with you. Please continue by inputting your USERID and completing the survey.

USERID

Module 1

Assessment of the Organizational Knowledge System Mechanisms Associated with the Information Acquisition Sub-System

Please assess each Mechanism in the associated areas. Refer to the following definitions and Likert scale when answering each question.

Definitions:

Importance - the significance of the mechanism to the particular sub-system and your organization

Usefulness - the utility of the mechanism toward the accomplishment of organizational tasks and responsibilities

Relevance - the suitability of the information provided by the mechanism

Accuracy - the correctness of the information provided by the mechanism

Timeliness - the ability of organizational members to gain access to the mechanism when required

Availability - the general accessibility of the mechanism to organizational members

Module 2

Mechanism Redundancy

In the first module of this survey you provided responses allowing your organization to assess the importance of the mechanisms, effectiveness of each mechanism, and access to the mechanisms. The second module continues and ultimately finishes the assessment of the mechanisms. This module will capture your assessment of the redundancies and relationships between the mechanisms in your organization. The computerized portion of this survey will assess the mechanism redundancies, while the corresponding EXCEL spreadsheets will assess the relationships between mechanisms associated with each subsystem.

Again, your responses are very important so please answer all the survey questions.

Please input your USERID?

Mechanism Redundancies

The following table is provided for you to identify the redundant mechanisms that comprise your organizational knowledge system. Where redundancy is defined as the UNNECESSARY duplication of capabilities within organizational mechanisms. The table lists all the mechanisms that your organization identified for this research. The mechanisms on the left edge of the table (rows) represent the question; while the mechanisms on the top of the table (columns) are the response. Please mark each column mechanism you feel is redundant with the corresponding row mechanism. Ignore the redundancy assessment of identical mechanisms (informal meetings to informal meetings). This is represented by the diagonal of this matrix. The following question is posed   to   help   guide   you   in   your   responses.

Organizational _____(row) is a redundant mechanism with organizational _____(column) which is NOT a positive departmental aspect?

Module 3

Subsystem Assessment
and Strength of Relationships

This is the third module to this survey. It enables all research participants to assess the strength of relationships between the mechanisms and their associated subsystems and the strength of relationships between subsystem and subsystem. This module, like the first two, requires each participant to input their USERID to provide positive tracking of survey responses. Again, all research participants should respond to every question in this module.

The module like the first utilizes a Likert scale for many of the questions. Again, the Likert scale falls in the family of summated scales, where subjects respond to questions in varying degrees of agreement or disagreement (Kerlinger, 1992). A characteristic of Likert scales that make their use appropriate for this study is their ability to quantitatively measure the intensity of a participant's expression. This will aid the research by numerically quantifying the goodness and affect the knowledge system mechanisms have on the knowledge system sub-systems, themselves, and the strength of relationships between entities. The Likert scale provided below.

1	2	3	4	5	6	7
Extremely Low	Low	Moderately Low	Niether Low or High	Moderately High	High	Extremely High

I thank you in advance for your participation and look forward to sharing the results of the survey with you. Please continue by inputting your USERID and completing the survey.

USERID?

Subsystem Assessment

In this section you are asked to rate each knowledge subsystem in three areas: importance, effectiveness, and use. Please refer to the follow three questions for your rating.

How would you rate the importance your organization places on each knowledge subsystem?

How effectively does your organization utilize each knowledge subsystem?

How would you rate the overall organizational use of each subsystem?

APPENDIX H
Research Data

This appendix provides the reader with the research data for this study. The appendix is divided into two tabs that contain the data for the Accelerator Development Department and the Analysis and Baseline Development IPT, respectively. This data was triangulated with the qualitative data obtained from the research surveys and was used to development each organization's knowledge system representation.

TAB 1
Accelerator Development Department

IA Mechanism to Mechanism Strength of Relationship within Subsystem

Literature	Technical Notes	0	0	3	2	2	2	2	1.88	0.000	2.25*
	JLAB Library	1	2	3	3	2	3	0	2.14	1.216	2.25*
	Training Assets	0	2	3	2	2	2	3	1.87	1.134	2.25*
	Personal Experience	0	1	0	1	1	3	0	2.00	1.188	2.25*
	Electronic Logbooks	0	0	2	0	1	1	0	0.43	0.838	0.5
	Document Control Office	0	0	0	0	0	0	0	0.28	0.788	0.5
Technical Notes	JLAB Library	1	2	2	3	1	2	0	1.71	1.113	2.25*
	Training Assets	2	0	0	3	1	3	0	1.00	1.188	1
	Personal Experience	2	2	2	1	2	2	3	2.00	0.877	2.25*
	Electronic Logbooks	0	1	0	1	1	1	0	0.57	0.838	0.5
	Document Control Office	0	0	0	1	1	0	0	0.28	0.448	0.5
JLAB Library	Training Assets	0	1	0	3	3	1	0	1.14	1.348	0.5
	Personal Experience	0	1	2	1	2	2	2	1.43	0.787	1
	Electronic Logbooks	0	0	0	0	0	0	0	0.28	0.788	0.5
	Document Control Office	0	0	0	0	0	0	0	0.00	0.000	0.5
Training Assets	Personal Experience	1	1	3	3	2	2	0	1.71	1.113	2.25*
	Electronic Logbooks	0	0	0	1	1	0	0	0.28	0.448	0.5
	Document Control Office	0	0	0	1	0	0	0	0.14	0.378	0.5
Personal Experience	Electronic Logbooks	1	0	0	2	1	2	0	1.00	0.818	1
	Document Control Office	0	0	0	1	0	0	0	0.14	0.378	0.5
Electronic Logbooks	Document Control Office	0	0	0	0	0	0	0	0.00	0.000	0.5

II Mechanism to Mechanism Strength of Relationship within Subsystem

	Relationship	effort	global	strise	relged	vclsgd	jdomt	medurg	ofdwek	lstrbl	perobt	Mean	Standard Deviation	Line Width
E-mail	Brainstorming	1	1	3	1		1	2	0			1.29	0.951	1
	Reflective Thought	1	2	3	1		0	3	1			1.57	1.134	2.25 *
	Progress Reviews	0	2	3	1		0	1	0			1.00	1.155	1
	Flowcharting	0	1	2	1		1	1	0			0.86	0.690	1
	Schematic Process Diagrams	0	1	2	0		1	1	0			0.71	0.756	0.5
	Quantitative Analysis	0	2	3	0		0	2	0			1.00	1.291	1
Brainstorming	Reflective Thought	2	3	3	2		1	2	2			2.14	0.690	2.25 *
	Progress Reviews	1	1	2	0		3	2	0			1.29	1.113	1
	Flowcharting	0	1	3	2		3	1	0			1.43	1.272	1
	Schematic Process Diagrams	0	1	1	2		3	1	1			1.29	0.951	1
	Quantitative Analysis	0	2	1	2		3	2	1			1.57	0.976	2.25 *
Reflective Thought	Progress Reviews	1	1	3	0		1	3	0			1.29	1.254	1
	Flowcharting	2	1	3	2		1	3	0			1.71	1.113	2.25 *
	Schematic Process Diagrams	3	1	3	2		3	2	1			2.14	0.900	2.25 *
	Quantitative Analysis	2	3	3	2		3	3	3			2.71	0.488	4.5 *
Progress Reviews	Flowcharting	1	2	3	1		2	1	0			1.43	0.976	1
	Schematic Process Diagrams	1	2	3	2		3	1	0			1.71	1.113	2.25 *
	Quantitative Analysis	1	1	3	2		3	2	0			1.71	1.113	2.25 *
Flowcharting	Schematic Process Diagrams	3	2	2	2		3	1	0			1.86	1.069	2.25 *
	Quantitative Analysis	1	1	3	2		1	1	0			1.29	0.951	1
Schematic Process Diagrams	Quantitative Analysis	0	1	3	2		2	1	0			1.29	1.113	1

Subsystem Assessment and Strength of Relationships

	Question ID											Mean	Standard Deviation	Median
Information Acquisition														
Importance	1	3	5	5	7	5	5	6	6	5	6	5.4	1.075	5.5
Effectiveness	2	4	5	5	2	4	4	5	4	5	3	4.2	1.033	4.5
Use	3	3	5	5	4	4	4	5	5	5	3	4.3	0.823	4.5
Information Storage														
Importance	4	2	5	7	5	5	6	4	5	5	4	5.1	1.449	5.5
Effectiveness	5	3	5	6	2	4	4	5	3	5	5	4.3	1.337	4.5
Use	6	2	4	5	3	4	4	5	3	5	4	3.9	0.894	4
Information Interpretation														
Importance	7	5	4	7	5	5	6	7	4	4	5	5.6	1.075	6
Effectiveness	8	3	5	6	3	4	5	5	4	4	4	4.4	1.265	4.5
Use	9	2	4	6	3	4	5	5	4	5	3	4.3	1.337	4.5
Information Dissemination														
Importance	10	4	4	7	5	5	6	5	5	5	5	5.4	0.966	5.5
Effectiveness	11	3	5	5	3	4	3	3	4	5	3	4.1	0.994	4.5
Use	12	3	4	5	4	3	4	3	5	4	4		0.816	4

Information Acquisition
- Informal Meetings
- Formal Meetings
- People/Experts
- E-mail
- Conferences/Workshops
- Travelers
- Internet
- Literature
- Technical Notes
- JLAB Library
- Training Assets
- Personal Experience
- Electronic Notebooks
- Document Control Office

Information Storage
- E-mail
- Travelers
- Internet
- Technical Notes
- Electronic Notebooks
- Document Control Office
- Personal/Individual Notebooks
- Computer Files (Individual)
- Publications
- Specification Development 12
- Personal/Individual Notebooks

Information Interpretation
- E-mail
- Brainstorming
- Reflective Thought
- Progress Reviews
- Flowcharting
- Schematic Process Diagrams
- Quantitative Analysis

Information Dissemination
- Informal Meetings
- Formal Meetings
- E-mail
- Conferences/Workshops
- Technical Notes
- Electronic Notebooks
- Publications
- Specification Development 12
- Phone
- Memos

	Mean	Standard Deviation	Line Width
Information Acquisition			
Storage	3.8	1.228	1
Interpretation	4.6	1.075	2.25
Dissemination	3.8	0.789	1
Information Storage			
Interpretation	4.3	1.059	2.25
Dissemination	3.8	1.033	1
Information Interpretation			
Dissemination	4.5	0.850	2.25

TAB 2
Analysis and Baseline Development IPT

IA Mechanism to Mechanism Strength of Relationship within Subsystem

Mechanism	Mechanism	MOUSE	BYpanD	eFazxE	EntveS	Mean	Standard Deviation	Line Width
Informal Meetings	Formal Meetings	1	3	2	3	2.25	0.957	2.25 *
	People/Experts	3	2	3	3	2.75	0.500	4.5 *
	E-mail	2	1	2	2	1.75	0.500	2.25 *
	Personal Experience	3	0	3	3	2.25	1.500	2.25 *
	IPT Analysis Plan	3	1	2	3	2.25	0.957	2.25 *
	Internet	1	1	1	2	1.25	0.500	1
	Internal Documents	2	1	1	2	1.50	0.577	1
	External Documents	2	1	1	3	1.75	0.957	2.25 *
Formal Meetings	People/Experts	3	2	2	2	2.25	0.500	2.25 *
	E-mail	1	1	2	1	1.25	0.500	1
	Personal Experience	2	0	2	1	1.25	0.957	1
	IPT Analysis Plan	3	2	1	2	2.00	0.816	2.25 *
	Internet	0	1	0	1	0.50	0.577	0.5
	Internal Documents	1	1	2	2	1.50	0.577	1
	External Documents	1	1	1	3	1.50	1.000	1
People/Experts	E-mail	2	2	2	3	2.25	0.500	2.25 *
	Personal Experience	2	2	2	2	2.00	0.000	2.25 *
	IPT Analysis Plan	3	0	2	2	1.75	1.258	2.25 *
	Internet	0	1	2	3	1.50	1.291	1
	Internal Documents	1	1	1	1	1.00	0.000	1
	External Documents	1	2	1	2	1.50	0.577	1
E-mail	Personal Experience	1	2	3	2	2.00	0.816	2.25 *
	IPT Analysis Plan	2	1	1	2	1.50	0.577	1
	Internet	1	1	3	3	2.00	1.155	2.25 *
	Internal Documents	1	1	1	2	1.25	0.500	1
	External Documents	0	1	1	2	1.00	0.816	1

Personal Experience	**IPT Analysis Plan**	2	2	2	3	2.25	0.500	2.25 *
	Internet	1	1	1	3	1.75	0.957	2.25 *
	Internal Documents	1	1	2	2	1.25	0.500	1
	External Documents	1	1	2	1	1.25	0.500	1
IPT Analysis Plan	Internet	1	1	1	2	1.25	0.500	1
	Internal Documents	2	1	1	2	1.50	0.577	1
	External Documents	1	1	1	2	1.25	0.500	1
Internet	Internal Documents	0	1	1	2	1.00	0.816	1
	External Documents	1	2	1	1	1.00	0.000	1
Internal Documents	External Documents	0	2	1	1	1.00	0.816	1

IS Mechanism to Mechanism Strength of Relationship within Subsystem

Mechanism	Relationship					Mean	Standard Deviation	Line Width
People/Experts	E-mail	2	2	2	3	2.25	0.500	2.25 *
	LAN K-Drive	3	0	2	2	1.75	1.258	2.25 *
	Organization Classified LAN	2	0	2	2	1.50	1.000	1
	Hard Files (public)	3	2	3	1	2.25	0.957	2.25 *
	Hard Files (private)	0	2	2	3	1.75	1.258	2.25 *
	Personal Computer Files	0	0	3	3	1.50	1.732	1
	Internal Documents	3	2	2	3	2.50	0.577	4.5 *
E-mail	LAN K-Drive	1	0	2	1	1.00	0.816	1
	Organization Classified LAN	0	0	0	1	0.25	0.500	0.5
	Hard Files (public)	1	1	1	1	1.00	0.000	1
	Hard Files (private)	1	1	2	1	1.25	0.500	1
	Personal Computer Files	1	1	2	3	1.75	0.957	1
	Internal Documents	2	2	2	2	2.00	0.000	2.25 *
LAN K-Drive	Organization Classified LAN	0	2	0	1	0.75	0.957	0.5
	Hard Files (public)	3	3	2	1	2.25	0.957	2.25 *
	Hard Files (private)	3	1	1	1	1.50	1.000	1
	Personal Computer Files	0	2	1	1	1.00	0.816	1
	Internal Documents	3	3	3	3	3.00	0.000	4.5 *
Organization Classified LAN	Hard Files (public)	0	0	1	0	0.25	0.500	0.5
	Hard Files (private)	1	0	1	1	0.75	0.500	0.5
	Personal Computer Files	0	1	0	0	0.25	0.500	0.5
	Internal Documents	2	1	1	1	1.25	0.500	1
Hard Files (public)	Hard Files (private)	1	2	1	2	1.50	0.577	1
	Personal Computer Files	1	1	1	1	1.00	0.000	1
	Internal Documents	3	2	2	2	2.25	0.500	2.25 *
Hard Files (private)	Personal Computer Files	2	1	2	1	1.50	0.577	1
	Internal Documents	1	2	2	2	1.75	0.500	2.25 *
Personal Computer Files	Internal Documents	1	2	2	3	2.00	0.816	2.25 *

II Mechanism to Mechanism Strength of Relationship within Subsystem

Mechanism	Relationship	fd5ns5	td7bm5	cfzzx5	km1vz5	Mean	Standard Deviation	Line Width
E-mail	Brainstorming	1	1	1	3	1.50	1.000	1
	Reflective Thought	3	1	1	1	1.50	1.000	1
	Trial & Error	2	0	1	3	1.50	1.291	1
Brainstorming	Reflective Thought	3	2	2	2	2.25	0.500	2.25 *
	Trial & Error	1	2	2	2	1.75	0.500	2.25 *
Reflective Thought	Trial & Error	1	2	2	2	1.75	0.500	2.25 *

ID Mechanism to Mechanism Strength of Relationship within Subsystem

	Relationship	hd3na5	td7bm5	cf2zz5	kn1vz5	Mean	Standard Deviation	Line Width
Informal Meetings	Formal Meetings	2	3	2	3	2.50	0.577	2.25 *
	E-mail	2	1	2	3	2.00	0.816	2.25 *
	Organization Classified LAN	1	1	1	1	1.00	0.000	1
	Newsletter	0	1	1	1	0.75	0.500	0.5
Formal Meetings	E-mail	2	1	2	1	1.50	0.577	1
	Organization Classified LAN	0	1	1	1	0.75	0.500	0.5
	Newsletter	0	1	2	3	1.50	1.291	1
E-mail	Organization Classified LAN	0	0	1	1	0.50	0.577	0.5
	Newsletter	0	0	1	0	0.25	0.500	0.5
Organization Classified LAN	Newsletter	0	0	1	0	0.25	0.500	0.5

Subsystem Assessment and Strength of Relationships

Subsystem	Attribute	Question ID	hd3na5	ld7am5	cf2zx5	kn1vz5	Mean	Standard Deviation	Median		Range
Information Acquisition	Importance	1	6	6	7	5	6	0.816	6	5	7
	Effectiveness	2	6	6	6	3	5.25	1.500	6	3	6
	Use	3	6	6	5	4	5.25	0.957	5.5	4	6
Information Storage	Importance	4	5	6	6	5	5.5	0.577	5.5	5	6
	Effectiveness	5	5	4	5	2	4	1.414	4.5	2	5
	Use	6	5	3	4	2	3.5	1.291	3.5	2	5
Information Interpretation	Importance	7	6	6	6	3	5.25	1.500	6	3	6
	Effectiveness	8	5	6	6	3	5	1.414	5.5	3	6
	Use	9	5	6	6	3	5	1.414	5.5	3	6
Information Dissemination	Importance	10	5	4	7	5	5.25	1.258	5	4	7
	Effectiveness	11	6	3	6	4	4.75	1.500	5	3	6
	Use	12	5	3	5	5	4.5	1.000	5	3	5

Information Acquisition							Mean	Standard Deviation	Line Width	Range	
Information Acquisition	Informal Meetings	13	6	7	6	6	6.25	0.500	4.5	6	7
	Formal Meetings	14	4	7	5	3	4.75	1.708	2.25	3	7
	People/Experts	15	6	6	6	5	5.75	0.500	4.5	5	6
	E-mail	16	5	5	6	5	5.25	0.500	2.25	5	6
	Internal Documents	17	5	5	5	4	4.75	0.500	2.25	4	5
	External Documents	18	5	6	5	4	5	0.816	2.25	4	6
	Internet	19	5	6	5	5	5.25	0.500	2.25	5	6
	Personal Experience	20	6	6	6	5	5.75	0.500	4.5	5	6
	IPT Analysis Plan	21	7	5	5	5	5.5	1.000	2.25	5	7

							Mean	Standard Deviation	Line Width	Range	
Information Storage	People/Experts	22	6	5	6	6	5.75	0.500	4.5	5	6
	E-mail	23	5	4	6	5	5	0.816	2.25	4	6
	LAN K-Drive	24	7	5	5	4	5.25	1.258	2.25	4	7
	Hard Files (private)	25	6	5	6	4	5.25	0.957	2.25	4	6
	Hard Files (public)	26	6	6	5	3	5	1.414	2.25	3	6
	Organization Classified LAN	27	5	6	5	4	5	0.816	2.25	4	6
	Personal Computer Files	28	6	5	5	6	5.5	0.577	4.5	5	6
	Internal Documents	29	6	6	5	5	5.5	0.577	4.5	5	6

							Mean	Standard Deviation	Line Width	Range	
Information Interpretation	E-mail	30	5	6	6	5	5.5	0.577	4.5	5	6
	Brainstorming	31	6	7	4	6	5.75	1.258	4.5	4	7
	Reflective Thought	32	6	5	5	4	5	0.816	2.25	4	6
	Trial & Error	33	5	5	4	5	4.75	0.500	2.25	4	5

							Mean	Standard Deviation	Line Width	Range	
Information Dissemination	Informal Meetings	34	6	7	6	6	6.25	0.500	4.5	6	7
	Formal Meetings	35	7	7	5	3	5.5	1.915	4.5	3	7
	E-mail	36	6	5	6	6	5.75	0.500	4.5	5	6
	Organization Classified LAN	37	6	4	4	4	4.5	1.000	2.25	4	6
	Newsletter	38	3	4	4	3	3.5	0.577	1	3	4

Information Acquisition

					Mean	Standard Deviation	Line Width		Range
Storage	39	5	5	5	3	4.5	1.000	2.25	3	5
Interpretation	40	5	6	5	5	5.25	0.500	2.25	5	6
Dissemination	41	6	5	4	3	4.5	1.291	2.25	3	6

Information Storage

					Mean	Standard Deviation	Line Width		Range
Interpretation	42	5	5	5	4	4.75	0.500	2.25	4	5
Dissemination	43	5	5	4	3	4.25	0.957	2.25	3	5

Information Interpretation

					Mean	Standard Deviation	Line Width		Range
Dissemination	44	6	6	4	3	4.75	1.500	2.25	3	6

VITA

Willie McFadden is currently an active duty Lieutenant Colonel in the United States Army. His educational experience started at the United States Military Academy, West Point, New York, where he graduated with a B.S. degree in Engineering in May of 1983. He then received his M.S. in Operations Research and Systems Analysis at the Naval Postgraduate School, Monterey, California in September of 1993. Currently, he is enrolled as a full time student in Doctoral Program in the Engineering Management Department at Old Dominion University, Norfolk, Virginia. His 17 year professional experience has been entirely devoted to uniformed service as a soldier and analyst. His research interests are engineering of organizational knowledge and learning, knowledge management, systems theory and methodologies, and computer-based knowledge systems.