Knowledge Strategies for Managers in a Networked World

by

Lisa M. Shaler-Clark

B.A, English (Honors), Georgetown University, Washington, D.C., 1986

Submitted to the Alfred P. Sloan School of Management
In Partial Fulfillment of the Requirements for the Degree of

Master of Science in the Management of Technology

at the

Massachusetts Institute of Technology
June 2002

Signature of Author ______________________
Lisa M. Shaler-Clark
MIT Sloan School of Management
May 10, 2002

Certified by ______________________
Wanda J. Orlikowski
Professor of Information Technologies and Organization Studies
Thesis Supervisor

Certified by ______________________
Ralph Katz
Senior Research Associate, Management of Technology
Thesis Reader

Accepted by ______________________
David A. Weber
Director, Management of Technology Program

Knowledge Strategies for Managers in a Networked World

by

Lisa M. Shaler-Clark

Submitted to the Sloan School of Management on 10 May 2002
In Partial Fulfillment of the Requirements for the Degree of
Master of Science in Management of Technology

ABSTRACT

As our world becomes more complex and information-rich, the effort needed to share and create knowledge is increasing greatly. Transformation from Industrial Age to Information Age organizations is not simple. But there are strategies managers can use and emulate, to make their organizations more successful in sharing and creating new knowledge, to achieve better performance.

Knowledge loss is a significant issue. Demographics may cause the "first-of-type" implementation pioneers to retire, or events such as those of Fall 2001 may cause people to be no longer available – or no longer able to reach their knowledge support systems, as seen when anthrax attacks closed Congressional offices for weeks.

Strategies can be implemented for the different kinds of knowledge – explicit knowledge, metaknowledge, and tacit knowledge. Processes can be used to enhance knowledge sharing, extending the number of people who know and reducing the risk of loss. The US Army is a learning organization which has spent the past decade becoming "knowledge centric and network centric." Techniques, processes and knowledge lessons learned are presented, including a case study of the Project Management Office for Bradley Fighting Vehicle Systems, as it transformed its people, organization, and vehicles being developed from Industrial Age to intenetworked Information Age systems.

Rather than focusing on knowledge management, which has become synonymous with archiving what is *already known* into digital databases, I am focused on the strategies real-world managers can use for knowledge. The goal is to help the organization achieve better performance by sharing knowledge. Technology can help, when supporting instead of driving the goals. Networking, both in person and virtually, can overcome the isolation of knowledge. Many of my examples tap into the experiences I had or observed in the US Army product development community -- but I believe they are valuable and generalizable to other high- performance organizations. "Hope is not a method" -- knowledge sharing is a better technique.

Thesis Supervisor: Wanda J. Orlikowski
Title: Eaton-Peabody Professor of Communication Sciences

Thesis Reader: Ralph Katz
Title: Senior Research Associate, Management of Technology

Acknowledgements:

"To see a World in a Grain of Sand
And a Heaven in a Wild Flower,
Hold Infinity in the palm of your hand
And Eternity in an hour."

- ***Auguries of Innocence*** **by William Blake**
- ***(thanks to Bernard Nee for Blake and Scott for fractals)***

This year, more than any other, I have become aware of the tremendous support generously given by my friends and family. You are all so dear to me, and I am grateful. I do want to acknowledge a few people by name, but many more helped me learn, grow, and survive the year of 9/11/2001. Some times were solemn, but we've also shared laughter and learning – a balance.

First, I'd like to thank my family. My friend and husband Scott has lovingly supported me in pursuing my dream, and taken care of us and our beloved children -- tall, funny Bobby and strong, charming Libby. Thank you for fractals and understanding.

My parents have been stalwart in their love, offering insight, long-distance support, a vibrant exchange of knowledge, and active grandparenting. Thank you for keeping us happy, focused and sane. My siblings were enthusiastic and interested, sharing knowledge and kind thoughts.

My friends and mentors guided me and offered comfort, even when far away. We have shared important learning together, and made things better. It's a worthy goal, and I gratefully acknowledge the help, guidance, and enthusiasm of Major General Yakovac, Colonel Ted Johnson, the Bectons, Karyn Peterman, and my colleagues from PM Bradley. This year also brought inspiration to renew ties with dear friends from college – especially Siobhan Dunn, Marianne Perciaccante, and Bridget Wong.

My teammates and classmates here in the Management of Technology Program have shared what they know generously. I especially appreciate the tremendous support, partnership, hard work and humor of Kei Hara and Bernard Nee, my System Dynamics teammates. I am grateful beyond measure, and hope I contributed too. Katie Manty, Damian Blossey, Ellen Brockley, Toshiro Kawahara, Jen Pararas, Waqas Khan, Marissa Martinez, and Vishal Mehta were partners in my journeys – and it has been marvelous. Thank you for the stories and the wisdom. As Kei says, it's the start of a life-long relationship. My contributors are listed in Appendix A, and many more helped me.

My thesis advisor, Wanda Orlikowski, and my reader, Ralph Katz, kept me inspired. Peter Senge taught me visioning, in a dynamic way. Jim Short led me to the knowledge theorists, and John Sterman explained knowledge as stock and flow – and sustainability and happiness. Jim Hines shared his thoughts on organizational evolution, and Rebecca Henderson imbued us with the spirit of technology strategy. For all these professors and more, I am appreciative.

I have been blessed. This year above all, whenever I felt alone, I learned that I was not – a tremendous gift. I offer my gratitude to all who helped me, and would love to build more wonderful knowledge together.

A Note On Fractals:

This has been the year when I pulled together learning about complex non-linear systems, thanks to John Sterman, Nelson Repenning, Jay Forrester, and Jim Hines in the MIT System Dynamics Group. The chapter dividers feature fractals my husband Scott Clark generated for me, using Fractint freeware software. They represent static images of dynamic non-linear systems changing over time -- marvelous. Although they are constructed mathematically, they resemble the real systems which represent complexity in life – such as the fern. You can dive down into the details, and then return to the top level to see the overall pattern -- auguries of change and complexity out of simple seeds.

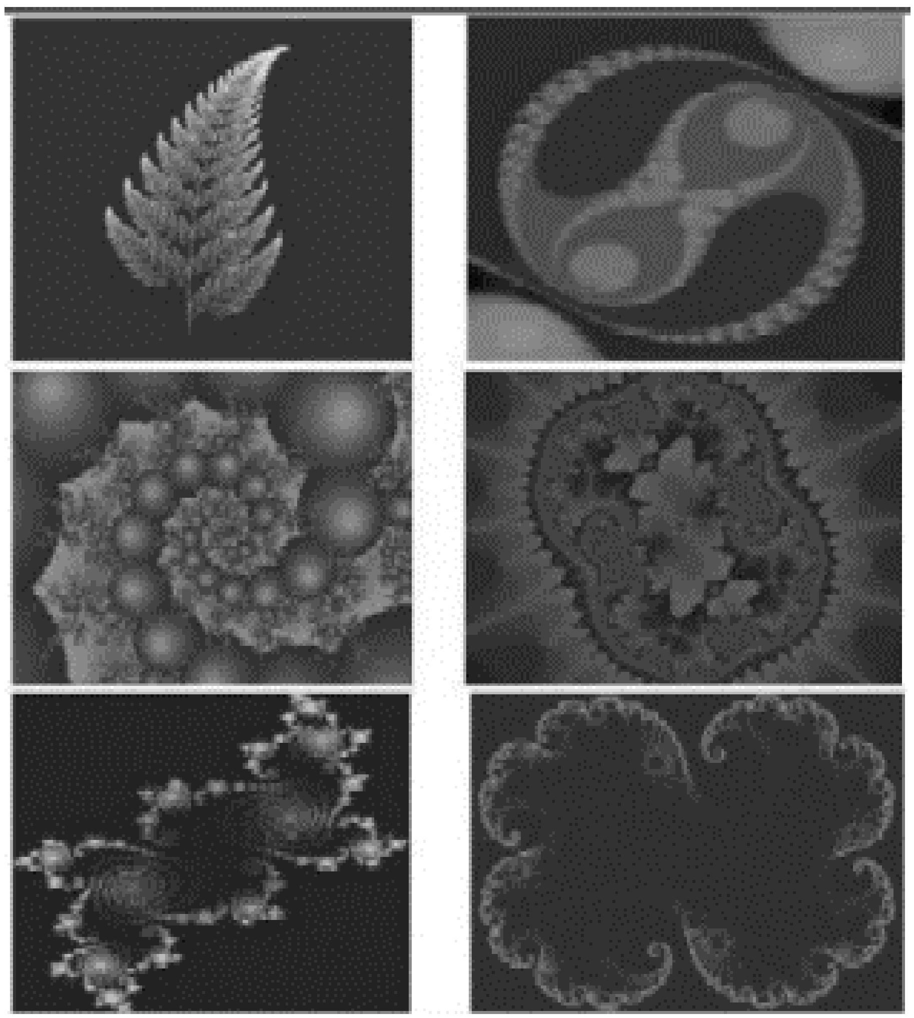
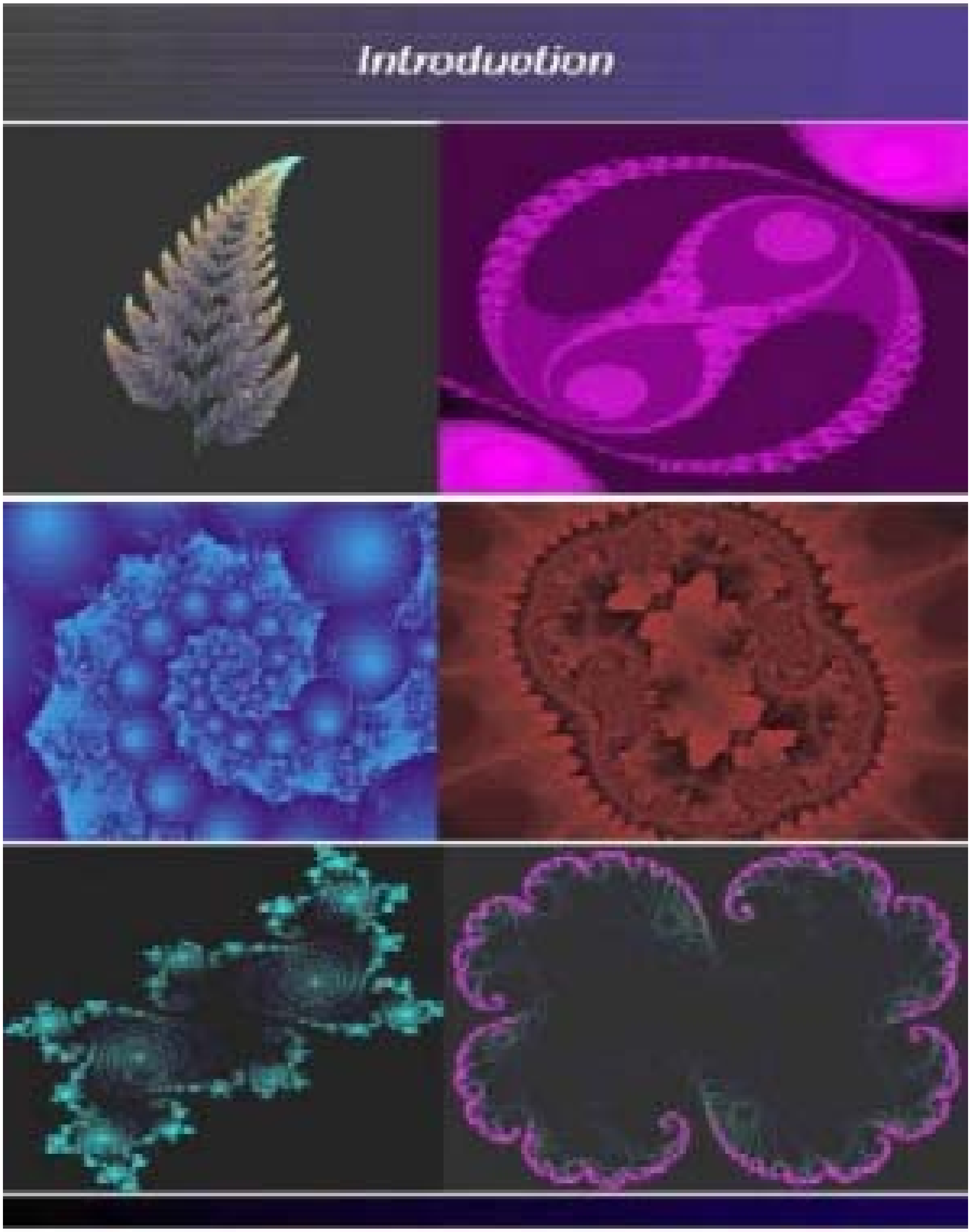


Table of Contents:

Figures:


Introduction

Introduction:
Impetus for Knowledge Sharing

Listening to a public radio show on the superstring theory of physics reinforced for me the difficulty of sharing knowledge which affects many people. As our knowledge of science increases in complexity, understanding the fundamental nature of the world in which we live is no longer within the realm of most people's daily lives.

In the leading-edge product development community where I spent the better part of the past decade, I've seen the transformation from stand-alone vehicles which are mostly analog systems to digitally internetworked "Systems of Systems." This transformation from Industrial Age to Information Age was fascinating to participate in – a snapshot in time of a radical change. But there are fundamentally different ways of understanding such radical transformation when it is GIVEN to a new user, instead of EARNED or LEARNED through invention. "First-of-type" implementations teach lessons which cannot be acquired any way except by being there. Doing early implementations of supply chain Management Information Systems (MISs) which we linked together by modems taught me the "nuts and bolts" of how to make software and communications connect. These experiences indelibly teach the meta-knowledge -- the *how* and *why*.

Understanding how to improvise and extend these implementations is much easier, if the improviser knows how the systems were first put together. However, the early implementers of a system or capability move up and on to other endeavors. The successor generation assumes the technology in place as a baseline, and builds on top of it. Events such as the Year 2000 computer date transition (when the year changed from ending with a '9' to ending with a '0' causing software errors and data overflows) taught many organizations how the knowledge gained during the first-of-type implementations can be lost, requiring significant work to overcome. As our information environment becomes richer, and knowledge boundaries such as bioinformatics are

more widely explored, the number of people who have the knowledge to understand both sides of a given boundary -- here, the region where life sciences meshes with information technology -- shrinks exponentially, exacerbating the lack of knowledge among followers.

As the pioneers of this first transition of high technology (such as Intel co-founder Andy Grove, the senior scientists and systems engineers at the Program Management Offices for Bradley Fighting Vehicle Systems and the National Aeronautics and Space Administration (NASA)) near retirement age, there is an increased risk of lost knowledge. Will that loss of knowledge be merely a hiccup? An experience of "don't know what you've lost, since it doesn't affect current operations?" Or will it bring suboptimized solutions, situations which demonstrate the costs of "but for the lack of that key understanding...."? This is the domain of my exploration.

I am not focusing on knowledge MANAGEMENT, which has become synonymous with archiving what is already known into digital databases. For me, the center is the strategies that real-world managers can use to manage their knowledge. The focus is on managers in organizations, who are seeking better performance. Technology can help, when it supports rather than drives the goals. And networking, both in person and virtually, can overcome the isolation of knowledge. Many of my examples tap into the experiences I had or observed in the US Army product development community -- but I believe they are valuable and generalizable to other high-performance organizations. "Hope is not a method" -- knowledge sharing is a better technique.

The Goal: **Provide managers with _**strategies for knowledge**_, understanding and using internetworking technology as appropriate, to develop, share, and leverage knowledge to improve the organization's performance.**

Challenges: **Focus on strategies to dynamically create and leverage genuine knowledge. Expand beyond mere knowledge management which focuses on the past, in order to take actions and innovate for the future. Avoid the fundamental errors identified by Fahey and Prusak (1998, 265-76):**

1. **Not developing a working *definition of knowledge***
2. **Emphasizing knowledge stock to the detriment of *knowledge flow***
3. **Viewing knowledge as existing predominantly outside the heads of individuals *(people focus)***
4. **Not understanding that a fundamental intermediate purpose of managing knowledge is to *create a shared context***
5. **Paying little heed to the role and importance of *tacit knowledge***
6. **Disentangling *knowledge from its uses***
7. **Downplaying *thinking and reasoning***
8. **Focusing on the past and the present and not *the future***
9. **Failing to recognize the importance of *experimentation***
10. **Substituting technological contact for *human interface***
11. **Seeking to develop *direct measures of knowledge***

Methodology: **Chapter 1 will lay out my own impetus for this exploration. The demographic realities of the aging technology pioneers was amplified for me by the attacks on the United States in September 2001. Chapter 2 will identify and develop working definitions of the types of knowledge which will be addressed, in order to explore aspects of knowledge as a stock or persistent state, and the dynamics of knowledge as a transformative experience. After the theory of chapter 2, chapters 3, 4, and 5 explore practical issues and lessons learned about strategies for three types of knowledge: explicit knowledge, metaknowledge, and tacit knowledge. Chapter 6 features the case study of the Project Management Office for Bradley Fighting Vehicle**

Systems (PM Bradley). It demonstrates how one US Army product development activity used knowledge strategies to transform from an Industrial Age organization to an Information Age one, while simultaneously changing its vehicle systems to create an internetworked knowledge-sharing capability for soldiers. Chapter 7 will conclude with a series of strategies that managers can use for the knowledge within their own organizations.

Inspiration for Challenging Tasks: Since I believe that knowledge is innately personal, it can be challenging to analyze. I have been fortunate to know and work with some great leaders, both practical and visionary, from the US Army. In this endeavor, the words of some of my mentors shall guide us:

"Do the best you can with what you have."	– Major General Joe Yakovac
"Enthusiasm gets you halfway there."	– Mike Shaler, US Army Colonel (retired)
"Create a path to the future that's brightly lit and broad enough to give you options…."	-- Mike Bracket, US Army Lieutenant Colonel (retired)
"Use the fat magic markers and the big pad of paper to explain – and if you get technical with me, I'll throw you out of my office."	– Colonel Scott G. West
"Yes, we can! Now tell me *how*…."	– Brigadier General James M. Wright

A Roadmap:

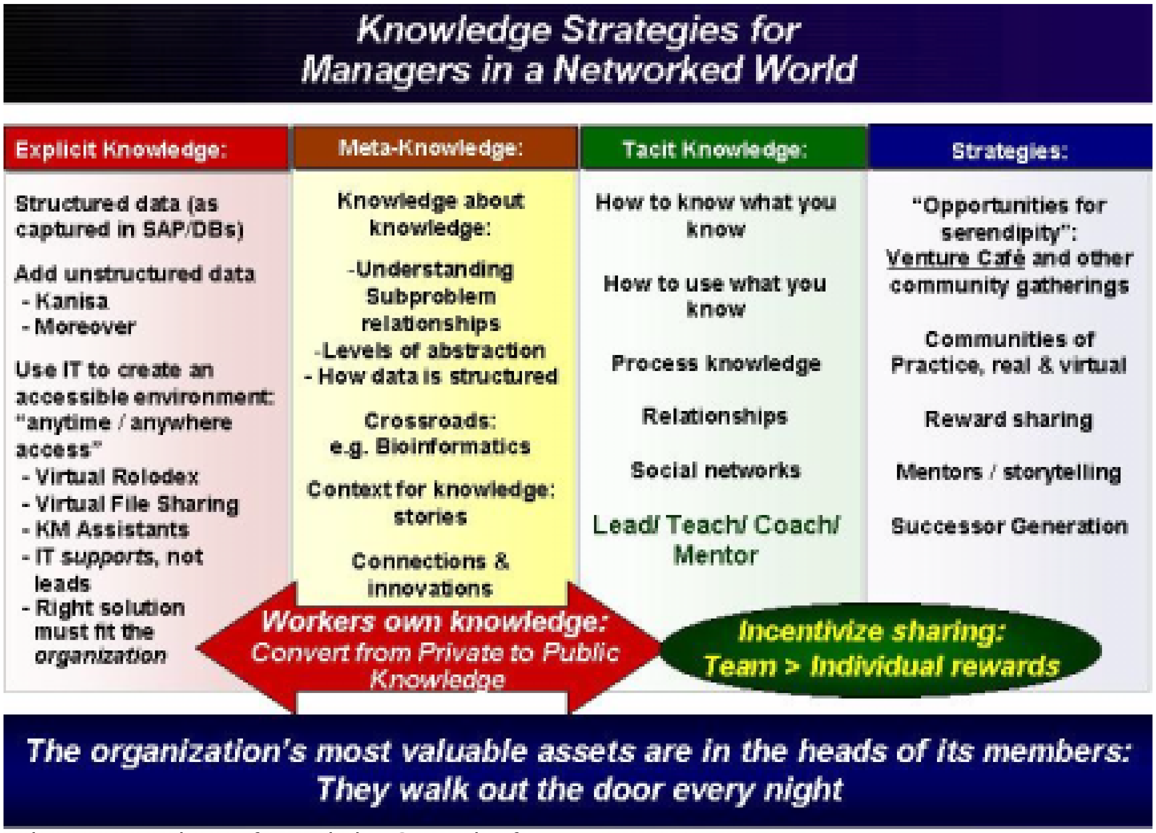


Figure 1: Roadmap of Knowledge Strategies for Managers

Chapter 1: Impetus for Knowledge Strategies

Chapter 1: Knowledge Strategies for Managers in a Networked World

Knowledge transfer and knowledge loss are significant issues. Organizations can face the loss of their talented people – through expected personnel actions, such as promotion, retirement, or departure, or from unexpected losses. Organizations and communities may lose knowledge in the heads of their most talented people – both explicit, factual knowledge, and the tacit knowledge of processes, practices, patterns, and networks. Physical archives, in file cabinets, computers and networks, can also be lost – either actively destroyed or through non-use. Obsolescence of digital file formats continues to challenge us, and requires continual rehosting to accommodate new digital file formats or operating system changes. Managers need strategies for recovering knowledge, and insights into future directions to preclude loss and share the knowledge so the organization can achieve new levels of performance.

Traditional Knowledge Management (KM) has focused on archiving in static databases the highlights of *past knowledge*: the "best practices" of a consulting firm, for example. However, often the most innovative thinking in an organization is not captured in a traditional KM database. Organizations may not reward time spent thinking about and documenting the last endeavor. As seen by many organizations challenged with rewriting software to address the Year 2000 date problem, software is likely to be less fully documented than may be later desired. Software developers can feel that they are working too hard solving "real" problems to take the time to do extensive, mundane documentation. Innovative thinkers may not take the time, or be willing to commit evolving thoughts to a widely available repository. Individuals or organizations may focus on competitive advantage over openness. Leading-edge thinking may need to be treated as proprietary, requiring protection as context-sensitive, valuable intellectual property.

Knowledge which relies on "best practices" of historical operations can and should be archived in databases which are accessible to train novices to become more knowledgeable. Shared best practices and benchmarking of existing knowledge and processes can increase the capabilities of a group or community. My interest, however, is in the far reaches of knowledge, beyond the comfortable frontier. The "learning how to learn" functions of innovation and invention are more intriguing to me than enhancing the efficiency of currently well-understood domains. Those discontinuous innovations which disrupt the current generation of products come from human insights which emerge from knowledge and experience. How are these insights generated and shared? Are there means to accelerate the ability of groups and communities to develop these insights which can make a difference? What tools are needed? Are there opportunities for technology to make a difference in building the knowledge generation capabilities of individuals or groups? And, importantly, how can managers and teams apply lessons learned and best practices from others to make better decisions and prevent mistakes?

In particular, I plan to explore areas where technology may make a difference in the area of human insights. The following describes my key questions:

- **Do different types of knowledge need different strategies? Routine, past knowledge could be amenable to traditional KM archiving in a searchable database, but non-routine, innovative new knowledge may require other technological approaches. "Bleeding edge" knowledge such as nanotechnology, which changes rapidly, requires different approaches than well-defined, codifiable bodies of knowledge such as bridge building. Nanotechnology is an example of a body of knowledge which is in a state of ferment, rapidly evolving and at the very beginning of its codification, with discoveries changing the "state of the art" on a daily basis. Bridge building is at the other end of a continuum of well-defined, well-understood, well-codified knowledge, which changes slowly**

and incrementally. Innovative learning may not be the domain of the lonely genius – can an Einstein have friends and followers who learn what he knows? How can affiliated groups share and build understanding?

- **Can organizations build structures to enhance knowledge retention and transfer? Communities of practice, internetworked sharing, and collaboration offer useful methods to extend and expand knowledge sharing, but meet resistance due to cultural concerns or issues about sharing power. Organizations should consider new ways to foster knowledge sharing among individuals and groups. Lotus Notes software tools have been implemented in many organizations, to enhance collaboration – but training to change the culture often lags the technical software implementation. More recent software, such as Microsoft Netmeeting, allows Internet-savvy users to see the same information on separated computer screens. Other organizations have implemented desktop video-teleconferencing systems such as PictureTel. But implementing technology is the lesser task, compared to changing power sharing and cultural and organizational incentives to encourage knowledge sharing. The substantial decrease on business travel which resulted from the terrorist attacks did create new motivation for grounded, geographically split teams to share information over the Internet, using these enabling technologies. However, only time will tell whether the changed behavior is permanent. The crux of the issue is that innovative individuals who are busy developing knowledge which increases their value in the community may not want to invest time and effort to capture and archive it via a computer.**

- **What helping functions can reduce the burden and increase the benefit of sharing knowledge? Several technologies seem to offer promise in this domain, including those gathered under the research umbrella of the Intelligent Room, part of MIT's Artificial Intelligence Laboratory's Project Oxygen, which will be discussed at greater length in chapter 3. Project Oxygen seeks to make computing power and communications as prevalent in the environment as oxygen – unobtrusive and essential for life. The Intelligent Room embeds sensors, microphones, cameras, automated data transcription and intelligent data storage and recall software into a meeting room. Meeting participants can have their activities documented and captured, and able to be recalled with ease. This approach certainly seems to offer much benefit in formal meeting settings – but can it be helpful to sharing knowledge through collaboration? What benefits and detriments to innovation might result from use of this system? One issue which continues to emerge among researchers in this domain are the ontologies and taxonomies which would be most useful in retrieving the volumes of information which these environmental systems could generate. However, the higher-level issue is that, instead of reducing confusion, the exponential growth in the volume of information captured by these systems seems likely to increase the "data smog" Heylighten describes as "Complexity and Information Overload in Society" (2002). The ability to generate and capture ever larger amounts of information reduces the ability of users to understand and control it adequately. As systems dynamics illustrates, humans have a difficult time understanding complex non-linear systems – and these technologies promise exponential growth in information. Will the "average user" be able to understand and make good decisions?**

- **What happens with abrupt loss of thought leaders? Loss of knowledge may result, which could lead to loss of voice of that community in policy or discussions. A classic example of this conundrum affected the US Navy during World War II, as my classmate US Navy Lieutenant Commander Damian Blossey explained he was taught at the US Naval Academy. The loss of the American battleships in the attack on Pearl Harbor discredited the battleship proponent admirals. Senior and rising leaders who were skilled at battleship warfare were killed, injured, or sidelined. The aircraft carrier proponent admirals became much more pivotal to the successful conduct of the Pacific campaign. Admiral John McCain, Senator John McCain's grandfather, was one of the newly prominent admirals, who crafted innovative and effective new Naval tactics based on air warfare, adding new dimensions to the surface warfare tactics that had been honed by generations of sailors. Synchronizing the air campaigns with surface and underwater submarine operations required the admirals to think in three-dimensional (3-D) spatial geometry, taking strategy past the level of chess and into a much more complex world. These tactics and strategies shaped the US and other armed forces for the subsequent half-century. They catalyzed the evolution of the US Army's "AirLand Battle" doctrine (described in Wass de Czege and Sinnreich, 2002), which synergizes forces to fight in the 3-D AirLand battlespace, instead of the old flat ground-focused warfare. Even today, sixty years later, the 3-D tactics and strategies developed by the aircraft carrier admirals shape the strategic thinking of battle planners. The battleship carriers are relegated to the support and supply functions, protecting the "crown jewels" of the battle groups.**

- **If this trade in positional importance was so critical and long-lasting in its impact among the Navy population, are other domains as susceptible? During the tragic attacks on the World Trade Center towers on 9/11/2001, the e-Business meeting on the 106th floor included innovative thinkers who shaped and understood the forces of the "New Economy." Some of these thought leaders did not survive the attack, while the "Old Economy" economists who were meeting on the 1st floor of the World Trade Center all survived. Should policy issues about the forces which drive the US economy be discussed, Old Economy economists are present and available to provide opinions on what dynamics drive the market – while some of the influential of the New Economy business creators are no longer able to contribute to the dialog again. We may never know what knowledge was lost because some key people were lost. It seems worthwhile to explore ways to expand and reconstitute this community, to recapture some of the New Economy dynamism. How can the knowledge that they were sharing and beginning to understand expand past that core group, so that it is not lost?**

After the Vietnam War, the US military faced a similar challenge as it extensively drew down the number of people on active duty, losing much institutional knowledge. Since then, both the Army and Navy have had to develop effective techniques for transmitting emerging knowledge to large cohorts rapidly. The Army's renowned National Training Center (NTC) in the Mojave Desert of California allows people and units to create knowledge on the ground and practice it together. As I'll describe later, the After Action Report (AAR) techniques can be used effectively, both by Army units undergoing training and by executives in management, to build a deeper understanding of events, teaching people to analyze *what*, *how* and *why* events happened, and build strategic awareness.

Impetus for Knowledge Strategies: Why Worry about Knowledge?

As shown in the graphic below, Congressional offices were closed for more than 7 weeks as a result of the anthrax attack on the offices of the Senate Majority Leader. The initial response was light-hearted, as aides set up a folding table with a jar of pencils, and the Congressional representatives used their cell phones to make calls out in the sunshine. As the crisis dragged on and the buildings were purged and cleansed with toxic gases, people faced the seriousness and potential recurrences of the situation:

Figure 2: Real World Knowledge Crises 2001: Anthrax Closes Congressional Offices

For the residents of the United States of America, Fall 2001 will be remembered as the time terrorism came to the US. The tragic attacks on the World Trade Center, the Pentagon, and airplanes, along with the anthrax scares, have changed normal patterns of

life and work. The class of "road warriors" could not travel, since all planes in the US were grounded. The sight of Congressional Representatives and Senators denied access to their offices for more than a month reinforces the impact of the loss of access to data. Even if the data physically exists *somewhere*, it may not be reachable. Continuity of Business Operations means much more than backing up the office computers on a backup drive on the same desk. Now, remote storage of data in digital format seems much more critical – but takes more effort, and requires habits and culture to change. Physical loss or loss of access to the office has caused large numbers of the knowledge workforce to consider anew what data and knowledge they need to access, from where, and when. "Anytime, anywhere" access is the desire, but the organizations are not generally configured to support these needs.

Unknown Unknowns:

One of the key challenges is "Unknown Unknowns." Until users are denied access to the knowledge they need – the data stored on their computers, or charts or phone lists on their office wall -- they may not recognize what knowledge they have institutionalized in physical storage, rather than in memory. Any person who has lost their World Wide Web browser bookmark file can understand the challenge of trying to determine what was known, with the "favorite sites" list. Computer savvy users may not even recognize the extent to which they are entrusting their patterns of computer search and connected networks of knowledge to the computer to track.

The US Army requires its units and people to learn what information they will need, by going on field exercises. Even camping trips of a week or less out to a local training area get people away from their offices, with the habitually available information. When users cannot see the wall chart with the key phone numbers, or cannot reach the

files with the historical data, they build awareness and begin to understand what knowledge they are assuming will be available.

Strategies for Knowledge Now:

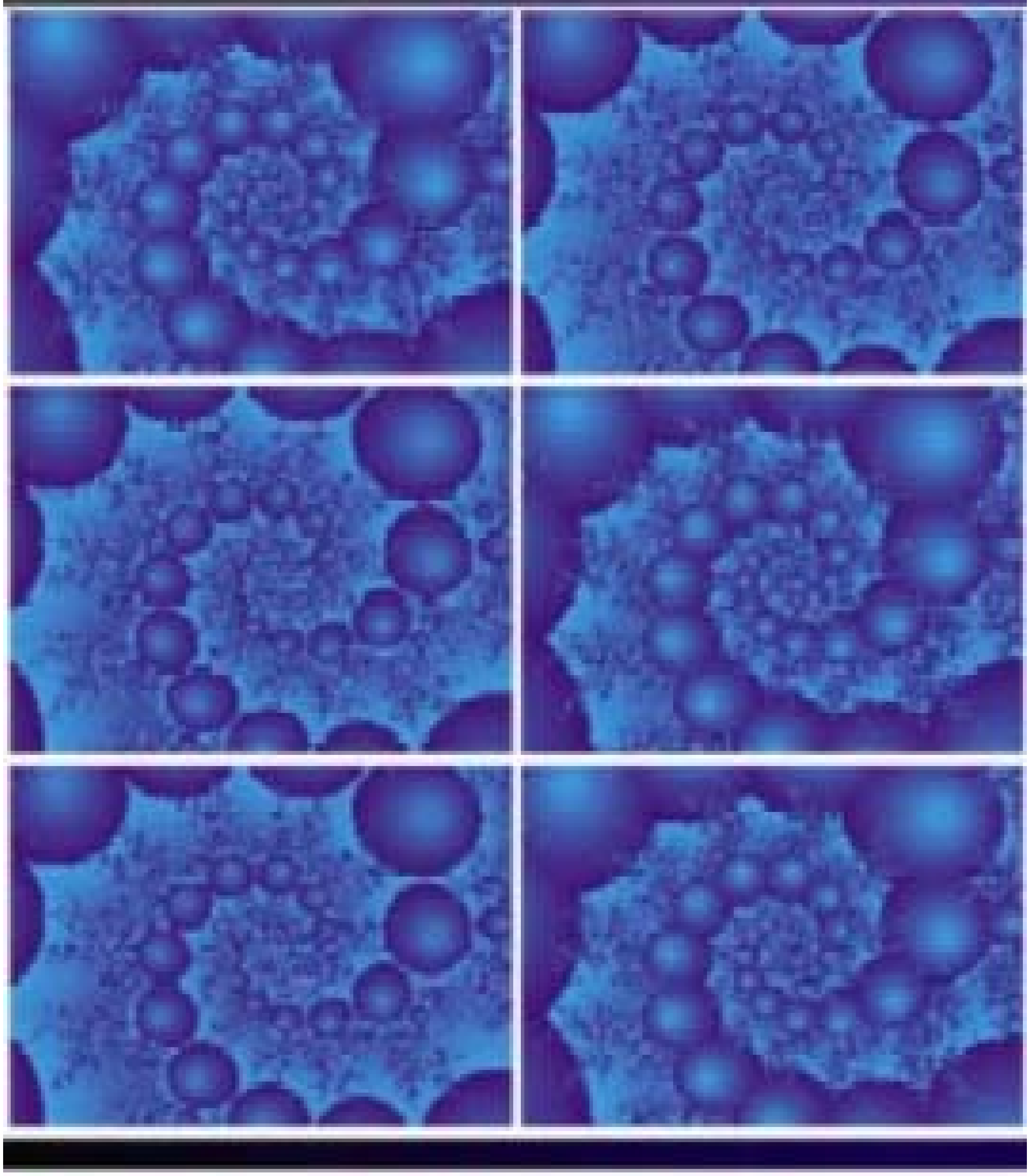
As outlined in this chapter, my proposition is that as more people share knowledge, the risk of knowledge loss is reduced. In this vein, organizations need knowledge strategies to identify and reconstitute knowledge and developing the processes to preclude catastrophic loss of future knowledge. Information Technology (IT) systems can help, but my emphasis is on expanding the base of knowledge in many ways, moving up in numbers and quality of information sharing from one brilliant but lonely innovator, up to larger communities which can share knowledge to create new knowledge for action. Building communities of practice that are robust and self-reinforcing is important, and we will review techniques and processes which may fit each type of knowledge described in the next chapter. However, as Ernst & Young Business Innovation consultant Rudy Ruggles described in the *California Management Review's* special Knowledge edition (Spring 1998, p. 80),

> **"If we have learned nothing else in four years of observing the knowledge management vanguard, we have seen clearly the importance of getting the**
>
> **approximately 50 / 25 / 25 people / process / technology balance**
>
> **right from the outset."**

What he means is that half of the efforts of all an organization's knowledge solutions need to focus on people factors, such as training and culture. One-quarter of the effort should be devoted the process changes which new technologies require, and only one-fourth of a major project should be expected to focus on the technology. In this way, the knowledge technologies represent the tip of the iceberg to addressing the organization's real knowledge needs. Ethnographer and MIT Sloan professor John van Maanen argues that organizations become more, not less,

unique over time, so solutions must be tailored to fit the specific circumstances. The right strategies should fit the organization's capabilities, culture, and capacities to learn and change, addressing the different types of knowledge. Given its current focus on transforming into the "knowledge centric, network centric" organization, the US Army will be used to provide examples of some of the transformations surrounding knowledge.

Chapter 2:
Impetus for Knowledge Strategies



Chapter 2:
Thinking about Knowledge: Theory

> **"Knowledge is more of a force than an object, more of a process than a product, more of a verb than a noun. Knowledge has no inventory part number or serial number. It can't be bought or sold. It can't be stored in a database or a warehouse. *Knowledge is created afresh whenever a conscious mind receives input through the senses.* Knowledge is refined when it is discussed through an internal or external dialogue. Knowledge takes meaning when the conscious mind appreciates its own influence on knowledge. And knowledge is interpreted in the context of prior knowledge. Knowledge can be tacit: the knowledge your hands and body remember when you perform a familiar, well-trained task; the unspoken meanings of love or fear or commitment that you learned from your family or your community, and that now influence you without your noticing. Knowledge can be explicit; understandings that spring to your consciousness when you read or hear or study something new. Knowledge can arise when you select and use a thinking strategy that enables you to investigate and resolve unforeseen challenges. There are innumerable variables in the creation, refinement, interpretation and sense- making of knowledge."**

In order to define effective strategies for an organization's knowledge, a necessary first step is developing an understanding of what knowledge is. In his presentation on "Warrior Development and the Human Side of Knowledge Management" (above, 2002), leadership consultant Samuel Welch reasserts the personal basis of knowledge, inseparable from the human knower and created fresh whenever a conscious mind encounters new input. His assertion that "it can't be bought or sold" captures the paradoxically voluntary nature of sharing knowledge – knowledge cannot be taken by force, but must be given. Interestingly, as MIT System Dynamics professor Jim Hines pointed out, the teacher might not know she or he is teaching, and the learner might not be consciously aware of learning – but the knowledge can still be shared, like Welch's "unspoken meanings … that influence you without your noticing." He highlights the fact that knowledge does not enter into a "tabla rasa" – the knower is not a blank slate, but already has prior knowledge, which informs current knowing and learning.

To understand knowledge from the manager's perspective, I started my exploration by considering knowledge along the continuums of degree knowledge is

shared and degree to which knowledge is objective or subjective, with examples at each crosspoint.

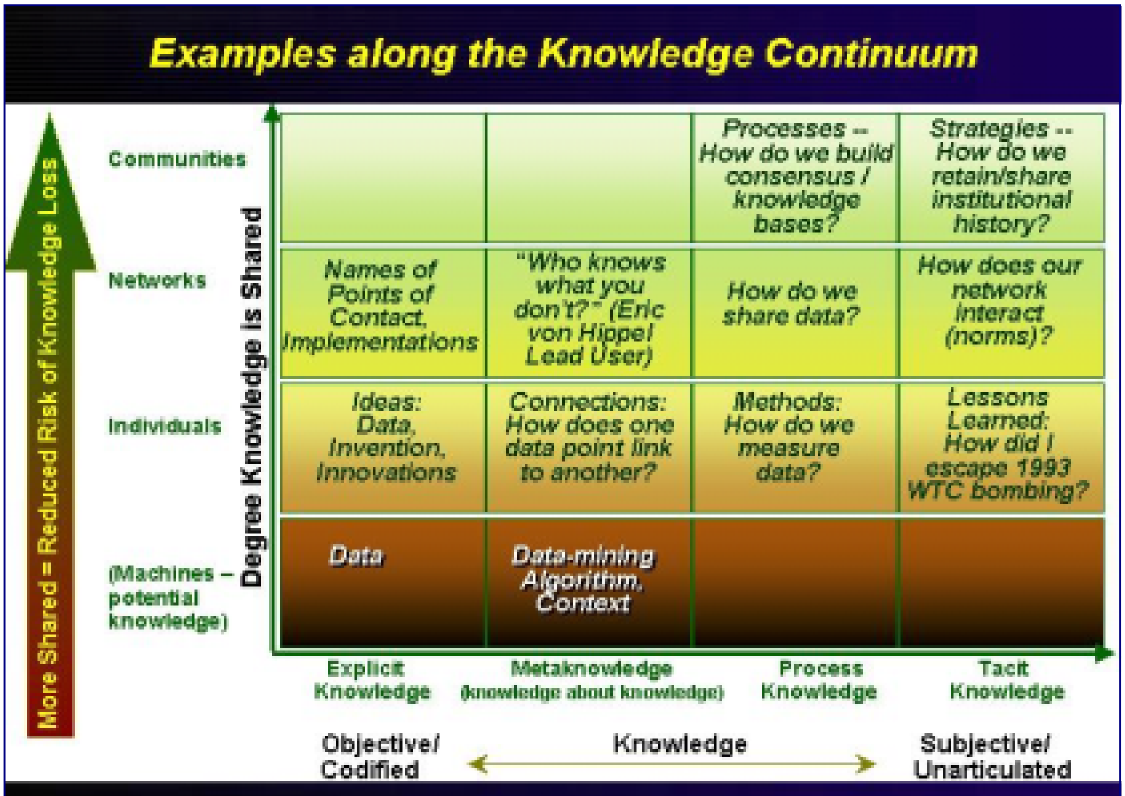


Figure 3: A Framework for Knowledge: Examples along the Knowledge Continuum

As shown in my framework above, if the goal is to reduce the risk of knowledge loss, then the more knowledge can be shared (moving up the vertical axis), the less risk there is of loss. The interesting case of zero individuals knowing suggests that machines can hold *potential* knowledge, but it becomes real only with human interaction. The concept that "only the computer has the knowledge" is becoming increasingly widespread, as computationally intensive processes such as bioinformatics become more prevalent. However, the key interface for actualizing information into knowledge is the human. The bioinformatics system can be thought of as the haystack, where the human can look and learn. As individuals accept the information, potential knowledge

can become actual. For the purposes of this exploration, I am assuming that networks of people can share, and can in turn extend to knowledge-sharing communities. Specifically, I assume that people can have a willingness to share, which implies telling the truth as they understand it, and that these same individuals have an ability to share, that they can recognize knowledge that another would find valuable. This is an idealized situation, and many of the strategies discussed will seek to enhance the organizations to approach this ideal state. The benefits are that organizations would not have to reinvent what they already know, as in "don't reinvent the wheel" efforts to leverage what other people know. There are also opportunities for knowledgeable people to come together and create new knowledge, such as innovations, which synergizes what each of them knows into a greater good.

The bottom axis shows knowledge categorized along a continuum between objective knowledge to subjective knowledge. The poles of this continuum are explicit and tacit knowledge. Although meta-knowledge and process knowledge are shown as different elements, process knowledge can be considered as on the boundary, between metaknowledge and tacit knowledge. Some knowledge is very explicit, which makes it "chunky" and easy to transfer -- the codifiable objective knowledge such as how to build a bridge. The more the knowledge moves AWAY from the explicit into the realm of the tacit, where it becomes more personal, more contextual, more experiential, farther from the consciously articulated knowledge, the more challenging it is to transfer and share. As we will consider below, knowledge theorists such as Japanese author Ikujiro Nonaka combine the non-explicit knowledge into a single category, of tacit knowledge. However, for managers it may be useful to consider all kinds of knowledge: explicit knowledge, metaknowledge, process knowledge, and tacit knowledge.

In the pivotal work *The Knowledge-Creating Company*, Japanese knowledge theorists Ikujiro Nonaka and Hirotaka Takeuchi (1995) briefly trace the historical Western

understanding of knowledge from Greek philosopher Plato through Wittgenstein's analytical philosophy and American pragmatism. In contrast to the Western focus on explicit knowledge, which can be articulated and written in manuals and procedures, Nonaka and Takeuchi show how Japanese firms approach knowledge less directly. They emphasize tacit knowledge, which is learned by experience and communicated indirectly, in metaphor and analogies. (p. 21-2) In a post-industrial society, Nonaka and Takeuchi argue that creating knowledge will be essential for firms to sustain competitive advantage.

Chemist-turned-philosopher Michael Polanyi published his seminal work *The Tacit Dimension* in 1966. He explored the distinction between tacit and explicit knowledge. He explains that <u>*explicit*</u> knowledge is declarative knowledge, readily codifiable and able to be described and transmitted in formal language. However, as Polanyi said, "We can know more than we can tell." (1966, p. 4) Polanyi described <u>*tacit*</u> knowledge as procedural knowledge which is personal, subjective, and context-specific. These attributes make tacit knowledge difficult to formalize, communicate, describe, and use. As Ford and Sterman describe in their 1998 paper, "Expert Knowledge Elicitation to Improve Mental and Formal Models," transferring and sharing this type of knowledge requires conscious effort and procedures to elicit, articulate, and describe. The knowledge that people can easily express in words represents only the tip of the iceberg of what they know.

People have this experience often, as when they recognize one another by the shape of the face or detect emotions by facial expressions. One promising area of research here at MIT's Artificial Intelligence Laboratory (AI Lab) seeks to capitalize upon this tacit human recognition of emotions through facial expressions by creating robotic faces which mimic human expressions. We visited the AI Lab and saw the Kismet project, on such "emotive" robot. One of the valuable outcomes of this type of

experimentation is to help people understand what they assume – making tacit knowledge more explicit. As shown on the Web screen capture from the AI Lab's Kismet project below, the artificial face is capable of signaling expressions which the human observers attribute as emotive. By understanding what appears to be emotive in a robot, people can become aware of tacit knowledge about human emotions, make it more explicit, and achieve new understanding.

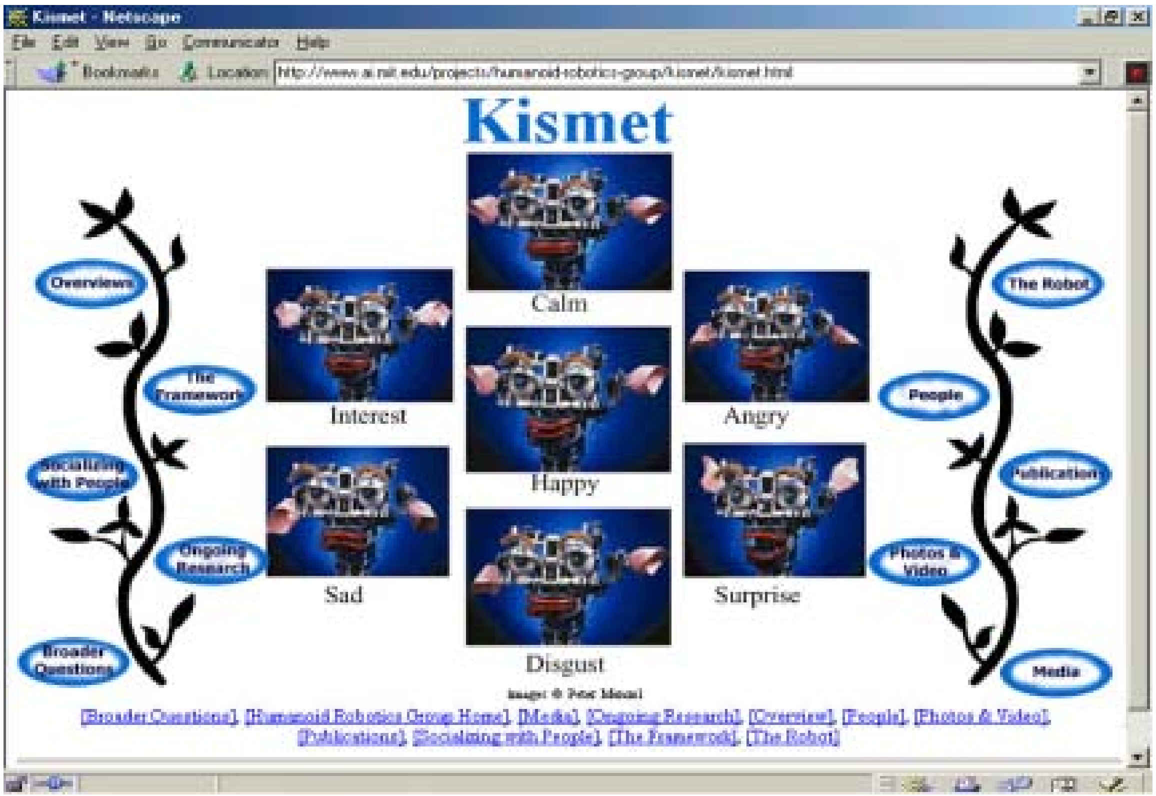


Figure 4: MIT's Kismet robot project explores making tacit understanding of emotions explicit.

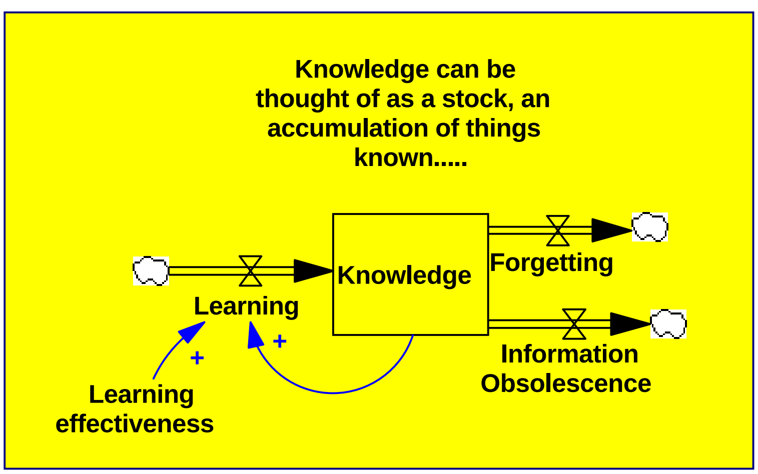
Nineteenth century Danish existential philosopher Søren Kierkegaard's work *The Concluding Unscientific Postscript* distinguished between what is known objectively and how the knower reacts subjectively. "Objectively the emphasis is on *<u>what is said</u>;* subjectively the emphasis is on *<u>how it is said</u>....* Objectively, the question is about *<u>categories</u>* of thought; subjectively, about *<u>inwardness</u>*." (1992, pp. 202-3) The knower's experience differentiates objective explicit knowledge which can be treated as a *<u>stock</u>*

from the subjective tacit and metaknowledge, which *flow* into and between other elements which the person knows.

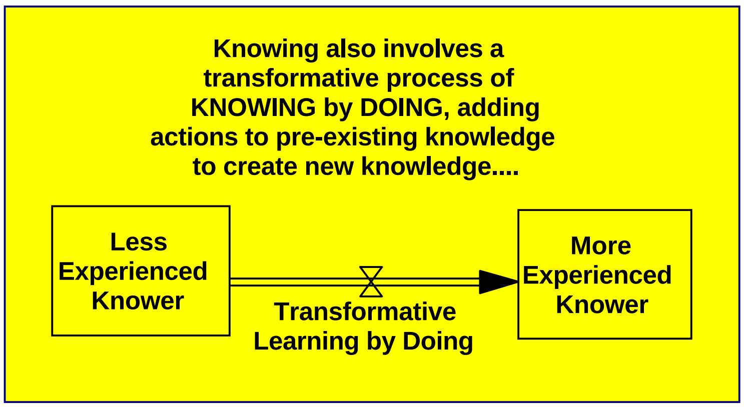
Knowledge as a Stock:

This distinction of knowledge as a stock, something which can be counted and accumulated, versus a flow, or dynamic process, has stirred up debate in the knowledge community. We will consider both knowledge as a stock and then knowledge as a flow. The practice of System Dynamics can help us understand the concepts stock and flow. System Dynamics founder Jay Forrester used the metaphor of a bathtub to explain stocks and flows (Sterman, 2000). A stock can be thought of as a persistent being, including intangibles such as memory, which holds contents – much as a bathtub holds water. (Stocks are shown in boxes.) The flows into the stock are represented by pipes, and represent contributions for the stock to accumulate, just as water from a faucet pours into a bathtub. The outflows of the stock work like drains, reducing the contents of the stock.

As shown in the diagram below, one approach is to think about knowledge as a stock, an accumulation of things that are known. John Sterman, Director of MIT's



System Dynamics Group, helped me conceptualize stock and flows about knowledge. As shown, knowledge can be thought of as a stock, an accumulation of learning, with outflows of forgetting and information obsolescence. The accumulated knowledge influences new learning, at some rate of learning effectiveness. An example of this kind of knowledge is the science of building bridges. Codified rules can be learned in the classroom. Existing knowledge informs the learning process, and allows for more advanced learning to take place.



The concept of flows can also apply to our consideration of knowledge, by focusing on the transforming process on the knower. Knowledge also involves a transformative process of knowing by doing. Actions can be added to pre-existing knowledge to create new knowledge, which transforms a less experienced knower (a "rookie") into a more experienced knower. Sterman (2000) has explored the nature of systems thinking and knowledge sharing in his research. He does ***not*** seek to demonstrate that only objective, quantifiable, explicit knowledge is learned. In fact, the Systems Dynamics course here at the MIT Sloan School powerfully demonstrate the transformative process of learning by doing, as less experienced learners become more experienced knowers. The process of systems thinking (the "what") and the tacit knowledge (the "how to") is passed on through experience. In "The Cognitive

Psychology of Systems Thinking" article, James Doyle (1997) applies concepts of cognitive psychology to the practice of systems thinking, and raises questions about how to elicit, share and transfer knowledge in the systems thinking context. A key emphasis and challenge in systems dynamics modeling is to understand the mental models of the participants. Ford and Sterman (1998) lay out a process to help experts elicit their understandings of the systems being modeled, making explicit awareness of tacit knowledge and procedures.

A Dynamic Theory of Knowledge:

Nonaka and Takeuchi (1995) provide useful insights in the understanding of tacit and explicit knowledge. Their dynamic model of knowledge uses social teraction between humans to create and expand human knowledge, through "knowledge conversion." (p. 61-72) This conversion process transforms explicit and tacit knowledge between forms, in an interactive spiral method.

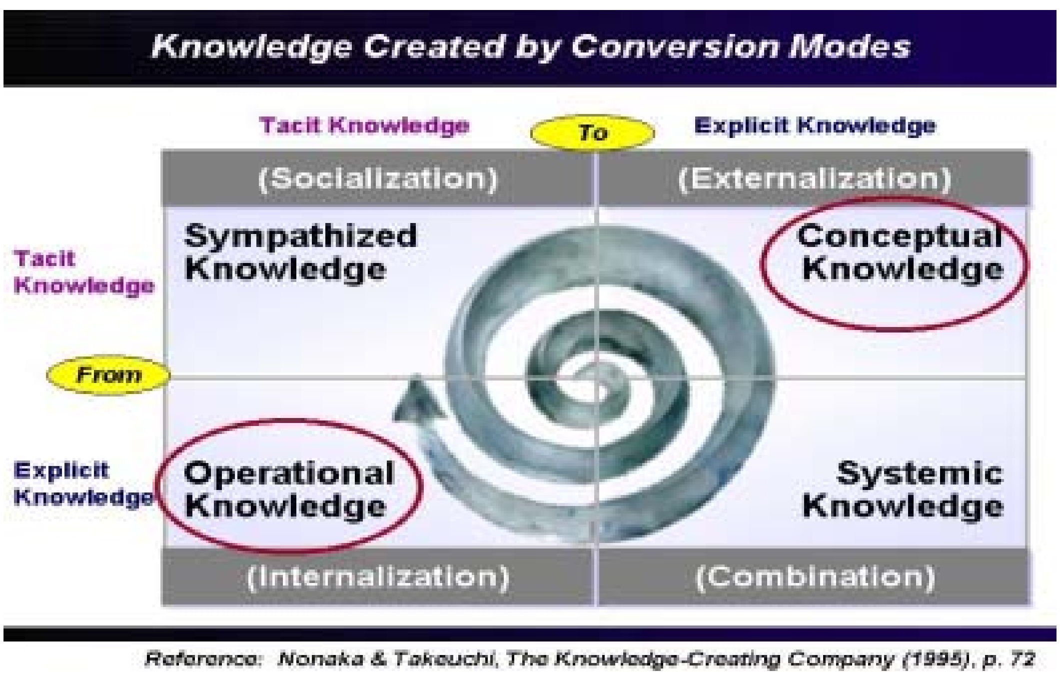


Figure 5: Knowledge created by conversion modes between tacit and explicit.

Nonaka and Takeuchi postulate four modes of knowledge conversion. "Within-type" conversions of tacit to tacit (socialization), and explicit to explict (combination), are somewhat passive, adding to existing knowledge. In contrast, "between-type" conversions, of tacit to explicit (externalization) and explicit to tacit (internalization), create genuinely new knowledge, shown in circles.

- ***Socialization*** **moves knowledge from tacit to tacit, as one person teaches another by doing. In the workplace, apprenticeship and on-the-job training use this concept by providing the learner with a shared experience, to create an understanding of the field. A shared experience helps learners reorient their mental models in the same direction, creating sympathized knowledge.**

- ***Combination*** **is the process of integrating explicit knowledge concepts into one's knowledge system, to create systemic knowledge. Classroom learning, where bodies of systematized "factual" knowledge are taught and transmitted from professor to student, offer many students the experience of combination. With hardly any irony, Nonaka notes, "An MBA education is one of the best examples of this kind." (1991, p. 67) Combining data from documents, spreadsheets, or databases can lead to new knowledge, as correlations are noted and elements are categorized. Companies which perform datamining on Web-stream data can profit from combinations, as they see trends in point-of-sale purchases. Business managers who network together codified information to create new knowledge demonstrate this combination. Companies can reap benefits of innovative new products by combining existing sets of explicit knowledge, as Proctor**

& Gamble did when they combined a paper towel with a detergent to create the new product (and product category) of Swifter floor wipes.

- ***<u>Externalization</u>*** **moves knowledge from tacit to explicit, as one person might verbalize actions to explain it to another. This is knowledge creation as classically conceptualized, with teachers developing metaphors and describing concepts, hypotheses, and models. Dialogue often triggers externalization. The Army Research Institute's studies on the Tacit Knowledge (TKML) discussed experiences with a number of Army officers. Initially, they would describe general-sounding principles of good leadership; peeled back, they could externalize deep tacit knowledge as conceptual knowledge, able to be shared with others. By explaining their tacit knowledge to others, these experts become more aware of it themselves. Becoming aware of their knowledge makes their understandings more amenable to experimentation and strategies – trying different emphasis, learning what works better. In this manner, both the teachers and the students are learners.**

- ***<u>Internalization</u>*** **embodies explicit within tacit knowledge, creating operational knowledge as the learner integrates the teaching with prior learnings and learns by doing. My experiences with Outward Bound showed many opportunities for people to internalize explicit knowledge into the realm of the tacit, as we showed each other how to tie knots to hold together improvised watercraft. Describing "how to" was confusing; actually doing the knots allowed teammates to acquire the skill and learn its benefits. Watching small children learn to tie shoes similarly** demonstrates the difficulty in translating explicit knowledge into tacit knowledge, which is most easily learned by doing. Experiential stories, such as "war stories" told by experienced soldiers to young ones, help listeners envision themselves in similar situations, allowing for vicarious experiences. Novices must internalize the explicit knowledge to attempt to develop a 'gut' understanding of how the world works as a system. Foreign language students experience internalization when they dream in the new language, or get humor.

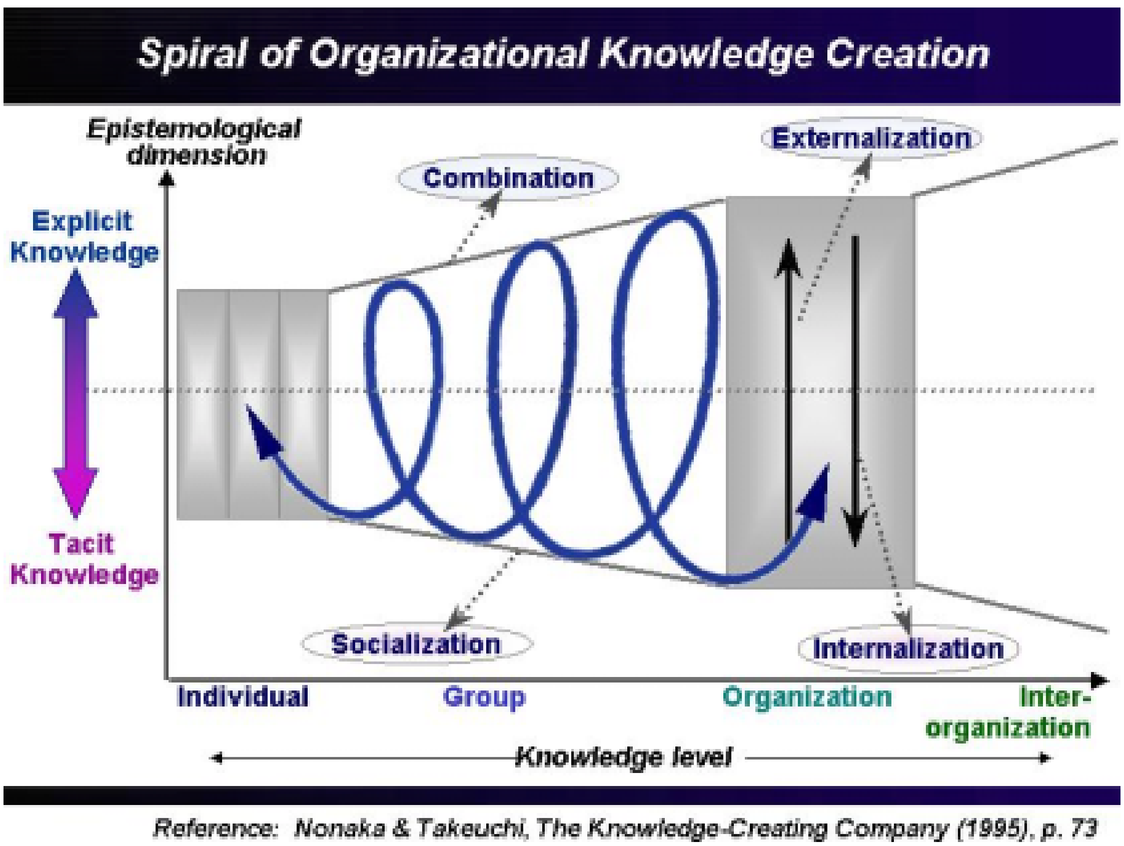


Figure 6: Knowledge dynamics extended to organizational level and beyond.

Nonaka (1991) argues that the new knowledge which is created by each knowledge mode and the dynamic conversion between explicit and tacit knowledge is

extended iteratively from the individual to the organization. This process allows individual learners to catalyze the organization, to move toward becoming the learning organization. Kierkegaard emphasized that *becoming* took precedence over simply *being*. The interaction between knowers and what is known proves to be transformative.

But as US Army and Fortune 500 leadership consultant and retired Army colonel Mike Shaler points out, "Knowledge is contextual. Pieces are stuck together as if with Velcro, and *it takes an expert* to ask a *really expert* expert to share his or her knowledge." Retired 3-star general Julius Becton observed this challenge while trying to write his memoirs. His first assistant did not even understand the lingo. Shared experiences, a shared context, and shared language are important precursors to knowledge sharing and transformation into communities of knowledge. Earlier learnings allow for later acquisition of more advanced knowledge. Novices may lack knowledge to understand a story, or even to detect that tacit knowledge is being shared.

While my class traveled in Asia in March 2002, classmates who could recognize Chinese characters demonstrated this experience of not recognizing tacit knowledge without the context. In Beijing, they were the experts, and I was the novice, as they explained the meaning of "grass writing," a very broad-brushed type of calligraphy. As shown in the picture, they explained that they could not read the artist's writing, but they knew what the words were *supposed* to be, because they knew the sequence of the character strokes.

Nonaka and Konno's article "The Concept of 'Ba:' Building a Foundation for Knowledge Creation" (1998) uses the concept of "*Ba,*" a Japanese word for "place" to

describe a shared space to support emerging relationships. To support knowledge creation, this space can be:

- ***physical*, as in offices, classrooms, dispersed business space**
- ***virtual*, as in e-mail, teleconferences, on-line newsgroups**
- ***mental*, as in shared experiences, ideas, ideals, values**
- **or any combination.**

Nonaka and Konno assert (1998, p. 41), "Knowledge is embedded in '*ba'* (in these shared spaces, where it is then acquired through one's own experience or reflections on the experiences of others. If knowledge is separated from '*ba*,' it turns into information, which can then be communicated independently from '*ba*.'" (1998, p. 41) Peter Senge extends this concept with the generative learning he describes in *The Fifth Discipline*. For Senge, the learning organization's adaptive learning "must be joined by generative learning, learning that enhances our capacity to create." (1990, p. 14) Generative learning goes beyond merely amassing a body of knowledge, the knowledge as stock concept. Generative learning seeks to amass a body of experience, and allow participants to interpret that experience, and change their behavior. He credits '*Ba*' with providing the needed *generative* *context* for people to create *knowledge* which leads to *action*.

In their Fall 2001 MIT Sloan School course on "Organizations as Enacted Systems," Sloan professors Wanda Orlikowski and Peter Senge introduced the concept of the system as being created or enacted by the people within it. In the knowledge framework I introduced, this allows for an understanding of the processes and metaknowledge – the "how do you do it" and "how you know what you know" aspects of knowledge. People use their experiences to create their organizations on a continuous

basis, enacting their organizations, and make sense of the world, with habits of action and habits of thought.

As discussed, codified explicit knowledge is important, but knowledge is more than merely lists of information about what other people already know. Tacit knowledge and metaknowledge can be conveyed as knowledge _processes_, essential to create new knowledge. Nonaka (1991) describes the powerful knowledge creating dynamics that come from conversion between tacit and explict knowledge. Kierkegaard (1992) pointed out that *becoming* was more primary than simply *being* reminds us that human activity, motivated by passion, creates energy, dynamism, and new knowledge.

Our understanding of the dynamics of knowledge is extended by Rudy Ruggles' characterization of knowledge in use by the following processes, engaged in by active human subjects (1998, p. 81):

- **Generating new knowledge**
- **Accessing valuable knowledge from outside sources**
- **Using accessible knowledge in decision making**
- **Embedding knowledge in processes, products, and/or services**
- **Representing knowledge in documents, databases, and software**
- **Facilitating knowledge growth through culture and incentives**
- **Transferring existing knowledge into other parts of the organization**
- **Measuring the value of knowledge assets….**

Our Roadmap:

Given its intense focus on transformation to become knowledge-centric and network-centric, I believe the US Army offers business leaders some important lessons on the power of organizational learning and knowledge creation. Many examples are lessons learned from my service with the US Army. Noted ethnographer John van Maanen documented police and fishermen, showing the uniqueness of communities over time, and also the length of time needed to be able to document and describe them. I am

a second-generation Army officer, now an alumna of active duty service and a defense contractor. I was part of the Army's product development and acquisition community, in the Office of the Project Manager for Bradley Fighting Vehicle Systems for eight years during a critical period of organizational change. I benefited from knowing and working with some of the Army's most respected leaders and mentors. As it refocused from the Vietnam era to the Information Age, the US Army has emerged as one of the most significant learning organizations in the United States.

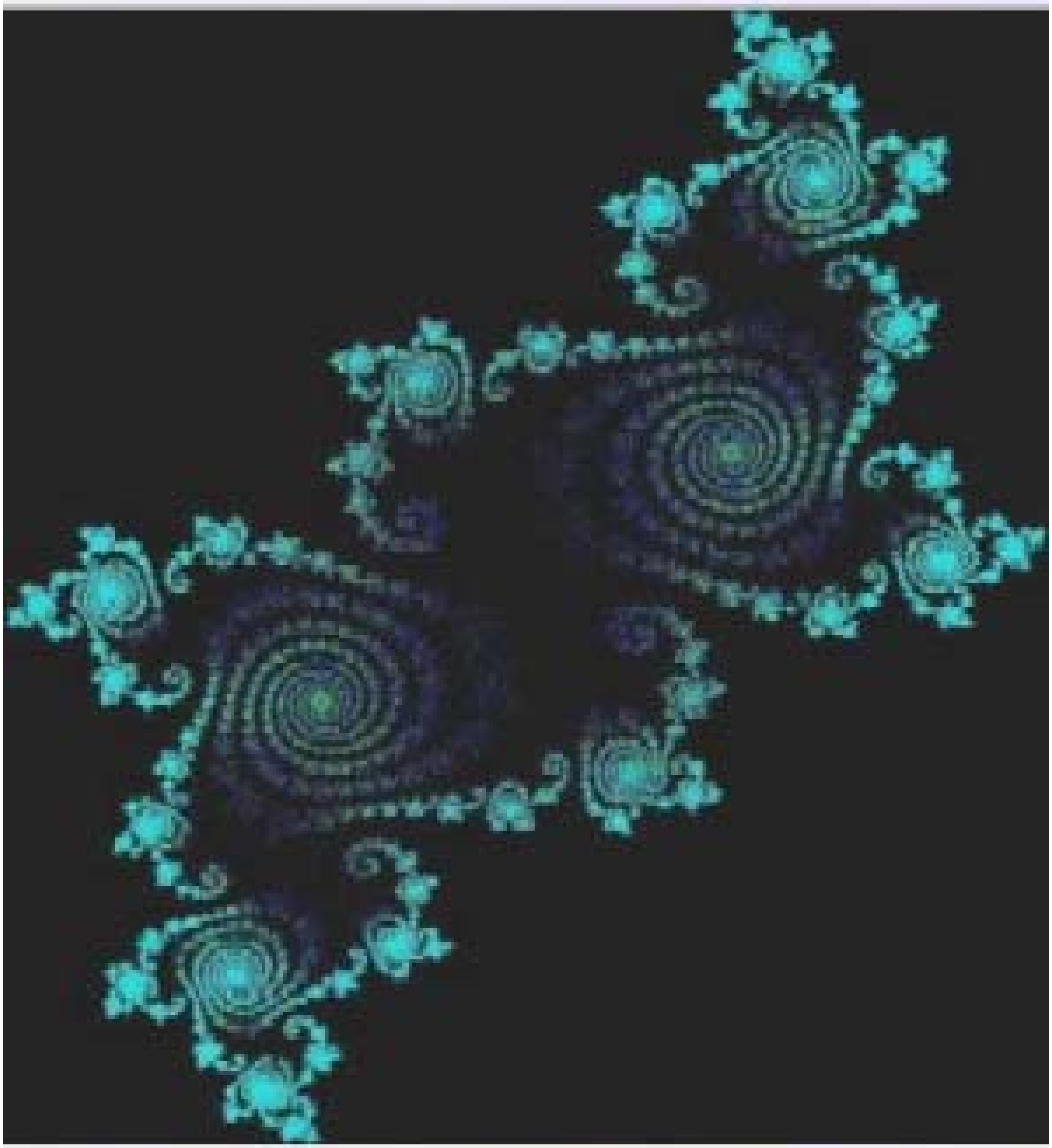
Army visionary and former Chief of Staff Gordon Sullivan wrote *Hope is Not a Method* with Mike Harper to share lessons from the Army's historic organizational transformation with business leaders, explaining "Despite dramatic budget and manpower reductions, the Army has succeeded in retooling for new missions, upgrading the skills of its people, developing new ways to assimilate and exploit technology, and achieving a higher degree of readiness than at any time in its recent history." (1996, p. xv) The annual report of the Army's Training and Doctrine Command, on the Army After Next, is called "Knowledge and Speed," highlighting the accelerating rate and scope of change and the need to be a knowledge-creating organization to master this new era. In April 2002, the Center for Army Lessons Learned (CALL) hosted the second Army Knowledge Symposium. In January 2002, General Eric Shinseki, current US Army Chief of Staff, reiterated this focus on the Army as a learning organization.

> **"The Army is a learning organization committed to lifelong learning through a balance of educational and operational experiences, complemented by self-study and self-development. To be a learning organization that supports lifetime learning, The Army must provide training and educational standards and products; a doctrine that fosters lifelong learning; and a digital "Warrior Knowledge Network" to provide one-stop information access for Soldiers, leaders and units.… We will keep you informed on our progress and the way ahead in our efforts. This is all about our People, the focal point of The Army Vision, on whom the success of our Nation has rested for more than 226 years."**

The Army is a knowledge innovator. Wired Magazine celebrated the launch of "the world's largest intranet," the Army Knowledge Network – 70 terabytes of storage space to serve as "the Army's remote hard drive," accessible anytime, anywhere, via Internet. A powerful technique called the After Action Review (AAR) used daily in US Army training and being learned in Fortune 500 companies will be discussed in chapter 4, as a framing technique to help organizations transform into learning organizations.

This chapter has discussed some of the theories around knowledge. The next three chapters will show how managers can put this theory about knowledge into practice, dealing with explicit knowledge, metaknowledge, and tacit knowledge. Information technology and networks can be enablers, but must be subordinate to the strategies and goals of the organizations. The successes and lessons learned from knowledge strategies in a US Army product development office, the Program Manager for Bradley Fighting Vehicle Systems, will provide a case of how an organization used knowledge strategies to shift from an Industrial Age organization to an Information Age organization – from "bending metal to managing software."

Chapter 3:
Explicit Knowledge



Chapter 3:
The Initial Investments in Automating What a Company Knows: Start by capturing explicit knowledge

WELCOME TO KNOWLEDGE TECHNOLOGIES 2002

Bridging Knowledge Communities

Last year, IDEAlliance launched a brand new conference entitled "Knowledge Technologies (KT2001)". This new conference was designed to provide bridges among the following critical knowledge communities:

- **Knowledge Representation/Artificial Intelligence**
- **Knowledge Organization/Libraries**
- **Internet/Semantic Web**
- **Document/Asset Management**
- **Knowledge Management**
- **Expert Systems/Agent Computing**
- **Machine Learning**

http://www.knowledgetechnologies.net/

As suggested by the IDEAlliance description above, the Information Technology (IT) industry has experienced explosive growth, and has affected many aspects of business and personal experiences throughout our lives. IT has automated many routine actions, and changed patterns of behavior. One of the unanticipated consequences of such IT use was the exponential growth in information available. As e-mail became as routine as having a telephone in the home, and Internet web pages were put up in cyberspace, information once locked in desk drawers, kitchen counters, and filing cabinets became available electronically.

IT increased access, but with such access came commensurate gluts of information. Sorting techniques became important to help find which of the thousands of possible responses to an Internet inquiry may be the “needle in the haystack” information being sought. The complexity of the IT and techniques to address knowledge created opportunities: technology conferences such as Knowledge Technologies 2001 organized around particular IT solutions.

The knowledge about the knowledge is an example of metaknowledge, and the process described is an attempt to create a Community of Practice to share information, but transferring explicit information of solutions to fit problems is an example of Nanoka's combination functions. Technology can assist knowledge sharing, especially for explicit knowledge.

As Harvard Business School professor Shoshana Zuboff writes in her Sept. 1995 Scientific American article, "The Emperor's New Workplace," IT provides businesses the means to generate value for customers "… with speed and efficiency. Doing so means using the modern information infrastructure to cope with the complexities of a business outside a central managerial cadre. It is more efficient to handle complexity wherever and whenever it first enters the organization – whether during a sale, during delivery, or in production." (p. 205)

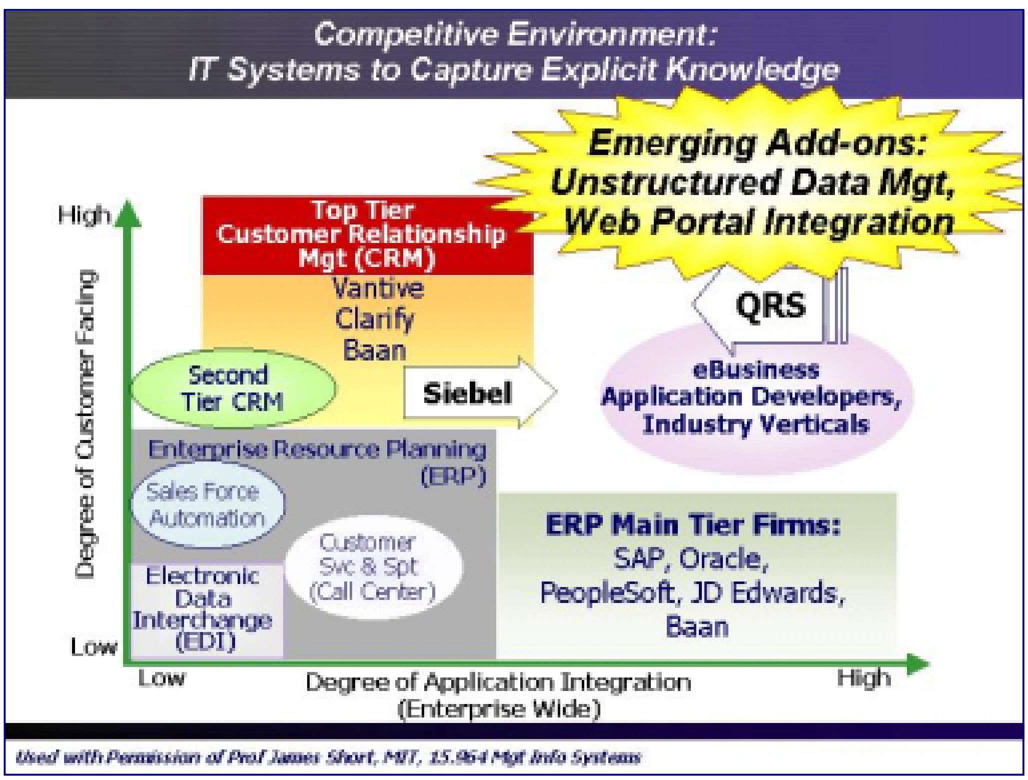


Figure 7: Competitive Environment: IT Systems to capture explicit knowledge

As shown by Professor Jim Short's graphical description of the competitive environment for IT systems, used in his Fall 2001 MIT Sloan School course on Management Information Systems, many providers offer solutions in different combinations of enterprise integration and customer integration. Knowledge management (KM) systems, both hardware and software, have been implemented by businesses and communities of interest to handle this complexity, by allowing users to categorize, find, and share knowledge. The experience of business process automation provides a roadmap for how IT may support knowledge sharing. During the 1980s and early 1990s, many businesses implemented a variety of business process automation products, as shown in the figure above. They evolved in the degree of application integration, from low to high, as shown on the bottom axis, and in the degree to which they are customer facing, as shown on the vertical axis. From relatively simple beginnings, these systems now allow more direct customer interface into the organization's systems, often using web-based entry.

In the beginning, businesses started with Electronic Data Interchange (EDI) programs, which offered a simple format to transmit electronic orders. EDI programs allowed companies to enter the world of electronic commerce, but required special software, hardware, and training. Many programs sought efficient data transmission, to minimize time to transmit data over 9600 baud modems, by use of cryptic codes explained in thick manuals. A supply requisition might have 80 characters of data, but three 3" manuals were required to correctly format each transaction. The skilled user was an essential part of this software interface.

Over time, companies became more sophisticated in their use of business process automation. The Enterprise Resource Planning (ERP) families of software allowed for production planning, and were extended to encompass much larger-scale enterprise-wide solutions. SAP is well-known for its extensive implementations of business process changes for a company's entire set of business practices. In order to implement SAP, many businesses chose concurrent business process reengineering. This made SAP implementations BOTH large-scale Information Technology (IT) projects, and major reorganizations of company practices and processes. Teams of contractors are often hired to assess the business, implement the ERP building blocks, and customize the modules to interoperate. Legacy systems are either shut off, or linked through a complex tie-in. Companies must choose an implementation strategy carefully, because the efforts needed to keep the information current in even a single system of record can be significant.

Companies progressed from automating their "back office" operations, to automating more of their customer-facing functions. The Customer Relationship Management (CRM) systems took over where more primitive Customer Call Center and Sales Force Automation systems left off. Especially useful for companies focused on a very narrow problem set, such as computer post-sales support, these CRM systems track customer needs, purchases, and history.

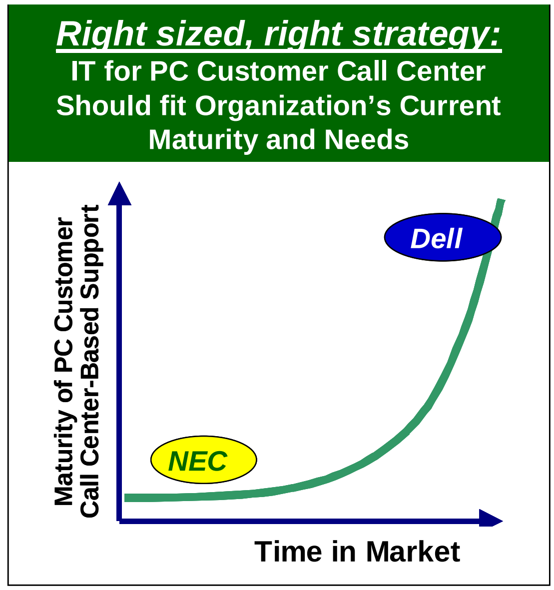
After the use of the World Wide Web became widespread in 1995, "e-Business" applications developers used the Web to provide simpler interfaces for conducting business operations. US Army Colonel Scott West, a senior logistics officer currently supporting the Army in the Department of Defense (DoD) Joint Logistics Office at the Pentagon, describes the problems integrating networks of supply information and collaboration. Although supply chain integration and collaborative networks need information to flow seamlessly, "There are more than 1,000 legacy systems in DoD and they are all different," he told reporter Ken Cottrill (Cottrill, 2001). A decade ago, Colonel West and I implemented many of the first business process and supply chain automations for the US Army at Fort Ord, California. Now the challenge, as in early EDI systems, is to take these "stovepipes" of data and information and link them together.

The technical challenges of interoperability are still exacerbated by the human issues. He describes these as "rice bowls" - internal empires and vested interests that resist change. The major challenge for the military is to turn "iron mountains" of repair parts inventories that were built up during the Cold War into "flowing rivers" of electronic transactions – a process the DoD calls "information fusion" that would enable integrated supply chains both within and between the services, linking the U.S. Air Force, Army, Marines and Navy. Web-based requisitioning is a centerpiece of this effort. "One of our biggest problems to date is that we tend to look at IT as a burden, and that's dumb," said West. (Cottrill, 2001)

Our MOT class trip to Asia in March 2002 allowed us to see how other companies are approaching this same challenge. At the Hong Kong trading and supply chain company Li & Fung, IT Director Albert Ip described the process of automating the supply chain. He pointed out that some of the companies which make the medium- and low-cost soft goods, such as garments, are medium sized and have some automation to interface into Li & Fung's automated ordering systems. Some of them, however, are 200-machine sewing factories with no automated recordkeeping at all. They may be valuable providers of the goods being traded, but the way to link with them for the supply chain is *not* to impose a "one size fits all" mega-IT system. Instead, these smaller providers are able to tap into Li & Fung's web page by Internet. If the family does not have Internet access at home, the children may have it at school, or they can go to an Internet café to access their orders. By right-sizing and tailoring their supply chain automation, Li & Fung can gain the benefits of increased knowledge without undue burden. Chief Financial Officer Frank Leung pointed out the benefits of this: by linking up the elements of the supply chain, Li & Fung can learn about excess capacity or forecasted shortfalls, and take appropriate steps to remedy or exploit these as opportunities. For Li & Fung, this process makes the tacit knowledge scattered throughout their many providers

visible, explicit, and actionable. This saves time, increases efficiency, and reveals opportunities to grow the business – very beneficial indeed.

Computer giant NEC in Tokyo was implementing their NEC 121 Customer Call Center to meet similar goals of using explicit knowledge to increase their customers' experience. Dr. Adachi, the General Manager of Customer Service, proudly described their year-old endeavor. The justification for the customer call center came from their study which showed that customers who were satisfied with their customer support had a 64% probability of purchasing a personal computer from the same vendor. The customer call center gave NEC an avenue to address the customers' questions, by making tacit knowledge explicit from company agents to customers. The call center was staffed by 400 customer care agents who had access to every single model of computer and printer that NEC had made, spanning more than 30 years, plus all the documentation and technical manuals. Customers could call up and ask for help in setting up or operating their personal computers. In this, NEC was taking a contextually appropriate implementation strategy. It would be inappropriate for NEC to treat customers like computer giant Dell, who strives to automate the customer care process with knowledge bases of "Frequently Asked Questions," a declining call time averaging less than 3 minutes, and early recourse to the "reload all the software" (rather than troubleshoot the complex interactions between the software code and plug-ins). NEC is early in its growth cycle, trying to work its way up the growth curve to takeoff and dominance – where Dell already is. At this early stage, NEC's 10-minute average customer calls and solicitous,

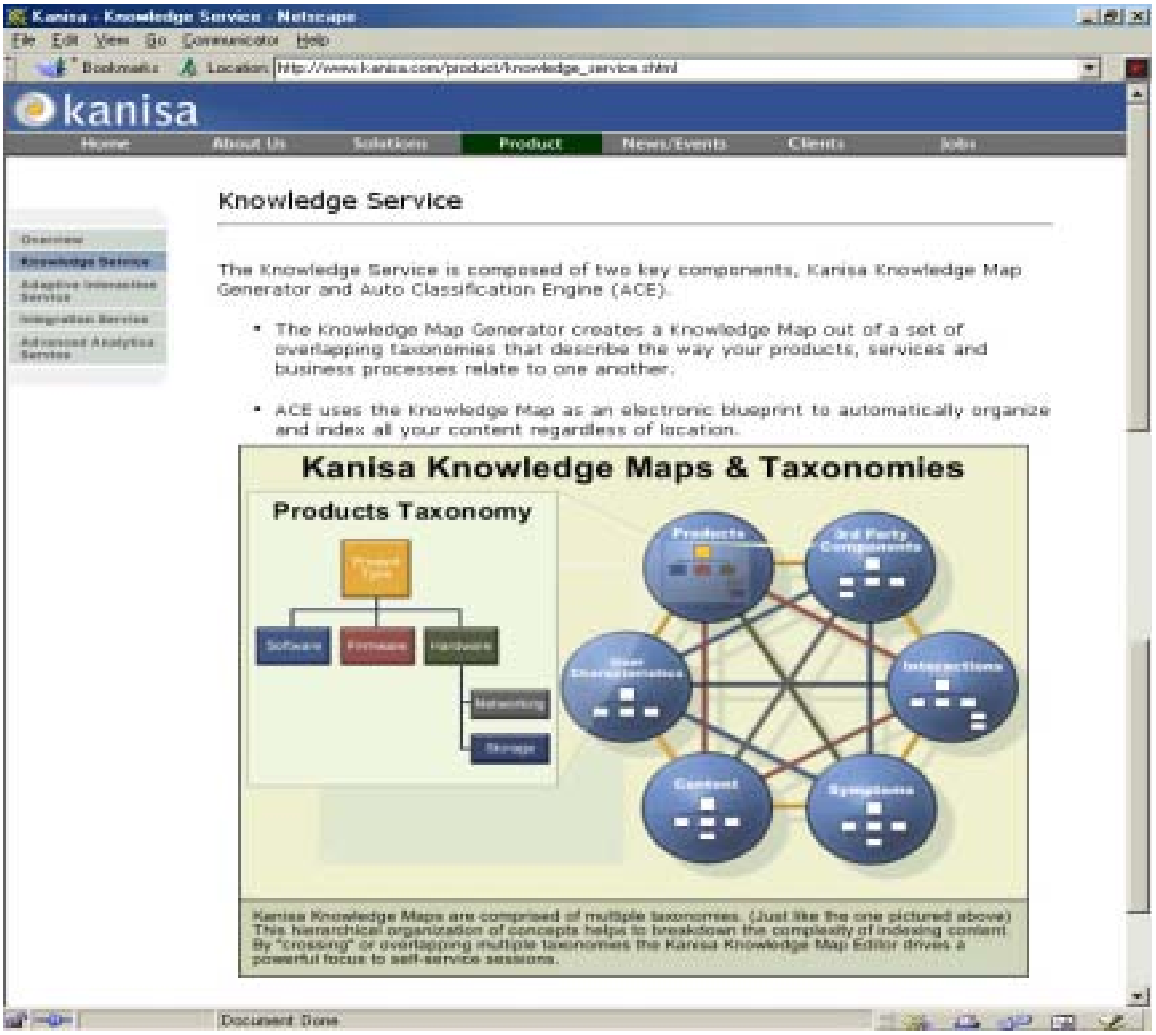


polite customer care agents are best suited, both to the business context and to the Japanese culture. Customer response calls do take a long time, because the call center customer support agents are building up their own knowledge base. As they make their tacit knowledge explicit, and develop and share the metaknowledge by teaching customers how to use the printed documentation to answer their own questions, their own knowledge bases are developing and maturing. At the same time, the customer base in Japan is becoming accustomed to having customer service by telephone, and is building knowledge of how to deal with it and expectations of how such a service 'should' be provided.

Although NEC's 121 Customer Call Center is at the right stage of development for an early implementation, they also need to look ahead. Since they are marketing the center as a service to which other organizations can outsource customer support, they need to be able to scale their operations. Their 400 agents will be overwhelmed if the customer base suddenly grows overnight by a factor of 5 – the challenges of success can be real. The lessons provided by other customer support centers offer a useful technology roadmap for how NEC's center can grow.

NEC's customer call center is nearing the point at which more formal knowledge bases can be implemented to increase efficiency. By documenting the problems and solutions already encountered by the customer care agents, NEC has the foundation for their knowledge system. They currently are exploring alternative software systems to document and cross-reference their customer support logs. Currently, responding by e-mail to a customer question is the costliest response technique, simply because each technician who responds to the e-mail must recreate the problem, research the documentation, find and test a solution, and respond back. As common problems are encountered, resolved, and documented, these messages can become the answers to "Frequently Asked Questions," allowing for efficient reuse of knowledge – both by the

agents and customers accessing frequently asked questions (FAQs) for self-service via the Web.

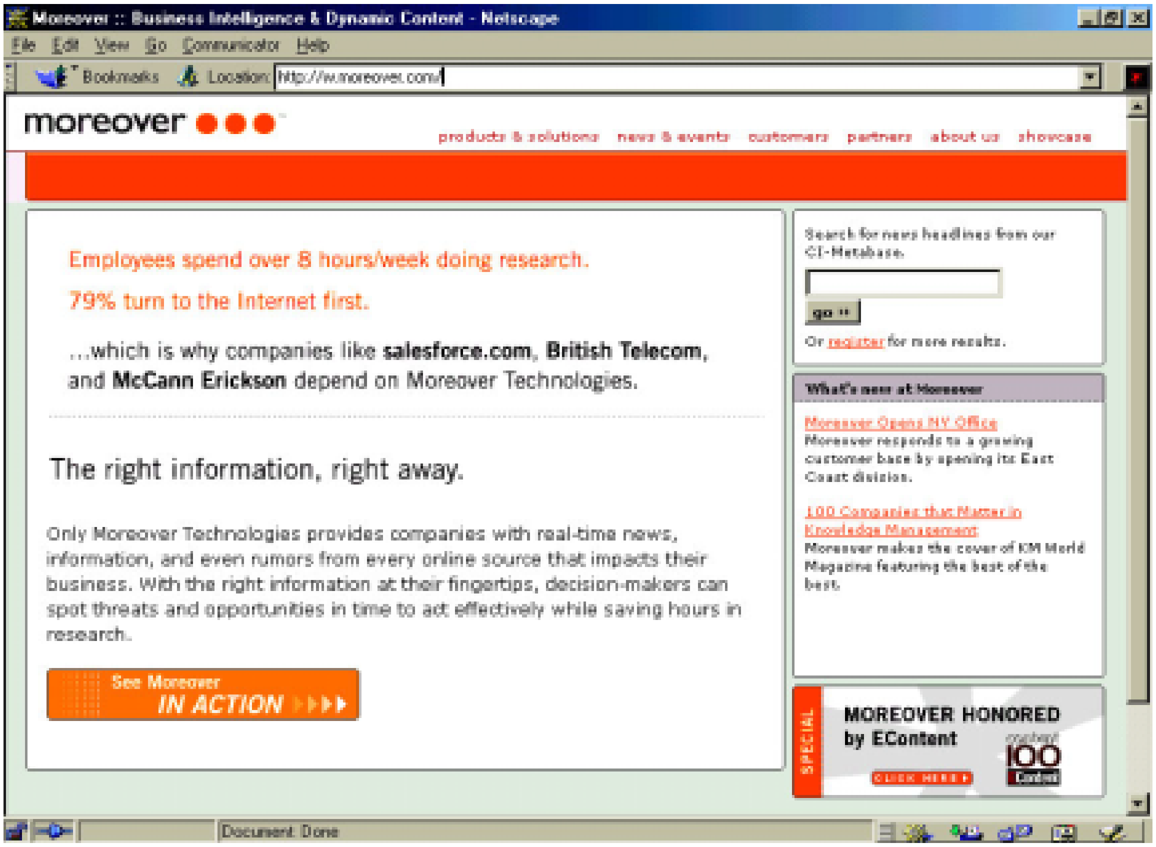


Other companies are offering software to augment the capabilities of these knowledge documentation systems. During the MIT Silicon Valley Tech Trek in January 2002, Mark Angel, Kanisa's Chief Technical Officer, described the additional functionality Kanisa provides. The core of the current solution set is called the "Kanisa Knowledge Map Generator," which creates taxonomies (lists) of the products and services the company wants to support in its automated call center. The software automatically suggests meta-data and generates a framework for organizing the knowledge. Once the

customer company generates their knowledge framework, they continue down the suggested process, using software, tools, and methodologies to deploy the Kanisa ServiceWeb. Kanisa uses Extensible Markup Language (XML) data tagging to classify and connect content. This is a crucial step to being able to find and access the information gathered. A "Knowledge Map" creates a "virtual knowledge network." After being deployed, the system should be analyzed and adapted. Angel attributes the customers' satisfaction with the system to the continuous improvement cycle, with the analytic software capturing all the customer interactions and using the information to "self-learn," by personalizing and tuning search performance.

One of the features Angel described as being particularly helpful is sorting the incoming queries from the web and telephone based on the language the customer uses. A call from a 90-year-old great-grandmother using her first PC to send e-mail to her family will include much different phrasing than that of the busy on-site IT professional at a Fortune 5 company. Directing the calls to customer support providers who can meet the customer's knowledge with matching language can greatly facilitate the knowledge transfer, save time, and increase customer satisfaction. As NEC's study showed, a satisfied customer is likely to be a repeat customer. Before NEC considers adopting this type of customer-context-centered solution, however, they need to identify providers who understand the cultural context of *their* customer base. Solutions for Japanese customers who are learning to use customer support through indirect means, rather than face-to-face, must negotiate culturally-specific tacit and metaknowledge. Here again, *context is key*.

Other software augmentations seek to exploit the value of knowledge the company is currently gathering, but cannot readily access. As shown above, Business Intelligence software provider Moreover offers companies portals, targeted at providing "revenue producing employees" (such as sales reps) "the right information, right away."

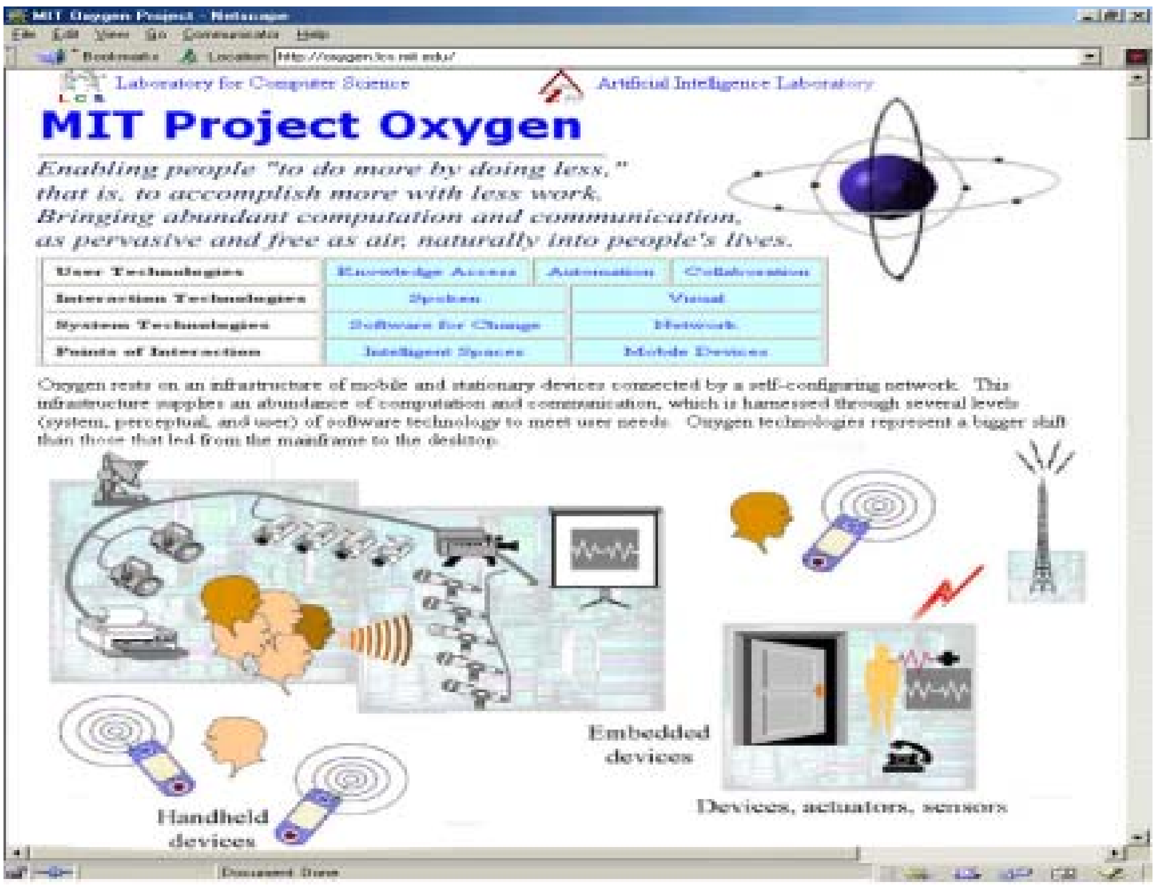


www.Moreover.com

The big selling point of Moreover's set of solutions is integration of external resources with the structured and, importantly, the *__unstructured__* data already captured by customer call center systems from SAP, Siebel, and related companies. It turns out that the most valuable, yet untappable, knowledge is entered by the customer call center technicians into unstructured text fields. All the reasons *__why__* the customer is calling (the metaknowledge) as well as the *__non-standard__* *__solutions__* (the tacit made explicit) are documented in these frustratingly unsorted fields. In addition to structuring the unstructured data, to uncover and access this hidden knowledge, Moreover's portal solution incorporates the outside world. Their software surveys the company's intranet and a variety of tailorable Internet news sources outside the company to present team members with the latest information, taking knowledge to the level of "actionable intelligence." The selling point is that a software sales representative who plans to make

a six-figure sale to a company should understand the current business context and concerns of the targeted company. An example of this is a company which is announcing layoffs – not a good day to try to sell expensive software that will require substantial investments and personal commitment by people within the company. Solutions like Moreover's improve the knowledge and therefore the timing and likelihood of success of such opportunities.

Another useful source of knowledge about knowledge is the Defense Advanced Research Project Agency (DARPA). DARPA funds research in cutting-edge,



breakthrough technologies, the next-generation Internet, the Semantic Web, artificial intelligence, expert systems, and learning. By tracking these projects, and leading-edge explorations in such universities as MIT and Stanford, companies can gain valuable

understanding of the transformative technologies of the next 5 to 10 years. MIT's Project Oxygen is a jointly sponsored set of projects hosted by MIT's Artificial Intelligence Lab, MIT's Lab for Computer Sciences, and several sponsors, which consider the transformative technologies and their impacts. The motto of the project is, "Bringing abundant computation and communication, as pervasive and free as air, naturally into people's lives." The Intelligent Room creates a knowledge rich environment for meetings, where actions and discussion are documented by searchable audio files and knowledge bases are readily accessible to meeting participants. The intersection of always-available communications, internetworked computers, and knowledge access will shape our lives in interesting and unforeseen ways. But as described in the first chapter, the proliferation of computation will also create a mountain of data which is possible to search – and therefore which needs consideration, even to decide which elements to discard – and at what interval. This fall's scandal about energy trading company Enron has illustrated that digitally stored data has a life long after paper documentation is shredded. Organizations should consider up front during the implementation what they expect to do with the data and knowledge created.

Stanford's Knowledge Systems Laboratory is conducting research under the DARPA-sponsored program on Rapid Knowledge Formation (RKF) and previously High Performance Knowledge Bases (HPKB) targeting improved collaboration. Effective reuse and construction of large-scale repositories of information, and reusable ontologies, are also key emerging technologies to help with knowledge sharing, modeling and understanding systems, and creative adaptive intelligent systems. The Ontolingua Server is especially intriguinging, leveraging the power of web-browser based access to allow participants in knowledge representation projects around the world to work with ontologies – browsing, creating, modifying and editing from any Internet-connected computer. The technology which created it may be overshadowed by

the significant cultural shifts this type of project can catalyze. The online knowledge base which uses the World Fact Book to gather, sort, and share the geographic, economic, demographic, political, historical and cultural summaries of countries around the world. The goal of the project is to facilitate global, cross-cultural knowledge sharing and knowledge creation. This useful knowledge resource is also designed to stress existing knowledge representation systems. These experiments help researchers learn more about the edges of this transformative domain.

Conferences such as Knowledge Technologies 20XX can help companies keep abreast of the latest IT technologies to consider for the portfolio. Learning about the technologies as they emerge, growing an understanding as they develop and mature, is much easier than playing "catch up." Implementing the latest buzzwords "because everyone else is" often is a costly, frustrating effort. IT should support the company's strategic goals, priorities, personnel skills, and current context – both technology and culture.

Ernst & Young Business Innovation consultant Andy Ruggles (1998, p. 88) recommends a portfolio approach to choosing knowledge support systems, but cautions managers to resist the seductively strong pull of technology-only solutions, since they don't address the most significant barriers. "The ability to move ideas swiftly around a company is worthless if those ideas are old and irrelevant." Easy projects may not be worth doing, if they don't allow the organization to generate new knowledge. As always, *adding value* is key. The measurement criteria for technology projects should be the degree to which those projects enhance the organization's processes that generate knowledge which adds real value. Selectivity and implementation are crucial to success, putting the right emphasis on people over technology. He reminds us: "If we have learned nothing else in four years of observing the knowledge management

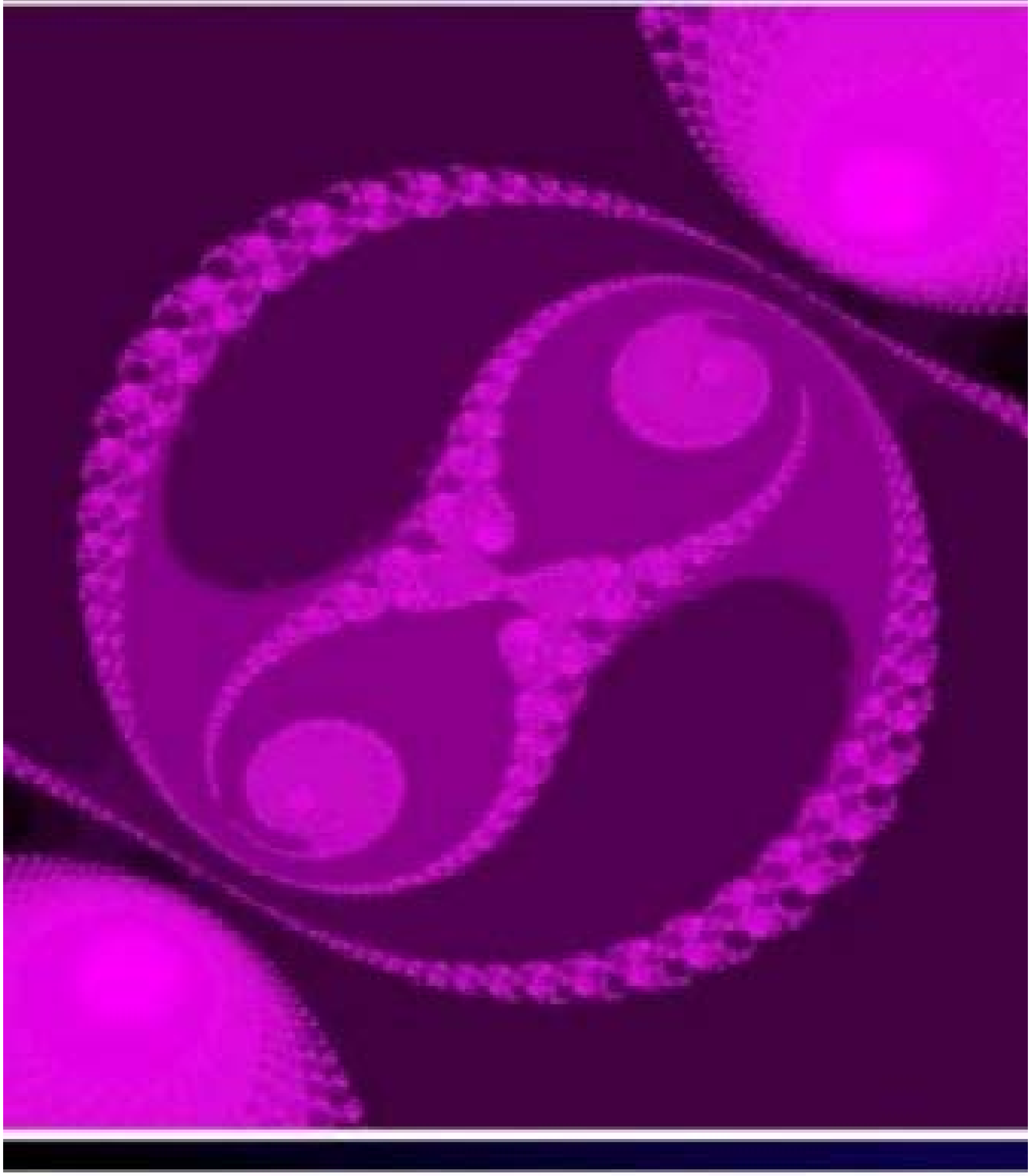
vanguard, we have seen clearly the importance of getting the approximately

50 / 25 / 25 people / process / technology

balance right from the outset." Focusing the biggest proportion of the effort on helping the people in the organization, and equal small shares of effort reengineering and understanding the processes and the technology, is much better than spending the lion's share of effort on technology, with people as an afterthought.

In this chapter, we have explored a number of companies, researchers and organizations who are developing new ways to capture and use explicit information. Clearly the systems being employed are being adapted by their users in ways the designers had not considered. The size and scope of these projects makes them need structuring data about the knowledge they contain – which segues into the next chapter, about metaknowledge.

Chapter 4: Metaknowledge



Chapter 4: Acknowledging the Metaknowledge:
Know what you do know, know what you don't know, learn how to learn

> **"Modeling is one of the most useful ways to consider alternatives. The most important part about modeling is to lay out the "tripwires." These are clearly identified assumptions that, if they change, would cause you to go back and reconsider the answers the model's suggesting. For example, if Alan Greenspan retired, that would be a big tripwire, and we'd have to relook a lot of what we were working on. Tripwires helped us avoid getting crunched by the Asian economic crisis. We had tripwires in place that automatically set off alarms, if the bhat (Thai currency) dropped in foreign exchange value by a certain percentage in a given amount of time. Tripwires give you the freedom to play with different scenarios. That's why cars have brakes – so you can go faster."**
>
> **-- John Reed,
Former CEO of Citicorp
6 Feb 2002**

Metaknowledge is oddly recursive: it is data about the data, the knowledge about the knowledge. One of the problems with explicit knowledge capture systems, such as many knowledge management projects or many web pages or many spreadsheets, is that the assumptions are not included. The output of these models, as in the learning simulations Michael Schrage described in *Serious Play* (2000, p. 41), can blind people to the assumptions built into them. The model ends up proving the assumptions – the mental models behind them. In his writings and lectures, Peter Senge demonstrates the value of Systems Thinking to create microworlds. MIT Sloan Professor John Sterman exposes introductory classes in Systems Dynamics to "management flight simulators," which allow students to try out a variety of actions in quick sequence to run "what if" scenarios. As Schrage points out, this rapid prototyping and simulation can be very useful – as long as people retain their focus on the metaknowledge. "Why" is as important as "how."

In the quotation at the start of the chapter, former Citicorp CEO John Reed describes the freedom to act that can result from awareness of this metaknowledge. By

making the metaknowledge explicit, in described, documented, and monitored "tripwires," the users of these simulations could have confidence in them. Understanding the types of conditions that are assumed allows the users to monitor changes in the fundamental baselines. If US Federal Reserve Chairman Alan Greenspan retired, many economic and financial projections would need to change. Until he retires, financial models can be run as they are.

Being seduced by the appearance of explicit data can lead organizations to make unrealistic, unwise, or unethical choices. The business and investment communities are still being shaken to the core by the ongoing revelations of the facts BEHIND the data presented by Enron. They demonstrated an understanding of the metaknowledge which was manipulated to present a very different front for the company's data. Assumptions do drive the solutions described, and suboptimized assumptions can skew the solutions seen. Becoming aware of the metaknowledge and making it explicit seems more urgent now.

One of the intriguing dilemmas about the increased use of automation in new business processes is that the *computer* can know what no human yet knows. Bioinformatics offers prime examples of this situation. Dr. Seth Taylor founded MolecularWare, a bioinformatics company recognized as an exemplary entrepreneurial opportunity with the 1999 MIT $50K competition award. MolecularWare uses robotic gene splicers for testing thousands of genomic samples, seeking the right combination to lead to a cure, a disease, or an understanding of how organisms work. Tiny microassays are arrayed by the thousands, and only the computer knows which sample holds the key. The knowledge is potential, until a human becomes aware of it – creating risks of knowledge loss, which may go undetected. The bioinformatics software used by companies such as MolecularWare tracks the correlations between assays and samples – metaknowledge. This information – knowledge ABOUT knowledge -- makes the tests

meaningful and useful. Finding the cure for a deadly disease that is the needle in the haystack does the genomic researcher no good without understanding the *context* of the haystack itself.

The Knowledge Network for Biocomplexity offers scientists and researchers software tools, designed specifically to catalog, categorize, sort and sift metaknowledge and metadata. One intriguing bit of metaknowledge that is demonstrated by this emerging discipline is what genomic elements are extraneous or unneeded. In the 4 May 2002 *New York Times* article "Citing RNA, Studies Suggest a Much Deeper Gene Pool," Andrew Pollack reports on two current studies that assessed the amount of RNA genetic material produced by human cells, and determined it was "too much" – suggesting that a "right" amount can be evaluated. The amount of RNA human cells produce is more than can be accounted for with the estimated 30,000 to 40,000 human genes – so why is the extra material there? In order to ask this tantalizing question, and push the frontiers of knowledge, the metaknowledge must be discretely understood.

While Dr. Taylor's bioinformatics systems lead the IT world in capturing crucial metaknowledge, they are not isolates in this field of metaknowledge. Meta-tags are increasingly important elements of HTML pages on the Internet. Most computer users do not select the option of viewing the source page, to see what metadata is provided by the page authors. However, popular Internet search engines such as Google or Yahoo rely upon that metadata to seek and sort out the most applicable files in response to a user query. Page authors know this, and often "salt" pages with hidden metatags – everything from "mother" to "XXX." The metadata, not the actual visible information, drives the search engine to determine of applicability of the page. This data will result in sorting out and elimination of part of the possible candidates – before the user ever sees them.

In Australian geophysicist Peter Watson's 1998 address to the Australian Society of Exploration Geophysicists in Hobart, Tasmania, he describes the uses of metaknowledge to assess confidence in a data set. A model may offer an appealing scenario – until the uncertainty is assessed. Acknowledging the fundamental uncertainties, assessing the metaknowledge, and examining assumptions, can help managers make better decisions.

> **"The important factor here was *metaknowledge*. Based on the available data, the reef model was clearly the best model. By quantifying the degree of uncertainty in that model, however, the explorers approached this prospect with their eyes wide open and took a realistic, calculated risk. . . . The great benefit of knowing what confidence we should apply to our model is that it enables us to compare different opportunities by assigning risked dollar values to them, and then to rank them in order of value. It's not enough to merely have a good model of each prospect, we must also have a realistic appreciation of how good that model is ... how likely it is to represent the actual truth of what lies beneath the surface."**

Understanding the assumptions and quantifying the uncertainty – which is separating what you know about a model from what you do not – frees the user to make calculated, understood risks. He concludes, "In any kind of exploration, it's not just *what* you know that counts, but what you *know* you know!"

While I worked with the Office of the Project Manager for Bradley Fighting Vehicle Systems, we used metaknowledge to develop the electronic component diagnostic systems. The integration of map imagery with live video feeds into an integrated display of the battlefield in the digitized Bradley A3 vehicle system substantially increased the "situational awareness" of the commanders and soldiers, but brought challenges which we had to address in the diagnostic systems. The real problem with such persuasive integrated displays is knowing the answers to two deceptively simple questions:

Diagnosing Complex Integrated Systems:

1. **How do you know *if* the system is working or not?**
2. **What must you do to fix it?**

Knowing **something was wrong – detection -- was the hard part. Complete failure of the electronics, although frustrating, was not misleading. Partial failure of a subsystem, or worse, a subtle voltage surge which affected sensors or data, could mislead the commander and create unwarranted confidence or unjustified skepticism in what was being displayed. Combining software, hardware, and data into an information display looks to the casual observer as if it's "real." We used several techniques to make the metadata explicit, to help the viewers understand what was real and what was suspect. One simple solution to this was to display a date/time stamp on certain displays. If the vehicle lost contact with the input devices – other internetworked friendly vehicles, or satellite-relaying radios – icons on the commander's display maps would change color, from "blue" indicating "friendly forces" to "yellow" for "unknown." The images would still be tracked, but the color change would challenge the viewer to examine their own metaknowledge. Awareness of a change allows for appropriate actions and responses.**

An emerging body of knowledge is being created to address this issue. At the DoD's 6th International Command and Control Research and Technology Symposium, Army researcher Gerald Powell (2001) described his own team's knowledge about "Metaknowledge Supporting Battlespace Planning, Execution Monitoring and Replanning." Effective collaboration, both in the battlespace and in the "real world," demands understanding and assessment of the context, assumptions, and metaknowledge which apply to a situation. As collaboration extends into more areas, distributing processes far and wide, checking assumptions and metaknowledge is becoming more essential.

Powell's paper explores subproblem dependence in technical terms. Following Colonel West's motto, we will not delve into the mathematical representations of subproblem dependence necessary to build robust software structures, fascinating though the study is. However, an understanding of which elements or aspects of a problem are dependent on others represents metaknowledge which can make or break a solution. Even in everyday planning situations, the metaknowledge of path dependency is important to understand.

The PM Bradley development community started the R&D effort to do major modernization and upgrade of existing vehicles with digital components and software by printing a 20-foot long wall chart which showed all the path elements needed to build a set of vehicles – everything from concept to filling the tanks with fuel. This chart mapped the critical path at each moment in time. By making the possible paths explicit, team members could and did stand around the chart and decide together whose effort was currently on the critical path. The critical path elements could delay the on-time handoff of the vehicles to the user community. Being explicit about the steps allowed team members to explicate and share the metaknowledge of changes in priorities and awareness of bottlenecks. Subproblem dependency was not academic – it became personal, as team members identified whose tasks were above and below them in the path. By sharing the metaknowledge, the community could work solutions. And by bringing all members of the team along during the plan's maturation, people understood which path dependencies were "locked," fixed by a need to have a precursor completed, and which could be made concurrent. Concurrent engineering allowed for substantial reduction in the time needed to bring the systems to the field. The testing schedule was a marvel of concurrent events, making maximum use of the flexibilities identified to provide knowledge and user feedback early and often. The key lesson: Being aware of

the metaknowledge, sharing it, personalizing it, and creatively problem-solving as a community helped this leap-ahead system transform the way soldiers use their Bradleys.

As former US Army Chief of Staff General Gordon Sullivan describes in *Hope is Not A Method* (1996), the US Army has transformed itself into a learning organization, in part by becoming aware of metaknowledge. The technique used to evaluate every single training activity in the Army is called the *After Action Review* (AAR). Leadership consultant Mike Shaler (Colonel, US Army retired) has been spreading this technique from the Army to Fortune 100 companies. The AAR offers "a structured way of facilitating learning from complex experiences that are often very ambiguous," (p. 191). This is a key enabler of the US Army's ability to be a learning organization, converting tacit knowledge to explicit knowledge, tapping into metaknowledge, and moving knowledge up the chain from individuals to transform the organization. As the technique is practiced, it becomes second nature, allowing participants to learn, improve, and do better the next time. At training events wherever the Army is, from the local training area to the "Dust Bowl" at the National Training Center in the Mojave Desert, a facilitator called an "observer-controller" (OC) walks the group through the events which just occurred. The AAR steps are simple, yet allow for deep and shared learning:

- ***What happened?* Agreeing on the facts is the first step. Leaders and players are active participants in developing a collective understanding of the events. The major training centers have high-fidelity electronic data collection and ubiquitous sensors to allow after-action playback of the events. This allows the people involved to agree on "ground truth," and then compare what actually happened with the shared understanding of what doctrinally would be recommended for such a situation.**

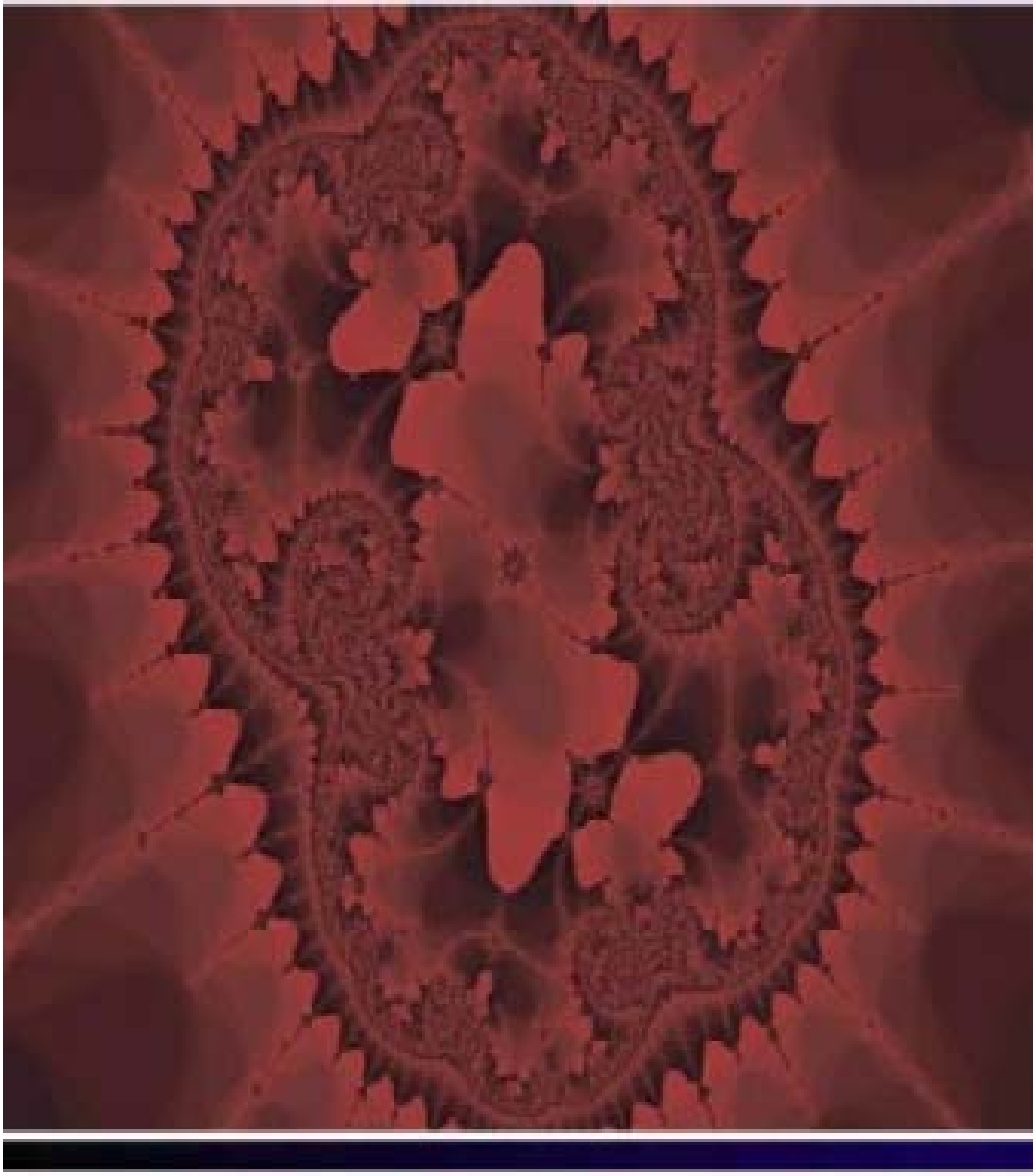
- ***Why did it happen?*** **The OC then leads the group in a discussion from what actually happened, to why it happened. At this stage, the focus is on articulating and making explicit what team members intended, and what their unexpressed (tacit) understanding of what they THOUGHT was required, or what was "supposed to" happen. Understanding the structure of the problem – subpath dependency, which can develop into systems thinking – taps into and explicates metaknowledge. This question opens real opportunities for organizational learning, both to reinforce successful behaviors, and to understand what caused other behaviors to be unsuccessful. The non-threatening, open environment is focused on finding ways to improve. No action goes perfectly, so the AAR process pushes the team to identify opportunities to improve performance.**

- ***What should we do about it?*** **This question moves the discussion from how well it worked, toward lessons learned: what could be done next time to improve.**

General Sullivan concludes, "You probably never become a learning organization in any absolute sense; it can only be something you aspire to, always "becoming," never truly "being." In the Army, the AAR has ingrained an expectation that decisions and consequent actions will be reviewed in ways that benefit participants and the organization, no matter how painful at the time. The only real failure is the failure to learn" (1996, p. 193).

In this chapter, we explored how knowledge gained from the information systems put in place to capture explicit knowledge require metaknowledge to understand how the knowledge is structured and what to do about it. Systems, from software to the processes used by the US Army during AARs, can help structure the processes of understanding what you know. The next chapter will continuing moving along the knowledge continuum, away from the explicit and metaknowledge, and into the tacit.

Chapter 5:
Tacit Knowledge



Chapter 5:
Knowing More than You Can Say: Tacit Knowledge and the Social Life of Knowledge

Tacit knowledge, by its nature, is difficult to describe and sometimes difficult to bring to conscious awareness. Nonaka calls it "secret" knowledge. As leadership consultant Mike Shaler says, "Knowledge is contextual. You pull on one memory and it's connected like Velcro to the next." Tacit knowledge takes time and shared context to access and transmit. People have to move through phases of getting to know each other well enough to turn inward, identify, and articulate that shared knowledge.

Formative experiences create a context for becoming aware of and sharing tacit knowledge. I know of a young Army officer who arrived at his new unit in Fort Riley, Kansas, and was told to gather his gear to go immediately for a 6-week training rotation to the National Training Center in Fort Irwin, California. After he overcame his astonishment, he came to appreciate the opportunity. If he had stayed back in Kansas while the unit went forth and did battle with the virtual enemy, the Opposing Force, he would have been excluded from important bonding experiences in the life of that unit. The joint learnings are often tacit, and are captured in stories, flavoring future endeavors with that coveted aura of authenticity: "I know, because I was there."

John Seely Brown, Chief Scientist of Xerox and cofounder of the Institute for Research on Learning, acknowledges the power of stories. In his 1991 article with Paul Duguid, "Organizational learning and communities-of-practice," they recognize that "… In telling stories, the rep is becoming a member…. Stories also act as repositories of accumulated wisdom." The authors emphasize the social nature of learning, inseparable from working, and tightly linking individuals and the collective group. "The insight accumulated is not a private substance, but socially constructed and distributed." Story-telling is the technique community members use to understand how to solve problems

and to share tacit knowledge – diagnostic processes, identification of anomalies, and group norms.

As systems become more complex, as Shoshana Zuboff describes in "The Emperor's New Workplace" (1995), users will increasingly need to share stories to deal with the "smart" machines. This lesson was demonstrated by many Army vehicle systems which were integrating command and control "battlefield visualization" software, as part of the Task Force XXI experiments. The maintainers who were learning to diagnose these systems on the fly quickly developed repertoires of stories to capture symptoms and possible solutions, embodying explicit, tacit and metaknowledge in compact, memorable stories.

The stories you can tell capture the tacit knowledge in ways no other words can. John van Maanen's ethnographic descriptions of police and fishing communities, and John Seely Brown's recurrent drawing on the stories copier field repairers tell each other, reveal the characteristics of the stories which allow people to share their tacit knowledge. A primary characteristic is a sense of shared context. Language and similar experiences are needed; the lack of these traits can create unbreakable barriers. A very distinguished Army leader who is trying to write his memoirs recently switched from one writing assistant to another. Although the first was an educated and charming person, the lack of a shared vocabulary was an obstacle that could not be overcome. When an Airborne-qualified soldier has to explain that a "chalk" is a group of parachutists, the obstacles to communication are so profound that the real issues of the discussion never get raised. It takes too long, or takes too much effort.

This may be why, as van Maanen has explored, cultures become more unique over time. The stories which bond groups of people together tribally become less accessible to the outside world. The experiences they have, especially first-of-type experiences, can also isolate them from the mainstream. In the context of this

knowledge glut, however, where significant investments of time and effort are required to become expert in the multiple domains which meet at the crossroads (such as bioinformatics), value is gained by finding ways to share the knowledge and extend the community, so knowledge is not lost.

The Center for Military History has a well-understood methodology for developing oral histories, as a way of capturing and sharing at least some of the highlights of this tacit knowledge. But as the Baby Boom ages, and generations of long-time supporters of the US Army, NASA, and "first of type" innovators like Andy Grove at Intel near retirement, knowledge and organizational capability may be lost. The pioneers of the current world of technology are aging as a demographic cohort, and the "successor generation" is not easy to develop. The lessons that are learned during "first of type" implementations are not learned at any other phase, and are difficult to identify and share. As we layer more complex information systems and capabilities on top of existing real and virtual infrastructures, we may not understand what the bases are. The Year2000 computer solutions demonstrated the challenges of unraveling that tacit, undocumented information about how and why millions of lines of software code were implemented as they were. Firms worldwide spent many millions of dollars to replace, path, or loop around legacy software, to avoid date-related problems. But those patches instead of fixes are like ticking time bombs, ready to go off at some undocumented date in the future. Awareness of how problems were fixed in the past helps avoid future issues.

My classmate Kannan Govindarajan, a software programmer and researcher for HP Labs, explained a technique called Extreme Programming (EP). The goal of EP is precisely to address this lack of time, willingness and ability to document by building a shared understanding of tacit and metaknowledge. Two programmers will sit side by side and develop software code. By working in tandem, they understand and challenge

each other, building tacit knowledge and sharing best practices. A longer-lasting benefit of this technique is an understanding of how each other thinks, to understand *approaches* to problem-solving. Companies would have to commit to organizational change to make this type of arrangement work, but it appears to offer benefits at the high end of software development. This could also serve as a way of apprenticing a novice codewriter to a more experienced one, to share the lessons of the master coder. As organizations continue to reward people by promotion out of the functional job, transferring this tacit knowledge becomes more important.

Another subtle challenge worthy of consideration is the decreased number of opportunities to pioneer dramatically. As fewer people become involved in "first of type" implementations, not only do the opportunity costs become high, but opportunities can become scarce. This can be true for intellectual pursuits, in fields such as molecular computing where years of expertise are required to address basic problems. This can also be true in the Army of the future – what is called "The Objective Force." The systems of the Objective Force are expected to extend the current path toward automation, using more robots remotely controlled by fewer people. This limits the exposure of our soldiers to enemy forces, which is good. But if being there is a key precursor to belonging & KNOWING, then what happens when fewer people are there? A recent organizational change called "Division XXI" reduced the number of vehicles in Armor and infantry units by 25%. Fewer Abrams Main Battle Tanks and Bradley Fighting Vehicle Systems mean that fewer young leaders will learn tacit lessons generated from being on the battlefield with these major weapons systems. The theory is that battlefield visualization systems will improve command and control, and that *knowledge* and *speed* will reduce the need for so many weapon systems. In recent operations during the war against terrorism in Afghanistan, clear images show lonely Special Forces soldiers riding on horseback with Afghan allies, using laptop computers to tap into the network and call

for artillery support. The Cavalry rides again, but there is little depth to the bench of people who share this knowledge.

My Navy cryptologist classmate Damian Blossey has a rare understanding of what front-line "other military forces" need to set up early command and control operations in primitive theaters, learned from a very early peacemaking excursion in Bosnia. How can his lessons learned be captured? His community is not inclined toward the academic documentation of their experiences, until they enter Senior Service Colleges many years after the events. The developers of the next generation of command and control computers, communications, reconnaissance and satellite systems for these lonely warriors with actual "boots on the ground" could develop much better systems if they could partake in the tacit knowledge of what it's really like to be one of these soldiers. They do not understand the real-world requirements for these systems – instead of being used in clean, well-lit offices, they are used in dimly lit tents and muddy caves half a world away.

Unfortunately, fewer Americans have the experience of soldiering, or even being related to soldiers, as World War II era veterans die out. The Congressional representatives and their staffers are increasingly isolated from the Army experience, and many have not even traveled outside the US. They do not know what conditions are like in the likely environments of conflict; they may not know what they need to know to make effective choices on priorities and funding. The Future Combat System focus is on unmanned robots. Unmanned aerial vehicles are very popular over enemy territory now, giving commanders on the ground in Florida the sense that they know what actions are like half a world away. But no one is *there*. Remote control vehicles give the viewers a pinhole view of the world; understanding what is *not* included is tough to communicate. Hard lessons may have to be learned to reinforce this lesson.

The US Army has been taking an active role in learning about Tacit Knowledge for Military Leadership (TKML). The Army Research Institute (ARI), the United States Military Academy Department of Behavioral Sciences and Leadership (BS&L), and the Yale University Psychology Department have spent years studying how Army leaders develop "as leaders" while on the job. Sternberg et al (2000) have produced a series of reports published through the Army Research Institute about the TKML tools, which outline the theory of "practical intelligence." This concept says that some people are more able to learn from and apply their tacit knowledge. MIT Sloan School Professor Ralph Katz described a study of a Fortune 5 company's R&D personnel, which showed that experience with innovation early in career enabled or freed leaders to be more innovative later. They learned how to apply tacit knowledge and be innovative. The acquisition of early tacit knowledge helped them be more successful later in their careers.

The focus of the ARI research has been on the tacit knowledge that Army officers acquire from leadership experience. They consider tacit knowledge as work-related knowledge that is action-oriented, practically relevant, and acquired on one's own. This kind of experience-based knowledge has a "behind the scenes" quality that makes it difficult to identify and leverage effectively in organizations. The studies indicate that these "lessons from experience" are critical to successful military leadership.

The TKML inventory tool was developed by interviewing company commanders and capturing those experiences through which they learned as leaders. The focus of the effort was to identify the important lessons of experience that enable officers to be effective leaders, and to use those lessons to help make people better leaders.

This "practical intelligence" allows people to understand and learn from their tacit knowledge. Tacit knowledge is passed on in ideas and stories. The US Army is capitalizing on this, with communities of practice including CompanyCommand.com, a web site targeted at helping young Army leaders be more effective. Under the Ideas and

Stories section, war stories and good advice are passed on. One example is "Don't Squat With Your Spurs On: Advice For Company Commanders," a compendium of advice by a Cavalry Captain, Gregory K. Jacobsen (Grim Troop, 2nd Squadron, 3rd Armored Cavalry Regiment), who is passing on words of wisdom from his own Armor officer father. This combination of "front porch dialogue" and the far-flung soldiers who tap into the tacit knowledge via the Internet clearly changes some of the relationships we have come to know. People can now become intimate friends without ever meeting each other face to face.

Problems such as "Managing Your Boss" are common with the military and civilian worlds. This is one scenario, an example of tacit knowledge inventory questions which are available to visitors to the CompanyCommand.com web site. The process can be replicated for the non-military setting. The ARI Newsletter from 1 March 2001, "Tacit Knowledge for Military Leadership," reports the results of using the TKML toolset. The newsletter reports that the project goal is to use the Web to accelerate leadership development, using both instruction and self-development. The ARI team of researchers interviewed nearly 100 senior Army officers, seeking their stories, advice, and lessons learned about leadership. These were simplified and codified into more detailed problem scenarios, with a number of possible responses – making the tacit knowledge explicit, in a superb example of Nanoka's externalization to create conceptual knowledge. The younger officers who are the targets can use the TKML questions as a leadership simulator, running through many scenarios and learning as they go. The CompanyCommand Web site (at URL www.companycommand.com/tacit2/index.html) teaches visitors by providing the preferred solution answers and the rationale, fulfilling the "lead / teach / coach / mentor" leadership function asynchronously, using the Internet.

Figure 8: The Web site CompanyCommander.com makes tacit knowledge explicit, and builds a community of practice over the Internet.

Results of the study were interesting and transferable. The authors report that "We found that tacit knowledge for military leaders (TKML) scores generally were a better predictor of leadership effectiveness than verbal ability, rank, or experience." Effectiveness is the measure, and the means to be effective is understanding this tacit knowledge.

CompanyCommander.com is one example of a Community of Practice, described by John Seely Brown and Paul Duguid (1991). It possesses classic characteristics, starting with its origins as a not-officially-sanctioned "good idea between us." Two company commanders who lived next to each other and shared problems, victories, and lessons learned on the front porch decided to share their hard-won knowledge with

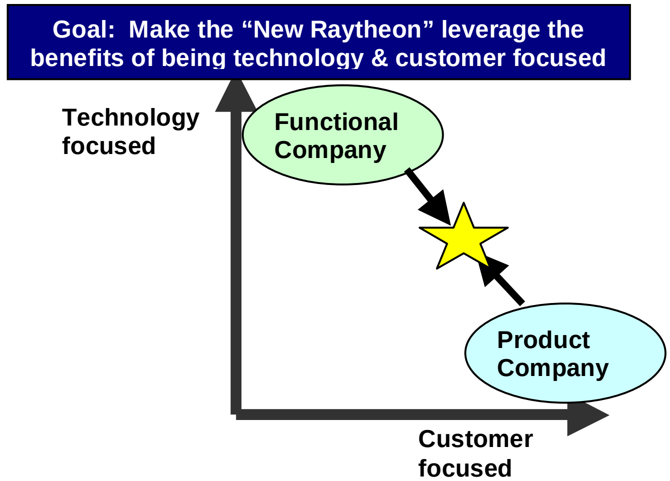
others. In 1990s fashion, they put up a web site and created a virtual community. They marketed it grass roots style with friends and acquaintances. Nobody mandated participation, and that was good. They had a target community who shared common experiences – thousands of young officers around the world are company commanders. Good information was valued and recommended; bad information was ignored or critiqued.

Other organizations are following similar paths in establishing electronic homes for communities of practice. The Defense Acquisition University is cosponsoring an on-line Project Management Community of Practice (PMCoP), which allows defense acquisition professionals to share knowledge, processes, and best practices. The system engineers have a subgroup area, as do the logistical support developers, the financial analysts, the contracts specialists, and other specialties. These professionals may work on different systems at different points in the life cycle from conception to full fielding to disposition, but they perform similar tasks in their day to day work. By sharing knowledge with each other, they can increase the capabilities of the community as a whole. The organization's challenge is to encourage people to use the system. It cannot be mandated, or people will rebel – but it can be encouraged and its use rewarded.

One Company's Experience: Raytheon R&D Vignette

Organizations can get so busy focusing on doing their day-to-day mission that they do not share their "best practices" and lessons learned with others. As said in the Army, the organizations are "too busy shooting, moving, and communicating" – focusing on the short-term, daily mission requirements, not abstracting the knowledge.

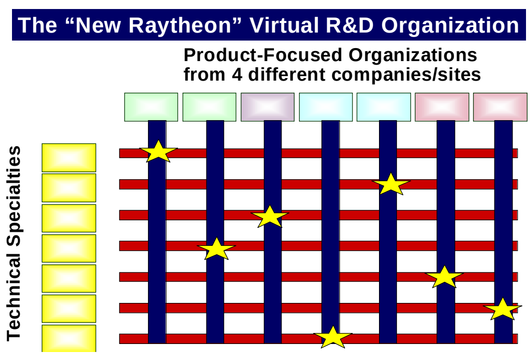
Dr. Phil Cheney, VP of Engineering & since 1998 Chief Engineer of defense company Raytheon, typifies this experience. Raytheon is one of the top 3 defense companies in the United States, and serves US and allied customers with a variety of high-tech defense products and services. Product lines include missiles, radar, electro-optics and infra-red (thermal) systems, command, control and communications, and software and support. A long-time lead innovator, Raytheon developed microwave ovens, developed the guidance systems to help Apollo 11 get to the moon and back, and provided current-generation missiles, electronics, radars, and the software to make them all work together.



At a presentation on May 2, 2002 to the MIT Sloan Management of Technology (MOT) program, he described how Secretary of Defense William Perry hosted a meeting with the CEOs of the major defense companies in the early 1990s, looked around at the 30-odd leaders, and said, "there are too many of you." This meeting came to be called "The Last Supper," and was the signal to start defense industry consolidation. Raytheon consolidated 4 different defense companies into one – the original Raytheon bought Hughes Air Craft (HAC), Texas Instruments (TI), and E-Systems into the new, larger Raytheon. As a result, Raytheon had to integrate the 30,000 engineers of the four companies into a new, combined R&D organization. In addition to being culturally disparate organizations, the elements were geographically dispersed – far flung, from New England, home of the "original" Raytheon, the Texans of E-Systems and TI, and the HAC engineers in California, Texas, and Arizona. As Dr. Cheney said, "Engineers don't like to move" – and in the backdrop of the dot-com explosion, forcing engineers to move would likely lead to loss of talent and knowledge. Raytheon faced a challenge in consolidating the existing organizations into a new, cohesive, cooperative, and functional entity.

Dr. Cheney observed that product-focused organizations tend to be very close to a specific customer, able to understand that customer's needs. Functionally-focused organizations tend to have a tremendous grasp on technology overall. However, the product-focused organizations can lack the tight ties to the technology, especially over-the-horizon future or disruptive technology. Similarly, the functional organizations can lack an understanding of the current needs of the customer. Raytheon needed to push the R&D organizations closer to the middle, to balance the strengths of customer awareness with the awareness of transforming technologies.

In order to push the organizational elements to leverage the best from the strongly product-focused, customer centered product lines, and from the deeply technical functional lines, while respecting the cultures of the different source companies, the new Raytheon took an innovative approach. Dr. Cheney sketched the new "virtual organization" out for us, as shown in the graphic.

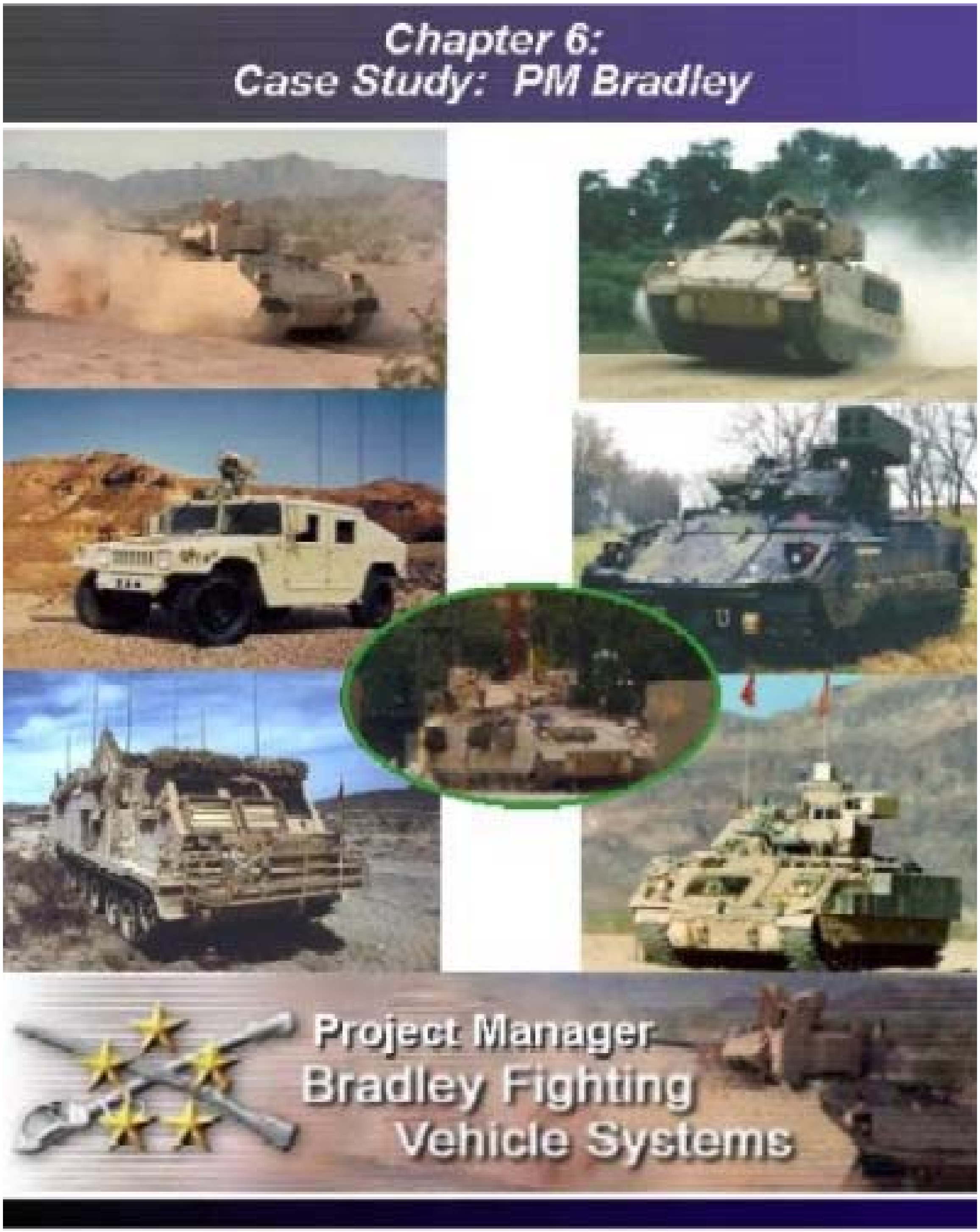


The programs at the top were the source of funding and products, centered on the requirements specified by customers among the various defense forces. They came from different companies of origin and were geographically dispersed. The technical functional areas along the side were called "The Seven Deadly Sins," and involved the key technical functionalities of Raytheon's R&D people: radar; electro-optics/infra-red; command, control and communications; systems; software; and so on. The points of crossing, where the lines cross, were where functional leads at each geographic site led the virtual organization's knowledge sharing. The functional leads

were not paid additional money to act as supervisors, as in a traditional matrix organization. Instead, they had engineering-focused incentives, such as opportunities to work on the company's most compelling projects, both from major customers and from the internal Independent R&D projects. Each functional area had a super-functional lead, one per site, as shown by the stars on the graphic.

Dr. Cheney affirmed that this was not a traditional matrix organization. Instead, the objective of the organization was to "work the human side." To increase technical knowledge interchanges, Raytheon would host technical symposia, and invite 500 R&D people to come. Dr. Cheney observed, "The researchers would present papers, and the engineers would all get together and try to solve interesting problems." The goal was not just to exchange information in the formal setting, but also to create people links between organizations. "It's much easier to pick up a phone or send an e-mail if you already know someone," he observed.

Raytheon experienced consolidating their several separate R&D activities within a year and a half into a functioning team – capable of winning the $1.4 billion US Navy DD(X) next-generation ship integration contract. They learned to sponsor opportunities for people with shared concerns to develop communities of practice. They used technologies, including the Internet and Netmeeting, to create collaborative spaces – "the virtual cocktail napkin" that engineers enjoy sketching ideas on. They allowed for explicit knowledge sharing, in order to tap into the tacit expertise through social networking between people who had met at a technical gathering. As in the chapter, they offer powerful lessons of how one organization accomplished this transformation into a knowledge-creating community. The next chapter will consider how the Office of the Project Manager for Bradley Fighting Vehicle Systems, under the stewardship of then-Colonel, now-Major General Joseph Yakovac and his deputy Brent Sherman, similarly transformed from an Industrial Age organization into one of the Information Age.


Chapter 6:
Case Study: PM Bradley
Project Manager
Bradley Fighting
Vehicle Systems

Case Study: Lessons Learned on Knowledge for High-Performance Teams from the Office of the Project Manager for Bradley Fighting Vehicle Systems

As a Colonel in the US Army, Joseph L. Yakovac was selected to be the Project Manager for Bradley Fighting Vehicle Systems (PM Bradley) from 1994 to 1997. This was his third time in PM Bradley. He had worked side-by-side with many of the same people, before returning to field Army units, then back to Bradley. He brought a credibility as an actual user of the systems, which he shared in stories: "When I commanded the 2/12th Infantry Battalion at Fort Carson, Colorado, and we were swimming the Bradley (testing the vehicle's floatation system), we put everyone into life preservers and hooked the M88 recovery vehicle cable to the Bradley before it went in the water to make recovery easy – just in case." His "real-world" knowledge of what it was like for units to use Bradleys gave PM Bradley team members an actual "user" to identify with. His stories made it real, making efforts to improve Bradleys more worthwhile.

Figure 9: Accomplishments of the Office of the Project Manager, Bradley Fighting Vehicle Systems

Now a Major General (MG) and Program Executive Officer for Ground Combat Systems (PEO GCS), the executive-level supervisor of the PM Bradley and other Army acquisition offices, then-Colonel Yakovac led the transformation of this organization from "Industrial Age" to "Information Age." With the help of his civilian deputy, Brent Sherman (who supported PM Bradley from its very beginnings in 1978), he guided an organization whose primary focus had been on making more vehicles faster and cheaper, to become an organization which integrated new capabilities into existing vehicles by adding next-generation electronics, optics, and software.

The core on-site PM Bradley organization included around 150 people, and they worked with more than 30 contractor companies and many governmental agencies and offices. The Bradley Systems controlled enough funding in the Defense budget to merit Army-level oversight as Acquisition Category I ("ACAT I") high-visibility programs, as well as smaller sub-programs which were ACAT II, III, and IV. "One size fits all" did not apply to the types of management needed to meet the requirements of all these systems.

Figure 10: PM Bradley Army Acquisition Organization: Matrix Support from five functional areas to Integrated Product Teams (IPTs)

Supported Army communities included the Infantry, Cavalry, Air Defense, Field Artillery, Maintenance, Supply, Medical, and Command & Control. Bradleys provided multi-functional vehicles configured to meet the needs of all these communities.

As shown in the graphic, PM Bradley was configured as a matrix systems development and acquisition organization, with Colonel Yakovac and Brent Sherman in the front office, leading the organization overall. The military PM functioned as the CEO. The civilian deputy's role was similar to that of COO, providing technical expertise, staff supervision, and institutional knowledge. As a result of their many years of working together, the two had a strong partnership and friendship. Disagreement was not disrespect, but they were just as likely to laugh about their children as they were to work out very difficult priority choices.

They agreed on the need to innovate the organization to meet the challenges of the new programs being funded. One innovation was restructuring the purely functional matrix organization, focused on vehicle subsystems such as powertrain and thermal sight subsystem, into a product-focused organization. In the graphic, these are represented by the horizontal disks, shown with the team name and icons of the products managed. The Bradley A3 was the major, multi-billion dollar ACAT I upgrade of existing vehicles with next-generation thermal sights, advanced electronics, and first-of-type command and control software for battlefield visualization. The Operation Desert Storm (ODS) variants included combat-feedback improvements. The Bradley Variants IPT took the classic Infantry and Cavalry systems developed under the Bradley A3/ODS concept, and added community-specific Mission Equipment Packages, featuring special electronics, systems, and software to meet the needs of the Air Defense and Field Artillery communities. This team faced the special challenge of rehosting electronics originally designed for the tracked vehicle Bradleys onto a wheeled vehicle. The Bradley Derivatives team focused on the extended-length carrier system, being considered for

reuse as a Advanced Command and Control Vehicle or as an Armored Medical Treatment Vehicle, with a mobile surgical suite.

As Dr. Cheney, Chief Engineer of Raytheon, described during his 2 May 2002 presentation to the Sloan Management of Technology class, as was described in the chapter 5 vignette, functional organizations orient strongly toward technologies, while product-focused orientations are closer to their customers. In the case of PM Bradley, each of the three Army-selected military Product Managers led an Integrated Product Team (IPT) which included acquisition specialists representing all the functional fields. Each team had program management representatives, to perform finance, accounting, and reporting to higher headquarters. Engineering team members worked with the civilian defense contractor companies, including Raytheon, to design, develop, and prototype new components and subsystems. Product assurance and test personnel were responsible for coordinating rigorous field tests and ensuring the systems participated in Army-level field experiments. Logistics teammates developed the supportability plans, including fielding and training, and oversaw the transition to manufacturing, along with manufacturing engineers. The acquisition staff prepared, staffed, and monitored contracts.

PM Bradley's long experience as a functional organization meant that the ties between the functional representatives were still strong when the PM reorganized into the product-focused IPTs. These teams demonstrated the strengths Richard McDermott describes in his "Learning Across Teams" article (1999):

> **"Teams reduce hand-offs. Because they are located together and share common goals, team members easily share the information and thinking that fell in the "white space" between the old functional silos. By focusing on a single output… teams develop a real sense of common purpose and focus. By working together in close proximity over an extended period, they develop a rhythm, rapport, common identity, and trust vastly improves their ability to build on each other's ideas and solve business and technical problems."**

Colonel Yakovac and Brent Sherman also recognized the potential shortcomings of teams McDermott highlights -- that they can become silos, isolated and myopic, too busy to share information, and causing the team next door to "reinvent the wheel." They can also become too focused on the immediate challenges to build long-term capacity, which Rebecca Henderson calls "absorptive capacity," as described in her MIT Sloan School Technology Strategy course. In the case of PM Bradley, the years of focus on manufacturing 600 more new Bradley A2s each year, with only incremental improvements, created a sustainment-focused organization. Profound change was needed to transform the organization.

A series of processes were implemented and emphasized to increase the creation and sharing of knowledge in PM Bradley. Although many of these were anchored on the classic Army acquisition requirements of meeting "cost, schedule, and performance" requirements, they had long-term benefits of making the organization and its people able to innovate radically and successfully. They also took place in a US Army context, which embedded the After Action Review processes in its everyday life. Every action was assessed, with the "how did we do?" questions a normal part of activities. The quest for improvement motivated the people to create and share knowledge to benefit their ultimate customers – the soldiers of the US Army who used the Bradley vehicle systems. Some processes that contributed to their mission accomplishment are listed below.

- MILESTONE CONTROL SYSTEM (MICOS): Dorothy Leonard-Barton's research in creative thinking (1997) indicates that new ideas are usually generated at the crossroads – the intersection of disciplines, points of view, or ways of thinking. As PM Bradley started up the Bradley A3 program, the Milestone Control System (MICOS) was revitalized, to create the opportunity for team members to meet at the crossroads. MICOS meetings were held every two months, to gather all members of the community, compare notes, and

understand relationships between key events. These meetings were held over three days at a local college, and involved 150 people: support contractors from California, Texas, Alabama, Maryland, New Hampshire, and overseas; Army-level staff members from the Pentagon; and representatives from the training schools and user communities would gather. All the stakeholders were present. Issues were each documented on a chart, reviewed by subsystem, and briefed by the subject matter expert on the issue. The charts had to be simple enough for everyone to understand. Although briefing issues by charts has become normal in the world of Powerpoint software, at the time, it was a radical departure from formal memoranda requiring days of staffing before leaving even a branch-level office. Streamlining the documents required for system acquisition was a key focus. Reports and issues which affected decisions, capabilities, supportability, or functionality were valued; otherwise, they were scrutinized for combination with other elements.

- **EVERYONE DOES RISK MANAGEMENT: Since the Bradley A3 was a "first-of-type" program seeking to compress its development by three years compared to the "old" way of acquiring systems, concurrent engineering was required for many subsystems. The entire program was managed by phases, with gates to pass each phase. The exit criteria for Army-level gates were defined at Army Systems Acquisition Review Councils, co-chaired by two generals. PM Bradley traced these exit criteria to requirements, which in turn traced down to subsystems. At MICOS and other reviews, each subsystem issue had a risk factor, shown on the chart with a simple thermometer graphic ("hotter" on the thermometer meant higher risk), and a "get well" plan with timeline. If timing was especially critical, milestones to improvement were detailed as "inch stones." By showing issues and timelines to everyone, people whose**

efforts were dependent on this action being completed could coordinate with the issue owner, in "sidebar" meetings, addressing subproblem dependence described in chapter 4. Often, these face-to-face meetings not only raised issues, but also allowed them to be resolved. By meeting their counterparts at the different organizations, relationships were strengthened, allowing for better collaboration and inventive problem-solving. Action items were tracked religiously, to ensure nothing slipped through the cracks. A final, major benefit of the MICOS meetings was that guidance and expectations were openly aired. Army-level staff members knew what priorities and decisions needed to be addressed at their level, and could explain and justify the programs. Team members understood the major external events driving the schedules. The user community members developed a rich understanding of how the acquisition community was meeting their requirements. Since the Army was shifting from the old sequential "waterfall" requirements, where all improvements were blocked together and applied once, to a "spiral development" requirements process, which constantly updated requirements to reflect changing technologies and capabilities, building a shared understanding and knowledge of the requirements solutions was critical.

- **KNOWLEDGE SHARING FOR PROBLEM SOLVING: Although the MICOS meetings were major community coordination events, PM Bradley used a variety of other processes to increase the teams' knowledge of issues and actions. Each week, each functional division chief was responsible for collecting and reporting 1-paragraph summaries of each of the significant events in the functional division. These "Weekly Significant Activities Reports" were disseminated to the entire PM by Intranet. Each short item submitted was reviewed and discussed at the Monday afternoon staff**

meetings, with the PM and the Deputy, the 3 Product Managers, the functional division chiefs, and anyone else whose expertise was needed to address the problems of the week. These PM meetings were helpful in ensuring that the different IPTs were sharing knowledge and solutions, and ensuring follow-up. The two-way check, with the IPT leaders and the functional division chiefs, helped spot and correct any divergences. The team focus of this endeavor meant that many eyes were looking for similar problems, or a problem to match a known solution. Remedies were informal – if people on one IPT saw an action which was a common problem, or for which they knew of a solution, they would walk over to the open cubicle of the person reporting the issue, and have an ad hoc meeting. Extra chairs were scattered around, and a few empty desks provided space to meet, discuss, and spread out the charts or technical manual references for shared discussion.

- **CUSTOMER-FACING: LESSONS LEARNED FROM THE FIELD: PM Bradley was also interested in communicating lessons learned with soldiers in the field, and getting their feedback and identification of problems. The soldiers in the field who were working with the Bradleys on a daily basis were the equivalent of the lead innovators described by Eric von Hippel (1986). To share information with the soldiers, PM Bradley published a quarterly newsletter called "Bradley Bits." As the Internet became widely accessible throughout the Army, this newsletter was accessible both in the traditional paper format, and on-line from the PM Bradley web site. Logistics Division Chief Bill Powell was an early advocate of using the Internet to communicate with soldiers in the field, and had his own e-mail address listed as the "go-to" person. He relished feedback from the field, and would frequently visit Bradley soldiers around the Army, building social networks of knowledge.**

- **TECH REPS, LIKE CONSULTING ENGINEERS: Bill Powell and his engineering and quality counterparts would often confer with the Weapons System Tech Reps (WSTRs), the original equipment manufacturers' (OEM) field service representatives stationed with the Bradley units. These technicians functioned like those described by John Seely Brown and Paul Duguid in their 1991 article "Organizational learning and communities-of-practice," learning collaboratively by doing. "Not only is the learning in this case inseparable from working, but also individual learning is inseparable from collective learning. The insight accumulated is not a private substance, but socially constructed and distributed. Thus, faced with a difficult problem reps like to work together and to discuss problems in groups…. to trade stories, develop insights, and construct new options." WSTR meetings were held at least quarterly, and the WSTRs accompanied PM Bradley team members on all field visits to "their" units. The Bradley WSTRs were fonts of knowledge for the soldiers in the field, and for the PM Bradley team members, providing two-way lessons learned. When an improvement was being recommended, such as a fuel cap which allowed refueling in the rain without allowing water to enter the fuel tanks, the WSTRs would be the extreme lead users, to evaluate and try early prototypes of the suggested improvement. They would provide feedback and recommendations to the engineers, who would iterate prototypes, much as Michael Schrage describes in *Serious Play* (2000). Testing the improvements also gave the WSTRs opportunities to solve real problems for soldiers in Bradley units, demonstrating value and earning their trust. They did the "lead / teach / coach / mentor" function, serving as super-users and well-trained diagnosticians who could solve the most difficult problems. Because they were the "good guys," soldiers trusted them bring back the**

urgent problems and unperceived benefits of solutions, lessons learned from the field.

- **SHARE PRIORITIES AND NEWS AT "ALL HANDS" BRIEFINGS: Lessons learned and achievements were shared in quarterly "all hands" briefings on priorities, accomplishments, and the path forward. Awards were given, to acknowledge the hard work of team members. Updates provided allowed team members to synchronize efforts and understand why and how priority changes at Army-level affected PM Bradley program efforts. Although priority changes could be frustrating, as the efforts of months were deemed no longer important, team members much preferred to *know* what was important, rather than finding out that they had been wasting precious time. And having "rapid prototyping" efforts acknowledged as valuable ways to learn lessons and build community knowledge, rather than derided as a waste of time, was important to motivate team members to keep going. The face-to-face gathering kept the team members of this busy, often-traveling organization feeling connected to each other socially, reinforcing the sense of community.**
- **TRAINING: Another important motivational and capabilities buildup assistance was also provided by the increased emphasis on training. Colonel Yakovac understood the challenge of converting people who understood mechanical systems – "bending metal" – into people who could manage software development efforts. This is a substantial change in skill set and knowledge base. The mechanical systems development could be seen and understood by watching – as a welder assembled large panels of aluminum, the shape of a Bradley hull emerges. The suspension system is clearly visible; roadwheels and track pads are tangible. Software is none of those things. Software may not *work* until much later in the development cycle. Or,**

alternatively, today's working software could just be a quick-and-dirty piece of prototype code, good enough to meet the requirements of a meeting, but not robust or stable enough to scale up to a whole system. To meet the challenge, one of the brightest young engineers was sent to a fully-funded master's program in computer engineering, at the very outset of the Bradley A3 program. Although it seemed like a high risk endeavor to take a key player out of the day-to-day planning for the better part of the year, this initiative proved to be invaluable. The engineer was so motivated to get back to work that he completed the entire program in nine months. He used the Bradley A3 software architecture as the core problem for his master's thesis. As a result of his schooling, he was absolutely current with up-to-the-minute knowledge and best practices in the field. He made invaluable contacts at school, with classmates who subsequently joined the team, and with professors who could tap into academic networks. His high-quality academic credentials gave him real credibility when talking with the software contractors in Silicon Valley. As a result, he was motivated to continue working for the US Army for the duration of the project. If he had not been able to get this valuable training, he expressed a desire to go work with one of the major automakers in town, implementing satellite radio communications in cars. The Army needed his skills and knowledge, and training him made him more capable and kept him willing to participate. Other team members were also encouraged and funded to take advanced training courses, in software management, project management, and a wide variety of acquisition professional training. To make the training convenient, PM Bradley hosted on-site training in Acquisition Streamlining, Cost As an Independent Variable, and Design To Unit Cost. The command even offered a series of graduate-level software engineering

seminars using the Ada programming language, which is robust, disciplined, and compiles to Java – a jumpstart to the knowledge base of the community.

- **TECHNOLOGY ENABLERS: PM Bradley spent money, time, and effort implementing technology on the desktop to make team members more connected and more efficient. The computers on people's desks were kept up-to-date with capable hardware and current software. If team members traveled a lot, their computers were laptops, with docking stations and easy-to-read screens. Cell phones and personal data organizers were provided to key members, along with PM Bradley-funded telephone calling cards. When traveling, communication by phone and email was encouraged, and leaders responded quickly to questions.**
- **LARGER TECHNOLOGY INVESTMENTS: Larger technology implementations were also funded, demonstrating concretely the value put on concurrent technology knowledge growth across communities. The engineers and logisticians shared system drawings via an on-line review system, to develop the design and its post-fielding supportability plans. Colonel Yakovac funded the Tank-automotive R&D Experimentation Center (TARDEC), across the compound from PM Bradley, to digitize the technical drawings and create a computer aided drawing (CAD) software Bradley, so the polygons generated could be reused in systems development, testing improvements, and developing digital training devices. This also kept the TARDEC engineers' knowledge and interest in Bradley fresh, keeping the "intellectual base warm."**
- **DATABASE CATALOG OF HISTORICAL RECORDS: KNOW WHAT YOU KNOW: The Bradley A3 Product Manager, then-Lieutenant Colonel Ted Johnson, implemented a useful Access database, listing all the historical documents in the office. PM Bradley had been accumulating test reports,**

videotapes, photographs, memoranda, and procurement documentation of all kinds for more than 15 years. The person who was listed as the point of contact was also shown on the database, allowing for face-to-face follow-up conversations about "how to" and "why," following a person-to-person knowledge base strategy similar to that described by Ezra Greenberg at McKinsey consulting firm and in Buschmann (2001). Many early documents were relevant to the Bradley A3, since it was starting a new acquisition lifecycle. Milestone documentation created in 1985 was needed and used, *when* people could find it with the organized archives and the database. This project was especially successful, since it was conducted in tandem with the "Throw out the trash day." For the first time in memory, people were given *time, permission*, and trash bins to dispose of unneeded old historical records. To facilitate this effort, and encourage people to keep the important records they needed, key documents were recorded on CD-ROMs, which were both distributed and accessible through shared computer directories on the server. The documents each team member – treated as the subject matter expert – felt were important were retained, logged in and databased, and centralized when needed. Personal duplicate copies were allowed to be trashed, especially those held long after the Army's recommended "dispose of" date. Even the filing cabinets with classified files were reviewed. These documents were much easier to stash and retain, even long after the units described had been downsized and inactivated. By having permission and resources, people could clear their desks of the redundant or unimportant materials, and refresh their knowledge of what they knew, and what was important.

- **WORLDWIDE VEHICLE DISTRIBUTION MODEL: Another major software project was a worldwide Bradley distribution model, which could simulate first-**

time fieldings and displacement/ cascade fieldings over a 25-year time horizon. The complexities of the problem were enormous, since fielding 400 new systems a year could result in 1600 vehicles being handed down to lower-priority units. This technique allowed all the US Army units to get a slightly better vehicle, and pushed the oldest systems out the bottom of the chain – where, in an innovative twist, they were inducted into the remanufacture program to emerge 18 months later as the latest-configuration Bradley A3s. The software to automate this planning process allowed fielding planners to test various scenarios of different unit priorities and modernization funding by year – what we called "what if" scenarios. Before the software system, these fielding drills required several days with pencils and pages of yellow legal paper taped together. The distribution model allowed for simulations – which ironically encouraged higher headquarters to ask for more complex scenarios. Because the capability was created to be able to answer difficult, non-linear questions, Army-level leaders learned to ask more of these long-range scenario questions – resulting in more complete understanding of options.

- **AUTOMATING ELECTRONIC DIAGNOSTICS AND TROUBLESHOOTING: The most interesting projects with which I was involved developed the diagnostic systems to determine if these new, highly complex Bradley A3s were broken or not; and if so, how to fix them. As Navy Commander Elizabeth Olbrys describes in her 1994 paper on "Information Culture in DoD: Preparing For The Third Wave," the electronic diagnostic systems sort out the signals from software, hardware, and voltage, and figure out what is wrong. The long-range plan is to have these systems use the on-board radios to self-report back to a maintainer in the rear of the battle area what is wrong, and what is needed to fix it. Ultimately, the goal is prognostics – detect errors before they happen.**

But the immediate benefit of the diagnostics we developed is to make tacit knowledge explicit. The diagnostic systems use the WSTR knowledge and the automated troubleshooting procedures to enhance the knowledge of the novice maintainer. The systems we developed will provide the baseline functionality to link together the logistic system, from the vehicle needing a part in the forward area to the warehouse with the part across a wide ocean. Information, timely and accurate, will reduce maintenance downtime, and thus reduce the amount of repair parts needed to source the current lengthy supply pipeline. By iterating this process, improvements can continue.

LESSONS LEARNED:

These are just some of the major actions PM Bradley took, under the stewardship of Colonel Yakovac and Brent Sherman, to transform the organization. The need for knowledge was clear: the mission changed from the old comfortable requirement to stamp out similar Bradleys like cookies, to the very new challenge of managing software. Expertise was borrowed from other commands, to help manage and to share knowledge on *how* to manage software efforts. Training was emphasized, even in the face of tremendous schedule pressure. The Bradley A3 effort started in 1994, and the first systems were due to be fielded only six years later, in 2000. Small sets of vehicles had to be upgraded, working, and fielded to units participating in the Army's Task Force XXI experiments at the National Training Center in 1996 and 1997 – early prototyping, Army-wide, of the new digitized command and control capabilities, to learn how situational awareness will change the way soldiers fight their systems.

To compress schedules and reduce costs, acquisition reform was encouraged. Requirements were streamlined, to reduce unneeded documentation while still meeting the performance specified – so at the same time the PM Bradley team was radically

innovating the *__products__* they developed, they were also fundamentally innovating the *__process__*. New procedures such as "Alpha Contracting," where the government and the contractor sit down and jointly define the requirements and write the contract together, reduce uncertainty and ensure that all parties understand what is needed. This process seeks to "reduce the kabuki dance," of contract gamesmanship of delivering the letter, not the intent of the contract. This first-of-type major system upgrade was this was so new that joint development of deliverables was needed. The team had to create shared knowledge and *__trust__* on both sides. Colonel Yakovac said, "I'd like to write a contract with the Nike swoosh: 'Just do it!' "

To build knowledge of the system while strengthening relationships between the government civilians and their counterparts at the prime contractor, Bradley familiarization training was given to everyone. All new PM Bradley team members, even the grandmother in tennis shoes, flew from Michigan out to the plant in San Jose, California, to tour the factory, get trained by WSTRs, and – most exciting -- *__drive a Bradley__*, to make it real.

The strength of PM Bradley was in the experienced people who worked and shared their knowledge -- people like Brent Sherman, Karyn Peterman, Bill Powell, Dr. Chong Liao, Tom Cronogue, Shirley Jacobs, Tom Hildebrand, John Beauduy, Barry Crawford, Gary Chamberlain, Cinda Hayden, and Lynn Livingston, had hundreds of years of experience total supporting the Bradley. They worked with younger people, closing the generation gap with young officers, as well as new people chosen for projects. Colonel Yakovac and Brent Sherman spent significant amounts of effort to pick the right people. As Colonel Yakovac said, "We could do these modernizations with 30 percent of the people who were assigned – you just have to pick the *__right__* 30 percent. You learn who's good, and you ride them like fast horses, and you'll be amazed at what they can do."

Because they knew all aspects of their systems, the teams were able to share and reuse knowledge, following Colonel Yakovac's dictum: "*Treat variants as low-density versions of the high density system*," by creating once, reusing often. This approach applied to logistical data, technical manuals, program formats, and engineering concepts. After years of becoming hidebound and ensnared in bureaucratic restrictions about how to specify requirements, the Army acquisition community was striving for acquisition streamlining. Good ideas about how to reduce red tape and provide the same needed knowledge, in the format in which it was created, were encouraged. Sharing was a strong goal of the culture, celebrated and rewarded.

Amid all the hard work in achieving things no team had ever done before, Colonel Yakovac also emphasized balancing work and life and having fun. In addition to the award ceremonies, people's life passages were acknowledged at hail and farewell parties. Halloween is Colonel Yakovac's favorite holiday, so the PM Bradley quarterly meeting on Halloween featured costumes and a volunteer briefcase drill team featuring the contract specialists. At the Joint Rollout Ceremonies for the very first Bradley A3 and the M7 Bradley Fire Support Vehicle, Colonel Yakovac allowed dozens of PM Bradley team members to fly out to the factory in California to celebrate this tremendous accomplishment. He looked out at the assembled mass of people who had worked so hard, and created an entirely new capability for the Bradley, and told the crowd, "You did well – give yourselves a hand!" This culmination of many months of hard work motivated people to do even more, and reinforced the community of Bradley.

Just like the great teams Bennis & Biederman describe in *Organizing Genius*, (1987, p. 131), the people of PM Bradley followed a philosophy similar to that described by Lockheed Martin's Skunk Works leader, Ben Rich: "We aimed to achieve a Chevrolet's functional reliability rather than a Mercedes' supposed perfection…. Eighty percent efficiency would get the job done, so why strain resources and bust deadlines to

achieve that extra 20 percent?" Since Bradley funding came from taxpayers, including the team members, there was a strongly-held need to balance the capability needed by the soldiers of the next decade with stewardship of scarce funds. Clever solutions were important to balance funding constraints with solving problems nobody had solved before. Bradley A3 Product Manager Colonel Ted Johnson emphasized to me the value of fearlessness in problem-solving that guided the team. He said, "when it was needed, we weren't afraid to stop the program and restart it, to be sure that we had the right system architecture and were on the right path…. Even though it set the program back in the short term, it was the absolutely right decision." Team members felt empowered and confident to do difficult things that might be unpopular, but were the right thing to do.

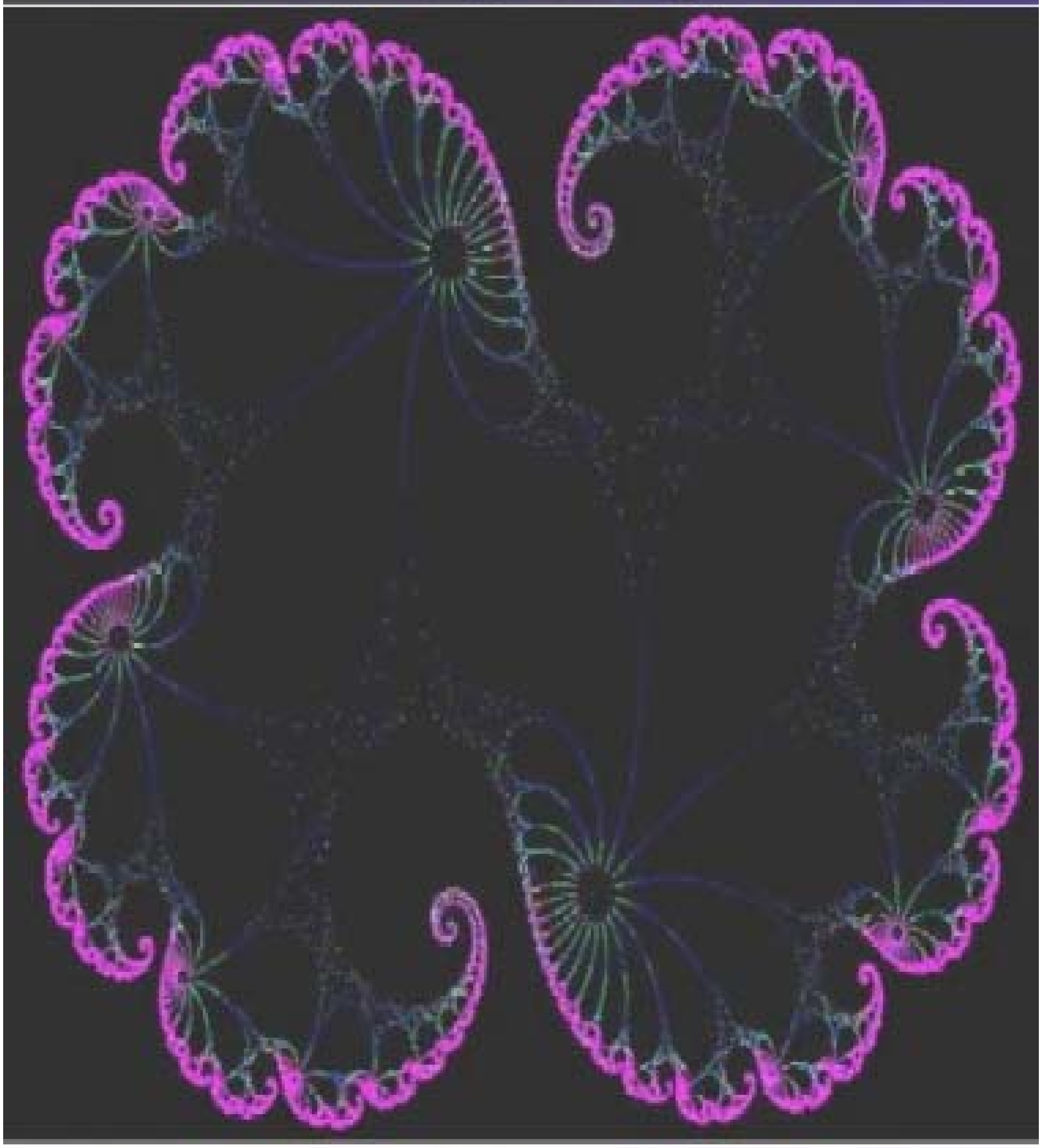
In *The Fifth Discipl*ine, Peter Senge (1990, p. 13) observed how people perceive the meaningfulness of creating and becoming a great team:

> **"When you ask people about what it is like being part of a great team, what is most striking is the meaningfulness of the experience. People talk about being part of something larger than themselves, of being connected, of being generative. It become quite clear that, for many, their experiences as part of truly great teams stand out as singular periods of life lived to the fullest. Some spend the rest of their lives looking for ways to recapture that spirit."**

As described in this chapter, the people who were part of PM Bradley at this formative moment – when the Bradley A3, ODS, Fire Support Vehicles, and Linebacker Engineering and Manufacturing Development programs were all getting started – acted like a great team, with the generative energy Senge describes. They were eager to implement the combat-feedback lessons learned from Operation Desert Storm, a strong effort against an enemy they perceived as dangerous and evil. Highly motivated, the PM Bradley team accomplished more in this short time period than most other program offices accomplish in a decade. As Colonel Ted Johnson told me, looking back as his experience as the Bradley A3 product manager under then-Colonel Yakovac and Brent Sherman, "…Together we made a great program better."

The case of PM Bradley shows how one leadership team used a variety of strategies to achieve more effective knowledge sharing and creation. The experience was transformative, and very productive: PM Bradley accomplished more in that short window of time than most program offices accomplish in a decade. And as described by Ralph Katz, the team member had the experience of innovation in their past – now they could carry that experience forward to be more innovative in the future. By bold problem-solving and empowered knowledge-sharing, the PM Bradley team created successful programs in the short term and provides the US Army with the successor generation of strong acquisition professionals for the long term.

Chapter 7:
Knowledge Strategies



Chapter 7:
Strategies for Knowledge in a Networked World:

The US Army's sense of urgency about *knowledge* and *speed* is keen:

"The urgency is generated not only by the ongoing "digitizing" of headquarters or large crewed vehicles such as tanks, but also by the effort to ensure that even individual soldiers are wired into the digital battlefield…. Much of the activity of swarm systems is based on peers influencing peers. Self-organization is by no means perfect, it is just inevitable."

-- Thomas K. Adams
"The Real Military Revolution"
From *Parameters*, Autumn 2000, p. 54-7

Organizations should pay attention -- there are costs to *not* knowing, and it is better to organize to share knowledge effectively. As US Navy Rear Admiral H. Winsor Whiton, Special Assistant for Information Operations, briefed an MIT Sloan School audience in April 2002, even the famously secretive US National Security Agency (NSA) is trying to create more effective ways of learning and sharing knowledge. The NSA faces many of the issues described: a need to know about emerging technology and its projected impacts; an aging pioneer generation nearing retirement who needs to pass knowledge on to the successor generation; and "first-of-type" innovators who are developing new processes or systems to solve incredibly complex problems.

If the knowledge is not shared, in a lasting way, it will be lost. As US Army Brigadier General Schenk described in his Center for Army Lessons Learned (CALL) Acquisition Lessons, about fielding the Interim Brigade Combat Team, today's youngsters will be tomorrow's leaders. He laments, "The Program Executive Officer for the Objective Force may not have even seen his first acquisition assignment. Even on the contractor side, those who learned from their Brigade Combat Team experience will be long gone by the time of the Objective Force." CALL allows US Army leaders to document and share their lessons, especially important for infrequent events or situations with long intervals between occurrences.

In a frustrating example of the difficulties of sharing knowledge to meet these "one-of-a-kind" events, the *New York Times* article on 26 April 2002 described the problems the Federal Emergency Management Agency (FEMA) is having disbursing money to people who were affected by the terrorist actions this fall. Potential FEMA clients do not understand the processes – they lack the metaknowledge to make the system work. Inside FEMA, information is stovepiped. A lack of critical local knowledge, such as understanding the geography of Manhattan, keeps valid claims from being approved. Not knowing who knows what impedes solutions, which in turn creates frustration and a loss of credibility. This situation highlights the problems associated with not having the right knowledge when you need it.

Affected people did not get money they needed to help mitigate the impact of the terrorist actions. Not knowing how to approve on the bureaucrats' end, and how to get through the paperwork maze on the workers' end, prevented the will of the American people from being carried out. American taxpayers supported this relief effort, and believed it was being done. These program obstacles caused needless suffering and additional anxiety for people who were already traumatized – anxiety which spreads in the form of decreased consumer confidence. The economic effects ripple down. As workers who lost jobs as a result of the attacks begin to default on their housing costs, landlords feel the economic crunch. The dynamic links in this system extend to those who clean the properties, finance the loans, serve lunch to the financiers, and fix the cars of the fast food workers. The trickle-down effects of these economic problems eventually complete the loop back to the government, in the form of reduced tax income and increased deficit spending. The economic kickstart that FEMA's money was intended to provide appears to have had the opposite effect on an already weakened American economy.

As other regions of the world look to America to boost the global economy out of its slump, the global economic cycle may stay down. Events like this have unforeseen long-term effects, as shown by Los Angeles, now 10 years after the racially-tinged riots sparked by the police beating of a black motorist named Rodney King. The opportunistic looting and burning that accompanied the riots left Los Angeles neighborhoods depressed, and convinced investors to seek other places to grow new businesses, thus continuing the cycle of poverty and frustration.

The non-monetary effects of FEMA's slow disbursement of relief funds are longer-lasting and perhaps more significant. The failure to execute this highly publicized effort reduces FEMA's credibility, and reinforces a perception of failure of the government to help or to carry out its promises. For public agencies even more than for commercial firms, lack of credibility is punished for years with reduced income. Funding from Congress can be reduced and punitively wrapped in "red tape" requirements for years to come.

Given the costs of not knowing, what can managers do? Managers can adopt strategies and adapt the best practices of the US Army and other learning organizations in ways which best suit their own organizations. These strategies can help, but only if the organization _rewards**_ knowledge sharing. The strategies listed below are the tip of the iceberg for reforming the organization. Innovation in this area works to make generic practices fit the culture and the people in the organization itself. Technology can assist in the implementation and effectiveness of these practices, but again must serve the organization's strategic goals, culture, and capabilities.**

SOME STRATEGIES FOR KNOWLEDGE:

- **Train people:**
    - **Teach them the equivalent of doctrine, the "school solution." Although specific circumstances require tailoring and improvisation, teaching people**

the generic information is helpful. It builds the "absorptive capacity for learning" described by Rebecca Henderson (1994 and in her Spring 2002 MIT Sloan School Technology Strategy courses).

- **Technology can assist in training, especially when knowledge being transferred is explicit – knowledge as a stock is amenable to being databased. MIT is pursuing its OpenCourseware initiative, to make information from courses such as Rebecca Henderson's Technology Strategy class available via the Internet, at http://web.mit.edu/ocw/. The US Army uses an elaborate system of geographically dispersed schools, and has been exploring distance learning for the past decade. IBM is moving much of its general knowledge – "how to" – to Internet-based e-learning. For stock knowledge, such as learning how to program in Java, this can be a cost-effective way of sharing knowledge.**
- **The AAR process described earlier allows the participants to extract the maximum benefit from training by articulating explicit knowledge – what happened, metaknowledge – why did it happen, and tacit knowledge. The stories shared from the different participants' points of view create a new common experience, which makes future knowledge sharing more contextually appropriate and easier to do. As General Sullivan says, this is at the heart of becoming a learning organization.**
- **Emphasize and reward sharing of lessons learned. The Army Center for Lessons Learned (CALL) has become the repository and distributor for lessons learned throughout the Army. Not only are people accustomed to sending lessons to CALL, but when major events happen, CALL sends observers to gather lessons learned. This dynamic exchange of knowledge keeps the CALL database current, useful, and value-added.**

- **Surround people with an information-rich context to gain and share knowledge:**
    - **Nanoka's concept of "Ba" refines the understanding that people need a context, a space, time, and freedom to interact and share knowledge. One technology which could support this in virtual space is wireless telephone and Internet access. NTT DoCoMo's third generation (3G) wireless service, called "Freedom Of Multimedia Access" (FOMA) has been deployed in Japan since October 2001. FOMA phones expand the services provided by the previous text-based service, called I-Mode (2.5G). Companies can use this type of always-on wireless service to provide accessible information to their team members, their customers, their shareholders – whatever public information they want to share. Experimentation is ongoing. An appealing series of experiments are creating virtual spaces for collaborations – chat rooms, virtual whiteboards, and so on. It is too early to see the full impact of this type of information-rich environment on populations, but the technology holds promise to help people share knowledge.**
    - **In the FEMA example, as with many geographically-based issues from disaster management to school support, providing team members with access to maps can be helpful in orienting actions to fit the specific context. Map boards are de rigueur in mobile and permanent operations centers across the Army. But as Wanda Orlikowski and Peter Senge discussed in their MIT Sloan School course on Organizations as Enacted Systems, maps also structure the viewer's perspective and shape the problem and its possible solutions. Very different maps would be used by the different sides of the conflict in Jerusalem. The maps themselves reflect and embody metaknowledge and tacit understandings – when was**

the boundary last changed? What are the appropriate names? Who owns the land?

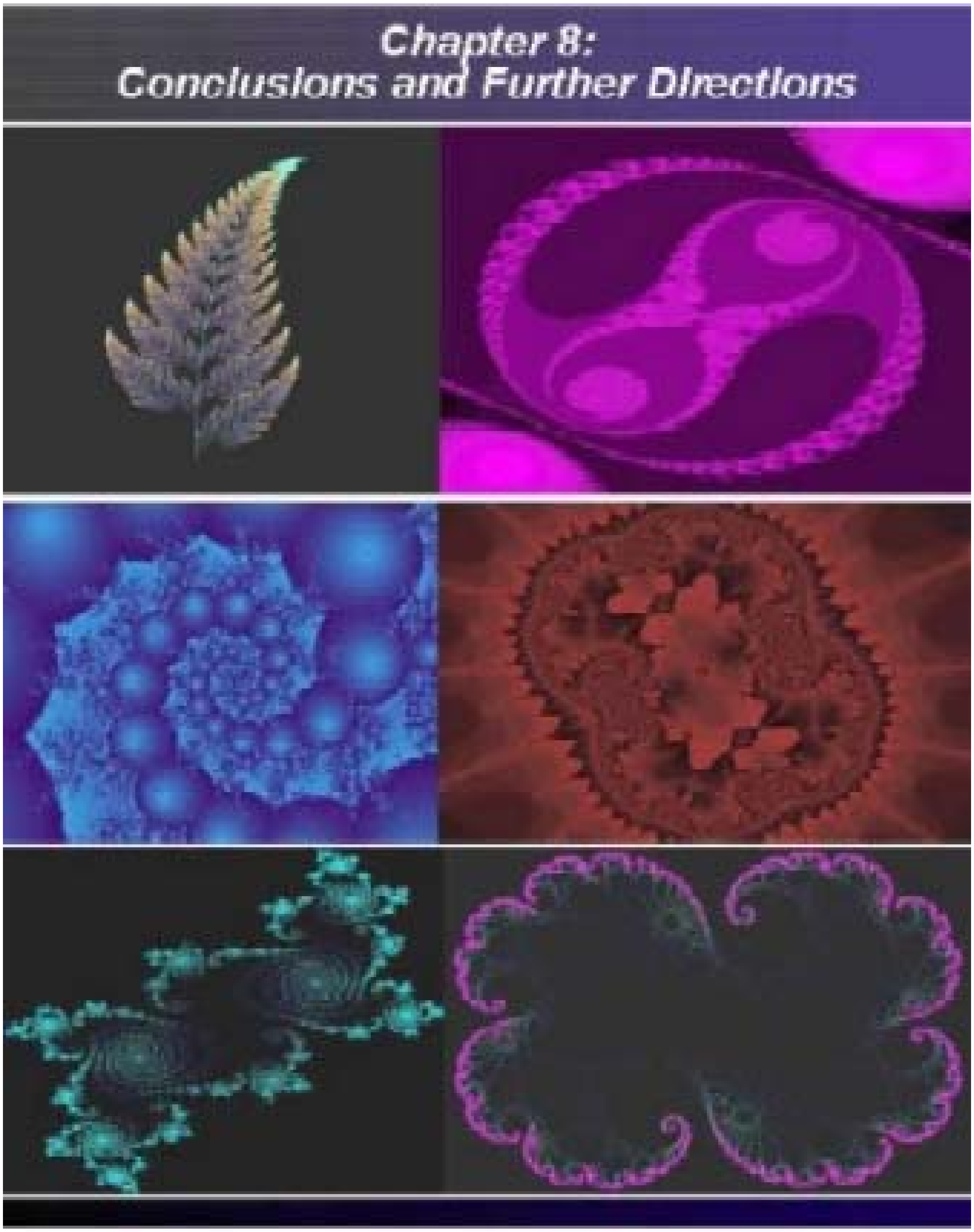
- **Maps are just one type of model of the world. System dynamics "microworlds," management flight simulators, US Army virtual reality training simulators, "what if" scenarios, even spreadsheets, can illustrate alternative outcomes. Being aware of the metaknowledge, including assumptions and subproblem dependence, allows the users to establish and use tripwires to ensure models stay valid.**
- **Consulting firms take different approaches to knowledge, depending on their company strategy. Sherry Buschmann (2001) studied a variety of consulting firms for lessons NASA could learn about knowledge, and Katie Manty of Ernst & Young and Ezra Greenberg of McKinsey filled in details for me. Consulting firm Ernst & Young provides consultants access to company portals, to access databases of internal information, external data, and past engagement reports. To provide appropriate context, the McKinsey consulting firm extends these knowledge bases with a personalization database, which helps consultants locate and talk with people who have recent or deep knowledge on a particular subject. McKinsey's culture supports this "reach out and touch people" by telephone access, so the personalization is part of the whole solution. The technology used fits the strategic goals of each firm: E&Y seeks to replicate best practices in domains across many businesses, while McKinsey seeks to tailor strategic solutions to complex problems with a closer, more idiosyncratic fit. Choosing the solution which fits the strategic goals is important.**

- **Allow for serendipity, but do not rely on it.**
    - **Communities of practice which spring up organically can be encouraged, or even benefit from benign neglect. Requiring people to participate will only lead to "policy resistance," removing any benefit of shared learning and shared experiences.**
    - **Augmenting virtual relationships with face-to-face ones, as Major General Yakovac said, keeps life personal. When tasks become challenging, having a personal connection makes them easier to accomplish. Innovative solutions can happen when people are just chatting. Being together allows for interesting opportunities to create new knowledge.**
    - **Don't hope for a terminator! In a military example which illustrates "hoping for a miracle," Trout (1998) describes the result of the Desert Storm forces lacking the means to "capture, store, and distribute lessons learned and knowledge gained." The US and Coalition forces did not even know what knowledge they had themselves. As the Gulf War was nearing its end,**

> **"…Frantic phone calls were made to try to find someone, anyone with knowledge on how to end the conflict and how to draw up suitable surrender documents…. As one State Department official said, "We're very good at fighting a war but not so good at ending one." Fortunately … a reserve Army Major … assigned to the CENTCOM Headquarters overheard the staff briefing. Major Ann Williams had just completed her Masters Degree in International Affairs from Georgetown University when she was recalled to active duty for the Gulf War… Her Masters Thesis was on conflict termination. Quickly pulled aside, the "Terminator" as Major Williams was nicknamed was put in charge of crafting the surrender documents…. The Department of State could locate no one with similar experience, and due to the sensitivity of the issue, did not go outside of the Department. Hence, the only person with the required knowledge and the one most readily accessible was - *by happenstance* - assigned to the CENTCOM Headquarters…."**

The Allied Forces didn't know what they knew, and by happenstance happened to have someone with appropriate knowledge available. Fortunately, a major outcome of Desert Storm was Army-wide AARs and lessons learned, which in turn led to many combat-feeback improvement programs – including the Bradley with ODS survivability enhancements. Civilian companies too have the experience of "hoping" someone will emerge with just the combination of skills, experience, and training required. Managers should strategically assess what they need now, and for the next few years, and commit to train or give knowledge-building experiences to those employees who have the potential to create the new reality. Loyalty in the form of funding its people's college training is not frequently implemented, but such famously innovative companies as United Technologies, who does fund this type of effort, benefit continuously from their small investments.

- **When communities of practice or communities of interest spring up, celebrate them. Many company leaders have commented on the value of the CompanyCommand.com web site, and recommend it. MIT alumna Teresa Esser's "The Venture Café" highlights the community of entrepreneurs that technology networker and "venture catalyst" Joost Bonsen gathers at the Muddy Charles pub at MIT. Nanotech Planet is an emerging community of interest. Project Management Communities of Practice (PMCoP) are seeking to improve the management of major systems development efforts. All these initiatives offer means to share knowledge and expand the community. Share the knowledge! Finally, as General Sullivan said, "Hope is not a method. When it's time to act, THINK – DO – BE!"**


Chapter 8:
Conclusions and Further Directions

Chapter 8:
Conclusions and Further Directions

Reviewing the key questions with which I started this thesis, a number of strategies have been suggested to match types of knowledge and organizational idiosyncracies. Let us review.

- **Do different types of knowledge need different strategies? We explored different types of strategies best suited for types of knowledge: explicit knowledge, metaknowledge, and tacit knowledge. The examples studied show a wide range of *content* for each type, in several domains. This suggests that managers can learn from the strategies and best practices of other organizations focused on type of knowledge, as long as they tailor the knowledge creation and sharing strategies to fit the skills, absorptive capacity, values, culture, and strategic goals of their own organization.**

- **Can organizations build structures to enhance knowledge retention and transfer? As seen, organizations are experimenting with communities of practice, internetworked dispersion, sharing, and collaboration, both in person and virtually over the Internet. These techniques can be helpful in providing useful methods to extend and expand knowledge sharing, along the lines of Nanoka's 'ba' or shared space. However, there are very real cultural and power issues in organizations which may induce resistance. If the organization does not reward knowledge sharing, it will not happen. Consistency is essential in this matter. As Major General Yakovac told me, "the first time you chew someone out for not giving you the nitty gritty details after you told them not to, you've lost credibility. Your people will see how you *act*, instead of what you *say*, and they will flood you with details, until you're just an encyclopedia with arms. You won't**

have time to think and work at the strategic level – which is why you're there." Implementing technologies, whether Lotus Notes, Microsoft Netmeeting, or PictureTel videoteleconferencing, is the lesser task, compared to training and changing organizational norms and incentives to encourage knowledge sharing.

- **What helping functions can reduce the burden and increase the benefit of sharing knowledge? Technologies may hold promise in this domain, including those being explored under the MIT Intelligent Room projects. Having computing and communication as prevalent as Oxygen will undoubtedly transform knowledge sharing. But just these systems allow users to categorize information, they also require volumes more metaknowledge and the tools to track it. The key to success, I believe, is meeting the real needs of each community – again, tailoring solutions, not implementing "one size fits all." As Dr. Cheney described to our class in his 2 May 2002 briefing, when the Raytheon engineers could not fly in fall 2001, they preferred to share charts via Netmeeting software connected by the Internet: "engineers don't want to see each other – they just want to draw the charts – the virtual cocktail napkin." In contrast, the contract specialists want to be able to look at their counterparts' faces, to establish trust and verify understanding. Technology can help provide some facilitators. A virtual whiteboard that allows engineers to animate designs and captures them to Computer Aided Design (CAD) systems without requiring dreary and time-intensive manual input could help this group spend more time collaborating and creating new knowledge, and less time tending the systems to capture that knowledge. This will however be a long uphill curve to implement.**

- **What happens with abrupt loss of thought leaders, in many domains? We may never know what innovations or knowledge was lost with loss of thought leaders. I believe that the only solution is to work proactively to preclude knowledge loss in the future, by expanding who knows from single individuals up through networks and communities. Especially as knowledge becomes more complex – who would have thought humans could unravel the human genome? – and more cross-functional areas emerge, such as bioinformatics and nanotechnology, the need to create communities to share knowledge becomes more immediate, challenging, and necessary.**

As professors Jeffrey Pfeffer and Robert Sutton describe in their book, *The Knowing-Doing Gap* (2000), managers know what to do, but implementation is hard. It's not enough for managers to *tell* people that they value knowledge sharing. People watch the actions, to see how closely they match the words. Managers who value knowledge sharing will show it in their own actions. They will share knowledge with people – telling people what they need to know, even before people ask. They will be glad people share knowledge with them, valuing candor even if the news is not good. An excellent way to avoid learning about bad news is to "shoot the messenger," by taking out anger and frustration on the person who delivers the unwanted news. To enhance knowledge sharing, leaders must act on all levels: demonstrating personal commitment, incentivizing and rewarding sharing, putting non-intrusive systems in place to support knowledge sharing without making it a burden, providing a knowledge-rich environment.

Emphasizing the cost of *not* sharing knowledge can be part of motivating the team. Recognize that not sharing the knowledge can lose the knowledge, team strength, organizational capability, and competitive advantage, however the organization defines

it. Even a team of individually strong performers can achieve more when the talents are pooled synergistically than individuals have time or effort to accomplish alone.

But not all organizations have the culture and values to focus on knowledge sharing. In organizations which reward individual stars, knowledge hoarding is often the incentivized behavior. For knowledge sharing to be part of the culture and practices of an organization, team members must believe the implicit contract the organization is making, that "us" matters more than "I" and that team success will benefit all. As Major General Joe Yakovac told me, "You've got to trust people to work details at their levels, and bring you the appropriate level of details. Sometimes you need to dive down into the details…. You've got to pick the right people, help them understand the problem, the priorities, your intention, and any constraints, and then let them do the job. When they need guidance, you give it to them. And in the end, you do the best you can with what you've got."

Further Directions:

In any interdisciplinary study, tantalizing trails of thought and research must be set aside for later. Some of the more compelling lines of inquiry which I plan to continue to study are the following:

Data Visualization: Yale professor Edward Tufte explores the challenges of presenting complex data sets in a graphical manner which increases understanding and knowledge. Shosona Zuboff describes the need to "informate" machines, by putting the automation into the system, but there is also a need to pull knowledge out, to gain an awareness of the metaknowledge. Humans need to understand which elements change, how often, what is trustworthy. As Internet information portals such as Moreover creates become more common, the information can lose its source metadata – allowing old, obsolete, non-credible information to be presented in the same manner as “good” information, distorting knowledge. The Commander's Decision Aid software used by PM Bradley sorts out sensor inputs that a commander might see, for a well-defined subset of inputs. This type of data fusion and the way data is represented to the humans who need to know will become more critical than ever, as available information continues to grow.

Systems Thinking to Understand Complexity: As the MIT System Dynamics Group professors Sterman, Senge, Hines, Repenning, and Forrester teach, humans are not good at understanding non-linear results, but need to become better. Unintended or unforeseen consequences are often exactly the results of what designers implemented. Microworlds, management “flight simulators,” and dynamic models can all help build awareness of interconnectivity.

Information Security: Noted cryptoanalyst Bruce Schneier, who invented the Twofish and Blowfish algorithms, uses his lectures and his Crypto-Gram email newsletter (available on-line at http://www.counterpane.com/schneier.html) to highlight the importance of computer security, cryptography, and privacy. As National Security

Agency manager, US Navy Rear Admiral Winsor Whiton, told our class during a briefing on 4 May 2002, the Internet was designed for openness, not security, and we now must deal with the results. The people who will be users of the next-generation Internet need to be aware and involved in security, but paradoxically lack the knowledge to contribute without self-education on the key issues. All the people who are involved in creating the standards are self-trained, evolving their knowledge to solve problems they could not envision a decade ago. But the challenges become more complex over time.

More thoughts on knowledge: Although Nanoka's concepts are a useful first start to developing a dynamic understanding of knowledge, they seem somewhat limited by his stark divisions between explicit and tacit knowledge. Other ways of thinking about knowledge are the following:

- **MIT Sloan School professor Jim Hines' organizational evolution and organic concept of knowledge, which applies genetic algorithms such as selection and mutation to organizations to see how they grow and learn.**
- **MIT Sloan System Dynamics Group Leader John Sterman's understandings of knowledge stock and flow, focusing on *Learner* versus *What is Learned*.**
- **MIT Sloan School professor Jim Short's explorations into public knowledge, which is open, versus private knowledge, which is closed. Organizations such as advertising firms would seek to amplify public knowledge, at the extreme creating a fad. Organizations such as think tanks would seek to amass and hoard large amounts of private knowledge, selling it for competitive advantage. Product development organizations would be in the middle, trying to convert public into private knowledge, and embody the knowledge into products or services. There is tension in the conversion. In the examples of three major players I interviewed, NSA under Rear Admiral Whiton would be an example of an organization**

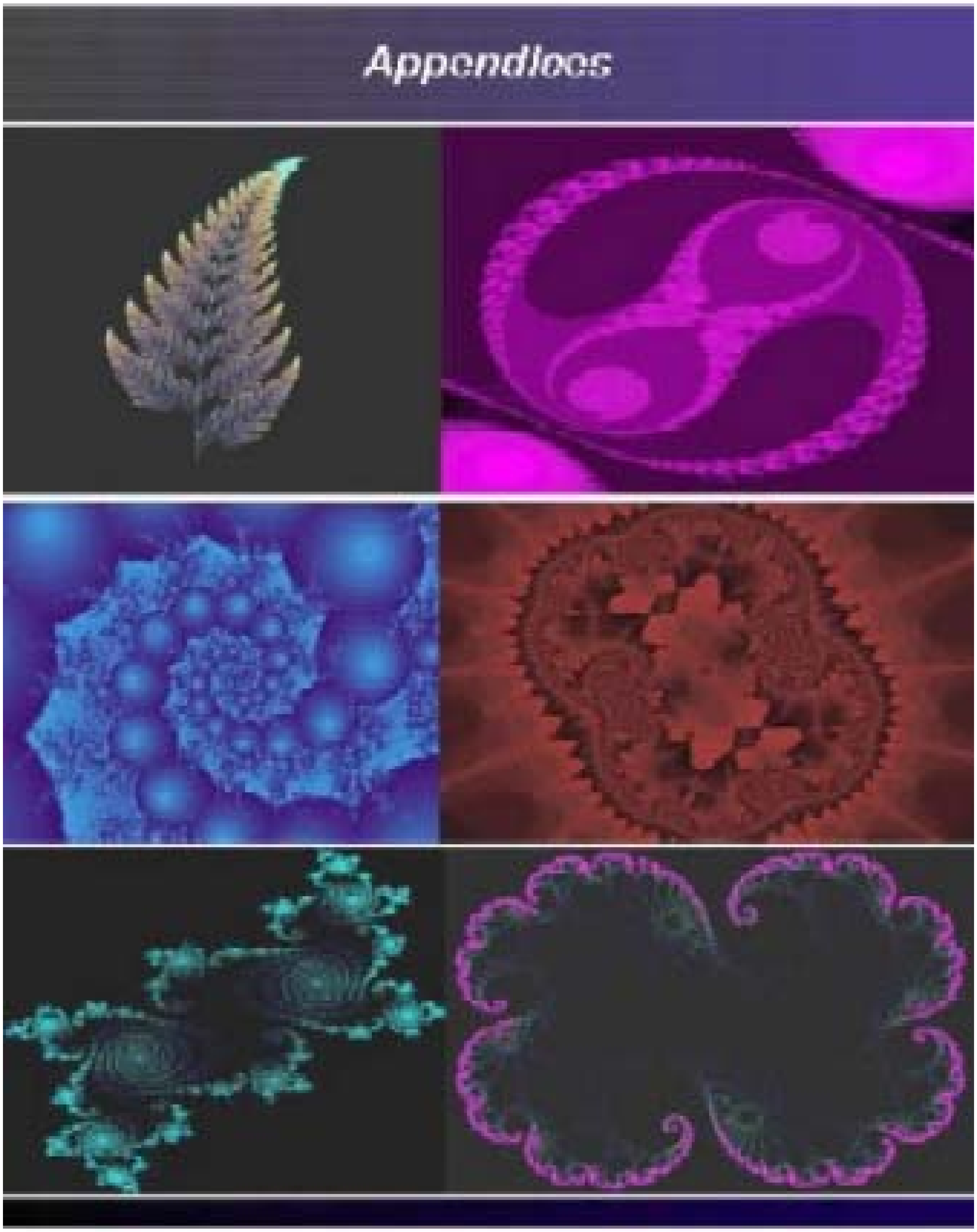
focused on closed, private knowledge; there is a one-way barrier taking knowledge into this organization, but not wanting it to escape. PM Bradley would fall more toward the open end of this continuum, seeking to compel contractors to provide their information about design and support to the government, to be shared within a large community. A defense contractor such as Raytheon, which makes products and provides services, would occupy regions in the continuum's middle – between the "closed" end, with company proprietary or defense secret information, and the "open" end with information provided to the PM Bradley office, which will share it freely with other members of the system integration and user communities.

Living off the past knowledge... In MIT Sloan School Professor Rebecca Henderson's course on Technology Strategy, we have discussed innovation, R&D and the future. Many MBA students view R&D as cost centers, and feel little need to continue to spend at the same rate as in the past. However, that short-life focus on a near-term report means that many companies look for the easy returns on incremental improvements, living off the R&D of the past. Small startup companies are encouraged to "pick one good idea, and focus." As Rear Admiral Whiton ironically pointed out, this drives products which are smaller, faster, quicker to market, miniaturized versions of existing products, as companies like Intel pursue current innovations of the transistor, which has been part of systems for decades. Jack Goldman, the founder of Xerox PARC, told me on 12 Dec 2001, that he believed that the "last new idea was 30 years ago," and that we may be in a fundamental innovation desert which could last 50 years. As the US lives off the Cold War research gains, new avenues of fundamental change need to be explored. As mentioned often in this thesis, possible frontiers of fundamental change include nanotechnology and the life sciences -- genomics, biotech, etc. We need to proceed quickly but cautiously, being aware of unintended consequences: Dolly the

cloned sheep is showing anomalies as she ages -- we don't know what we don't know -- and the effects won't show up for another century. The exciting new long-life batteries for all our devices are little wells of toxins, which can degrade the carrying capacity of our planet. Professor John Sterman encourages system dynamics students to consider sustainability: try to do no harm, while taking advantage of technology.

Mentoring & the Successor Generation: As people increasingly live lives undocumented except in cyberspace, often within closed communities, knowledge can be more stovepiped, increasing the risk of loss. Future generations will wonder what we know, and look to the tangible world and see only shadows of the knowledge, discussion, and debates which enrich our lives. Attempts are being made in pockets to archive the Web, capturing at least the front page of the exponentially increasing number of web sites over time. The "Long Now" project seeks to capture information on glass disks, to make our knowledge tangible and available over 10,000 years – but for now, is focused on being a Rosetta Stone of the Bible in many languages. Paper is our most durable media, but people often do not take the time to document their lessons learned – as with the transformation of PM Bradley from an Industrial Age to an Information Age organization. If you are not part of the cohort at the time, the lessons may not even be articulated. As transforming leaders of the generation of Yakovac, Becton, and Shaler move into strategic leadership roles and away from the one-on-one small unit level leadership, the questions arise of how you pass on the lessons / the *experience* for those who weren't there? If lucky, you get to be physically present; if not, you can settle for a pale image, such as the MIT Opensource videotapes on technology strategy – insightful, but not the same as being in the same room.

These explorations will motivate me for years….


Appendices

REFERENCES:

Adams, Thomas K., “The Real Military Revolution,” in *Parameters*, Autumn 2000: 54-65. Online at URL: <http://carlisle-www.army.mil/usawc/Parameters/00autumn/adams.htm>

Bennis, Warren & Patricia Ward Biederman. *Organizing Genius: The Secrets of Creative Collaboration*. Reading, MA: Addison-Wesley Publishing, 1997.

Berkman, Eric, “When Bad Things Happen to Good Ideas,” April 2001. Online at *Darwin Magazine* at URL: <http://www.darwinmag.com/read/040101/badthings_content.html>

Brown, John Seely & Paul Duguid, “Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation,” 1991. Online at The Institute of Management Sciences (now INFORMS), at URL: <http://www.parc.xerox.com/ops/members/brown/papers/orglearning.html>

---. *The Social Life of Information*. Boston: Harvard Business School Press, 2000.

Brown, John Seely Brown, Allan Collins & Paul Duguid, “Situated Cognition and the Culture of Learning,” in *Educational Researcher*; Vol. 18 No. 1, Jan-Feb 1989: 32-42. Online at the Institute for Inquiry at URL: <http://www.exploratorium.edu/IFI/resources/museumeducation/situated.html>

Buschmann, Sherry L. *Knowledge Management: Obstacles and Opportunities-- What Can NASA Learn From the Consulting Industry?* Massachusetts Institute of Technology, Sloan School of Management Thesis, Management of Technology Program, 2001.

Campbell, Kurt, project director. “Project on the Successor Generation in US Foreign and Security Policy,” under the Center for Strategy and International Studies (CSIS) International Security Program. Online at URL: <http://www.csis.org/isp/projects.htm>

Chidi, George A. Jr., “IT companies offer tech help, equipment,” 19 Sept. 2001. Online at *Network World Fusion* at URL: <http://www.nwfusion.com/news/2001/0919techhelp.html>

Cottrill, Ken, Associate Editor for Logistics, “e-Strategies: Online Fire Power,” 18 June 2001. Online at *Traffic World*, the Logistics Weekly at URL: <http://www.trafficworld.com/news/headlines/estrat061801.html>

Cuviello, Pete, Lieutenant General, US Army CIO/G-6, “Army Knowledge Management… The Strategic Transformer,” Army Knowledge Symposium 2002 Opening Remarks and AKM Update, 2 Apr 2002. Available at Center for Army Lessons Learned Army Knowledge Symposium 2002 site, at URL: <http://call.army.mil/KS/2002/Plenum/Day2_02Apr2002/Day2_Cuviello_AKS_files/v3_document.htm>

Davenport, Thomas H. & Laurence Prusak. *Working Knowledge*. Boston: Harvard Business School Press, 1998.

Doyle, James K., “The cognitive psychology of systems thinking” in *System Dynamics Review,* Volume 13, Issue 3, Autumn 1997: 253-265

Echevarria, Antulio J. II, "Tomorrow's Army: The Challenge of Nonlinear Change," in *Parameters,* Autumn 1998, pp. 85-98. Available online at URL: <http://carlisle-www.army.mil/usawc/Parameters/98autumn/echevarr.htm>

Esser, Teresa. *The Venture Café: Secrets, Strategies, and Stories from America's High-Tech Entrepreneurs*. New York: Warner Books, 2002.

Fahey, Liam & Laurence Prusak, "The Eleven Deadliest Sins of Knowledge Management," in *California Management Review*, Vol. 40, No. 3, Spring 1998: 265-81.

Fontana, John & Deni Connor, "Disaster recovery then and now," Nov. 26, 2001. Online at Network World Fusion at URL: <http://www.nwfusion.com/research/2001/1126featside1.html>

Ford, David. N. & John D. Sterman, "Expert knowledge elicitation to improve formal and mental models" in *System Dynamics Review,* Volume 14, Issue 4, Winter 1998: 309-340

Frauenfelder, Mark, "A Smarter Web," *MIT Technology Review* article about Tim Berners-Lee and the Semantic Web project, November 2001, at URL: <http://www.technologyreview.com/articles/frauenfelder1101.asp>

Gaudin, Sharon, "Lehman Brothers' network survives: Investment giant doesn't miss a beat after IT headquarters is leveled in WTC attack," 26 Nov 2001. Online at *Network World* Fusion at URL: <http://www.nwfusion.com/research/2001/1126feat.html>

Hedlund, J., Horvath, J.A, Snook, S., Forsythe, G.B., & Sternberg, R.J. "Tacit Knowledge in Military Leadership: Some Research Products and Their Applications to Leadership Development." Technical Report 1081. Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences, May 1998.

Hedlund, J., Sternberg, R.J., & Psotka, J. *Identifying the Abilities involved in the acquisition of tacit knowledge.* Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences, 2000.

Henderson, Rebecca M., "The Evolution of Integrative Capability: Innovation in Cardiovascular Drug Discovery." *Industrial and Corporate Change*, Vol. 3, No. 3, 1994: 607-30. Referenced in MIT Sloan School course lectures for 15.912, Technology Strategy. The executive education version of this course has slides available online, at URL: <http://www.mit.edu/people/rhenders/home.html>

Henriques, Diana B. & David Barstow, "Change in Rules Barred Many From Sept. 11 Disaster Relief," 26 Apr 2002. Online at *The New York Times* URL: <http://www.nytimes.com/2002/04/26/nyregion/26FEMA.html>

Heylighen, Francis, "Complexity and Information Overload in Society: why increasing efficiency leads to decreasing control," draft paper, version dated 12 Apr 2002, to be submitted to *The Information Society*. Accessible online through Community Intelligence Labs, at URL: <http://www.co-i-l.com/coil/collaboration/index.shtml>

Jacobsen, Gregory K., “Don’t Squat With Your Spurs On: Advice For Company Commanders,” April 2002. Online at CompanyCommander.com at URL: <http://www.CompanyCommander.com>

Kierkegaard, Søren. *Concluding Unscientific Postscript To Philosophical Fragments.* Hong, Howard & Edna Hong, translators. Volume XII.1. Princeton, NJ: Princeton University Press, 1992.

Knapp, Louise, “Army Intranet: World's Largest,” 15 Nov 2001. Online in *Wired Magazine*, at URL: <http://www.wired.com/news/print/0,1294,48183,00.html>

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

Leonard, Dorothy & Sylvia Sensiper, “The Role of Tacit Knowledge in Group Innovation,” *California Management Review*, Vol. 40, No. 3, Spring 1998: 112-32.

MacSweeney, Greg, “Disaster Recovery Planning: Sadder But Wiser,” 7 Feb 2002, online at *Insurance & Technology Online*, at URL: <http://www.insurancetech.com/story/coverStory/IST20020207S0006>

McCausland, Jeffrey D. & Gregg F. Martin, “Transforming Strategic Leader Education for the 21st-Century Army,” in *Parameters*, Autumn 2001: 17-33. At URL: <http://carlisle-www.army.mil/usawc/Parameters/01autumn/Mccausla.htm>

McDermott, Richard, “Learning Across Teams: The Role of Communities of Practice in Team Organizations,” in *Knowledge Management Review*, May/June 1999. Available online at Community Intelligence Labs, at URL: <http://www.co-i-l.com/coil/knowledge-garden/cop/learning.shtml>

Nonaka, Ikujiro, “The Knowledge-Creating Company,” in *Harvard Business Review*, Nov-Dec 1991, Vol. 69: 96-104.

Nonaka, Ikujiro & Hirotaka Takeuchi, *The Knowledge-Creating Company*. New York: Oxford University Press, 1995.

Nonaka, Ikujiro & Noburo Konno, “The Concept of ‘Ba’: Building a Foundation for Knowledge Creation,” *California Management Review*, Vol. 40, No. 3, Spring 1998: 40-54.

O’Dell, Carla & C. Jackson Grayson, “If Only We Knew What We Knew: Identification and Transfer of Internal Best Practices,” in *California Management Review*, Vol. 40, No. 3, Spring 1998: 154-74.

Olbrys, Elizabeth Bres, Commander, US Navy, “Information Culture in DoD: Preparing For The Third Wave,” Industrial College of the Armed Forces Report Number 94-S-21, 1994. Online at URL: <http://www.ndu.edu/library/ic6resppr.html>

Perera, Rick, “Laser-based recovery tool may reveal WTC data,” 19 Dec 2001. Online at *Network World Fusion* at URL: <http://www.nwfusion.com/news/2001/1219lasertool.html>

Pfeffer, Jeffrey & Robert I. Sutton, *The Knowing-Doing Gap: How Smart Companies Turn Knowledge into Action*. Boston: Harvard Business School Press, 1999.

Polanyi, Michael, *The Tacit Dimension*. Garden City, N.Y.: Doubleday & Co., 1966.

Pollack, Andrew, "Citing RNA, Studies Suggest a Much Deeper Gene Pool," in *The New York Times*, 4 May 2002, p. A10.

Powell, Gerald M., "Metaknowledge Supporting Battlespace Planning, Execution Monitoring and Replanning," US Department of Defense 6th International Command & Control Research & Technology Symposium, Theme: Collaboration in the Information Age, 21 June 2001. At URL: <www.dodccrp.org/6thICCRTS/Cd/Tracks/Papers/Track4/066_tr4.pdf>

Ruggles, Rudy, Manager with Ernst & Young Center for Business Innovation, "The State of the Notion: Knowledge Management in Practice," in *California Management Review*, Vol 40 No 3, Spring 1998: 80-89.

Salkever, Alex & Olga Kharif, with Amy Tsao and David Polek, "Business' Killer App: The Web" 15 Apr 2002. Online at *Business Week*, at URL: <http://www.businessweek.com/technology/content/apr2002/tc20020415_3981.htm>

Schenk, BG Donald F. Program Manager, Future Combat Systems, & George J. Mitchell, Army Acquisition Corps, "Center for Army Lessons Learned Acquisition Lessons: The Interim Brigade Combat Team and the Interim Armored Vehicle," Nov-Dec 2001. Online at the Center for Army Lessons Learned (CALL) Acquisition Lessons Learned, at URL: <http://call.army.mil/products/nftf/novdec01/novdec01ch5.htm>

Schrage, Michael. *Serious Play*. Boston: Harvard Business School Press, 2000.

Senge, Peter. *The Fifth Discipline*. New York: Doubleday, 1990.

Senge, Peter, "Creating the Learning Organization: An Interview with the author of The Fifth Discipline," by David E. Meen & Mark Keough, *The McKinsey Quarterly*, Number 1, 1992: 58-86. Online at URL: <www.mckinseyquarterly.com/article_page.asp?tk=488424:867:21&ar=867&L2=21&L3=36>

Sparrow, John. *Knowledge in Organizations: Access to Thinking at Work*. London: Sage Publications, 1998.

Sterman, John D. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Chicago, IL: Irwin/McGraw Hill, 2000.

Sternberg, R.J., Forsythe, G.B., Hedlund, J., Horvath, J.A., Tremble, T., Snook, S., Williams, W.M., Wagner, R.K., & Grigorenko, E.L. *Tacit Knowledge in the Workplace*. Technical Report 1093. Alexandria, VA: US Army Research Institute for the Behavioral and Social Sciences, 2000.

Sullivan, Gordon R., & Michael V. Harper. *Hope is Not A Method: What Business Leaders Can Learn From America's Army.* New York: Times Books, 1996.

Trout, R. Scott, Lieutenant Colonel, US Marine Corps, “Competing on the Edge,” Industrial College of the Armed Forces Executive Research Project Number 99-E-06, 1999. Online at URL: <http://www.ndu.edu/library/ic6resppr.html>

US Army Training and Doctrine Command. *Knowledge & Speed*, the annual report of the Army After Next project. Ft. Monroe, Va., TRADOC: July 1997.

Van Maanen, John. *Tales of the Field*. Chicago: University of Chicago Press, 1988.

Von Hippel, Eric, "Lead Users: A Source of Novel Product Concepts," July 1986, *Management Science* Vol. 32, no. 7: 791-805. Available online at URL: <http://web.mit.edu/evhippel/www/Publications.htm>

--- "Cooperation Between Rivals: Informal Know-How Trading," 1987, *Research Policy* Vol. 16: 291-302.

Wass de Czege, Huba, and Richard H. Sinnreich, “Conceptual Foundations of a Transformed US Army,” Institute for Land Warfare Paper No. 40, Mar 2002, and AirLand Battle doctrine, available through the Association of the US Army, at URL: <http://www.ausa.org>

Watson, Peter, “Knowledge, metaknowledge, and the geophysicist,” Sept. 1999. Online in *The Leading Edge*, Vol. 18, No. 9 at URL: <http://edge-online.org/pdf/tle1809r1028.pdf>

Welch, Samuel C., “Warrior Development and the Human Side of Knowledge Management,” presented at the Army Knowledge Symposium 2002, April 4, 2002, in Overland Park, KS. Available online at the Center for Army Lessons Learned (CALL), at <URL: http://call.army.mil>

Zuboff, Shoshana, “The Emperor’s New Workplace,” Sept. 1995, in *Scientific American*, Vol. 273(3): 202-204.

ORGANIZATION INFORMATION ONLINE:

Harrow, Jeffrey R., "The Harrow Technology Report," which “explores the innovations and trends of many contemporary and emerging technologies, and then draws some less than obvious connections between them, to help us each survive and prosper in the Knowledge Age.” <http://www.TheHarrowGroup.com>

Kanisa uses its KnowledgeWeb suite of software tools to help clients automate self-learning customer support systems: <http://www.kanisa.com>

Knowledge Network for Biocomplexity provides tools for dealing with life sciences metaknowledge and metadata: <http://knb.ecoinformatics.org/>

Knowledge Technologies Conferences track the emerging technologies which affect the knowledge domain: <http://www.knowledgetechnologies.net/>

Li & Fung was established as a trading company in Canton, China in 1906 and is now using the Internet for trading with clothing and soft goods: <http://www.lifungdistribution.com/>

MIT Artificial Intelligence Laboratory Intelligent Room Projects are part of the Project Oxygen experiments, to see how pervasive computing and communications will transform life, work, and the people who do both: <http://www.ai.mit.edu/projects/iroom/projects.shtml>

MIT Artificial Intelligence Laboratory Humanoid Robotics includes Kismet project: <http://www.ai.mit.edu/projects/humanoid-robotics-group/kismet/kismet.html>

MIT’s OpenCourseware initiative seeks to make information from MIT available via the <Internet, at http://web.mit.edu/ocw/>

Moreover develops integrated business portals bridging Intra/Internets to provide users with “actionable knowledge”: <http://www.moreover.com>

NEC’s 121 Call Center provides Japanese computer customers support on-line at URL: <http://www.sw.nec.co.jp/english/library/jirei/121cc/>

NTT DoCoMo’s new technologies for third generation (3G) wireless service, which Research Scientist Toshiro Kawahara worked on, are online at URL: <http://www.nttdocomo.co.jp/corporate/rd/new_e/index_e.html>

Organizational Evolution Lab, a joint effort between MIT Sloan School of Management and Oregon Graduate Institute, explores how companies can be structured so they get better naturally and automatically: <http://web.mit.edu/org-ev/www/resources.htm>

The Project Management Communities of Practice (PMCoP) site is fostered by the Defense Acquisition University to increase opportunities to share lessons and knowledge among the defense project and program management professionals: <http://www.pmcop.dau.mil/pmcop/>

Stanford University’s Ontolingua software tools, developed as part of the Defense Advanced Projects Agency (DARPA) Knowledge Sharing Effort, is available online: <http://www-ksl.stanford.edu/knowledge-sharing/>

US Army Center for Lessons Learned is the US Army’s on-line knowledge base, gathering and disseminating lessons learned: <http://call.army.mil>

US Federal Acquisition Reform Network (ARNet) includes the Federal Acquisition Training Institute, a searchable database of best procurement practices, and a reference area of useful acquisition documents: <http://www.arnet.gov>

US Army Research Institute for the Behavioral and Social Sciences sponsors research to enhance US Army performance and understanding, including work on the Tacit Knowledge for Military Leadership (TKML): <http://www-ari.army.mil/>

US Army Knowledge Online is the US Army-wide Intranet, remotely accessible to registered users anytime, anywhere, via the Internet and in-Army networks: <http://ako.us.army.mil>

*** All URLs valid as of 6 May 2002**

APPENDIX A:

Contributions are gratefully acknowledged from interviews with the following people:	
Project/Product Development and Leadership:	
Major General Joseph L. Yakovac	US Army Program Executive Officer, Ground Combat Systems, Washington, DC
Rear Admiral H. Winsor Whiton	US Navy Special Assistant to the Chief of Naval Operations, Information Operations and the National Security Agency, Washington, DC
Dr. Philip Cheney	Vice President for Engineering and Chief Engineer, Raytheon Corporation, Cambridge, MA
Colonel Theodore Johnson	US Army Project Manager, Soldier Systems/ Land Warrior, Washington, DC
Elizabeth Cole	VP for Engineering, Boeing Commercial Aircraft, Seattle, WA; Leadership in Challenging Times
Scott R. Clark	Warrior Information Network - Terrestrial, General Dynamics Communications Systems, Taunton, MA
Michael Bracket	US Army Strategic Modernization Planning and Training Systems, PM Bradley Fighting Vehicle Systems, Warren, MI
Karyn Peterman	PM Bradley Fighting Vehicle Systems Logistics and Worldwide Distribution Planning, Warren MI
William Powell	US Army Tank-automotive and Armaments Command Readiness Officer, Warren MI
Julie Briggs	Weapons Platform Diagnostic and Maintenance Systems Development, BAE Systems and Miltope, Nashua, NH
Leadership:	
Julius W. Becton II	Lieutenant General, US Army (retired), Association of the US Army Council of Trustees Deputy Chairman, Springfield, VA; Leadership Development, Knowledge Sharing and the Successor Generation
Michael D. Shaler	Colonel, US Army (retired) and President of Steamboat Leadership Institute, Steamboat Springs, CO; Leadership Development throughout the Army and beyond
Lieutenant Commander Damian Blossey	US Navy Information Operations Officer, Cambridge, MA; Information Systems in Other Military Operations
Technology & Knowledge Sharing:	
Siobhan Dunn	Continuity of Business Operations in Investment Banking, New York City, NY
Marianne Perciaccante	American Religious Studies scholar and lawyer, Washington DC
Ezra Greenberg	Knowledge Management, McKinsey Consulting, Cambridge, MA
Katie Manty	Information Technology and Web/Legacy Systems Integration, CapGemini Ernst & Young Consulting, Cambridge, MA
Michael Shaler	Moreover Technologies, San Francisco, CA; Business Intelligence and Dynamic Content via the Internet
Janice Rudenauer	Schwab, San Francisco, CA; Customer Database Marketing Strategies
Mark Angel	CTO, Kanisa, Palo Alto, CA; Customer Service Automation vendor
Kei Hara	ExxonMobil Strategic Planning; Cambridge, MA
Toshiro Kawahara	Researcher, 3G Wireless / Freedom Of Multimedia Access, NTT DoCoMo; Cambridge, MA
Jen Pararas	Radio Frequency Identification Devices (RFID) in Unilever's Supply Chain; Cambridge, MA
Simon Ellis	Supply Chain Futurist, Unilever Corporation; Greenwich, CT
Bernard Nee	The System Dynamics of Singapore Economic and Strategic Planning; Cambridge, MA
David Matheo	Strategic Manufacturing Planning, Motorola IDEN Wireless Division; Plantation, FL
Kannan Govindjaran	Extreme Programming, HP Labs; Cambridge, MA
Organizations:	
Naval War College strategy experts	MIT Center for Strategic Studies
RAND Al Qaeda expert	MIT Center for Strategic Studies
NEC 121 Customer Call Center	Tokyo, Japan
Li & Fung Trading and Distribution	Hong Kong, Special Administrative Region of China
MIT Professors:	MIT Sloan School Courses:
Wanda J. Orlikowski	Organization as Enacted System
Peter Senge	Organization as Enacted System
Ralph Katz	The Human Side of Managing Technology
James Short	Management Information Systems
John Sterman	MIT System Dynamics Group
Jay Forrester	MIT System Dynamics Group
James Hines	MIT System Dynamics Group
Rebecca Henderson	Technology Strategy
Eric von Hippel	Lead Users and Innovations
Eric Brynjolffson	MIT Center for e-Business
Loren Hitt	MIT Center for e-Business/Wharton School of Business

Opening Stanza of T. S. Eliot's *Chorus I from The Rock* (1934)

The Eagle soars in the summit of Heaven,
The Hunter with his dogs pursues his circuit.
o perpetual revolution of configured stars,
o perpetual recurrence of determined seasons,
o world of spring and autumn, birth and dying
The endless cycle of idea and action,
Endless invention, endless experiment,
Brings knowledge of motion, but not of stillness;
Knowledge of speech, but not of silence;
Knowledge of words, and ignorance of the Word.
All our knowledge brings us nearer to our ignorance,
All our ignorance brings us nearer to death,
But nearness to death no nearer to GOD.
Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?
The cycles of Heaven in twenty centuries
Bring us farther from GOD and nearer to the Dust.

(available online at URL http://www.westminster.edu/staff/brennie/wisdoms/eliot1.htm)