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Intelligence Surveillance Target Acquisition and Reconnaissance (ISTAR) Technology Demonstration Project.

KNOWLEDGE MANAGEMENT IN THE MILITARY CONTEXT

by S.G. McIntyre, M. Gauvin and B. Waruszynski

The 21st century Revolution in Military Affairs (RMA) is predominantly characterized by a rapid pace of technological change and the required transformation in doctrine and organization[1]. The new warfare highlights the rising importance of having a knowledge advantage over adversaries. New technologies have resulted in increasingly dynamic, unpredictable and complex operations that require people to filter and analyze information from multiple sources. Sense-making, problem solving and decision-making are more complex and more essential in military situations than ever before. Similarly, know-how, expertise, and interoperability are also important factors in a military organization's ability to attain knowledge superiority. Command and control is taking on new dimensions, and the role of military personnel is evolving into that of 'knowledge worker'.

Knowledge management (KM), which facilitates the creation and use of knowledge for increased innovation and value, could have a profound influence on the doctrinal shift anticipated by the RMA. The application of KM principles and techniques in the military context could affect both how new military technologies are employed for the knowledge advantage, and how Canadian Forces (CF) doctrine will evolve. It is important, therefore, to determine how KM might be applied to the military environment.

AN ENVIRONMENT FOR KNOWLEDGE MANAGEMENT

Knowledge superiority in military operations requires dominant battlespace awareness and visualization. As the battlefield changes and the tempo of war increases, the pace of information creation and decision-making also multiplies.[2] Modern warfare relies on information from many sources that must be assessed and compiled for immediate use. The timelines are shorter, and the players more individually significant in their roles. This type of warfare requires superiority at all levels of command and control. It demands situational awareness tools that are superior to those of opponents for anticipating their reactions, for sense-making, for problem solving and for superior decision-making.

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The globalization of warfare and the accompanying elements of joint and combined operations is another significant change for modern military conflicts. Warfare and its derivatives of peacemaking and peacekeeping take place on a global stage, far beyond local or regional conflicts. This means that situational awareness and decision-making rely to a greater extent than ever before on sources beyond the immediate theatre; these can be instantaneous and from anywhere in the world. Working effectively with joint or combined forces in coalition situations also requires the ability to communicate and coordinate operations in a 'seamless' environment. As a result, interoperability becomes essential to joint operational success.

"Explicit knowledge is that which is stated in detail and leaves nothing merely implied. It is termed "codified" ...because it can be recorded."

On the human resources side, the military, like their corporate counterparts, recognize the important role of intellectual capital in the modern military enterprise. Rapid technological advancement means that training must become faster and more effective. Time for learning is reduced. Additionally, demographic changes to the work force, and the loss of military knowledge suffered through reduced military spending in the 1990s, have had a long-term impact on the military's corporate memory. Military personnel are rotated through positions for both operational experience and career development. They acquire vast resources of tacit knowledge through their experience, but when they leave at the end of their military careers the expertise acquired during their service is lost.

Can knowledge management be applied to these realities and provide solutions? In the corporate business world, where KM is being embraced as a management approach, the environment is more static and predictable than in military situations. Yet, the growing quantities of information in an increasingly complex operating environment call for new philosophies and methodologies for operational realities, and the ability to 'leverage' defence knowledge. KM principles may be able to provide them.

PRINCIPLES OF KNOWLEDGE MANAGEMENT

Knowledge management is a multi-disciplinary field that draws from theories in economics, sociology, philosophy and psychology. Applied disciplines such as information technology, library science and business also contribute to understanding this field. KM combines and applies multiple theories to practical problems within organizations. It has a pragmatic approach that is concerned with real solutions and the ability to analyze and measure its applications accurately.

One authority on the subject, Larry Prusak, writes that knowledge management is rooted in economics and in the need to increase productivity and innovation for economic gain.[3] KM arose from the economic tenet that productivity is improved through learning, and that continuous improvement occurs through sharing tacit knowledge. Sociology offers insight into social networks and structures as they pertain to knowledge exchange. Psychology provides understanding of human factors and cognitive processes, i.e., how people learn, share, use and create knowledge, and philosophy offers ways of understanding the nature of knowledge itself.

Knowledge is defined as "the fact or condition of knowing something with a considerable degree of familiarity through experience, association or contact."[4] It has also been defined as "a dynamic human process of justifying human belief toward the truth."[5] Forty years ago, Michael Polanyi provided an explanation of knowledge upon which models of knowledge creation have been built.[6] He differentiated between explicit, tacit and implicit forms of knowledge. Explicit knowledge is that which is stated in detail and leaves nothing merely implied. It is termed "codified" or "formal" knowledge because it can be recorded. Tacit knowledge is that which is understood, implied and exists without being stated. It is informal, experiential, and difficult to capture or share. It is knowledge that cannot be expressed. For example, an individual knows how to reach with his arm to grasp an object, but cannot describe how he knows how to do it. Implicit knowledge is that which could be expressed, but has not been. It is most often thought of as existing within the minds of individuals or in social relationships.

Nonaka and Takeuchi argue that effective organizational knowledge creation best occurs through the spiral process where knowledge is converted from tacit to explicit in a continuous and dynamic cycle, as illustrated in Figure 1.[7] It is when tacit knowledge and explicit knowledge interact that innovation occurs. Knowledge creation is facilitated by deliberately managing the cycle. Organizational knowledge creation begins with socialization, where individuals share experience and mental models. It develops into externalization when individuals use metaphors or analogies to articulate hidden tacit knowledge that is otherwise difficult to communicate. It moves into the combination phase for knowledge to be articulated, shared and expounded. Finally, individuals learn by doing and internalizing the new knowledge. The spiral begins again as the experience-based operational knowledge learned in the first cycle provides a larger knowledge base for continuous innovation and growth. It is this model that demonstrates how knowledge is actioned.

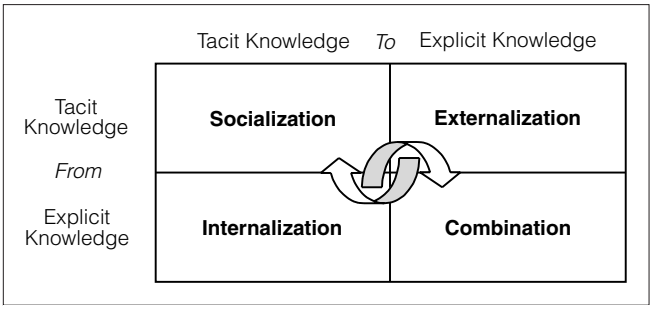

Figure 1: Four Modes of Knowledge Conversion

Chun Wei Choo combined this model with two other strategic information processes to create what he refers to as the "knowing organization", shown in Figure 2.[8] Initially, through sense-making, an organization interprets the ongoing environmental data and establishes a shared understanding. If the experience is routine and known, then the organization can go directly into the process of decision-making. In this stage, the organization searches for more information and selects alternatives. The Nonaka model of knowledge creation is engaged when the sense-making process has determined that new knowledge is required or that the situation is novel and requires new responses. After the sense-making process, the organization then calls upon a knowledge-creation process that will give it additional input to move into the final stage of decision-making.

This cyclical model is reminiscent of the command and control OODA loop (Observe, Orient, Decide, and Act)[9] in which information and then knowledge are transformed into action. McCann and Pigeau have also applied the Nonaka model to a redefinition of command and control theory.[10] The following discussion demonstrates the processes in a knowledge management cycle and how they fit into the model's quadrants.

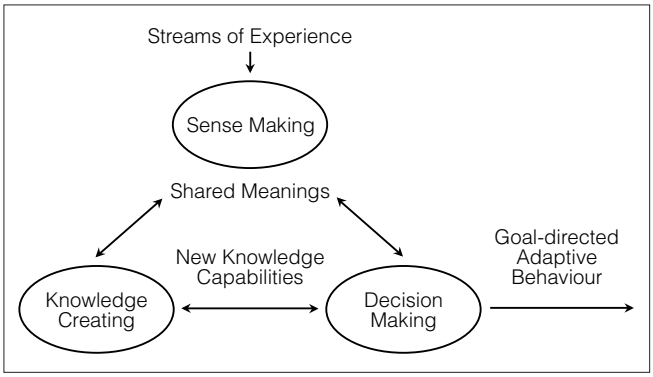

Figure 2: The Knowing Cycle

KNOWLEDGE MANAGEMENT CYCLE

How knowledge processes in a KM environment are managed to convert knowledge for action and to achieve the desired results of increased value in the organization or specific operations is illustrated in the model in Figure 3.[11] There are three general perspectives in the cycle: management, application and people:

- **Management** focuses on capturing, organizing and facilitating knowledge. Many of these activities span the externalization and combination quadrants of the Nonaka model.
- **Application** focuses on effective retrieval of relevant content through advanced searches and mining to conduct knowledge-related work and tasks and on the use of the results for discovery. It relies on the knowledge combination portion of the model.
- **People** focuses on learning, sharing and collaboration. This is the education component of the cycle that is within the internalization quadrant, moving into the socialization portion.

Although people, individually and in groups, are part of all perspectives, either as 'producers' of background knowledge or as 'consumers' of knowledge in the *management* and *application* perspectives respectively, it is within the *people* perspective that their contribution to the collective memory is maximized. Technology may aid them, but in the end, it is their ability to use and innovate with what is available that will create the value realized in KM. Activities occurring in the cycle are briefly described below.

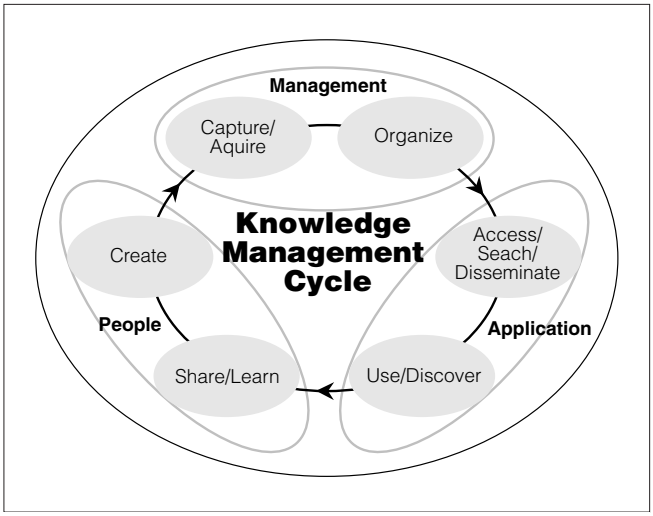

Figure 3: Knowledge Management Cycle

EXTERNALIZATION

Capture and Acquire: The drive to capture explicit and tacit forms of knowledge has resulted in the creation of technology tools for creating information repositories and for document and content management. A major challenge in the capture and acquisition of knowledge is to integrate the information collected from a large number of heterogeneous, distributed and disparate 'silos'.

Organize: The creation of a KM system requires a structure to organize the content once it is captured. The system must begin with a knowledge model or a meta-model. Models reflect the knowledge components and flows that are inherently embedded in the particular organizational culture and processes. They provide a framework, structure and context to the knowledge base by adding order to the chaos of data, information and knowledge. They also provide the conceptual structure for the design of KM systems and tools. Such modelling is accomplished through the creation of taxonomies, ontologies, semantic networks, glossaries, dictionaries, hierarchies, thesauri, topic maps and metadata.[12]

COMBINATION

Access, Search and Disseminate: Effective access, search and dissemination are critically dependent on the organization of knowledge, whether in technological or traditional systems. In technological solutions, search engines are the common applications for these processes. Most are based on full-text indexing using statistical methods (e.g., counting the occurrence and location of words) and on linguistic rules. Alternatives to text indexing are semantic approximation, natural language systems and pattern-recognition technologies that make use of semantic functionality to improve the effectiveness and efficiency of retrieving relevant content.

INTERNALIZATION

Use and Discover: The potential to extract or share the information in repositories is one of the opportunities of KM technologies. 'Knowledge discovery' refers to eliciting knowledge from large data and information sets by identifying new patterns and connections. Within the military setting there is a growing interest in applying technology towards the knowledge management of sense-making, threat analysis and decision-making. Applications include visualization, data mining and software agents.

SOCIALIZATION

Share and Learn: The results of a recent study conducted by the IBM Institute for Knowledge Management found that even in a company with a well-developed infrastructure of knowledge management technology, people still turn first to other people as they seek solutions to problems and knowledge.[13] Keeping track of who knows what in an organization, particularly a large and geographically dispersed one like the CF, remains a challenge. Social networking allows people to exchange information, and is still one of the most popular means for finding information.[14] Technologies to support knowledge sharing and learning include: portals, web collaboration, smart technologies, e-learning and collaborative intelligence.

Create: It is evident that knowledge creation *per se* is a complex process that involves social and cognitive processes. It is primarily fostered by creating an environment where structure, tools and relationships are made available to the knowledge creators for them to make tacit-tacit, tacit-explicit, explicit-explicit, and

explicit-tacit exchanges. When the conversion has occurred, whether it is implicit or codified capture, the cycle returns to the beginning and it is at this point that technological tools can be employed.

KNOWLEDGE MANAGEMENT FOR THE MILITARY

Do such models apply equally to the military context? Is KM inherently different from the corporate environment? If the large number of definitions in the corporate world is any indication, KM is not easily defined and perhaps it is organization- or function-driven.[15] Two well-known definitions are representative, although not comprehensively, of how KM is used in corporate management communities.

- The conscious strategy of putting both tacit and explicit knowledge into action by creating context, infrastructure and learning cycles that enable people to find and use the collective knowledge of the enterprise.[16]

- The process by which the organization generates wealth from its intellectual or knowledge-based assets.[17]

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Situational Awareness: the Common Operating Picture 21 (COP 21) Technology Demonstration Project aims at integrating and sorting mission specific information to permit contextual analysis and enhanced collaboration and information sharing.

A recent study within the Department of National Defence suggested that knowledge management in the military varies not in premises or theory from corporate versions, but in terms of context, content and pace.[18] Whereas corporate KM tools can depend on a more sedentary infrastructure, military operational settings require mobile solutions with corresponding issues of security, bandwidth, robustness and reliability. The content varies as well, often more targeted to the particular operation. Finally, most corporate situations do not need the comparable, quick reaction time required in conflict situations.

KM in the military context requires:

- knowledge processes that are robust and reliable within operational contexts;

- knowledge content and intellectual assets that are focused, precise, reliable, with suitable recall levels; and

- knowledge creation and conversion processes that match the pace of operations.

A possible definition is proposed for critique and testing against existing KM initiatives. Military knowledge management is:

> ...a strategic approach to achieving defence objectives by leveraging the value of collective knowledge through the processes of creating, gathering, organizing, sharing and transferring knowledge into action. It requires processes that are robust and reliable within operational contexts, content and intellectual assets that are focused, precise, reliable, with suitable levels of recall, and knowledge creation and conversion processes that match the pace of operations.

Knowledge management and the knowledge cycle within the context of military operational environments, therefore, require emphasis on these additional requirements of robustness, content and speed. Research and development in the military KM arena must address all components of this definition to be effective.

DEFENCE R&D FOR MILITARY KM

The role that KM has to play in the military operational element has been identified as a growth area in Defence R&D Canada's Technology Investment Strategy (TIS).[19] Three foci to support knowledge superiority have been identified:

- Advanced techniques and architectures for more effective sharing of information and knowledge across the enterprise's distributed and heterogeneous information systems;

- Knowledge modeling, discovery and creation for improved situational awareness through research of processes and human knowledge representation in meaningful and intuitive ways; and

- Visualization and geo-spatial systems for enhanced understanding of spatial- and time-related knowledge in complex environments.

These foci both incorporate the KM cycle components of management, application and people and encompass the components of the military KM definition. Examples from current research illustrate how KM solutions must go beyond the civilian definition to focus on the components of robustness, content and speed.

KNOWLEDGE MANAGEMENT IN SITUATIONAL AWARENESS

The interactive picture that gives a timely and accurate assessment of all operations within the battlespace enables the decision maker or group to gain a clear understanding of the current situation with regard to opposing forces and the environment, as well as to visualize a desired end-state. Currently, the problem is exceedingly complex because there are vast quantities of information requiring weeding, sorting and analysis. Data fusion and information management can be and are applied to the problem, but without the addition of knowledge conversion processes they can contribute to the overload. The management of knowledge in such complex environments should enhance the effectiveness of situational awareness systems.

A group from the COP (Common Operating Picture) 21 Technology Demonstration Project team established a medium-term vision to gradually provide military personnel with a customized, mission- and task-oriented knowledge portal that pulls together into a suite of work-oriented portfolios, mission specific content, operational task management and knowledge sharing and creation capabilities.[20, 21] The target portal will provide contextual assistance, federated access to a variety of multi-media information sources, arbitrary navigation, contextual searches and semantic connections

on any sources and products. It will take into account individual interests and group constraints within dynamic and evolving task contexts, and allow for enhanced collaboration, virtual teamwork, publishing and notification. The utility of this knowledge tool could be demonstrated in situations that require swift reactions to surprising events, such as an unanticipated epidemic crisis where Canadian troops are deployed. The portal could provide diverse background information and analysis, such as alert to threats, pre-deployment documents, risk analysis, vaccine sources, transport mechanisms, schedules and courses of actions tools.

KNOWLEDGE MANAGEMENT IN MILITARY INTELLIGENCE

Similarly, battlefield intelligence requires KM that is accurate and timely to "determine enemy or potential enemy force composition, position, capabilities and intentions; while reducing the potential for strategic, operational, tactical, or technological surprise."[22] The intelligence cycle is a four-step process for obtaining, assembling and evaluating information, converting it into intelligence and disseminating it. The first phase, **direction**, is when commanders determine the requirements, communicate them to staff who in turn collect existing material and request collection from other sources. The second phase, **collection**, occurs when reconnaissance and surveillance data is gathered by sources and agencies. The third, **processing**, phase involves the collation, evaluation, analysis, integration and assessment of the gathered information. This phase is the conversion of information into intelligence. In the final, **dissemination**, phase intelligence is distributed to those who require it.

KM is being applied to the battlefield intelligence cycle in the Intelligence Surveillance Target Acquisition and Reconnaissance (ISTAR) Technology Demonstration Project.[23] The ISTAR TDP will demonstrate how advanced technologies can significantly enhance the current process by providing a commander with more effective battlefield visualization. The leading objective is to capitalize on advanced technologies to enhance the intelligence production capability through the integration of mature and emerging information technologies supporting collection management, storage and retrieval, information fusion, data mining, knowledge discovery, visualization and dissemination activities into an advanced demonstrator. Other project objectives are to influence the concepts, doctrine and capabilities of future Land Forces ISTAR command and control.

KNOWLEDGE MANAGEMENT AND INTEROPERABILITY

Interoperability, which refers to the ability of "systems, units or forces to provide services to or accept services from other forces to enable them to operate effectively together," involves more complex content management because it addresses common operating systems between various military sectors.[24] It also requires robust systems and the ability to work in real-time environments. Knowledge systems architecture designed for effective information and knowledge sharing, to enable knowledge creation and workflow integration across distributed and heterogeneous information systems, is required. Common understanding and translation in the most elementary form is essential. Interoperability in knowledge management systems requires the use of ontologies, or structures of knowledge, as the fundamental mechanism for developing this mutual comprehension. Security, confidentiality, integrity and availability are other important issues that must be dealt with in order to achieve 'unity of effort' through the 'common operating picture'.

Defence R&D Canada is participating in a coalition experiment initiative, called C-CINC21 (Coalition – Commander in Chief 21st Century), to advance the state of knowledge and to contribute in the interoperability of future coalition operations within the four nations, Canada, Australia, the US and the UK. As part of this initiative, DRDC – Valcartier has developed a methodology and a web-based tool to facilitate the collaborative construction of ontologies among nation members.[25] In simple terms, ontologies are to be used as the agreed *thesaurus* where all national COINS (Coalition and Information Services) will be able to exchange information upon a shared understanding on what is requested and expected. A simple ontology on the civilian-tracking domain was built as a first step. Ontologies in this coalition context ensures the usefulness of the content to participants.

TRAINING AND KM

Training in the "fast, digitized environment" of today requires special emphasis for numerous reasons.[26] Operations are now more technologically dependant. Rapid technological change means that systems are being replaced more frequently, and are often more complex than the systems that they replaced. The global nature of war means that there are cultural factors in training that require quick study in social and cultural issues. Individuals are required to take more responsibility for decision-making. Knowledge management approaches to learning should improve the effectiveness and timeliness of training, particularly in complex situations.[27]

Canadian Forces Combat Camera photo by Master Corporal Brian Walsh

A Naval Combat Information Operator aboard HMCS Winnipeg monitors one of the many sensors in the ship's operations room, Gulf of Oman, November 2002.

The after-action-review (AAR) was developed by the US Army in 1999 as a structured process by which a team can learn as it goes by capturing learning and enabling it to reflect on and learn while it is performing.[28] In Canada, there are two major initiatives underway to facilitate lessons-learned creation and sharing: one is at the Army Lessons Learned Centre and the other is at the Air Force 1 Wing Lessons Learned Cell. Each one is built on the Interactive Lessons Learned Knowledge Warehouse developed for the Army, which is a KM platform based on the e-learning model that will help in formulating and learning doctrine.[29] A third initiative is beginning to study the applicability of the platform at the Joint level.

COLLABORATIVE CAPABILITY ENGINEERING

KM is also being applied to help establish a new process in which the Department of National Defence, the CF and industry are enabled by robust, collaborative use of simulation and systems engineering technology that is integrated across acquisition phases and programs in order to define, engineer and manage future capabilities. The Collaborative Capability Definition, Engineering and Management (CapDEM) Technology Demonstration Project,

for example, will demonstrate how capabilities can be created in less time, with higher quality and lower cost, as well as with optimized effectiveness. The goals of CapDEM are to: (a) identify and establish key capabilities with substantially reduced time, resources and risk associated with the whole process; (b) increase the quality, military worth and supportability of fielded systems while reducing total ownership costs throughout the life cycle; and (c) enable Integrated Product and Process Development (IPPD) across the entire acquisition life cycle. CapDEM is more than technology. It is a fundamental change in culture and process. CapDEM TDP incorporates KM principles, focusing on a system-of-systems approach. The architecture will help to facilitate greater collaboration and interoperability through the sharing of modelling and simulation resources and tools, collaborative planning tools, integrated multiple systems, linked engineering analysis, and shared data and experimental environments to enable interoperability both within and across acquisition programs and stakeholders.

CONCLUSION

These applications illustrate how KM principles can be brought to situational awareness, sense-making, and decision-making in military settings. In essence, knowledge organization and human knowledge conversion processes can bring a comprehensive foundation to the common operating picture, interoperability, intelligence, training and acquisitions.

As a strategic approach to achieving defence objectives, military KM will play a valuable role in leveraging existing knowledge and converting new knowledge into action through the KM cycle. Robust, precise and timely military KM will require technological, cognitive and socio-cultural focused solutions. Further research and development in the subject areas of cognitive science, information and knowledge management technology, command and control and related domains will be needed to formulate effective operational systems.

The application of KM principles and techniques in military environments could affect both how new military technologies are employed for the knowledge advantage and how CF doctrine will evolve. As such, KM is likely to be an important contributor to meeting the challenges encountered during the 21st century's first RMA, and to have a profound influence in the doctrinal shift anticipated by the RMA.[30]

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NOTES

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