WORKING TOWARDS A KNOWLEDGE INVESTMENT STRATEGY—
An Analytical Overview of the Science and Technology Community

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Abstract

This paper provides an analytical overview of how science and technology organizations are moving toward knowledge investment strategies in establishing more effective processes and mechanisms for capturing, using and leveraging knowledge. The paper looks at science and technology organizations that are engaging in the implementation of strategic knowledge leveraging initiatives, and focuses on how these organizations are building their knowledge-based enterprises based on collaborative innovation processes. It investigates the role of community dynamics (e.g., communities of practice or communities of interest), and synthesizes how these organizations are involved in the future innovation process. The perspectives on leveraging science and technology knowledge are surveyed, including: defence, communications, oil, health, chemical and electrical sectors. This paper also reports on the imperatives in knowledge innovation (e.g., business intelligence and intellectual property; information management and information technology), and examines the science and technology knowledge-related strategies that are considered to be the most effective in fulfilling future business mandates. Emerging themes on the developments and trends of knowledge management within the scientific community are discussed and analyzed, focusing on: collaborative environment; communities of practice; support tools and technologies for developing new scientific knowledge; organizational learning; and performance measurement/performance management of knowledge investment strategies. The analysis demonstrates that knowledge leveraging initiatives and collaborative processes, techniques and tools are being implemented and assessed within science and technology-based organizations, including: communities of practice, networked organizations, knowledge centres, business directories, virtual laboratories, virtual information networks, ShareNets and Technology Watch. Management issues that are addressed, include: learning organization, skills and competencies, rewards and recognition programs and mentorship/protégé programs. These knowledge leveraging initiatives and management processes are considered to be among the main building blocks for developing knowledge investment strategies within science and technology organizations.

Résumé

Le présent article donne un aperçu analytique de la façon dont les organisations scientifiques et techniques se tournent vers les stratégies d'investissement dans le savoir pour mettre en place des méthodes et des mécanismes plus efficaces servant à acquérir, à utiliser et à exploiter du savoir. L'article examine les organisations scientifiques et techniques qui élaborent des initiatives stratégiques d'exploitation du savoir et se focalise sur la façon dont ces organisations développent leurs entreprises fondées sur le savoir, à partir de processus d'innovation et de collaboration. Il analyse le rôle de la dynamique des communautés (p. ex., réseaux d'échange de pratiques ou communautés d'intérêts) et généralise la façon dont ces organisations participent au futur processus d'innovation. Il recense les optiques sur l'exploitation du savoir scientifique et technologique, y compris des secteurs de la défense, des communications, du pétrole, de la santé, de la chimie et de l'électricité. L'article fait également état des exigences sur le plan de l'innovation du savoir (par exemple, la veille économique et la propriété intellectuelle; la gestion de l'information et la technologie de l'information) et examine les stratégies liées au savoir scientifique et technologique qui est jugé le meilleur pour réaliser les mandats de l'avenir. Il traite et analyse les nouveaux sujets de développement et de tendance au sein de la communauté scientifique, mettant l'accent sur l'environnement de collaboration, les réseaux d'échange de pratiques, les outils et les technologies de soutien nécessaires à la création de nouveau savoir scientifique, l'apprentissage organisationnel et la mesure/la gestion de la performance des stratégies d'investissement dans le savoir. L'analyse montre que des initiatives, des processus de collaboration, des techniques et des outils visant à exploiter le savoir (réseaux d'échange de pratiques, organisations réseautées, centres de savoir, répertoires d'affaires, laboratoires virtuels, réseaux d'information virtuelle, ShareNets et veille technologique) sont en train d'être appliqués et évalués par des organisations scientifiques et techniques. Les matières de gestion examinées comprennent l'organisation apprenante, les capacités et les compétences, les programmes de récompenses et de reconnaissance et les programmes de mentorat/d'encadrement individuel de stagiaire. Ces initiatives d'exploitation du savoir et ces processus de gestion sont considérés comme faisant partie des principaux éléments de base nécessaires pour élaborer des stratégies d'investissement dans le savoir au sein des organisations scientifiques et techniques.

Executive Summary

Science and technology organizations are increasingly engaging in strategic knowledge leveraging initiatives as part of their investment strategies. Nationally, knowledge management is receiving increased recognition in helping organizations establish more effective processes and mechanisms for capturing, using and leveraging knowledge. Science and technology organizations within the federal government and private industry are examining the importance of engaging in collaboration processes—focusing on strategies to help build their knowledge-based enterprises.

This paper provides an analytical overview of how science and technology organizations are moving toward strategies to establish more effective processes and mechanisms for capturing, using and leveraging knowledge. It investigates the role of community dynamics (e.g., communities of practice or communities of interest), and examines the important contributions made by organizations in innovating the future. Different sector perspectives on leveraging science and technology knowledge are surveyed, including: defence, communications, oil, health, chemical and electrical. This paper identifies the knowledge innovation imperatives (e.g., business intelligence and intellectual property; information management and information technology), and the science and technology knowledge-related strategies that are considered to be the most effective in fulfilling future mandates.

The analysis reveals that science and technology organizations are exploring various approaches for leveraging knowledge. Collaboration for innovation is evidenced throughout the different sectors. The role of information management is explored within the context of leveraging science and technology knowledge. Tools for collaboration are examined as enablers in capturing, sharing and transferring knowledge. Emerging themes on the developments and trends of knowledge management within the scientific community are discussed and analyzed, focusing on: collaborative environment; communities of practice (including knowledge centres and networked organizations); support tools and technologies for developing new scientific knowledge; organizational learning (including learning organizations, skills and competencies, rewards and recognition programs, and mentorship/protégé programs); and performance measurement/ performance management of knowledge investment strategies. The analysis demonstrates that knowledge leveraging initiatives and collaborative processes, techniques and tools are being implemented within science and technology-based organizations, and are considered to be among the main building blocks for developing knowledge investment strategies.

Waruszynski, B. 2001. *Working Towards a Knowledge Investment Strategy—An Analytical Overview of the Science and Technology Community*. DRDC TM 2000-003. Directorate of Science and Technology Policy.

Sommaire

Dans le cadre de leurs stratégies d'investissement, les organisations scientifiques et techniques multiplient les initiatives stratégiques d'exploitation du savoir. À l'échelle nationale, il est de plus en plus reconnu que les organisations s'inspirent de la gestion du savoir pour mettre en place des méthodes et des mécanismes plus efficaces servant à acquérir, à utiliser et à exploiter le savoir. Les organisations scientifiques et technologiques de l'administration fédérale et du secteur privé, sont à étudier l'importance d'adopter les processus de collaboration, se concentrant sur les stratégies pour établir leurs entreprises axées sur le savoir et les inscrire comme partenaires stratégiques dans le système d'innovation.

Le présent article donne un aperçu analytique de la façon dont les organisations scientifiques et techniques se tournent vers les stratégies d'investissement dans le savoir pour mettre en place des méthodes et des mécanismes plus efficaces servant à acquérir, à utiliser et à exploiter du savoir. Il étudie le rôle de la dynamique des communautés (p. ex., réseaux d'échange de pratiques ou communautés d'intérêts) et l'apport important des organisations à l'innovation de l'avenir. Il recense les différents points de vue sur l'exploitation du savoir scientifique et technologique dans, entre autres, les secteurs de la défense, des communications, du pétrole, de la santé, de la chimie et de l'électricité. L'article énumère les exigences de l'innovation du savoir (p. ex., renseignements d'affaires et propriété intellectuelle; gestion de l'information et technologie de l'information) et les stratégies relatives au savoir scientifique et technologique qui est jugé le meilleur pour réaliser les mandats de l'avenir.

L'analyse révèle que les organisations scientifiques et techniques étudient différents modes d'exploitation du savoir. Des initiatives de collaboration se font jour dans les différents secteurs. On examine le rôle de la gestion de l'information dans le contexte de l'exploitation du savoir scientifique et technologique et on étudie des outils de collaboration à titre de catalyseurs favorisant l'acquisition, le partage et le transfert de savoir. Les nouveaux sujets de développement et de tendance au sein de la communauté scientifique sont analysés en mettant l'accent sur l'environnement de collaboration, les réseaux d'échange de pratiques (notamment les centres de savoir et les organisations réseautées), les outils et les technologies de soutien nécessaires à la création de nouveau savoir scientifique, l'apprentissage organisationnel (y compris les organisations apprenantes, les capacités et les compétences, les programmes de récompenses et de reconnaissance, les programmes de mentorat/d'encadrement individuel de stagiaire) et la mesure/la gestion de la performance des stratégies d'investissement dans le savoir. L'analyse montre que des initiatives d'exploitation du savoir, des processus de collaboration ainsi que des techniques et des outils sont en train d'être mis en œuvre dans des organisations scientifiques et techniques et sont considérés comme faisant partie des principaux éléments de base nécessaires pour élaborer des stratégies d'investissement.

Waruszynski, B. 2001. *Vers une stratégie d'investissement du savoir – Un aperçu analytique de la communauté scientifique et technique* (RDDC TM 2000-003). Direction – Sciences et technologie (Politique).

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Table of Contents

List of Tables

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Working Towards a Knowledge Investment Strategy—
An Analytical Overview of the Science and Technology Community

1 Introduction

In the new knowledge-based economy, science and technology organizations are increasingly engaging in strategic knowledge leveraging initiatives to advance their investment strategies. From a global perspective, knowledge management is receiving increased recognition in helping organizations establish more effective processes and mechanisms for capturing, using, leveraging and reconfiguring knowledge. Science and technology organizations are recognizing the importance of engaging in collaborative processes and strategies to build their knowledge-based enterprises. Promoting a knowledge-sharing culture is considered to be advantageous for companies and government departments—embracing and nurturing collaborative environments to achieve knowledge creation, innovation and competitive advantage.

To understand the strategic direction of science and technology organizations in knowledge capture, use, transfer and reuse, an analysis is conducted on the current state and trends in knowledge management—focusing on the processes and techniques applied for leveraging knowledge. Although the intent of this paper is to present examples of how some science and technology organizations are implementing knowledge management into their everyday work practices, it is not intended to offer an exhaustive overview of knowledge management within the science and technology community. This paper provides an analytical overview of how science and technology organizations are moving toward knowledge investment strategies by establishing more effective processes and mechanisms for capturing, using and leveraging knowledge. It examines how these organizations are building their knowledge-based enterprises by being engaged in collaborative innovation processes. It investigates the role of community dynamics (e.g., communities of practice, communities of interest) and how these communities benefit knowledge innovation and creation. Different sector perspectives on leveraging science and technology knowledge are examined, including: defence, communications, oil, health, chemical and electrical. The paper explores the impact of information management and information technology on knowledge leveraging initiatives, and puts forward examples of collaborative tools. The paper also outlines the knowledge innovation imperatives (e.g., knowledge collaboration and intellectual property; information management and information technology). An analysis of the trends and developments within the science and technology community is put forward; and examples of the most effective science and technology knowledge-related strategies in fulfilling future mandates are examined. The paper concludes by advocating the importance of instilling a collaborative culture in leveraging science and technology knowledge.

2 Building a Knowledge-based Enterprise

In her speech [1] on *Serving in the Knowledge Age: A Commitment to Lifelong Learning*, Jocelyne Bourgon, the President of CCMD, focused on the Government of Canada's priorities for preparing Canadians for the Knowledge Age. The Speech from the Throne to Parliament (October 12, 1999) relayed the importance of "knowledge" and "creativity" as the principal drivers in the new economy. According to the Speech, "countries that are innovative have high levels of productivity, quickly adopt the latest technology, and invest in skills development for their citizens." Moreover, a recent report, *Stepping Up: Skills and Opportunities in the Knowledge Economy* by the Advisory Council on Science and Technology in Canada (2000), states that: "government and private industry must both actively invest in the knowledge infrastructure."[2] This investment represents the cornerstone of strategic business mandates for science and technology organizations—propelling knowledge workers to devote their time and energy to developing and sustaining a collaborative working environment based on knowledge use, knowledge discovery and knowledge transfer.

In building a knowledge-based enterprise, science and technology organizations are focusing on the importance of capturing tacit, implicit and explicit knowledge from their workers—a prerequisite for engaging in knowledge management strategies. For the purpose of this paper, knowledge management can be defined as: 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" (American Productivity and Quality Center 2000a, 1).[3] In general, knowledge is based on both *tacit knowledge*—experiences, abilities/skills, artistry, values, culture, and *explicit knowledge*—codified information (e.g., databases, document repositories, portals). The structure of knowledge as incorporating tacit components can be evidenced through the skills that are learned through personal experience (Michael Polanyi, 1966). Our experiences are based on subjective, personal knowledge—not objective knowledge. Tacit knowledge consists of "know-how" skills (e.g., a craftsman's expertise), mental models, beliefs and perspectives ingrained in people, thus shaping their perceptions of the world (Nonaka, 1998). In the corporate business environment, employers are examining the importance of retaining tacit knowledge, and the knowledge that stems from collaborative initiatives. Moreover, implicit knowledge is also considered to be integral to understanding knowledge processes. Kull (2000) refers to implicit knowledge as knowledge that is fused and transferred across time and space (e.g., conversations, expert locators, conventions, norms)[4]. The exchange of tacit and implicit knowledge occurs through the discussions held by individuals—the knowledge and wisdom that are imparted onto others that allow the evolution of knowledge to occur. Thus, science and technology organizations are examining the importance of leveraging and

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[1] Jocelyne Bourgon, President, Canadian Centre for Management Development at Technology in Government Week, Ottawa, Ontario, October 19, 1999. *Serving in the Knowledge Age: A Commitment to Lifelong Learning*. Speech. Canadian Centre for Management Development.

[2] Advisory Council on Science and Technology. (2000). S*tepping Up: Skills and Opportunities in the Knowledge Economy*. Report of the Expert Panel on Skills. Presented to The Prime Minister's Advisory Council on Science and Technology, Industry Canada, p. 34.

[3] For a more thorough discussion on knowledge management, please review the Technical Memorandum 2000-002, entitled: *The Knowledge Revolution—A Literature Review*, written by Barbara Waruszynski.

[4] See Michael Kull. The State of Knowledge Management in the Public Sector. Tutorial T-6A and T-6B. Knowledge Management: An e-gov conference. The Foundation for Electronic Government. April 10-13, 2000. Kull focuses on "corporate storytelling through digital video"—a method for sharing implicit knowledge.

maintaining this tacit and implicit knowledge to continuously nurture the innovativeness, creativity, ingenuity and entrepreneurial spirit of its knowledge workers.

2.1 Innovation Through Collaboration

The ability to innovate through collaborative ventures is considered to be integral to the viability of organizational performance. Innovation is defined as: "a process through which economic value is extracted from knowledge through the generation, development and implementation of ideas to produce new or significantly improved products or processes" (Conference Board of Canada 2000, 6). Collaboration is defined as: "a relationship that involves active participation of partners (whoever these partners may be) in joint projects in order to develop new or significantly improved products (goods or services) and/or production processes (Statistics Canada, 1999)[5]. Creating partnerships for innovation is a key component of science and technology policy, and is a major contributor to enhancing national competitiveness.[6]

According to a recent report on *Collaborating For Innovation*[7], benchmarking Canada's efforts in technological innovation has yielded discouraging findings. The report states that although Canada's efforts and performance are slowly improving in comparison to other countries, Canada needs to improve its relative position and performance in technological innovation. As a result, organizations are being challenged to change their business management strategies to enhance their innovative capacities in the new knowledge economy. Innovation stems from collaboration—where knowledge workers reach out for captivating ideas. Organizations are striving to enhance the innovative capacity of its employees and the entrepreneurial spirit that is necessary for organizational creativity and ingenuity. By building networking partnerships, organizations are able to find solutions to problems through collaboration.

Companies are capable of producing new products or processes without collaborative involvement; however, the Conference Board of Canada's report on *Collaboration for Innovation* affirms the importance of forming collaborative partnerships for the introduction of new products, systems and processes—contributing to the innovativeness of the corporate social capital. For example, 'successful innovators (firms that have put forward new or significantly improved products) are significantly more likely to report collaborative partnerships than prospective innovators (firms that did not introduce new or significantly improved products but engaged in the innovation process)'. [8] Also, firms engaged in collaboration are more likely to produce "breakthrough innovations".

In general, the organizational dynamics of firms engaging in collaborative ventures are changing core business strategies. The Conference Board of Canada report[9] states:

- *Globalization, knowledge, and information technologies are spearheading an increase in the importance of collaboration in technological innovation between firms and between industry and public sector organizations.*

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[5] Statistics Canada. Innovation Survey, 1999.
[6] Mario Cervantes, "Public/Private Partnerships in Science and Technology," STI Review, Special Issue, OECD, 1998.
[7] The Conference Board of Canada. (2000). Collaborating For Innovation, 2nd Annual Innovation Report, 303-00 Detailed Findings. Canada, p. 9.
[8] Ibid., p. 12.
[9] Ibid., p. 9.

- *Countries are placing emphasis on developing networks and collaborative linkages in order to enhance the knowledge diffusion power of their national systems of innovation.*

Collaboration with federal government research labs yields cost-efficient research and development. This involves gaining access to research and development, and sharing costs. Industry is highly interested in partnering with federal government labs. The reasons are primarily due to enhanced access to skills and knowledge base; diverse applied research; management of large-scale projects; collaboration; defined roles and responsibilities; and global scientific relations.[10] Another report[11]put forward five critical characteristics of the future government lab, including: "generator of excellent research; performer of multi-disciplinary research; catalyst of collaborative linkages; flexible/empowered; and committed to long-term research." In a related report,[12] identifying success of a cluster may be contingent upon collaboration, along with the establishment of "informal networks" that help to promote an environment that encourages innovative thinking.

Moreover, building communities to support collaboration has been revealed in a recent report by the Council of Science and Technology Advisors (1999, 25), which states:

> *Science and Technology(S&T) is a global enterprise. S&T performed and funded by the federal government must be tied in with other activities within the federal government, with the other sectors in the Canadian innovation system (universities and the private sector), and with the global pool of knowledge and technology. These linkages ensure that federal performance of S&T capitalizes on the best available inputs, regardless of their source, and that overlap and duplication are minimized.*

The Canadian federal and provincial governments have initiated several mechanisms for fostering multi-stakeholder collaboration. These venues or mechanisms are designed to assist companies in the innovation process—to help build "multi-stakeholder collaboration" across Canada, including[13]:

- *Networks of Centres of Excellence (NCEs)—Growing Private-Public Sector Science Relationships*
- *Canada Foundation for Innovation (CFI)—Building Innovation Through Science Infrastructure*
- *Ontario Centres of Excellence(OCEs)—Cultivating Innovation at the Small Firm Level*
- *TRLABS—Leveraging Multi-Partner Collaboration*
- *Canada-Israel Industrial R&D Foundation—An Innovative Service for Entrepreneurial Firms Seeking International Partners*
- *Connecting Partners in Geomatics*

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[10] Ibid., p.25.
[11] The Conference Board of Canada. (1999). *Government Research Laboratories: Finding the Right Chemistry for the Future*, by Jacek Warda (Ottawa, 1999).
[12] The Conference Board of Canada. (1997). *What Makes Technopoles Tick?* Janusz Zieminski and Jacek Warda, Members' Briefing, 219-97 (Ottawa, 1997).
[13] The Conference Board of Canada. (2000). *Collaborating For Innovation*, 2nd Annual Innovation Report, 303-00, Detailed Findings. Canada.

Similarly, the Council of Science and Technology Advisors (CSTA, 1999) states that Canada's innovation system is based on the "knowledge needed for a progressive society and economy." According to CSTA, participation with governments, the private sector and universities, and science and technology institutions (including their linkages) will allow Canada's innovation system to continue to excel in the Canadian innovation process. Intensified global competition will increase as a result of collaboration with both public sector and private industry. As a result, the science and technology community is increasingly discovering the importance of implementing collaborative strategies to enhance community dynamics in leveraging science and technology knowledge.

3 Community Dynamics in Leveraging Science and Technology Knowledge

Identifying potential communities of practice has been regarded as an integral element to the development of an organization's core competencies. Communities of practice, communities of interest or communities of knowledge involve groups that share certain types of knowledge, information, interests or expertise—forming communities that engage in collective learning through social practices. Wenger (1999a, 1) defines these communities as "communities that accumulate collective learning into social practices." Wenger and Snyder (1999, 1) state that communities of practice are "groups of people informally bound together by shared expertise and passion for a joint enterprise." Moreover, Amidon (1997, 49) complements the above definitions by putting forward the following mission of *communities of knowledge practice*: "Harnessing complementary competencies with a shared purpose toward a common strategic vision."

Community dynamics are evidenced through the development of common interests in particular issues or areas of study. According to Leif Edvinsson, *"knowledge capital doesn't sit in the company. Knowledge is important from other companies or communities. The migration is much more important than management"* (APQC 2000d, 9). Hence, knowledge migration. The importance of stewarding knowledge through communities of practice or collaborative work teams is helping organizations develop their core roles and work practices. Wenger and Snyder (1999, 5) put forward the following example in identifying potential communities of practice:

> *At Shell, a potential community leader joins forces with a consultant and interviews prospective members. They look at challenges and problems that people across units and teams have in common and that would thus serve as bases for a community of practice. After laying the groundwork, the co-ordinator calls the community of practice together, and the group begins discussing plans for activities that will build individual and group capabilities and advance the company's strategic agenda.*

Federal departments, agencies and private industry are increasingly examining the prospects of implementing communities of practice into their everyday work practices. These communities of practice are helping companies and organizations by supporting and promoting collaborative venues for enhancing individual and organizational knowledge. Several examples include:

- *CIO Council—US Federal Government*: The CIO Council has formed a knowledge management working group to examine the interrelation of culture, process and technology. This working group functions as a community of

practice—offering meetings and collaborative facilities and archived resources to special interest groups.[14]

- *Buckman Labs:* Members of communities of practice from across the globe respond to practice-specific queries within 24 hours.[15]
- *Xerox:* The creation of advanced development technology centres allow the organization to bridge the gaps between research and the business community. This is reflected in the company's definition of communities of practice.[16]
- *Analog Devices:* Ray Stata, CEO and Chairman of Analog, encourages the development of a "community of inquirers", encouraging employees to understand and leverage each other's knowledge, skills, experience and ideas.[17]
- *Shell:* Shell has put forward a community-development toolkit which guides communities through successive life stages.[18]
- *DaimlerChrysler:* DaimlerChrysler has engineering communities of practice, called "Tech Clubs", which bring together specialists in specific subsystems (e.g., brakes or seats). These communities of practice discuss issues, co-ordinate efforts, document engineering practices and lessons learned, maintain relationships with vendors, make recommendations to purchasing and work closely with training and competitive teardown.[19]
- *Siemens Business Services:* Siemens is focusing on creating a supra-culture of virtual communities and is maintaining these communities of practice. To date, employees have been gaining experience through technical communities, learning networks and interest groups. Through the process of creating and building communities, the company has been focusing on creating common processes for knowledge creation, knowledge sharing, and incentives and rewards for people to adopt new behaviours.[20]
- *Intel Corp:* Intel Corp employs communities of interest or communities of practice for implementing knowledge sharing activities. [21]
- *Dofasco Inc.:* Dofasco developed a communities of practice model and framework (DCOP). It focuses on organizations and roles, modes of interaction, IT technology, participation and culture, communication, rewards and recognition with human resources involvement and sponsorship. The DCOP helps to promote and sustain a learning environment.[22]

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[14] See Mary Eisenhart. (2001). "Washington's Need to Know: Faced with downsizing and the retirement of half its workforce, the US government turns to KM." Destination CRM.com. Knowledge Management Magazine. Web site: http://www.destinationcrm.com/km/dcrm_km_article.asp?id=658. January 2001.

[15] Ibid.

[16] See Bob Bauer (1999), "Turning Knowledge into Innovation", in Rudy Ruggles and Dan Holtshouse (Eds.), *The Knowledge Advantage*, pp. 96-97.

[17] See Debra Amidon (1997), *Innovation Strategy for the Knowledge Economy: The Ken Awakening*, pp. 68-72, for a more thorough review of Analog Devices.

[18] Etienne Wenger. (1999a). *Communities of Practice: The Key to Knowledge Strategy.* Paper. p. 8.

[19] Ibid., p. 13.

[20] Anne Jubert. (1999). "Developing an infrastructure for communities of practice: The Siemens Experience." *Proceedings of the International Online Information Meeting*, Vol. 23, pp. 165-168.

[21] See Peter Ruber. 2000. "Extended Enterprise". Knowledge Management Magazine. Destination CRM.com. March. URL: http://www.destinationcrm.com/km/dcrm_km_article.asp?id=250&ed=3%2F1%2F00.

[22] Presentation given by Victor Tychowsky, Project Manager with Dofasco on "Building Knowledge-Based Strategies." 2001 Knowledge Conference: Building and Managing Your Organization's Destiny." May 1, The Hilton Toronto (May 1-2). Offered by the Conference Board of Canada and sponsored by the National Research Council Canada 2001.

- *Interdepartmental Knowledge Management Forum (IKMF)*: The Canadian Interdepartmental Knowledge Management Forum focuses on "understanding and applying new and emerging issues of knowledge management within the public sector."[23] This Forum engages public service employees to discuss some of the important and current issues in knowledge management within the Canadian federal government. They bring to the Forum various perspectives and come from diverse backgrounds (e.g., science and technology, health, human resources).

Communities of practice or communities of interest can be found within businesses, across business units, across institutional boundaries and across multiple organizations.[24] For example, *www.knexa.com* is pushing the way for the "commercial exchange of ideas and information [through the Internet] by giving buyers and sellers an opportunity to set a fair market value on knowledge assets." [25] These communities of practice and communities of interest continue to be regarded as integral elements to successful knowledge leveraging. In achieving successful communities of practice, McDermott (1999)[26] outlines the following critical success factors, including:

- *The Management Challenge:* This involves taking into account topics important to the business and community members; finding a well-respected community coordinator; ensuring that people have the time and encouragement to participate in the community; and building on the core values of the organization.
- *The Community Challenge:* This involves getting key thought leaders involved in the process; developing personal relationships among community members; developing an active passionate core group; and creating forums for thinking as a community, including systems for sharing information.
- *The Technical Challenge:* This involves establishing easy access to the community's knowledge and practices.
- *The Personal Challenge:* This involves engaging people in cutting edge issues through real dialogue.

4 Leveraging Science and Technology Knowledge—Sector Perspectives

By bringing people, ideas and technology together, science and technology organizations are increasingly realizing the importance of engaging in collaborative discussions with their global counterparts to advance business products and services. According to David Skyrme Associates (2000), there are three interrelated driving forces that are having an impact on the rules of business and national competitiveness: globalization, information/knowledge intensity, and networking and connectivity. From a global standpoint, markets, products and resourcing are becoming more internationally focused. Information and knowledge intensity are becoming more contingent upon information and know-how which in turn impact on the efficiency of production. Networking and connectivity, as demonstrated through the Internet, have opened the doors to a new "global village". These elements are descriptive of leading

[23] Interdepartmental Knowledge Management Forum (IKMF). Terms of Reference (draft). January 31, 2001.
[24] Wenger, Etienne. (1999b). *Communities of Practice: Stewarding Knowledge*. November 6, 1999, pp. 1-17.
[25] See www.knexa.com for more information.
[26] Ibid.

science and technology organizations—those that are compelled to be creative, innovative and a leader in competitive intelligence.

Under the American Productivity and Quality Center (APQC 2000b), the Society of Competitive Intelligence Professionals conducted a study on *Using S&T Intelligence to Drive Business Outcomes*. In a conference call setting, participants discussed four critical areas, including: 'justifying the role of science and technology intelligence in driving business results; identifying the processes and techniques for collecting, prioritizing and utilizing science and technology information across the organization; storing technology intelligence and facilitating its distribution; and measuring and analyzing successful science and technology intelligence programs.'[27] The main objective of this benchmarking study was to try to unveil the importance of understanding competitive science and technology intelligence. The focus is on answering the following questions: "*Who is working on technologies that could benefit us? How might we access them? Which of our key technologies are maturing? What will replace them?*"[28]

The complexities of employing collaborative strategies are contingent upon the needs of organizations as well as the sectors in which organizations are engaged in the leveraging of science and technology knowledge. In Canada, the Federal Partners in Technology Transfer (FPTT) focus on building "partnerships and collaborations that support national technology and knowledge transfer, foster innovation, respond to national strategic issues, and bolster the development of Canada's professional S&T capacity."[29] Within FPTT, there are 15 departments and agencies that make up the scope of federal science and technology activity, 'saving time and money in developing more effective ways of managing and exploiting research and development.' To illustrate the importance of fostering innovation through collaboration, several examples of collaborative knowledge strategies have been put forward in this paper. These examples unveil how some science and technology organizations are engaging in the collaborative innovation process, and are evidenced within the following sectors: defence, communications, oil, health, chemical and electrical.

Defence—National and International Perspectives

Defence Research and Development Canada (Department of National Defence)—Canada

In fulfilling the Canadian Defence mission—*to defend Canada and Canadian interests and values while contributing to international peace and security*—the Department of National Defence (DND) and the Canadian Forces (CF) have put forward a key document, *Shaping the Future of the Canadian Forces: A Strategy for 2020*, focusing on Defence's long-term objectives and short-term targets for the future. The CF of the future must be able to deal with a wide Spectrum of Conflict, respond to the changing nature of Coalition Operations and provide assured protection against Asymmetric Threats.[30] This Defence Strategy also requires resources for enhanced collaboration with our allies to facilitate

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[27] American Productivity and Quality Center. (2000b). *Using Science and Technology Intelligence to Drive Business Outcomes.* Conference Call Materials. Web site: http://www.apqc.org/proposal/6580ci/. September 28, 2000.
[28] Ibid.
[29] Federal Partners in Technology Transfer. *Report on Activities. Annual Report 1999-2000*. P. 1. Cat. No.: NR16-53/2000E, ISBN: 0-662-29106-9.
[30] Defence R&D Canada. (2000a). *Increasing Demand for Science and Technology for National Security and Defence*, Directorate of Science and Technology Policy, Defence R&D Canada, The

interoperability and to leverage knowledge and expertise.[31] As the principal research and development agency for DND and the CF, Defence R&D Canada is focusing on developing and implementing a *Knowledge Management Strategy* to help leverage knowledge in science and technology. One of its mission elements is to "facilitate and enhance the ability of decision-makers to make informed decisions on defence policy, force generation and procurement by providing expert S&T knowledge."[32] Through its science and technology network (comprised of the CF, DND, research partners, Canadian industrial base, industrial research and development partners and allies), Defence R&D Canada is able to promote synergistic and strategic partnering in capturing and using science and technology knowledge for input to defence policies and strategies. As part of Defence R&D Canada's Technology Outlook Thrust, this Knowledge Management Strategy will focus on knowledge assets for improving products, services and client relationships which will allow DND and the CF to provide more enhanced strategic advice and services in defence issues. The Strategy will incorporate working groups, seminars, workshops, symposia and fora for exploring the diverging perspectives and synergies in knowledge leveraging initiatives. Forward-thinking groups, such as the Technology Assessment Working Group (TAWG)—whose mandate is to advise how technology and resources of the future research and development program can be aligned to meet the defence research and development needs of DND and the CF—will help to establish closer partnerships in understanding what knowledge should be leveraged and which vehicles would provide the best venues for promoting the latest developments in science and technology.

Within Defence R&D Canada, there are many examples of collaborative research and development. On an international level, The Technical Co-operation Program (TTCP), which is comprised of Australia, New Zealand, UK, U.S and Canada, provides an effective forum for co-operation in a broad range of defence science and technology activities (e.g., Chemical, Biological and Radiological Defence, Aerospace, Knowledge Management). Another example centres around collaboration within the NATO Research and Technology Organization (RTO)—to create a better capability through the synergy of working together on problems as part of a larger team.

In understanding the importance of capturing, using and leveraging science and technology knowledge, Defence R&D Canada is in the process of completing a knowledge audit to determine the knowledge needs of the agency, and how more efficient and effective knowledge processes can be implemented to improve its products and services. This audit will help to form a knowledge management strategy and framework which will allow Defence R&D Canada to envision the importance of knowledge leveraging within the agency as well as with its national partners and international collaborators.

In addition, the Technology Investment Strategy (TIS) incorporates knowledge management as a research and development activity from a warfighter perspective. It defines knowledge management as: "the process of comprehending static and dynamic relationships within and among sets of information and the process of synthesizing models to explain relationships" (Defence R&D Canada, 2000b). The agency's Defence Research Establishment in Valcartier (DREV) is focusing on the 'investigation and advancement of techniques, architecture and

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Department of National Defence. This article focuses on the importance of recognizing the increasing demands of science and technology in fulfilling Defence's long-term vision, focusing on the following implications: new facilities and equipment, increased investment in innovative national programs and enhanced collaboration with our allies.

[31] Ibid., p. 4.

[32] Defence R&D Canada. 1999. ADM(S&T) Business Plan, 2000-2001.

tools that support knowledge creation processes.' Some areas of interest include: the technologies behind collaboration, knowledge capturing, knowledge discovery and advanced visualization. Information and knowledge management will be required in: Machine Learning, Knowledge Modelling, High-Level Data and Information Fusion, Multi-dimensional Spatial and Temporal Data Stores and Organizational Dynamics.

Department of Defense (United States)

The Department of Defense (DoD) has been engaged in the area of knowledge management for several years, with central core initiatives under the auspices of the Information Management division. For example, DoD's Information Management (IM) Strategic Plan supports the DoD corporate-level goals, the Report of the Quadrennial Defense Review (QDR), the Defense Reform Initiative Report (DRIR), and Joint Vision 2010 (JV2010) [33], and is in keeping with its knowledge management initiatives. This Strategic Plan focuses on facilitating the creativity, sharing and management of knowledge. It states that information technology and services alone will not be able to achieve information superiority. By incorporating knowledge management methods and tools, a collaborative culture will help to facilitate creativity and sharing for optimal strategic and tactical decision-making.

Moreover, the Army has put forward its *Army Knowledge Online (AKO) Strategic Plan* which "provides a roadmap to achieving knowledge management (KM) competencies in the people, processes, and technical design of the Army institutional elements and operating forces."[34] For the U.S. Army to be able to access job-related and mission-related data, information and knowledge in a timely and accurate manner, the AKO encompasses a Web site with the following features: The Army Home Page; Army Online; The Army Flow Model; The HQDA Data Sharing Initiative; and the AKO KM Implementation and Support functions. The mission of Army Knowledge Online is to: "institutionalize knowledge management into Army culture and processes to achieve a sustaining momentum that will carry it forward through the Army After Next. This will be accomplished through changes in organizational structure, facilities, people, processes and technology" (Department of Defense 1999, 6). The AKO encourages strategic collaboration and promotes a continuous learning environment for its knowledge workers.

The Department of Navy (DON) has spent $30 billion to transfer itself into a knowledge-centric organization.[35] DON has developed a *Knowledge-Centric Organization Toolkit* to help navigate the world for better knowledge. This toolkit focuses on providing "the right information at the right time for decision and action; and learns, collaborates and innovates continuously." The site concentrates on building awareness of the changing world; and the importance of implementing a knowledge management strategy and framework. It focuses on culture, leadership, user needs, relationships, communications, performance measures, and incentives. It also tries to build awareness around knowledge brokering, intermediating and transacting knowledge, building communities of practice, and other critical issues that would impact on the DON's vision and mission.

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[33] Department of Defense (DoD). Chief Information Officer. *Department of Defense—Information Management (IM) Strategic Plan. Information Superiority" (Version 2.0)*. October 1999. URL: http://www.defenselink.mil/dodreform/briefs/itmstpln.doc.

[34] Army Knowledge Online (AKO) Strategic Plan. Version 2.0, p. 1.

[35] Knowledge Management Magazine. January 2001. "Washington's Need to Know: Faced with downsizing and the retirement of half its workforce, the US government turns to KM." Web site: http://www.destinationcrm.com/km/dcrm_km_article.asp?id=658.

The Air Force Center (Randolph Air Force Base, Texas) for Quality and Management Innovation developed and implemented a Web-based best practices and knowledge management clearinghouse.[36] Working smarter to increase efficiency and productivity within the Air Force is the basis for putting forward the clearinghouse. Similarly, the Air Force Knowledge Management Team (Wright Patterson Air Force Base, Ohio) have put together a Web-based knowledge directory and repository—for collecting and sharing "all categories of knowledge to include virtual education and training, consulting resources, lessons learned and best practices, learning histories and other nuggets of knowledge related to a wide variety of product-support business areas, weapons systems, programs and processes."[37]

Finally, the Aerospace Knowledge Diffusion Research Project, under the auspices of the National Aeronautics and Space Administration (NASA) and DoD, have been involved in the area of knowledge diffusion for decades. Pinelli et al (1997) have presented their results of a decade of work, focusing on "multiple aspects of knowledge diffusion—specifically, its production, transfer, and use in the large commercial aircraft sector of the United States aerospace industry, which is a rich source of knowledge, product and process technologies, and sophisticated manufacturing and production techniques."[38] DoD is critical to note that a better understanding is needed on how the knowledge and technology resulting from federally funded research and development expenditures are disseminated at the individual, organizational, national and international levels.

Defence Evaluation and Research Agency—The United Kingdom

Prior to its splitting up into QinetiQ and Defence Science and Technology Laboratory (DSTL), the Defence Evaluation and Research Agency (DERA) played a fundamental role in providing technical services to the Ministry of Defence as well as to non-government and civil markets. It focused on the importance of looking at ways to exploit emerging technology and new practices. As a knowledge-based organization, DERA perceived knowledge management as a significant thrust to their overall program. DERA's definition of knowledge management states that "it is information plus meaning and context able to be combined with other knowledge and put to useful application." [39] Scientists cannot be forced to share knowledge: the "mindsharing" must be personally rewarding and can be carried out through lunch seminars, publications and mentoring. Newsgroups and special interest groups represent important ways to share knowledge.

Table 4-1 puts forward an example of a Wargaming exercise which DERA implemented for knowledge sharing. With the increasing development of complex systems, more emphasis will continue to be placed on modelling and simulation—focusing on the importance of using and reusing models that are more dependent on tacit and contextual knowledge. In addition, globalisation is playing a critical role in the world economy. To be a successful world supplier and to stand up to global competition you have to be world class, and that puts a premium on having superior knowledge, identifying what knowledge really matters, and

[36] Air Force News. (1999a). "Air Force establishes management clearinghouse." 25 Feb 1999. Web site: http://www.af.mil/news/Feb1999/n19990225_990312.html.
[37] Air Force News. (1999b). "AFMC unveils knowledge management Web site." 18 June 1999. Web site: http://www.af.mil/news/Jun1999/n19990618_991200.html.
[38] Defense Technical Information Center (U.S.)
http://www.dtic.mil/share/share2/rtaimc…usion_in_the_US_Aerospace_Industry.html.
[39] Dr. Adrian Mears puts forward his views on *Keeping KM Vital—Winning Mindshare in a Changing Business World.* Defence Evaluation Research Agency. Ministry of Defence, 2000.

using it to get technical and commercial advantage (DERA 2000, 2).[40] The *pace of change* that results from globalisation and from the digital networking revolution implies that knowledge must be shared efficiently and quickly between people who have different viewpoints and possible different languages and perspectives (DERA 2000, 3).[41] *Disintermediation and life-long learning* will continue to be important aspects for organizations, focusing on the need to develop and maintain the competitiveness of individual personal knowledge and skills, with emphasis on life-long learning which will be reflected in the growth of computer-based education and of distance learning over the Internet.[42] *Knowledge intermediation* is coming back (reintermediation); and there are growing opportunities for technical support organizations and consulting firms to act as knowledge intermediaries (e.g., knowledge gatekeepers in research and technology) to assist organizations in helping to understand the complexities behind science and technology knowledge.

[40] Ibid.
[41] Ibid.
[42] Ibid.

Table 4-1—Mindsharing in Wargaming (DERA)[43] *(reprinted with permission)*

Wargaming is part of the process of understanding how warfare may evolve and how technology, security threats, politics, international structures, military doctrine and other factors may affect defence and security in the timeframe up to 2030. It requires creative and imaginative sharing of knowledge between military staff, defence analysts, scientists and engineers.

DERA staff provided the scientific and engineering input to the wargame. The game itself was played at a location remote from the DERA team by military staff and defence analysts. The DERA team was spread across all of DERA's major sites: England, Scotland and Wales, and any of DERA's staff were free to take part if they had relevant knowledge to contribute. Everything was conducted in real time. Questions concerning technical feasibility….were passed through two moderators, one overseeing the wargame and framing the questions, and the other in DERA. Questions [were] passed to selected senior experts and at the same time posted onto the wargame newsgroup [DERA intranet]. All of the questions had a time limit for responding [20 to 45 minutes] and [were] dictated by the pace of the game.

The existence of the Wargaming newsgroup were merely posted each day under "what's new" on the DERA intranet. Word quickly spread among relevant DERA staff and many contributed their knowledge, often over their lunch breaks and in the evenings adding further ideas to the answers already given. These inputs from the wider knowledge community across DERA proved a good source of lateral thinking and cross-disciplinary ideas. They typically started "I am not an expert on this topic, but an idea might be…" . This participation was spontaneous and self-organising, and it is still continuing as the "community of virtual war veterans" continue to throw in further ideas. These ideas are being collected by the moderators and contribute to their thinking about the implications of the game's outcome.

The example demonstrates the importance of making mindsharing fun, purposeful, rewarding and interesting. The fact that the wargame was providing a serious input to MOD's thinking created the sense of purpose. The diversity and unpredictability of the questions created the interest, as did the replies. The fact that the wargamers were very responsive to the replies and strongly associated the inputs added to the reward. The need to reply within the tight timescales and the fact that the replies were critical to the outcome of the combat created an intensity and real-time excitement.

The two moderators acted as the funnel through which all the information flowed, articulating and posting the questions in a suitable sanitised form on the newsgroup and by e-mail, and ensuring that activities kept to the deadlines. When the day's game had ended, the DERA moderator posted the day's output [onto] the newsgroup, with a forecast of topics likely to come up the following day. During the day, she built a rapport with the contributors and this has encouraged the continuing flow of ideas.

A major wargame, such as this, provides a particularly stimulating context for mindsharing, but it is an approach that can be used more generally to couple knowledge into any application context. Mindsharing, established as a regular activity, can motivate other knowledge processes. In DERA's context this means giving greater purpose to technology watching, encouraging staff to think more imaginatively about how technology can be applied and how it can be coupled with other technology, encouraging people to capture knowledge in explicit form so that they easily insert it into future events.

[43] Dr. Adrian Mears puts forward his views on *Keeping KM Vital—Winning Mindshare in a Changing Business World.*. Defence Evaluation Research Agency (DERA). Ministry of Defence, 2000, p. 9-10. Reprinted with permission from Dr. Adrian Mears.

Communications

The field of communications has been engaging in knowledge leveraging initiatives in the new global knowledge economy. Communications Research Centre Canada (CRC), an agency of Industry Canada, is the leading federal government laboratory for research and development on advanced communications technologies and systems.[44] The CRC Innovation Centre gives start-up companies the ability to test their wings by having access to their technologies, research and development expertise and CRC's facilities. Their vision statement reflects their dynamic organization: "National leadership in collaborative research and development on innovative communications, broadcasting and information technologies for a strong Canadian knowledge-based economy."[45] CRC focuses on management teams which provide expertise in 'high-speed networks, interface tools, and pedagogy to support the advancement of knowledge management and collaborative learning and knowledge management applications over advanced networks'.[46] For instance, CRC is collaborating with the National Research Council (NRC) in a Virtual Classroom Project, as part of the Global Interoperability for Broadband Networks (GIBN) project.[47] According to CRC, "the program serves as a collaborative national and international testbed for researchers, corporate partners, educators and students in multiple sites to interact and support each other's learning through the use of broadband ATM/IP protocols over terrestrial, wireless, optical and satellite links."[48]

Another example involves the collaboration between CRC and NRC in CANARIE LearnCanada project, where its mission is to "leverage the potential of CA*Net3 to develop a broadband interactive virtual learning community for Canadian K-12 educators….With access to advanced networks and tools, members of the community will collaborate in developing the requisite pedagogical expertise to migrate to an innovative learning culture that will sustain and enhance Canada's position within the global knowledge economy."[49]

Nortel Networks, a global leader in networking and communications, employs knowledge management business processes to improve their products and services. Nortel has implemented a collaborative knowledge management software called Livelink to help meet their business objectives.[50] Livelink is used internationally, across all Nortel departments: Europe, North America, Asia and South America. Nortel also has chartered the Global Knowledge Council to further promote knowledge sharing and collaboration.

Nokia Telecommunications is taking on a knowledge transfer business strategy to change the "hierarchical organization to a network-based learning organization, focusing on the following: global efficiency and effectiveness, learning across organizational boundaries, and local flexibility and responsiveness,"[51] according to the International Knowledge Management Newsletter (1999).

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[44] Communications Research Centre (CRC) Annual Report 1999-2000. Pamphlet on the Innovation Centre.
[45] Ibid.
[46] CRC Web site: http://www.crc.ca/?d=research/network/system_apps/virtualclassroom_e.
[47] Ibid.
[48] For further discussion of the program, see CRC Web site: http://www.crc.ca/?d=research/network/system_apps/virtualclassroom_e.
[49] CRC Web site: http://www.learncanada.ca/summary./html.
[50] Business Wire. December 15, 1998, Waterloo, Ontario.
[51] The International Knowledge Management Newsletter. "Knowledge Transfer: Nokia Telecommunications Approach to KM". URL: http://www.mjm.co.uk/knowledge/nokia.html.

Hughes Space and Communications (HSC), a United States subsidiary of Hughes Electronics, represents another example of a knowledge management program designed to support its strategic direction.[52] As the world's largest producer of commercial communications satellites, Hughes Space and Communications is able to bring forward technological innovation by managing its intellectual capital. By moving away from "knowledge silos", HSC reengineered its satellite development and design process into an Integrated Satellite Factory. This Integrated Satellite Factory was designed around communities of practice, *groups of people informally bound together by shared expertise and passion for a joint enterprise*.[53] HSC supports the communities of practice by promoting knowledge-sharing processes such as collaborative conversations, providing collaborative technologies such as GroupWare and desktop video conferencing, and developing new support roles such as knowledge stewards, communities of practice facilitators and boundary spanners.[54]

Oil

Oil companies seem to be at the forefront of applying knowledge management systems.[55] The oil business is considered to be knowledge-focused, especially in its exploration, refining and retailing components. The setting up of communities of practice is becoming increasingly important to the successful sharing of knowledge among practitioners around the world. Communities of practice are very popular and effective on the exploration side of the spectrum, including drilling, geology and geophysics. John Keeble of Enterprise Oil states: "Since our success is built on the ability of our highly qualified staff to identify potential oil fields which may lie thousands of feet below the surface, and in ever-increasing water-depths, making the most of the knowledge and skills of those staff is a key priority."[56] The communities of practice communicate via electronic discussion groups, conferences and community meetings. For example, Shell exploration has grown into a global network, establishing a number of global community networks that are depicted as the guardians of corporate knowledge. Shell's learning centre is a major driving force for knowledge management and organisational learning within the company, and provides support for the communities of practice (Milton 2000, 16). Shell Oil has also purchased Ford Motor Company's Best Practice Replications System, and is aligning their "Pearls" system for the development of oil and gas explorations. Table 4-2 puts forward Shell Oil's example of implementing communities of practice, demonstrating how communities of practice focus on solving technical problems in a collaborative manner.

[52] Ramona Dzinkowski. (1999). Mining Intellectual Capital. Strategic Finance. 81, 4, 42.
[53] See Wenger and Snyder (1991).
[54] Ramona Dzinkowski. (1999). Mining Intellectual Capital. Strategic Finance. 81, 4, 42.
[55] Nick Milton. (2000). Why are the oil companies so far ahead in knowledge management?" In, *Knowledge Management Magazine*, September.
[56] Ibid.

Table 4-2—Shell's Communities of Practice[57]

Communities frequently link people with a common interest who do not have regular day-to-day contact. For example, in Shell Oil's New Orleans operation, communities link people who work on different teams. In this double knit organization, teams are the core organizational structure. Communities form around technical disciplines and topics that draw people from many teams. Each community operates in its own way, but the Turbodudes community is fairly typical. The Turbodudes draw people from different disciplines (geology, geophysics, petrophysics, reservoir engineering) who are interested in a particular kind of geological structure common in the Gulf of Mexico, turbidites. The Turbodudes stay together through five key components: a coordinator, mentors, a weekly meeting, presentations by outside vendors, and a website that stores topics discussed at previous meetings. For the last two years, the Turbodudes have met every Tuesday at 7:30 in the morning, before the other organizational meetings begin. Typically twenty to forty people come to the meetings. While there are often many new faces at the meetings, there is a core group of ten high-contributors who make most of the meetings. The meetings seem very informal. The coordinator asks who has a question or problem. After a short presentation, others offer their observations, describing the logic or assumptions they made in formulating those observations. A technical specialist takes notes on her computer. The following day, meeting notes are posted on the community's website. While the meeting only lasts an hour, people often leave in small groups hotly engaged in discussions of the meeting's topic. But these meetings are not as informal as they seem. Between meetings, the coordinator "walks the halls" connecting people with others who share similar concerns, following up on the meetings topics, and finding topics for the next meeting. To keep discussions focused on cutting edge topics and to keep senior community leaders engaged, the community developed a mentorship program for people new to the field. The mentorship program provides an avenue for basic questions and distributes the job of educating new community members *(Richard McDermott 2000)*.

Setting up expertise databases or repositories, such as a yellow pages directory system, has also become popular in large organizations. For instance, Texaco, a leader in these systems, has set up its PeopleNet system, which allows for the creation of linkages among people on their knowledge and activities, thereby developing public and private profiles of each user. Collaboration technologies, such as the email, intranet and Internet systems, have contributed to connecting people within communities of practice.

Moreover, the story of the British Petroleum (BP) 'virtual teamwork' project shows how desktop videoconferencing was used to bring global knowledge and skills to bear on local problems.[58] Kent Greenes, head of knowledge management at BP, emphasizes the need for

[57] Richard McDermott, Ph.D. (2000). Knowing in Community: 10 Critical Success Factors in Building Communities of Practice. Web site URL: http://www.co-I-l.com/coil/knowledge-garden/cop/knowing.shtml. Reprinted with permission from Richard McDermott and IHRIM Journal. Original Citation: "Knowing in Community: Ten Critical Factors for Community Success." *IHRIM Journal*. March. Vol. 4, Number 1 (2000).

[58] Nick Milton. (2000). Why are the oil companies so far ahead in knowledge management?", In, *Knowledge Management Magazine*, September, p. 17.

people to use knowledge to conduct work better, quicker, cheaper and easier.[59] BP refineries has a portal known as *Olympus*, allowing and encouraging refinery engineers instant access to reference materials, best practices and to communities of practice.[60]

Chevron Corporation, one of the world's largest integrated petroleum companies,[61] is highly acknowledged for its knowledge management achievements in best-practice sharing systems. Ken Derr, the Chairman and CEO of Chevron states: "every day that a better idea goes unused is a lost opportunity…we have to share more, and we have to share faster."[62]Chevron engages in benchmarking activities to assess where the best practices lie, both internally as well as externally. A Best Practice Resource Map was developed to demonstrate where the corporate knowledge lies within the organization. Best practice teams and networks of practitioners have been implemented as knowledge sharing mechanisms (along with a best practices database).

According to Milton (2000), the oil and gas industry has also been involved in an industry-wide knowledge exchange forum, known as PIKME—the Petroleum Information and Knowledge Management Exchange. This forum focuses on exchanging best practices and sustaining communities of practice. The knowledge exchange forum focuses on the impact of e-commerce on the general direction of the industry. Milton (2000, 18) concludes:

> *The major benefit that knowledge management has given oil companies is 'protecting the base'—oil company jargon for maintaining and improving the core business. This focus is on reducing capital and operating costs, increasing utilisation and up time, and improving market positioning. Knowledge is captured and shared about topics such as increasing success in finding oil fields, reducing maintenance down-time in oil refineries, and increasing the speed of build of gas stations.*

Health

Health Canada has put forward its "Vision and Strategy for Knowledge Management and Information Management/Information Technology (IM/IT)." In developing this vision and strategy, the Information, Analysis and Connectivity Branch within Health Canada has incorporated knowledge management as a departmental strategy to ensure that knowledge and information related to health are captured, used and disseminated to improve the health of Canadians. Health Canada focuses on analyzing, creating, sharing and using knowledge to maintain and improve the health of Canadians (Health Canada, 2000). Scientists are able to plug into the most up-to-date information, thereby creating a more productive and efficient working environment for its department.

In addition, Health Canada, in conjunction with the Institute for Intellectual Capital Research (McMaster University), is engaged in a pilot event, focusing on leveraging the federal

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[59] David Skyrme Associates (1999) provides an overview of the IQPC findings on virtual laboratories within the R&D environment. See his web site: URL: http://www.skyrme.com./updates/u17.htm as well as links to IQPC web site.

[60] Nick Milton. (2000). Why are the oil companies so far ahead in knowledge management?", In, *Knowledge Management Magazine*, September.

[61] Chevron Corporation. 2001. Web Site: URL: http://www.chevron.com/about/frame.html.

[62] Nick Milton. (2000). Why are the oil companies so far ahead in knowledge management?", In, *Knowledge Management Magazine*, September, p. 17.

government's knowledge through an introductory course in knowledge management and intellectual capital. This course, *Knowledge Management 101*, benefits participants by taking a "step towards the development of a sharing culture where people and their knowledge are valued, shared and mobilized strategically to enhance federal government expertise, innovation and sound human resource practices" (Health Canada, 2000).

Chemical

Dow Chemical has pushed its way into the innovation revolution.[63] Dow Chemical has put forward its CEO Growth Forum, comprised of senior management, focusing on prototypes and new business models, and examining vertical integration options and other growth initiatives. This may be considered to be a form of mining intellectual capital.

Buckman Laboratories, a renowned chemical company for aqueous industrial systems, is highly regarded for its knowledge management practices. The headlines read: *"Buckman Labs makes chemicals—but it sells knowledge. The challenge: invent a way for the global sales force to spend more time with customers and share its brainpower."*[64] One of its main goals is to provide employees with the opportunity to learn about knowledge management through sharing knowledge and through accessing the Knowledge Nurture Web site. Buckman Labs is also adamant about leveraging their employees knowledge through specialized systems for knowledge transfer. Through the Knowledge Transfer Department, Buckman associates use "KNetix"—an interconnected system of knowledge bases for knowledge sharing and collaboration across 80 countries.[65] In addition, Buckman employees work within communities of practice across the globe to respond to practice-specific queries within 24 hours.

Electrical

For General Electric (GE), the focus is on best practices in organizational learning.[66] At the GE training center, every individual is encouraged to uncover best practices from around the world and explore the applicability of these practices to GE. This encouragement helps to remove barriers and promotes the transfer and utilization of knowledge. The goal is to achieve a "boundaryless organization".

Siemens is known as one of the world's leading electronics and electrical engineering companies and a noted electronics systems innovator for the automotive industry.[67] Recently, Siemens has been named one of the world's top 10 Most Admired Knowledge Enterprises.[68] The company is known as a "Corporate Knowledge Management organization" and more than 150 knowledge management projects worldwide. ShareNet, is the most significant, "linking 13,000 telecommunications sales and marketing experts in more than 80 countries." ShareNet is a Web site that allows employees to store and share information to allow their

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[63] Ramona Dzinkowski. (1999). Mining Intellectual Capital. Strategic Finance. 81, 4, 42.
[64] The Magazine. "Buckman Labs is Nothing but Net." June, 1996.
http://www.fastcompany.com/online/03/buckman.html.
[65] Buckman Laboratories International. See Web site:
http://www.bus.utexas.edu/kmrg/Team305/buckman.html
[66] Ibid.
[67] Siemens News Release. June 15 2001. *Siemens One Of 10 Most Admired Knowledge Enterprises Named To MAKE Hall Of Fame For World Class Knowledge Management.*
http://media.siemensauto.com/mediacenter2/queries/releasefull.phtml?prjob_num=1349.
[68] Ibid.

sales and service employees to collaborate more efficiently and effectively throughout the world.

In summary, these examples demonstrate the importance for science and technology organizations to employ collaborative strategies for leveraging corporate knowledge to advance business products and services—the new "Innovation Superhighway."[69] In understanding the growth of knowledge economies, science and technology organizations are moving towards the globalization of knowledge—the new global knowledge economy.[70] Creating a cross-cultural knowledge paradigm is key to innovative thinking, and is integral to understanding the dynamics and interlocking relationships of the knowledge worker, the knowledge infrastructure and knowledge processing technologies.

5 The Role of Information Management and Collaborative Technologies for Leveraging Knowledge

Many organizations are marrying information management to knowledge management, realizing the interplay between these strategic management processes. There is a distinction, however, between these two processes. According to a special report on knowledge management marketing, "KM differs from information management by seeking to:

- *Add value for users through synthesising, interpreting and filtering content and keeping it up to date—rather than simply delivering information;*
- *Incorporate on-going user contribution and feedback—rather than providing a one-way transfer of information; and*
- *Support improvements and innovation—rather than the existing operations."*[71]

Although knowledge management differs from information management, it is integral to note that information management does play an important role in the development of knowledge leveraging initiatives. For example, attaining access to key documents for the further advancement of knowledge in a particular subject area is important for organizations. Gaining access to expertise databases can also benefit organizational workers in problem-solving exercises. Thus, the role of effective information management practices needs to be examined and aligned with advancing knowledge leveraging strategies.

5.1 Collaborative Tools and Technologies

Technology is depicted as an enabler, allowing individuals to capture, share, transfer and leverage their knowledge within and across organizations. With the advent of advanced computer technology (e.g., intranet, Internet and extranet), people within organizations are able to share and leverage their knowledge more effectively, efficiently and rapidly than ever before. For instance, the Internet is being recognized as an important tool and mechanism for collaboration in research (e.g., genetics and molecular biology; biotechnology; nanotechnology). Yet, search engine technology is becoming more of a challenge for easy

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[69] See Debra Amidon discussion on "the new global knowledge economy." 13 UPDATE / ENTOVATION International News, Issue No. 49, March 2001. See Web site: http://www.skyrme.com.

[70] See Debra Amidon discussion on "the new global knowledge economy." 13 UPDATE / ENTOVATION International News, Issue No. 49, March 2001. See Web site: http://www.skyrme.com.

[71] Knowledge Management. December/January 2001. "KM strikes a marketing nerve." pp. 30-31.

search retrieval for the scientific community. According to *The State of the Knowledge Industry Progress Report / Government 2000* (SKIPR-Gov 2000), technologies at the centre of a knowledge management strategy include: Data Warehousing/Decision Support; Data Mining; Search Engine / Workflow / Document Management; E-mail/Messaging; Collaborative Computing; Video-conferencing; and Web Technologies. The Report supports the notion that technology is an enabler in knowledge management; however, it cannot be seen as a stand alone in providing a knowledge management solution for leveraging tacit knowledge.

The American Productivity and Quality Center (2000c) outlines several information technology tools and applications used to encourage knowledge leveraging, including: structured document repositories (e.g., databases), discussion databases, directories of expertise and information and knowledge transfer through documentation exchange and video infrastructure (e.g., emails, videoconferencing).[72] Technologies used for databases, directories, emails, videos and video-conferencing all play significant roles in leveraging knowledge. Interactive technologies (i.e., electronic communications) are very beneficial in capturing the day-to-day information necessary for the collaborative transfer of knowledge. It is important to understand, however, how technologies are mapped against the applications of knowledge management. For instance, emails can provide valuable information, and thereby, enhance knowledge; however, many organizations do not have more functional email systems set up to filter out irrelevant information. On the other hand, virtual working environments are continuing to be promoted and supported by organizations to encourage global collaboration among knowledge workers.

There are several examples of collaborative tools and technologies that are being employed within organizations for enhancing organizational knowledge. These examples focus on business directories, virtual laboratories, virtual information networks, ShareNets, and Technology Watch.

Business Directories: There are several business directories that assist organizations in identifying expertise, information and knowledge within organizations, including: Yellow Pages (expertise indexing), White Pages (employees), knowledge mapping and other related repositories. These business directories enable workers to leverage their knowledge by locating experts and communicating with them to further advance organizational knowledge. For example, *Strategis*, Canada's largest Web-based business directory, has the most up-to-date information on specific industries, export opportunities, company capabilities (profiles of 50,000 companies), international intelligence and business contacts, new technologies and processes (35,000 licensable technologies from more than 40 countries), management experts, market services, government programs, micro-economic research, statistical data and much more.[73]

Virtual Laboratories: A virtual laboratory can be defined as "a heterogeneous, distributed problem-solving environment that enables a group of researchers located around the world to work together on a common set of projects" (Internet 2 2001).[74] Virtual laboratories offer

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[72] American Productivity and Quality Centre. (2000c). "Knowledge Management: Making it Work." See APQC for a complete review of information technologies, pp. 33-40.
[73] Canada Science and Technology, Related Web Sites: http://www.ta.doc.gov/itp/can/RSTS.HTM.
[74] See *Internet 2* for a more thorough understanding of virtual laboratories. http://www.internet2.edu/html/virtual_laboratory.html. Internet2 is a group of more than 180 universities that are collaborating with industry and government for advancing network applications and technologies.

virtual learning environments and focus on real-time knowledge sharing, resource sharing, and problem-solving.

At a recent International Quality and Productivity Centre (IQPC) event in London, England, *Knowledge Management in R&D: Emerging Trends in Innovation Management*, the issue of managing virtual research and development laboratories provided some insights into how R&D laboratories are being transformed through the implementation of advanced technologies.[75] The research findings indicate a move away from centralized to decentralized labs (or business units). "Robustness through diversity" is indicative of engaging in more collaborative functions between organizations and universities (a continuing trend). The world is depicted as the "resource bank for knowledge" with no one single company being able to meet the needs of all organizations. Examples of virtual laboratories can be found in university settings (e.g., VLAB developed at the University of Calgary, Department of Computer Science). Examples of "virtual laboratories in action" include: *Sunshine Engineering*: twenty-four hour project engineering where work is transferred across different time zones; *Bioinformatics*: used in "speeding up the process of drug discovery targeting"; and, *Laboratory Design*: demonstrating how the design of laboratories can enhance creativity and knowledge sharing among employees.[76] Moreover, the NASA Ames Research Center, under the Aviation Systems Division, is currently developing their virtual modelling and simulation laboratory.[77]

Virtual Information Networks: Schlumberger, a company that provides services and products to the petroleum, technology, energy and communication industries, focuses on the following key processes, including: technology watch, vision and road maps, portfolio analysis and concurrent engineering.[78] ClientLink, an internal database linking client needs to joint research initiatives, focuses on balancing needs with solutions. SINet (Schlumberger Information Network) connects 25,000 users at 500 locations in over 55 countries. This database focuses on features that help knowledge sharing (e.g., project archives with project histories, discussions and decisions). The focus is on "What are we doing? Why are we doing this? What have we learned?" This resource enables Schlumberger to generate the knowledge and thereby reduce knowledge drain as a result of people leaving the company.

DuPont is building its collaborative networks by focusing on several important initiatives. Skyrme (1999)[79] summarizes these initiatives in the following:

- *Strategic selection of project—selecting the development method (such as acquisition, in-house or partnership) based on a business-competitive strength matrix.*
- *Selecting partners based on key criteria—world-class competency, commitment, trust, etc.*
- *Matching projects and partners—meshing complementary competencies, matching interests, and in general creating a win-win situation.*

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[75] David Skyrme Associates (1999) provides an overview of the IQPC findings on virtual laboratories within the R&D environment. See his web site: URL: http://www.skyrme.com./updates/u17.htm as well as links to IQPC web site.
[76] David Skyrme Associates (1999) provides an overview of the IQPC findings on virtual laboratories within the R&D environment. See his web site: URL: http://www.skyrme.com./updates/u17.htm as well as links to IQPC web site.
[77] NASA Ames Research Center. http://www.simlabs.arc.nasa.gov/. Simulation Laboratories.
[78] Ibid.
[79] Ibid.

- *Effective project management, with clear understanding of goals.*
- *A strong com-manager (business champion) who sets the pace, respects cultural diversity and has high credibility.*
- *Effective communications and networking, not forgetting the importance of face-to-face communications and local support infrastructures.*

Although DuPont's collaborative virtual research has contributed to new discoveries, as well as time-savings and costs, there are still several challenges which face companies while trying to improve their innovation process. Skyrme (1999)[80] outlines the following challenges:

- *How to shift from a competitive to a collaborative mentality, both externally and internally: "managers did not get where they are by being team players".*
- *How to protect intellectual property when knowledge is shared more freely; preventing leakage of vital knowledge.*
- *Working across different culture, both company and national.*
- *Entry and exit strategies for collaborations.*
- *The blurring of boundaries between companies and between employees, contractors, suppliers and partners.*
- *Using technology effectively, to help people communicate as well as accessing information.*

The Canadian International Development Agency (CIDA) is also committed to the application of knowledge management initiatives, designed to support renewal, knowledge creation, knowledge sharing and knowledge transfer within the Agency—both nationally and internationally. Their focus is based on: "Connecting people to tap into their tacit knowledge, facilitate its flow and create new knowledge—using NETWORKS as their main tool; and creating incentives for learning and knowledge creation and sharing."[81] One of their main challenges is to foster a collaborative environment among their scientists, analysts and development officers who work within the same network.

Agriculture and Agri-Food Canada (AAFC) is also concentrating its efforts on strengthening science and technology linkages through collaborative research and innovation—focusing on the importance of extending information networks to create a more viable knowledge infrastructure.

ShareNets: Bob Turner, Director of the Federal Aviation Administration Team Technology Center (US), is developing a project called ShareNets—"an informal knowledge hub for technical subjects." [82] The objective is to establish a 'network of professionals with shared technical interests, which in turn, will develop a shared knowledge bank.'

Technology Watch: Within the defence community, there is a greater emphasis and reliance on knowing and being aware of the latest, greatest and most applicable technologies. "Technology Watch" is a good example of sharing knowledge. This has been realized by most defence organizations, and is increasingly becoming an essential initiative in many

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[80] Ibid.
[81] CIDA Presentation. Knowledge Management Approach: Presentation to Policy Committee, October 30, 2000.
[82] Knowledge Management. January 2001. "Washington's Need to Know: Faced with downsizing and the retirement of half its workforce, the US government turns to KM." Web site: http://www.destinationcrm.com/km/dcrm_km_article.asp?id=658.

science and technology organizations. Technology Watch is regarded as a process or system for creating awareness of the latest and emerging technologies. It can involve the application of software tools for organizing, accessing, analyzing, interpreting and connecting information across science and technology organizations. Technical and market developments are being observed by more advanced surveillance systems (e.g., Technology Watch systems) and expertise systems. For example, Schlumberger Cambridge Research Limited (SCR) works closely with the marketing and engineering organizations of the Schlumberger Oilfield Services to help define research goals and to solve client problems.[83] They employ a technology watch program aimed at identifying world-class technologies.

The above collaborative tools and technologies are being employed within science and technology organizations, and are considered to be among the main building blocks for advancing knowledge leveraging initiatives and strategies. These collaborative tools and technologies have paved the way to improve knowledge collaboration and have contributed to a more comprehensive understanding of "healthy competition." Although science and technology based organizations are increasingly supporting collaborative environments, many have acknowledged the importance of maintaining intellectual property policies, ensuring that their intellectual assets are protected under the organizational umbrella.

6 Knowledge Collaboration and Intellectual Property

Corporate knowledge has become a leading competitive factor, where knowledge is embedded within information, patents, trademarks, and copyrights (known as intellectual assets or intellectual property) as well as within corporate management systems, customers and human resources.[84] Collaboration, whether conducted one-on-one or within a group, is seen as an effective approach to sharing, using and leveraging knowledge. However, the issue of collaboration and the protection of intellectual property is receiving increased recognition in the new knowledge-based economy. Restrictive intellectual property policies have become major obstacles to collaboration.

In Canada, the Federal Partners in Technology Transfer (FPTT) work diligently on developing common methodologies for managing their intellectual property—enabling departments and agencies to deliver their completed projects to both private and public industries in a timely and effective manner. In 1997, the FPTT put together, *The Guiding Principles on the Management of Intellectual Property*, to help government labs manage their intellectual property. FPTT acknowledge that in a era that encompasses global trade and technology development, taking on a collaborative approach to intellectual property policy makes good sense. A cohesive and workable set of standards governing the broad application of intellectual property is especially necessary as more and more Canadian research institutions engage in joint research and development projects with other nations (FPTT 2000, 18).

A recent report by the Conference Board of Canada, *Collaboration for Innovation*, states:

> *A collaboration agreement has to anticipate the potential for creating intellectual property. All issues with regard to the access, ownership, control and protection of intellectual property need to be discussed and resolved. This also includes arrangements for publication,*

[83] Schlumberger. Web site URL: http://www.slb.com.
[84] Ramona Dzinkowski. (1999). Mining Intellectual Capital. Strategic Finance. 81, 4, 42.

> *confidentiality of information, and identification of the pre-existing intellectual property of each partner. As one company participating in our research said, "Getting adequate intellectual property position is the most important in collaboration—we structure the project this way."*[85]

According to Michael Porter, a leading theorist on business competition: "Companies achieve competitive advantage through acts of innovation [which] always involve investments in skill and knowledge, as well as in physical assets and brand reputation."[86] One form of knowledge that can enhance competitive advantage is called high-value enterprise know-how (Read 1999). High-value know-how refers to those companies that have capabilities and competencies that are long-lasting and difficult to replicate (e.g., Microsoft, Boeing, Toyota). To create this environment, managers must engage in the following competencies:

> *One, management must reach out for knowledge, internally and externally. Two, management should sponsor intellectual exercises, in which ideas are debated and constructive confrontation produces both a flow of new information and support for projects based on that information flow. And, three, management should never accept an organizational design as perfect.*[87]

In sharing one's knowledge assets, we need to focus on "new capitalising contracts around immaterial assets"(APQC 2000c). The focus will be on the need to critically examine the benefits, costs and risks associated with supporting collaborative environments and protecting one's intellectual property. Thus, the issues revolving around intellectual property will continue to impact on organizational policies—focusing on collaboration as a healthy strategic approach to innovation or as an approach that may hinder future collaborative initiatives.

7 Leveraging Knowledge Within the Science and Technology Community—Analytical Overview of Developments and Trends

Knowledge Management will continue to experience rapid growth well into 2004. According to a recent study by Ovum, knowledge management is continuously being incorporated into organizational information technology strategies—predicting a healthy $12.3 billion of the Knowledge Management market share by 2004.[88] In addition, a recent study conducted by Ipsos-Reid and Microsoft Canada Co. reveals that "a majority of Canadian business leaders indicate that knowledge management practices have created value by improving organizational effectiveness, delivering customer value, and improving product innovation

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[85] Conference Board of Canada. (2000). Collaboration for Innovation: 2nd Annual Innovation Report.
[86] William H. Read: *Knowledge as a Strategic Business Resource*. Program on Information Resources Policy: Harvard University, Center for Information Policy Research, Cambridge Massachusetts, January 1999.
[87] William H. Read: *Knowledge as a Strategic Business Resource*. Program on Information Resources Policy: Harvard University, Center for Information Policy Research, Cambridge Massachusetts, January 1999, p. 13.
[88] Knowledge Management. December/January 2001. "KM market still on target for $12.3 billion in 2004", p. 4.

and delivery."[89] Based on 65 per cent of Canadian companies engaged in knowledge management initiatives, "91 per cent agree that knowledge management practices have succeeded in creating value in improving organizational effectiveness; while 88 per cent agree that knowledge management practices have succeeded in delivering customer value."[90]

The future of knowledge-based initiatives within science and technology organizations will be contingent upon the support of government and private industry who will continue to be engaged in national and international collaborative strategies. In Canada, the Advisory Council on Science and Technology outlined in a recent report:[91]

> *For Canada to succeed in the knowledge-based economy, it will require public and private investment in activities to create, maintain and renew knowledge. This includes basic and applied scientific research, innovation, technology transfer and commercialization. Governments must develop policies that encourage private spending on knowledge creation, but we cannot rely on the business sector alone to provide the level of investment required for Canada to gain a competitive advantage.*

The trends in the science and technology community on the development of knowledge investment strategies will undoubtedly have an impact on future business dealings and relationships. According to Intel Corp., it is integral to understand the business practices, culture and organizational changes that businesses will have to face when implementing knowledge management initiatives.[92] Moreover, the top five management consultant firms are moving away from promoting knowledge management as a "separate theme". There seems to be a new generation of knowledge management—a second generation—with a more narrow focus on knowledge management and its relationship to segmented markets and specialized areas such as 'storytelling', [93] and customer relationship management. Also, there still remains some confusion over the terminology "knowledge management;" however, it is important to realize what is intended behind knowledge management. Understanding what works best for enhanced organizational performance will be a significant lever for science and technology organizations. For instance, Milton (2000, 18) states that in the oil industry:

> *Companies may find that they must become partners in know-how beyond their historic experience. They will look to purchase solutions and knowledge-based services rather than to product. Competitive edge will come from managing relationships. The nature of the 'critical knowledge' will change—from 'how to build gas stations in Poland' to 'how to manage relationships in the Polish retail business' for example. Knowledge*

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[89] Microsoft Canada Business. "Knowledge management gives Canadian businesses competitive edge." Mississauga, Ont. March 14, 2001. URL: http://www.microsoft.com/canada/business/kmstudy/ .

[90] Ibid.

[91] Advisory Council on Science and Technology. (2000). S*tepping Up: Skills and Opportunities in the Knowledge Economy.* Report of the Expert Panel on Skills. Presented to The Prime Minister's Advisory Council on Science and Technology, Industry Canada, p. 48.

[92] See Peter Ruber. Knowledge Management Magazine. 2000. "Extended Enterprise". March, 2000. URL: http://www.destinationcrm.com/km/dcrm_km_article.asp?id=250&ed=3%2F1%2F00. Article found through www.knexa.com.

[93] David Skyrme Associates. (2000). *Skyrme Newsletter. 13 Update / Entovation International News No. 46.*

management is a key lever for today's oil companies, it will be a vital component of their survival in the future.

The knowledge infrastructure will continue to encourage the generation of new ideas, creating a knowledge marketplace that survives on innovation and collaboration. Some of the critical issues revolving around knowledge management within the science and technology community will focus on strategies to improve organizational performance. These strategies will be incorporated into varying organizational cultures—all taking into account the fundamental principles behind a healthy knowledge leveraging environment.

Throughout this paper, it has been demonstrated that science and technology organizations are engaging in knowledge leveraging strategies for optimizing organizational performance. There are several emerging issues that continue to dominate the successful employment of these strategies, including: collaborative environment; communities of practice; support tools and technologies for developing new scientific knowledge; organizational learning; and performance measurement/performance management.

7.1 Collaborative Environment

For science and technology organizations, working within a collaborative environment is integral to preserving the innovative and creative mentality of its employees. Cultures that enable best practices, virtual teams, organizational learning and other knowledge leveraging mechanisms and processes are continuously focusing on encouraging innovative thinking for generating new scientific knowledge. As a result, science and technology organizations are focusing on collaborative strategies for augmenting their organizational mechanisms for leveraging knowledge.

Science-based organizations will continue to focus on the knowledge tools and techniques needed for creating a collaborative infrastructure. For example, communities of practice or communities of interest are continuously demonstrating the efficacy of working within networked groups. Moreover, moving away from organizational stovepipes or internal hoarding of information will help to promote knowledge innovation and knowledge sharing across many functional domains. Through the establishment of multidisciplinary teams, organizations will contribute to more effective decision-making and problem-solving processes.

Science and technology organizations are demonstrating that innovation within a collaborative environment will help to further creativity, diligence and value for advancing future science. By sharing and transferring knowledge within a collaborative environment, the science and technology community will be able to better leverage global scientific thought.

7.2 Communities of Practice

An effective strategy for enhanced collaboration involves the building and leveraging of communities of practice. Science and technology organizations are being asked to work with communities to advance their innovative capacities in furthering research and development. These organizations are incorporating communities of practice to further advance innovative strategies. Building closer partnerships between experts from multidisciplinary backgrounds are helping to promote stronger communities. For the most part, science and technology organizations depend on cross-functional teams to solve particular problems, assess different perspectives and forge new ideas and concepts. Connecting scientists, engineers,

management teams to other experts (e.g., anthropologists, sociologists, industrial psychologists) are enhancing the organizational core capabilities in decision-making processes as well as in research and development. People with various backgrounds and interests can help to resolve issues and questions surrounding the effectiveness of new products and technologies.

There are several mechanisms for building and leveraging knowledge. Knowledge Centres and networked organizations, in particular, are being linked to communities of practice, and are being depicted as effective mechanisms for leveraging people's knowledge.

Knowledge Centres: Knowledge Centres are becoming more popular in organizations, and are being connected to communities of practice. David Skyrme Associates (1999) describe an average knowledge centre as having the following feature characteristics: 'being able to identify important knowledge sources internal and external to the organization; obtaining easier information retrieval through catalogues and indexes; maintaining an up-to-date knowledge bank; providing a one-stop shopping; and offering information sources of expertise.'[94] For instance, Ernst & Young consulting firm have developed a *Knowledge Centre* for easier accessibility to information. The focus is on the people, the culture and the processes for sharing knowledge.[95] The development and implementation of communities of interest allow people to share their knowledge across service lines. The staff at Ernst & Young have knowledge available from three main venues: 'direct practice experience, expert knowledge from within communities and external information sources.' The Ernst & Young Online allows its clients to learn more about its projects, initiatives and topics via a Web-based link. Similarly, the U.S. Army Knowledge Online (AKO) Strategic Plan also incorporates the importance of knowledge centres—as a form of communities of practice. According to the U.S. Army, these knowledge centres will exist throughout the Army, which will be supported by elements of Headquarters and the Department of the Army (HQDA) agencies.[96] Knowledge centres will continue to grow in popularity within the scientific community, realizing the importance of tapping into the corporate knowledge bank for scientific excellence.

Networked Organizations: Collaboration via networks may be the way for the 21st century. According to Lipnack and Stamps (1994), networked organizations involve independent people or groups with individual roles who are connected across boundaries to work towards a common purpose with various points of contact. A network allows greater informal conversations to take place both internally and externally. Companies are discovering the importance of implementing collaborative strategies to augment their community dynamics in leveraging science and technology knowledge. These collaborations also involve communities of practice/communities of interest and other similar venues for knowledge leveraging initiatives. Virtual laboratories is another example of how employees and colleagues around the globe can enhance their creativity and knowledge sharing. Thus, the important role of collaboration will continue to be emphasized within the competitive arena, promoting the importance of establishing networks to advance science and technology.

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[94] David Skyrme Associates. 1999. See his section on Knowledge Centres. URL: http://www.skyrme.com./pubs/lawlib99.htm.

[95] Knowledge Management Magazine. "Knowledge Bank? KM is developing fast in the financial services sector"…."Piggy in the middle." UK, October 2000, pp. 14-17.

[96] Army Knowledge Online (AKO) Strategic Plan. Version 2.0, p. 1.

7.3 Support Tools and Technologies for Developing New Scientific Knowledge

Tools and technologies (e.g., knowledge portals, information systems, ShareNets, virtual laboratories) are depicted as enablers to knowledge use, sharing and leveraging. Connecting people through the utilization of tools and technologies is enabling science and technology organizations to further advance their knowledge. Data mining and visualization tools are examples of how technology can assist organizations in advancing the discovery process. The main goal for these tools and technologies is to rejuvenate the existing science into new science.

There are many tools and technologies that are continuing to advance scientific knowledge. Knowledge management tools and technologies concentrate on synergizing know-how with technologies for reconfiguring the existing knowledge into new knowledge. Several examples revolve around collaborative software and systems for communicating and sharing information, including: Web-based file sharing, Web-based learning tools, video conferencing, repositories for best practices and lessons learned, white boards, bulletin boards, data/text mining and visualization tools. These examples illustrate how technology can assist organizations in advancing the knowledge discovery process. These tools provide beneficial results to leveraging knowledge; however, it is important to discern what knowledge needs to be leveraged to maximize organizational communication, sharing and learning.

7.4 Organizational Learning

Issues revolving around human resources development and management are increasingly promoting the importance of investing in organizational social capital. Based on the speech given by the President of the Canadian Centre for Management Development at Technology in Government Week (*October, 1999*), *Serving in the Knowledge Age*: "A commitment to lifelong learning would play a key role in our ability to recruit, retain and develop the talents needed in the Public Service." This commitment:

> *…would consider learning as an essential and critical investment for a knowledge-based organization ….[As knowledge workers, we would] play a key role in keeping our knowledge up-to-date and in expanding our skills…A commitment to lifelong learning would mean creating tools for self-assessment, self-learning, distance learning and a single electronic window for all government-wide training opportunities…Learning is about converting knowledge into know-how. It is a collective undertaking…A commitment to lifelong learning must be supported by a leading-edge knowledge infrastructure…*[97]

Such a commitment can be linked up to several human resources initiatives, including: the development and sustainability of a learning organization; the enhancement of employee skills and competencies; the promotion of rewards and recognition programs; and the implementation of mentorship/protégé programs.

Learning Organizations: For the science and technology community, establishing expertise and know-how is critical to the success of organizational performance and product output.

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[97] Jocelyne Bourgon, President, Canadian Centre for Management Development at Technology in Government Week, Ottawa, Ontario, October 19, 1999. *Serving in the Knowledge Age: A Commitment to Lifelong Learning*. Speech. Canadian Centre for Management Development.

The Deputy Secretary to the Cabinet, Plans and Consultation from the Privy Council Office also acknowledged the importance of the Public Service becoming "a centre of excellence in knowledge of public policy issues.[98] By becoming a learning organization, the Public Service will be able to "better analyze complex issues, develop creative solutions, and manage complex relationships." Learning technologies, such as collaboration software, are considered to be beneficial in helping communities of practice achieve their goals of knowledge sharing. By focusing more on becoming a learning organization, the science and technology community will concentrate further on its intellectual assets to enhance decisions, services and products. As a result, knowledge management complements and enhances other organizational initiatives such as total quality management (TQM), business process re-engineering (BPR) and organizational learning, providing a new and urgent focus to sustain competitive position.[99]

Skills and Competencies: Skills and competencies for the science and technology knowledge worker will be associated with technology integration which will become increasingly valued within organizations (DERA 2000, 6). Working in conjunction with human resources managers will unfold the importance of programs aimed at recognizing the individual employee working within a collaborative environment.

Rewards and Recognition Programs: These programs will incorporate the importance of engaging in knowledge leveraging initiatives. Knowledge sharing may continue to be one of the terms of condition of employment—ensuring the importance of leveraging scientific knowledge. For example, Ernst & Young have incorporated knowledge sharing as part of the terms of condition of employment.[100] As a result, the scientific community will need to explore the importance of rewarding collaborative work within their performance evaluation systems and policies.

Mentorship/Protégé Programs: Companies are starting to examine the benefits of developing and implementing a "mentor-protégé program". A recent article in *Infosystems Executive* (December 2000), entitled: *Grey Zone: A skills shortage notwithstanding, discrimination on the basis of age is becoming a serious problem in the IT Industry*, focuses on the importance of putting together a "mentor-protégé program," where an older worker can put his or her knowledge to good use by sharing it with a younger employee before retiring." With some organizations incorporating orientation programs, mentoring programs are designed to help companies improve the retention of corporate tacit knowledge—to impart the knowledge and wisdom to the next generation of employees (e.g., the new generation of scientists and technicians). Such a mentor-protégé program is extremely valuable and would highly support any knowledge management initiative. Mentorship/ Protégé programs may become more popular within the human resources community, focusing on developing and implementing a program that will help to retain corporate knowledge within the lab environment, industry or government department.

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[98] Samy Watson. Deputy Secretary to the Cabinet, Plans and Consultation, Privy Council Office. "The Learning Organization". *Canadian Government Executive: The Magazine for Canada's Public Sector Decision-Makers*. *Volume 6*, Issue 2, 2000, p.31.

[99] Grey, Denham. "What is Knowledge Management?" The Knowledge Management Forum (1996).

[100] Knowledge Management Magazine. "Knowledge Bank? KM is developing fast in the financial services sector"…."Piggy in the middle." UK, October 2000, pp. 14-17.

7.5 Performance Measurement and Performance Management

By implementing performance measures into a human resources program, science and technology organizations are able to determine the effectiveness of their knowledge management initiatives (e.g., Return on Investment (ROI), value-added knowledge leveraging projects, etc.). This will inevitably impact on the efficacy of organizational performance management. For instance, the Army Knowledge Online (AKO) Strategic Plan incorporates the following measures: Cost Avoidance Measures; AKO Operations Measures, including: AKO Content Growth (e.g., increase in knowledge objects submitted by the pilot community); AKO Community Growth (e.g., increase in registered community members); AKO Usage (e.g., requesting and downloading AKO objects/information); Collaboration via Discussion (e.g., activity level in discussion forums); and Process Measures.[101] Another example revolves around Hughes Space and Communications (HSC)—demonstrating the importance of examining the performance management through the performance measurement of a community of practice. By implementing a community of practice, HSC was able to "eliminate some of the repetition involved in project development and design and thereby reduced costs and cycle times. As a result, customers that were once excluded from purchasing satellites due to high telecommunications market entry costs and long payback periods are now able to seek HSC solutions"[102] more effectively and efficiently.

The *science and technology community* will continue to experience many of the issues surrounding the benefits of investing in knowledge leveraging strategies. As innovators of the future, science and technology organizations will be continuously challenged in creating and establishing innovative business incentives that will create value for their employees and customers. At a recent presentation at the Organisation for Economic Co-operation and Development (OECD) high-level forum on knowledge management, Fortier (2000) stated that "a strategic approach to innovation must play a key role in a productivity agenda." This strategic approach must incorporate: a 'knowledge infrastructure to encourage Canadians to generate new ideas'; a 'commercialization of knowledge to better examine the mechanisms to capture the economic benefits of new ideas'; a 'strategic human resources to develop, train and maintain leading edge human capital'; and 'marketplace strategies to better reflect growing knowledge-based industries.'[103]

By focusing on world-class knowledge leveraging practices, science and technology organizations will be able to capitalize on knowledge superiority to help them fulfil their mission and goals. Companies will continue to focus on the knowledge tools and techniques needed for creating a collaborative infrastructure; however, the future of knowledge management within the scientific community will be contingent upon an organization's strategic direction, leadership, management and culture that will help to advance and exploit knowledge.

The future direction of science and technology will embrace collaborative knowledge investment strategies through boundaryless partnerships. Innovation within a collaborative environment will be nurtured within healthier working environments designed to promote creativity, diligence and value for the future of research and development. Breaking down

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[101] Army Knowledge Online (AKO) Strategic Plan. Version 2.0, pp. 28-30.
[102] Ramona Dzinkowski. (1999). Mining Intellectual Capital. Strategic Finance. 81, 4, 42.
[103] Pierre Fortier, senior advisor at Innovitech, Inc. put forward his *presentation* on the "Commercialization of University Research: A Comparison between the United States and Canada", at the OECD Knowledge Management Seminar, September 22, 2000.

the barriers and eliminating the growth of silos will encourage knowledge innovation and will contribute to our understanding of a knowledge centre of excellence.

A new management paradigm has emerged over the past five years…building a new framework for thinking about what constitutes value in a company—a new framework for growing, extracting, and measuring corporate value that doesn't necessarily rely on revenue flows or tangible assets.[104] This new framework embraces the social capital of knowledge—the knowledge workers. People represent organizational successes, and they are depicted as the drivers—the mover and shakers—of corporate leadership in knowledge innovation and creation. According to Gregory Evanik (1995, 1):

> *Traditional views of organizations with tightly engineered and controlled processes are giving way to alternative views of highly adaptive, flexible and intelligent entities. Networks and alliances are forming and reforming as needs dictate, creating seemingly virtual organizations and people. Technology may fuel the process but it is the human ingredient that is becoming the rate determining step for success: either leading or limiting organizational survival.*

[104] Ramona Dzinkowski. (1999). Mining Intellectual Capital. Strategic Finance. 81, 4, 42.

CONCLUSION

The science and technology community is increasingly realizing the value of leveraging its knowledge assets, and acknowledging the importance of working towards a knowledge investment strategy. In building a knowledge-based enterprise, science and technology organizations are moving towards more innovative knowledge bases and knowledge sharing venues. These knowledge sharing mechanisms and processes have been evidenced within the defence, communications, oil, health, chemical and electrical sectors. For some organizations, knowledge-sharing initiatives have not resolved the issue of intellectual property policies that focus on the safe-guarding of knowledge. However, current intellectual property policies indicate that organizations are examining the importance of engaging in collaborative initiatives with global partners—realizing the implications of remaining competitive in the marketplace. Moreover, the ability to innovate through collaborative ventures is an integral element of organizational performance. Communities of practice and communities of interest are effective mechanisms for knowledge collaboration and innovation. Instilling a collaborative culture will progressively augment the community dynamics in leveraging science and technology knowledge, and will, in turn, contribute to the leadership of excellence in science and technology.

Information management and collaborative tools play important roles in the development of knowledge leveraging initiatives. Information technology is an enabler for capturing, sharing and transferring knowledge within and across organizations; however, technology alone will not address how tacit knowledge is leveraged across organizations. Web-enabled expertise databases/directories have been developed and implemented; however, these repositories need to be supplemented with other forms of knowledge leveraging tools and techniques (e.g., knowledge portals, communities of practice). Virtual laboratories, virtual information networks, ShareNets and other similar knowledge sharing venues are increasingly becoming more popular in the science and technology community—promoting the importance of reconfiguring knowledge into new knowledge through more creative processes and systems.

The future of knowledge-based initiatives within science and technology organizations will be contingent upon the management processes and issues that are integral to promoting knowledge-based enterprises. Emerging themes on the developments and trends of knowledge management within the scientific community focused on collaborative environments; communities of practice; support tools and technologies for developing new scientific knowledge; organizational learning; and performance measurement/performance management of knowledge investment strategies. The analysis demonstrates that knowledge leveraging initiatives and collaborative processes, techniques and tools are being implemented and assessed within science and technology-based organizations, including: communities of practice, networked organizations, knowledge centres, business directories, virtual laboratories, virtual information networks, ShareNets and Technology Watch. Management issues that are addressed, include: learning organization, skills and competencies, rewards and recognition programs and mentorship/protégé programs. These knowledge leveraging initiatives and collaborative processes are helping to advance scientific knowledge and are contributing to knowledge innovation, creation and organizational learning.

Science and technology leadership will continue to embrace a strategic vision that encompasses an investment in science and technology excellence. Although knowledge investment strategies will have a direct impact on future policies and programming outcomes, the value of knowledge leveraging strategies within the science and technology community will continue to be examined with great scrutiny, challenging industry and government departments to become more innovative in their strategies and programs for advancing science. As innovators of the future, science and technology organizations will be increasingly challenged with creating and promoting a

knowledge marketplace that thrives on strategic initiatives and future opportunities for exploiting world science and technology.

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14.ABSTRACT

This paper provides an analytical overview of how science and technology organizations are moving toward knowledge investment strategies in establishing more effective processes and mechanisms for capturing, using and leveraging knowledge. The paper looks at science and technology organizations that are engaging in the implementation of strategic knowledge leveraging initiatives, and focuses on how these organizations are building their knowledge-based enterprises based on collaborative innovation processes. It investigates the role of community dynamics (e.g., communities of practice or communities of interest), and synthesizes how these organizations are involved in the future innovation process. The perspectives on leveraging science and technology knowledge are surveyed, including: defence, communications, oil, health, chemical and electrical sectors. This paper also reports on the imperatives in knowledge innovation (e.g., business intelligence and intellectual property; information management and information technology), and examines the science and technology knowledge-related strategies that are considered to be the most effective in fulfilling future business mandates. Emerging themes on the developments and trends of knowledge management within the scientific community are discussed and analyzed, focusing on: collaborative environment; communities of practice; support tools and technologies for developing new scientific knowledge; organizational learning; and performance measurement/performance management of knowledge investment strategies. The analysis demonstrates that knowledge leveraging initiatives and collaborative processes, techniques and tools are being implemented and assessed within science and technology-based organizations, including: communities of practice, networked organizations, knowledge centres, business directories, virtual laboratories, virtual information networks, ShareNets and Technology Watch. Management issues that are addressed, include: learning organization, skills and competencies, rewards and recognition programs and mentorship/protégé programs. These knowledge leveraging initiatives and management processes are considered to be among the main building blocks for developing knowledge investment strategies within science and technology organizations.

15.KEYWORDS,DESCRIPTORS or IDENTIFIERS

(U) Knowledge; Knowledge Management; Knowledge Revolution; Knowledge Innovation; Knowledge Creation; Collaboration; Communities of Practice; Communities of Interest; Knowledge-based Economy; science and technology; defence.