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A CONTRIBUTION TO KNOWLEDGE MANAGEMENT THROUGH A CANADIAN RESEARCH INITIATIVE

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ABSTRACT

Knowledge is an asset. It has value and thus should be an integral part of asset management. In fact, all three levels of asset management, strategic, network/system wide and project/location specific, have knowledge explicitly or implicitly embedded in each activity.

Knowledge is generally viewed as being in one of three basic types:

a) Explicit knowledge, which is essentially documented information
b) Implicit knowledge, or "know how"
c) Tacit knowledge, which is contained in the human subconscious (eg., creative or innovative capabilities)

Knowledge management has a variety of definitions. Essentially, it is a process for the effective utilization of available knowledge to produce results, both short term and/or long term.

Organizational approaches to knowledge management generally consider explicit knowledge as having a lower value than implicit knowledge. The most valuable, arguably, is tacit knowledge, but it is also the most difficult to maintain and vulnerable to loss. One of the major pitfalls is the belief that a knowledge management system will build organizational culture. The reverse holds, where organizational culture must exist to achieve success.

A Canadian research initiative which views knowledge management as a vital part of its success is the Centre for Pavement and Transportation Technology (CPATT). This Centre was made possible by an unprecedented $9 million funding package from Federal, Provincial, Municipal and private sector partners. It has articulated a vision focussed on emerging and innovative technologies, a state-of-the-art research infrastructure, training and education, and sustainability in research capabilities, programs and partnerships.

CPATT's approach to knowledge management incorporates the following strategic elements:

- Identifying the activities of CPATT within explicit, implicit and tacit types of knowledge
- Defining knowledge management (KM) and succession planning as synonymous
- Establishing the key reasons for KM
- Identifying the key components for proper KM
- Establishing the cost-effectiveness of KM
- Ongoing program of training and skills development for students and staff
- Developing measurable, key performance indicators for KM systems

INTRODUCTION

Knowledge is a universally recognized term, but it can have different meanings, contexts, applications, degrees of sustainability and usefulness, depending on the organization and/or individual(s) involved. Certainly knowledge can be a valuable asset, particularly in the context of asset management systems and the training of people.

Knowledge, human resource and physical assets, combined with adequate financing, are essential to sustaining an effective program of imparting skill sets, carrying out research and development and managing these assets effectively over the passage of time.

Asset management has, to date, focussed almost exclusively on physical assets. However, knowledge and human resource assets are vital to good asset management. Thus, knowledge management should be an integral component of asset management and in turn the principles of asset management are equally applicable.

This paper builds on a Ministry of Transportation Ontario innovation grant to the University of Waterloo for "Knowledge Management in Transportation", and on the training experience gained from the Centre for Pavement and Transportation Technology (CPATT) program of research and development. CPATT was formed on the basis of a $9 million funding package from the Canada Foundation for Innovation, Ontario Innovation Trust, Ontario Research and Development Challenge Fund and a number of key partners from the public and private sectors. This initiative involves an integrated program of laboratory and field research, including a central test site and various satellite test sections. It has also, and will continue to, involve various senior and junior faculty members, postdoctoral candidates and research staff and undergraduate and graduate students, who in turn add to the much needed resource base of skilled people for the transportation industry.

The paper describes how knowledge management is integral to the vision and focus of CPATT, how the needs for training and succession planning of the initiative are being met and how the lessons learned are being used to ensure an ongoing, sustainable program of research and training. As well, the paper provides background information on how organizations manage their knowledge assets on a continuing basis and it identifies the key strategic elements of CPATT's knowledge management system in terms of long term sustainability, periodic monitoring, operational needs and cost-effectiveness. Finally, the paper provides recommendations toward operational protocols for knowledge management in the research and associated training environment.

KNOWLEDGE WITHIN THE CONTEXT OF ASSET MANAGEMENT

Over the past few years, asset management interest has been widespread, largely because of the belief that business principles could be effectively applied to the management of public assets. Many initiatives have come forward, including the publication of Asset Management Primers in Canada, the United States and Australia, the establishment of an Office of Asset Management by the U.S. Federal Highway Administration, and numerous other agency and/or organization driven workshops, seminars and the like. These reveal, in general, that the scope of asset management varies within and between agencies, that the component management systems for pavements,

bridges, etc. represent the operational dimension, and that asset management is more of a process or framework than an operating system.

The process of asset management incorporates three distinct functional levels [1,2]:

- Strategic level where various social, political, economic and environmental factors are considered, public input occurs, long range financial forecasts are carried out and desired or specified levels of service (LOS) and safety for the system or network as a whole are defined as well as cost estimates to meet the LOS and safety targets. Current and future needs should be established and asset values should be determined.
- Network or system wide level where alternative programs are considered, performance estimates are made and life cycle cost analysis (LCCA) are used to determine an optimal program for given budget(s) or funding. As well, future asset values should be estimated.
- Project level where LCCA and other relevant factors are used to identify and implement the most economically effective alternative for a project/link/site specific area.

All three levels must fit within the agency's business scope and/or plan to be acceptable, useful, practical and understandable. For example, the City of Edmonton articulated a "Corporate Business Plan" (June 26, 2001, available on their web site) and their infrastructure strategy fits within that plan [3].

The interrelationships of these three levels are schematically illustrated in the Figure 1 framework. It is generic in the sense of being applicable to any component system (eg., bridge management, pavement management, etc.). To effect a proper tie-in or integration between the component systems requires an integration platform, and this has been discussed in more detail in Ref. [4].

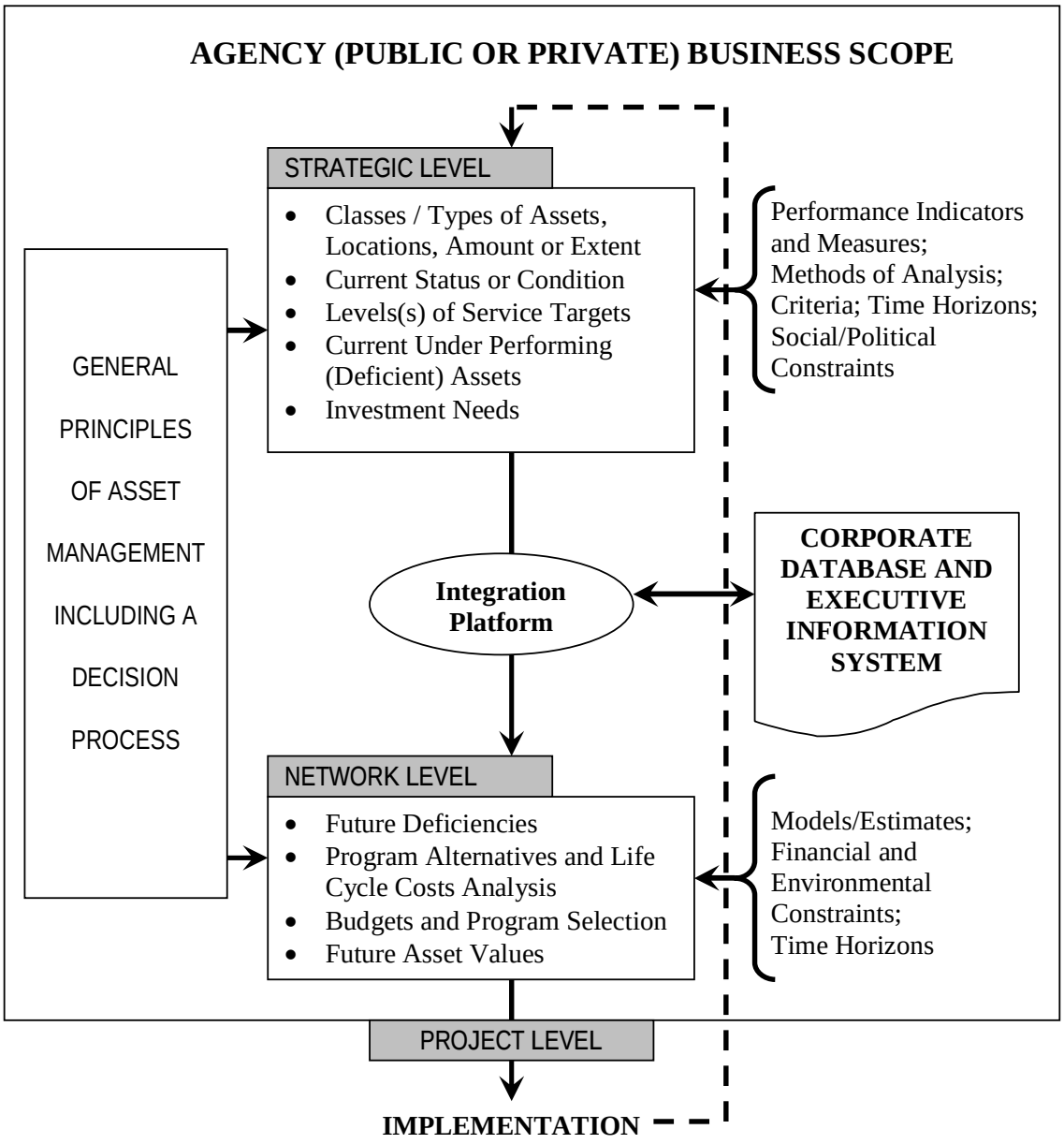

Figure 1 Overall Framework for Asset Management, Including Knowledge Assets

Regarding the element of knowledge, it is explicitly or implicitly embedded in each item or activity at all three levels. For example, the strategic level first identifies “Classes/Types of Assets, Location, Amount or Extent”, and these can of course be physical assets, but they can also be in the form of documents representing an accumulation of knowledge in the organization. As another example, again at the strategic level, “Current Asset Values” can be assigned to both physical assets and knowledge assets. Still another example is “Investment Needs”, which certainly can be assigned to knowledge assets. In essence, the Fig. 1 framework should be applicable in it’s entirety to knowledge management.

CURRENT SITUATION: SKILL SHORTAGES IN CANADA AND ABROAD

Another key aspect to knowledge management in the transportation field is the looming shortages of civil engineers and technicians. As noted recently in an article, "Where's the talent"?, (in the Globe and Mail on February 21, 2006), two thirds of Canadian employers are struggling to find qualified job candidates, putting Canadian employers among the worst off of the 23 countries that were surveyed as part of the study. In Canada, engineers are the fifth most difficult position/profession to fill. Contributing to this talent shortfall are the aging population, lower birth rates, inadequate education programs, globalization (many engineers have left Canada for other markets), social evolution, and entrepreneurial practices such as outsourcing and offshoring. Human Resources Canada has suggested in order to rectify shortages and build skills, that over the coming years there be enhanced links with schools, investment in training, re-skilling and up-skilling of employees [5].

Over the next ten years, it is predicted that many businesses will fail because they haven't planned ahead for the talent shortages and they will be unable to find the appropriate people to run their businesses. Human Resources Canada has also stated that, "This is not a cyclical trend, as we have seen in the past, this time the talent crunch is for real, and it's going to last for decades"[5].

The situation in many other countries is similar to Canada. For example, the International Hays Quarterly report has just identified that civil engineers are not only short in Canada but also in the Australia, Czech Republic, France, New Zealand, Poland, Spain and the United Kingdom. Employers are encouraged to retain existing civil engineers within their respective organizations through pay raises [6]. With an ever aging population, it is anticipated that the shortages in these countries will continue to put pressure on the ability for both the public and private sector to provide goods and services in both national and international marketplace.

The foregoing discussion establishes the context for knowledge management. It also provides the basis for defining the various types of knowledge, how organizations manage their knowledge assets and the relationship between succession planning and knowledge management and the associated economics. These are further discussed in the following sections.

DEFINITIONS, TYPES AND ORGANIZATIONAL APPROACHES TO MANAGING KNOWLEDGE ASSETS

Definitions

Although there are various definitions of knowledge, a widely accepted definition is that of Davenport and Prusak [7]:

> "……a fluid mix of framed experience, values, contextual information, and expert insight. It originates and is applied in the minds of knower. In organizations….. not only in documents…. but also in organizational routines, processes, practices, and norms."

Thus, knowledge can be viewed as an organizational and personal resource. But why is it important for an organization to treat knowledge as any other asset and implement a system for managing its knowledge?

In order to be successful in business, an organization must stay a step ahead of its competitors by continually coming up with new strategies and innovations in an efficient manner. This occurs through knowledge creation. But knowledge can become outdated or lost. Thus it is highly important in today's knowledge-based economy to have a well utilized knowledge management system in place that preserves existing knowledge and promotes the creation of new knowledge.

Similar to asset management, there are various definitions of knowledge management. For example, Mentzas et al. [8] believe the term knowledge management refers to "a broad collection of organizational practices and approaches related to generating, capturing and sharing knowledge that is relevant to the organization's business". Arora [9] believes that knowledge management means managing intellectual capital by applying three basic objectives: "leveraging the organization's knowledge; creating new knowledge or promoting innovation; and increasing collaboration and hence enhancing the skill level of employees".

In a broad sense, knowledge management could be defined as a process of leveraging and utilizing available knowledge to achieve innovation and produce results. From this broad view of knowledge management it is apparent that there are two predominant perspectives, the product and the process approach [8].

The product approach views knowledge as an object to be captured, distributed, measured, and managed. This approach encourages the preservation of records and artefacts using means such as databases, archives, networks, and repositories.

The process approach focuses more on promoting, monitoring, encouraging, nurturing, and guiding knowledge creation and distribution through "knowledge communities". (eg., discussion boards, e-mail, messaging services, and white-boarding [8].

To function profitably, the product approach requires the process approach to provide it with fresh knowledge while the process approach requires the product approach to provide it with existing knowledge. In the transportation field both approaches are essential in order to achieve a properly functioning knowledge management system.

The idea of viewing knowledge management from two differing yet related perspectives suggests that the framework best suited to the transportation industry incorporated three components or types: explicit knowledge, implicit knowledge, and tacit knowledge.

Types of Knowledge

Explicit knowledge is quite widely defined as documented information. This form of knowledge is stored within information management systems making it widely accessible to those who require it. Explicit knowledge is articulated through written language and lends itself to the idea of viewing knowledge as a product.

Implicit knowledge can also be termed 'know how' It is a form of knowledge that can be expressed and articulated. As well, it can be transferred through both documentation and verbal communication.

Tacit knowledge is the most difficult form of knowledge to capture as it is created while humans interact with both those around them and their environment. The majority of tacit knowledge is contained within the human subconscious making it extremely difficult to articulate and transfer. In order to manage this fragile knowledge an organization must manage the body it is contained within, its employees.

A characterization distinction between the different components of knowledge management based on the type of knowledge sharing occurring within organizational communities was devised by Ernst and Young. They believe a relationship exists between the organizational reach of a group (global versus local) and its level of cohesion between members (low versus high) [8]. As seen in Figure 2, the more local a group is, the higher is its level of cohesion and the greater is its aptitude for creating and distributing tacit knowledge. Inversely, the more global a group is, the lower is its level of cohesion which leads more towards explicit knowledge. Implicit knowledge falls in the middle of the organizational reach scale, allowing for a moderate level of member cohesion.

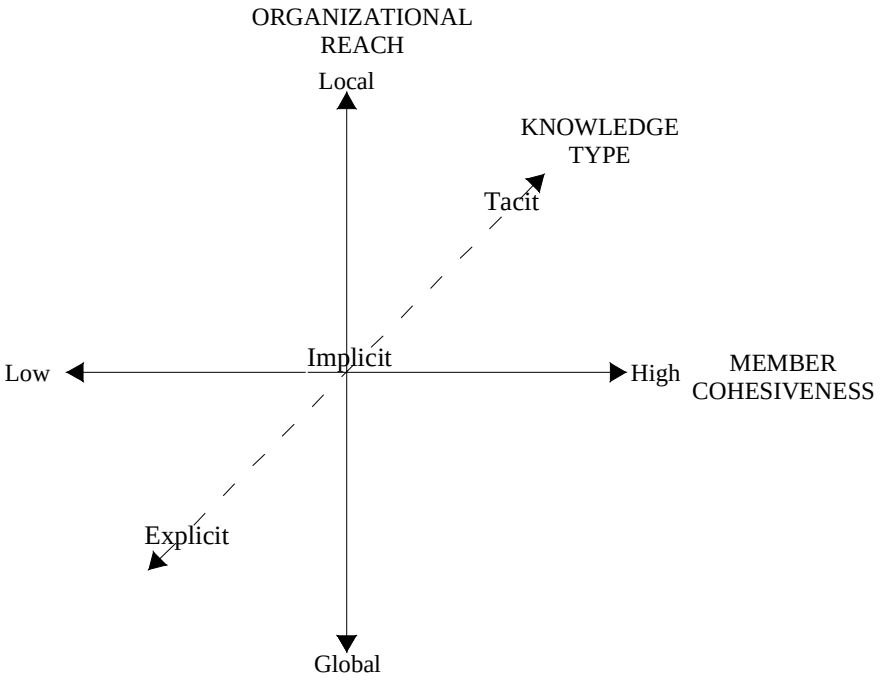

Figure 2 - Impact of organizational reach and member cohesiveness on knowledge
From Ref. [8]

Organizational Approaches

Explicit knowledge is the most commonly considered and lowest valued aspect of knowledge management [10]. The main difficulties faced by explicit knowledge arise from its sheer magnitude and the daunting task of keeping it up to date. A common mistake made when managing explicit knowledge is to treat it as an object rather than an activity [11]. Storage locations for explicit knowledge include computer networks (Internet and intranet) and central library bodies. It must be remembered that technology is simply a facilitator that transmits and exchanges information, not a knowledge manager. Technology is only one of three explicit knowledge components, the carrier. Both a language and means of expressing knowledge and coded potential knowledge are essential [8].

Implicit knowledge falls between explicit knowledge and tacit knowledge in its level of value. Similar to tacit knowledge, it is embedded in the minds of individuals. However, unlike tacit knowledge, implicit knowledge can be made explicit through verbalization [12]. There are many different approaches to managing this form of knowledge including mentoring programs, communities of practice, and network based user help services. Mentoring is a dynamic professional relationship that promotes the exchange of knowledge, experience, and skills to enhance personal growth [13]. These programs have seen great successes in many areas of industry and the academic world. A community of practice is an employee forum that transforms the water cooler gathering into a more formal and organized meeting that incorporates the free flow of knowledge within an agglomeration of people [9]. Network based user help services operate within an organization to link employees with questions or problems to employees with knowledge on the subject who otherwise would not be a realized resource.

Arguably the most valuable, but also most difficult to maintain aspect of knowledge management is tacit knowledge. It is embedded in individuals experience and sense of judgement and includes "insight, hunches, intuition and skills that are highly personal and hard to formalize" [8]. Tacit knowledge is "something we know, possibly without the ability to explain…Human beings are the storage medium of tacit knowledge. When the storage medium is an individual then it is vulnerable to loss" [14]. Much tacit knowledge is lost when experienced employees leave an organization. Thus, storing tacit knowledge in a community, not just in a single individual, reduces its vulnerability to being lost as well as enhancing its potential for reuse. Organizations whose workforce consists mainly of mature employees are especially vulnerable. Efforts to maintain tacit knowledge include phased retirements, advisory teams, and employee retention strategies. Phased retirement encourages employees eligible for immediate retirement to remain with the organization on a part time basis to allow the organization to continue to draw from the employee's knowledge and expertise [15].

Pitfalls in Organizational Approaches

A common misconception that organizations have about knowledge management systems is the belief that they will build organizational culture. On the contrary, knowledge management systems require organizational culture to exist before they are implemented to obtain success. Employees must be open to the introduction of a knowledge management system and be willing to freely share and transfer knowledge within the organizational structure [16].

A major mistake made by companies when implementing knowledge management is being afraid to jump in with both feet. Companies with a clear vision of what they want to achieve and a well laid out approach of how to achieve the desired outcome typically experience success. Those who choose to join the knowledge management bandwagon in an effort to reap some quick benefits, but focus only on the explicit knowledge side and don't implement a long-term strategy typically experience failure. All three components of knowledge management, explicit knowledge, implicit knowledge, and tacit knowledge, are crucial. Each component serves its own purpose, but relies on the other components for support. If a knowledge management system does not prevent reinvention of the wheel by leveraging knowledge assets already in existence it is not doing its job [9].

Attempting to place only a dollar value on knowledge capital is another common mistake. Not only will much difficulty be encountered in doing so, but results will be unrepresentative of the true value of knowledge, especially in the early stages following the implementation of a knowledge management system. This is due in part to the fact that an organization does not own its human capital like it does with other assets [17].

Another major pitfall is an inadequate strategy for recruiting and retaining individuals. While a National Cooperative Highway Research Program Report [18], based on a survey of 24 states and 3 provinces, provides some valuable information and insight, Issues of salary, training programs, incentives, work environment and lack of exit questionnaires are still all too prevalent in the transportation industry.

A CANADIAN RESEARCH INITIATIVE

Background

The Centre for Pavement and Transportation Technology (CPATT) was formed at the University of Waterloo in 2002-2003, based on a long track record of research in the area plus a new and unprecedented funding package of $9 million from the Canada Foundation for Innovation, Ontario Innovation Trust, Ontario Research and Development Challenge Fund and a number of public and private sector partners.

This enabled the development of new central and field laboratories, various central and satellite test sites, and state-of-the-art testing capabilities. Very importantly it also contributed to being able attract additional, highly skilled researchers as well as talented graduate and undergraduate students.

It is essential for the success of any such activity to articulate an achievable vision and for CPATT, this included the following:

- Focus on emerging and innovative technologies
- State-of-the-art research infrastructure
    - Tackling specific problems
    - Developing new technologies
    - Training (students, practitioners)
- Increasing the talent pool of highly qualified personnel (HQP)
- Sustainability in research capabilities, programs and partnerships

Essential to realization of this vision, and particularly the component of sustainability, is an ongoing and strong commitment to knowledge management.

Strategic Elements of CPATT's Approach to Knowledge Management

The following strategic elements are included in CPATT's approach to knowledge management:

- Development of an umbrella concept for the interrelationships between people and program areas (see Figure 3)
- Recognition of what activities and components of CPATT relate to explicit, implicit and tacit knowledge
- Defining succession planning and knowledge management as entities but also synonymous.
- Commitment to mentoring.

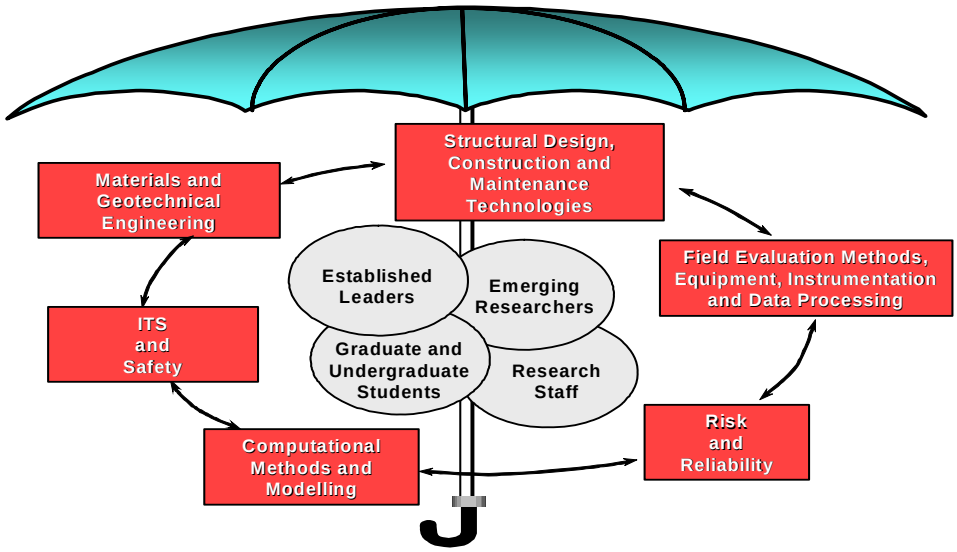

Figure 3 Umbrella concept for the interrelationships of people and program areas

- Establishing the key reasons for knowledge management/succession planning (KM/SP)
- Identifying the key components for proper (KM/SP)
- Establishing the economics and/or cost-effectiveness of KM/SP
- An ongoing program of training and skills development for students and staff
- Developing measurable key performance indicators (KPI's) for KM/SP

Interrelationships: An Umbrella Concept

CPATT's structure and program has been designed within an umbrella concept; that is, a group of established leaders, emerging researchers, students and staff who work as a team. There is a complementary linked program of activities, priorities and resource allocation in major thrust

areas of (a) materials and geotechnical engineering, (b) structural design, construction and maintenance technologies, (c) field evaluation methods, equipment, instrumentation and data processing, (d) risk and reliability, (e) computational methods and modelling and (f) ITS and safety.

In fact, succession planning and knowledge management were considered as an absolutely essential component of CPATT's long term success and sustainability. As an example, the founding principals of the initiative were two senior, well established researchers and one new, assistant professor. Over the next four years, the originally planned succession strategy was executed. It is notable that one of the primary reasons such an unprecedented amount of funding was provided to the CPATT initiative was the identified commitment to knowledge management through the inclusion of both senior and the junior researchers in the overall plan. This involved one senior principal becoming the Founding Director, then being succeeded by the external recruitment of a Canada Research Chair as the new director, and the third founding principal, newer, individual becoming Associate Director and also a Canada Research Chair. Both founding principals have now become senior advisors. In essence, the plan has gone smoothly, the partners in the initiative and Board of Directors as well as the University are strongly supportive and the prospects for long term sustainability are excellent.

CPATT's Activities re Knowledge Types

The activities and components of CPATT which are directly related to the three basic types of knowledge include the following:

- Explicit knowledge-documented research results, publications and technology developments, information and data generated, public and professionally associated access to briefings (eg., web site)
- Implicit Knowledge – skills and expertise resident in CPATT's researchers and staff, with the capability of being transferred to others and/or documented
- Tacit Knowledge – creative/innovative capabilities resident on CPATT's researchers and staff

Knowledge Management vis a vis Succession Planning

It has been argued that a key part of knowledge management should be proper succession planning (17), and in fact the definition originally advanced is applicable to or synonymous with both (18):

> "A process for ensuring the orderly planning for renewal, upgrading and continuity of an organization's resources including people, technology and information/data"

It should be noted that this definition comprises three main elements: (a) people and their experience and expertise, (b) technology in terms of methods and procedures, codes of practice, software, hardware, facilities, etc., and (c) information and data, particularly in terms of the time dimension.

Commitment to Mentoring

There is a concerted effort within CPATT to encourage mentoring, both formal and informal. This includes active faculty involvement in the supervision of undergraduate and graduate theses, hiring of intern or co-operative education students, involvement of high school students as part time employees, various initiatives in the promotion of civil engineering to girl guide troops, prospective first year students, and first year students through the use of an introductory transportation engineering lecture, as well as a number of promotions to professional groups. In addition, there is a genuine effort from the senior, more experienced researchers to assist newer researchers in the preparation of proposals and supervision of research. In turn, the younger researchers and students provide assistance with regard to computer packages, assimilation of new technologies, etc. Senior researchers also graciously volunteer their time to provide guest lectures and are actively involved in the outreach of the research centre.

Essentially the mentoring within the CPATT organization works at all levels and is cross generational. A cornerstone to the success is a concerted effort to improve communication and to actively engage all members of the CPATT team to work as a team and provide mentorship as required.

Key Reasons for Knowledge Management/Succession Planning

These are good reasons for having a system or program for knowledge management/succession planning and they include the following [19]:

- It is cost-effective and contributes to organizational cohesiveness
- It is good public relations and good for the "marketplace" (both internal and external)
- It preserves a substantial investment
- It is just good business

Key Components for Proper Knowledge Management/Succession Planning

Several key components are involved in knowledge management/succession planning and they include the following:

- Recognising the need and obtaining top level commitment
- Developing a plan which involves a clear identification of what activities, information, resource requirements allocation of responsibilities will go into the various knowledge elements, including a program for timing of people replacements, including sufficient training and overlap, provision for contingencies (e.g., sudden resignations) and mentoring responsibilities
- Making the necessary investments
- Keeping the plan dynamic by periodic updating and periodic assessment of its effectiveness
- Documenting the plan and procedures, its ongoing activities and accomplishments and the lessons learned.

There can also be obstacles to knowledge management/succession planning including the following:

- Rapid turnover of administrators
- Financial exigencies
- "We can buy people, technologies and information" philosophy
- Frequent resignations and/or "poaching" by competitors
- Lack of commitment and lack of resources
- Lack of documentation (technology, methods, equipment, procedures, etc.)
- Lack of training programs
- Lack of balance between outsourced work and "knowledgeable client"
- Short term political decisions

Economics of Knowledge Management/Succession Planning

Regarding the economics of knowledge management/succession planning, the issue is really return on investment. There is a direct investment cost associated with explicit knowledge, compared to a less easily quantifiable but quite important investment cost associated with people who have or are being trained for implicit knowledge and tacit knowledge. Returns on the investment can include the development of new and/or better technologies, better more efficient ways of doing things and new ideas for advancing the state-of-practice or technology. As well, cost savings can be viewed as a return on investment.

For example, employee turnover rates are an excellent measure of cost savings. A U.S. based software company provides tremendous benefits to its employees including use of extensive recreational facilities, day care and medical facilities, etc. In an industry where annual employee turnover rates are 20%, this company has an average turnover rate of 3% per year. Experts at Stanford University have estimated that this dramatic reduction in employee turnover results in conservative savings of 60 to 80 million U.S. dollars per year [20]. These savings are simply associated with the retention of corporate knowledge, stability in the workforce, and reduced stress associated with convenience of amenities.

Although it is difficult to completely quantify the cost savings associated with succession planning, it is evident that if employees at all levels in the organization are part of a team they are less likely to leave. Effective organizations are those that capitalize on their resources and transfer knowledge across the organization. In short, succession planning can be a key area of cost savings for the transportation and pavement sector.

A comprehensive study on the value of training and its relationship to succession planning, summarized by [21], states that:

> "Knowledge is a vital organization asset….. .Today,……..organizations are routinely valued not on their physical but rather their intellectual capital", where intellectual capital is [22] "The possession of the knowledge, applied experience, organizational technology, customer relationships and professional skills that provide an organization with a competitive edge in the market".

The study by [21] indicates that a return on investment (ROI) analysis of the value of training ranges widely but even the most conservative estimate would put it at 7%. Another way to look at this is in terms of knowledge creation, and in turn knowledge

management. In essence, any management process seeks a positive ROI and certainly training/knowledge creation can and should provide that ROI.

Training and Skills Development

One of the most critical elements of ensuring sustainability in CPATT's approach to knowledge management is a program of training and skills development. The latter is accomplished through normal course work, and hands-on tasks in the laboratories and field sites. In turn these tasks also provide a valuable training function for both graduate students, undergraduate work term or intern students and research staff.

For example, the central research lab has state-of-the-art test equipment for "Superpave" characterization of materials, and for materials characterization input required by the new AASHTO Mechanistic Empirical Pavement Design Guide. As well, the unique test track and other field sites enable students to see pavement field testing equipment and learn many hands-on skills about pavement design and management practices. Overall, this enables students and research staff to become trained in the use of the most advanced equipment available.

As another example, CPATT's main field test site contains weighing-in-motion (WIM), temperature sensing, strain indicator, pressure cells and other instrumentation installation, all of which provide wireless transmitted data to the central CPATT research offices. The installations, operation and maintenance of these installations has provided invaluable training for the graduate and undergraduate students involved.

The steady state expectation for the above, at least over the next few years, will be about 20 graduate and 5 undergraduate students involved at any one time.

Performance Indicators for Knowledge Management/Succession Planning

The development of measurable performance indicators for knowledge management/succession planning is still in the formative stages for CPATT. It is expected that this will be patterned largely after prior work on key performance indicators for properly functioning asset management systems [25].

CONCLUSIONS

- Knowledge is an asset. It has value and thus should be a component of asset management. A generic, overall framework for asset management illustrates that knowledge is explicitly or implicitly embedded in each item or activity at all levels (strategic, network/system wide and project/site specific)
- The current identified shortage of skilled civil engineers in Canada and abroad further emphasizes the need for agencies to seriously implement knowledge management strategies.
- Knowledge itself has been defined by various people and organizations but perhaps more important is the categorization:
    a) Explicit knowledge, usually in the form of documented information

b) Implicit knowledge, or "know how", can involve both documentation and verbal communication
c) Tacit knowledge, a human embodiment of experience, skills, judgement and other attributes

- Recruiting and retaining individuals in transportation agencies is a cost-effective endeavour and an asset preservation or enhancement strategy
- Succession planning, in terms of people, technology, and information, covers explicit, implicit and tacit knowledge. It should be a key part of knowledge management.
- A Canadian research initiative, involving the Centre for Pavement and Transportation Technology (CPATT) has adopted a comprehensive knowledge management strategy as a cornerstone of its long term sustainability. This strategy incorporates the following key elements:
    a) An umbrella concept for the interrelationships between people and program areas
    b) Identifying the activities of CPATT within explicit, implicit and tacit types of knowledge
    c) Defining knowledge management and succession planning as synonymous
    d) Establishing the key reasons for knowledge management
    e) Identifying the key components for proper knowledge management
    f) Establishing the cost-effectiveness of knowledge management
    g) Ongoing program of training and skills development for student and staff
    h) Developing measurable key performance indicators for knowledge management systems

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REFERENCES

1. Haas, Ralph, Lynne Cowe Falls and Susan Tighe, "Integrating Pavement and Asset Management in Functional and Operational Terms", Proc., Transp. Assoc. of Canada Annual Conf., 18 pp, CD-Rom, Quebec, Sept., 2004
2. Haas, Ralph, "Challenges of Managing the Build Infrastructure", Keynote Lecture, 1st special conf. on Infrastructure Technologies, Management and Policy, Proc., Can. Society for Civil Eng. Annual Conf., 26 pp., CD-Rom, Toronto, June, 2005
3. Siu, K. L. and Theresa Cloake, "Implementation of An Infrastructure Strategy for the City of Edmonton", Proc. INFRA 2001, Montreal, Nov., 2001
4. Haas, Ralph, Susan Tighe and Lynne Cowe Falls, "Determining the Return on Long Life Pavement Investments", paper presented to Transp. Res. Board Annual Conf., and to be published in Transp. Res. Record, Washington, D.C., Jan., 2006
5. Grant, Tavia, "Where's the talent?"Globe and Mail, Tuesday February 21, 2006
6. International Hays Quarterly Report, The Weekend Australian, Weekend Career One February 18 – 19 , 2006
7. Davenport, T. H., & Prusak, L., "Working Knowledge: How Organizations Manage What They Know", Harvard Business School Press, 1998, pp.
8.. Mentaz, Gegoris et al., Knowledge Asset Management: Beyond the Process-centred and Product-centred Approaches, Springer-Verlag London Limited, London, England, 2003, pp.
9.. Arora, R., "Implementing KM – A Balanced Score Card Approach", Journal of Knowledge Management, Vol. 6, No. 3, 2002, pp.
10. United States Department of Agriculture, "Knowledge Sharing and Transfer, Experimental learning Team, Final Report", 2001, pp.
11. Al-Hawamdeh, S., "Knowledge Management: Re-thinking Information management and Facing the Challenge of Managing Tacit Knowledge", Information Research, Vol. 8, No. 1, 2002, pp.
12. Wilson, L.T., "Knowledge Harvesting – The Impetus for Next-generation Knowledge Management", Knowledge Harvesting, 2000, pp.
13. New York State Department of Transportation, "Mentoring Program", Work Force and Succession Planning, 2003.
14. Snowden, D., "A Framework for Creating a Sustainable Knowledge Management Program", Butterworth/Heinemann, Boston, MA, 1999, pp.
15. Federal Highway Administration (US), "Workforce Planning and Professional Development Task Force – Final Report", United States Department of Transportation, 2000, pp.
16. Dunne, D. and Horgan, T., "What is an Intranet?", Darwin Magazine, December 13, 2001, pp
17. Bassi, L., Ludwig, J., McMurrer, D., and Van Buren, M., "Profiting from Learning: Do Firms" Investments in Education and Training Pay Off?", ASTD and Saba, 2000, pp
18. National Cooperative Highway Research Program, "Recruiting and Retaining Individuals in State Agencies – A Synthesis of Highway Practice", Transportation Research Board, 2003, pp. 50 - 59

19. Tighe, Susan and Ralph Haas, “Assessing Knowledge Management”, Final Report, Prepared for Ministry of Transportation Ontario, Dec. 2004
20. Haas, Ralph, Lynne Cowe Falls and Susan Tighe, “Integrating Pavement and Asset Management in Functional and Operational Terms”, Proc., Transp. Assoc. of Canada Annual Conf., Quebec, Sept., 2004
21. Tighe, S. and Haas, R., “Challenges of Succession Planning in Achieving Long Life Pavements”, Proc. Transportation Association of Canada, 2003
22. CBS 60 Minutes, “SAS Success”, Aired April 20, 2003
23. Muench, Steve, “The Value of Training”, Newsletter of the Institute for Transportation Studies at the University of California, Berkeley, Fall, 2004
24. Edvinson, L. and M.S. Malone, “Intellectual Capital: Realizing Your Company’s True Value by Finding Its Hidden Brainpower:, Harper Business, New York, N.Y., 1997
25. Haas, Ralph, Susan Tighe and Lynne Cowe Falls, “Performance Indicators for Properly Functioning Asset Management Systems”, Proc., CD-Rom, ARRB Conf., Cairns, May, 2003