KNOWLEDGE MANAGEMENT FOR TECHNICAL AND PRODUCTION ORGANIZATIONS

by

Gregory George Richards
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Name: **Gregory Richards**

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Supervisory Committee:

_____

Professor Ian McCarthy
Faculty of Business Administration
Canada Research Chair in Technology & Operations Management
Senior Supervisor

_____

Mark Selman, PhD
Special Advisor to the Dean
Faculty of Business Administration
Second Reader

Date Approved: _____

Abstract

Trail Operations faces critical challenges in the coming years, including: a substantial change in feed materials, significant workforce renewal and increasing environmental pressures. Technical and operating knowledge must be organized to leverage its potential for sustaining the business. A knowledge management system offers the potential for this by capturing and transferring knowledge for maximum benefit. The system must work to codify knowledge appropriately and provide a platform to facilitate application of tacit knowledge. This is a significant change for the organization and should be managed through a structured change management process. In this paper I will apply this approach to address the knowledge management issues of the operations and present a plan to effectively leverage organizational knowledge to address the business challenges.

Keywords: knowledge management; explicit knowledge; information management; organizational change; information; knowledge

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Glossary

data	Discrete facts or relations between items
explicit knowledge	Knowledge contained in an explicit form such a written document
information	Patterns in the data
knowledge	Meaning of the information for an application
knowledge management	Identification and leveraging of knowledge for value creation
knowledge map	Graphical representation of knowledge related to a object
metadata	Fields attached to a document to hold reference information
tacit knowledge	Knowledge internalized in individuals

1: Introduction

A considerable store of very specialized knowledge is required for the effective functioning of Trail Operations. In common with all organizations, this business unit uses knowledge in every aspect of its operation including production, human resources, finance and legal affairs. However, it is in the technical area where relatively uncommon, and in some cases unique, knowledge is necessary to sustain the operation. It is therefore important that special attention be paid to the maintenance and preservation of this aspect of the knowledge base. The scope of this paper addresses the need for a comprehensive knowledge management system to effectively capture and use the knowledge required to sustain and improve the production processes. It is acknowledged that this is only one component of a business-wide knowledge strategy, but it is an aspect of the issue which is of a relatively specialized nature, and therefore should not be approached with a preconceived structure or pre-packaged solution.

1.1 Trail Operations

Trail Operations is located in Trail, British Columbia on a bench above the Columbia River. Processing of ore from the copper-gold mines in nearby Rossland began in 1896, and there has been a continuous metal extraction operation on the site since that time. As the mines in Rossland were exhausted, the smelter switched to the processing of the silver-rich galena ores from the local Slocan mining district. The Consolidated Mining and Smelting Company of Canada Ltd. was formed in 1906, combining the Trail smelter with lead-zinc-silver mines of the East Kootenays into one company. This company eventually grew into Cominco Ltd. and remained a subsidiary of the CPR until the 1980s when it was sold to a consortium which included the present owner. Trail Operations is now a division of Teck Metals Ltd. itself a wholly owned subsidiary of Teck Resources Limited.

The processing of metal ores and concentrates is a complex business, requiring the application of specialized equipment and a considerable knowledge of metal chemistry. In general, metals are extracted through the processing of complex ore minerals in aqueous systems (hydrometallurgy) or at high temperatures with the production of molten phases (pyrometallurgy). In order for the efficient production of metals, it is necessary to operate using a wide range of

processes selected and modified appropriately to achieve the desired chemical and physical conditions for recovery and purification of the constituent metals.

The operation of a smelting complex is subject to a number of key forces which determine the profitability of the enterprise. The main feed stocks are metal concentrates derived from mines located around the world. These materials are relatively heterogeneous and contain a wide variety of minerals and chemical elements. A successful smelter must therefore have the ability to manage these inputs and adapt its process to an ever varying stream of inputs. In contrast, the products are commodity metals that are bought and sold in relatively specific compositional grades in the international market place. This poses a significant challenge to the operation for several reasons. The variability in inputs requires that there be constant vigilance to anticipate their impact on the operation, and work in advance to mitigate the adverse consequences to the degree possible. However, not all of these can be anticipated, and the plants must cope with the changes as they flow through the operation. All of this is exacerbated by the large number of recycle streams which result in material feedback loops that circulate the problematic elements or conditions in cycles which can take considerable time to dissipate.

The smelter essentially buys concentrates on the market, paying for a large fraction of the contained metal value. In addition, the mine pays a 'treatment charge' to cover the cost of smelting and conversion to metal. Therefore the profitability of a smelter is determined by the treatment charge and the "free" metal contained according to the terms of the contract. A smelter essentially works on the small margin in between and has to operate very efficiently. This is especially true when treatment charges are low, generally in times when there is a shortage of concentrates giving mines increased bargaining power.

As a result of these pressures, and increased competition from the developing countries, Trail Operations is facing significant challenges. In this environment it is necessary to look for new opportunities for treatment of other materials and the production of new products. It is also necessary to make the most effective use of the resources that are available to efficiently carry out the operation of the plant. In moving in either strategic direction it increasingly requires that the knowledge contained in the organization be maintained, harnessed and grown so that the capital invested is used to its highest capacity.

Over the history of the operation there has been a considerable wealth of knowledge developed in parallel with the capital investment in the smelter and its infrastructure. New processes have been developed and installed, and integrated into the existing flowsheets. Operating and technical knowledge has been developed as part of this process, and become a vital

part of the ability to sustain the operation. A considerable amount of this knowledge has been retained by transfer in the workforce from one generation to the next. This has been relatively effective during periods of social stability in which employees have remained with the operation for all of their working lives. However, the dynamics have changed and this stability is no longer the milieu in which we operate. Consequently, it is important that we have in place the systems to generate, maintain and exploit knowledge at a pace and in a fashion that is suited to the velocity of our environment (McCarthy, Lawerence, et al. 2010).

There have also been major changes in the requirements for environmental performance. Internal and external monitoring of environmental issues has increased significantly, along with the need for a more comprehensive level of reporting to government agencies. These activities require an improved way of managing information, and at the same time demand the more effective application of our knowledge for control and improvement of the performance.

1.2 Scope and Objectives

The primary objective of this work is to develop a technical and production knowledge management system for Trail Operations with a transition plan from the existing structure.

A wide variety of knowledge of metallurgical processes and operating practices is necessary to sustain the operation, and this is becoming an increasingly critical factor in maintaining a long term successful business. The scope of this paper examines the application of knowledge management principles to the use of technical and related production knowledge for value creation in Trail Operations. There is a considerable range of knowledge used throughout the organization, and a complete review of the knowledge management issues would require an extensive study, beyond the goals of this analysis.

The application of knowledge plays a critical role in achieving and sustaining a firm's competitive advantage. The concept of knowledge management provides a useful perspective on the means by which corporations operate and add value to products and services. Technical organizations within an industrial company are, by nature, intimately involved in the creation and application of knowledge as a means of enhancing the performance of the business units. A focus on knowledge can provide a means of organizing the operation of technical departments and the development of technical strategies which will contribute to the overall success of the company. This paper will only set the stage for these applications by providing the basis of the knowledge management system that could be applied to these higher level activities. For example, once a knowledge management system was functional it would bring a new perspective on the flow of

information and knowledge which should lead to insights for efficiency increases in the way knowledge was generated. To an extent this paper tries to anticipate some of these improvements as part of the development of an implementation plan, however it is beyond the scope of this analysis and recommendations presented here to propose a fully comprehensive program. Part of the rationale for this lies in the need to learn more about knowledge management and how it can be integrated into Trail Operations before planning too far out.

The challenges of knowledge management are increasing as the work place evolves in response to a number of forces including: increased dependence on sophisticated technology, increased worker mobility, globalization of information management and heightened levels of competition. The effective application and enhancement of knowledge in this environment is an important component of long term success. In addition to external drivers, the development of a structured knowledge management system must address internal complacency and entrenched cultural behaviours. Although knowledge management should apply to all business activities, the focus of this paper is on the technical and related operational knowledge since there are particular challenges to relatively unique to this site. Although the scope is restricted to the technical and related operating knowledge, the result should form a blueprint for a review of other areas of Trail Operations. This could be considered a secondary objective of the paper.

The design of a knowledge management system must incorporate the following general activities: inventory, agents, capture, storage, access and transfer. The system needs agents which identify knowledge and are active in the process of recording and tracking it as an inventory. Knowledge can be stored in an explicit form and access can be provided in several ways. However, to fully leverage the value of the knowledge there must be an active transfer process to ensure that it is used where it can add value. A passive storage system or repository does not make knowledge an active player in the business. An active transfer process is thus a key ingredient of the system.

In order to implement a comprehensive knowledge management system, attention must be paid to all aspects of the change management process. The implementation plan therefore must present a clear vision to guide and align the organization. This paper reviews the pieces of the system already exist, and can help to bring the development along. At the same time, if not aligned with the change in philosophy, existing information and data structures can represent obstacles to a smooth transition. The process requires not only training in new protocols, but attention to changes in attitude that increase the respect for the role of knowledge in the organization. This transformation is vital to the long term consolidation of the initiative. The

change management process described by (Kotter 2007) is used as the basis for development of the recommend implementation plan. The paper uses this model to develop the stages of the transition plan. The scope of the paper mainly focuses on the stages leading up to the short term wins. Development of the plan in any detail beyond that is considered premature since there is considerable learning required within the organization, and it is anticipated that the direction of the implementation would need to account for issues uncovered as development proceeded.

In the closing section of the paper the focus is returned to a general assessment of what knowledge management can bring to Trail Operations. The perspective of knowledge management, to a degree, brings a new way of thinking about a fundamental aspect of the business processes. It strengths are the recognition it brings to the role that knowledge plays and the systematic approach it offers to leveraging the full value of the knowledge. However, it must be articulated and implemented in a way which is appropriate for the particular business environment. This can be a significant challenge.

1.3 Summary

The purpose of this paper is to define a technical knowledge management system for Trail Operations with a transition plan from the current situation. To achieve this, the paper is broadly structured as follows. In Chapter 2 the analysis of the knowledge management challenge for Trail Operations is described in detail. It is argued that knowledge management will be a key driver of a sustainable operation as competitive forces and demographic changes impact in the years to come. In order to effectively structure a knowledge management system is important to understand the components required to collect and transfer knowledge. Chapter 3 reviews the general nature of knowledge management, and the key components required for a comprehensive system. This review concludes by bringing together the needs of Trail Operations and the benefits of knowledge management in a detailed presentation of the value proposition. This is key to building the business case for implementation. From this point the paper moves to outlining the necessary components of the knowledge management framework as it applies to technical knowledge. This systematic approach is covered in Chapter 4 with a brief review of some of the issues that are present in the organization. This sets the stage for a detailed proposal on implementation which is presented in Chapter 5. It is proposed that a full change management approach be used because of the deep nature of this transformation of the operation, both at the technical and cultural level. A systematic knowledge management structure and change management approach is the foundation on which a detailed implementation plan is developed.

This is fully developed as a step-wise plan for the operation beginning with clearly establishing the urgency for action through to ultimate institutionalization of knowledge management. Finally, Chapter 6 contains concluding remarks.

2: **The Knowledge Management Challenge**

The case for a comprehensive knowledge management system rests on the need for effective management of organizational knowledge to meet the growing challenges faced by Trail Operations. In this chapter these issues are examined in detail, and the potential role that knowledge can play in addressing the needs are outlined. This is then compared to the existing state of information or knowledge management, and the contrast highlights the significant contributions that a systematic approach can bring to the business.

2.1 Trail Operations: Looking Forward

As outlined in Chapter 1, Trail Operations faces a number of critical challenges in sustaining the operation and maintaining a viable business. In summary, the following issues were identified as important for the future:

- competency in operation of specialized metallurgical equipment, technology and processes
- variability of heterogeneous feed materials
- long term changes in feed materials
- commodity product
- operation in a tightening margin between mines and commodity prices
- workforce downsizing and delayed renewal
- need for continuous improvement in environmental performance

In each area there is important need for various types of organizational knowledge. Specialized knowledge is required to effectively address the challenges faced in all of these aspects of the business. In order to use the knowledge in the organization efficiently it is important to actively manage knowledge. This is the goal of a knowledge management system. Generally, knowledge management is the leveraging of knowledge for creation of value.

The processing of ores, concentrates and urban waste streams for the recovery of metal values is a complex activity. In order to extract value in this endeavour it is necessary to use very specialized metallurgical technology and knowledge. For example, the KIVCET^{TM} furnace at Trail Operations is only one of three operating in the world, and each one is distinctly different in construction and operation. Although the fundamentals of this lead smelting process are common

to other methods, there is a significant amount of highly specific knowledge that is necessary to effectively operate the Trail unit. One of the implications of this is that there is a very limited pool of skilled workers external to the company that can quickly assume a lead role in addressing new issues and problems in critical areas of the operation.

The effective operation of the Trail facility as a whole adds an additional layer of complexity. The annual production plan involves setting target metal and by-product outputs that is a complicated balance between available input feed stocks and anticipated market demands. An important part of the exercise involves accounting for the abilities of the individual plants on the property to handle these materials. This requires knowledge of, not only how to process the feed materials to make the production plan, but also how to handle the host of impurities that accompanies the metals of interest. Inevitably these are tied to the effective operation of the site as a whole. Efficient use of the capital invested in Trail is therefore dependent on knowledge of how best to integrate the operation of plant.

In the long term this particular issue takes on more significance for two reasons. By the midpoint in the current decade Trail will have consumed the large stockpiles of zinc plant residue materials. The loss of this feedstock, and the contained metal which has been written off, will dramatically change the type of material treated on site, and the underlying economics and of the operation. This will require that the smelter return to the processing of a higher proportion of concentrates. Changes of this kind will inevitably require adjustments to individual processes and to the flowsheet of the operation. A smooth transition through this period will be dependent on making full use of the available knowledge, and minimizing the need for relearning. A second impact related to feed materials is the increasing trend to process externally recycled material such as e-waste, e-scrap or ‘urban ore’. This addresses some of the raw material supply issues that arise as the residues are consumed, and can add significantly to profitability since this material comes with significant treatment charges. However, the processing of these materials brings a set of new issues, including a need to cope with new elements and compounds in the metallurgical circuits.

Table 2.1 Knowledge Management Challenges

Issue	Knowledge Management Challenge
Specialized metallurgical technology	• Need for a complete inventory of highly specialized technical knowledge • Transfer of this knowledge to new personnel • Repository of technical knowledge and history
Varying, heterogeneous feed material	• Need for highly specialized knowledge of non-ferrous metallurgy
Long term feed stock changes	• Repository of historical operating information and associated knowledge of plant constraints
Reduction in operating margins	• Knowledge of how to approach productivity and process efficiency objective within constraints • Application of existing knowledge to new problems
Workforce renewal	• Capturing the tacit knowledge of retiring workers • Ensuring knowledge retention with increased rates of personnel turnover
Environmental performance and CSR	• Knowledge of how process operation and modification can impact on environmental issues

These trends all speak to the need to adapt to change, an activity that strongly benefits from the application of existing knowledge and the creation of new knowledge. In a situation where there is a long lead time, or other buffer which delays or slows the impact of change, adaptation can be evolutionary. In other words, there is some sort of cushion which allows for 'trial and error' as a means of coping and ultimately profiting in the new business situation. However, two of the other drivers of changing are removing the luxury of long adaptation time. Margins for the operation are narrowing. As treatment charges fall, and concentrate contracts deliver more value to the mines, the margin that Trail Operations works on is reduced. As the margin shrinks, there is less profit available and return on capital decreases. In order to maintain profitability it is critical to increase productivity, by making more effective use of the capital employed. This, in part, can come from efficiency improvements such as increased on-line time and an increased rate of return to full operating rates when disruptions take place. It can also come from the more efficient use of the installed capacity, for example increasing the throughput in a given unit operation. Both of these tactics depend on having a broad knowledge base, particularly any effort to improve capacity above demonstrated rates. In this case there is a need to identify the rate controlling steps, and make suitable modifications to reduce their impact on the process. A critical part of this in an ability to anticipate any safety or hygiene issues that

might be encountered in pursuit of these changes. Again it is important to be able to draw on a large knowledge base.

The issue of knowledge management is exacerbated by the changes taking place in the workforce as a result of the response to significant competitive pressures. Downsizing of the workforce in the 1980s and 1990s led to an extended period in which there was little hiring of new employees. As a result, there was a long period over which the natural generational knowledge transfer ceased. During this time there was also a considerable investment in new technology, which required the organization to undertake considerable learning (Babcock, et al. 1998). Emerging into the second decade of the 21st century these trends have converged to further stress the organization. In the first place, the older workers who have developed the background knowledge to operate the newer technology are retiring and leaving without necessarily the time to fully train the new hires. Secondly, there are more subtle changes that are affecting the devotion of employees and their commitment to the health of the organization. In each case they have the most dramatic impact the transfer of tacit knowledge. One of the issues with workforce reduction and short or medium term productivity improvements is that they can come at the expense of long term knowledge retention. In the short term the downsizing does not represent a significant loss of tacit knowledge since there may have been considerable redundancy. However, workforce reductions not only remove the redundancy which is a buffer against retirements and other turnover, but also restrict the time available for the transfer process. If crews are reduced to the minimum required to run the plant, which implies very little opportunity for job shadowing, then learning through an immediate coached experience is minimal.

The final issue raised above is related to the need for improved environmental performance and, in general, the increasing importance of corporate social responsibility (CSR) initiatives. Process and operational improvements in this area rely on a high level of technical knowledge which would also support the capacity and efficiency improvements discussed above.

2.2 Current Level of Knowledge Management

There has been a growing recognition of the general knowledge management issue within Trail Operations. A 'Controlled Document' system is in place which is used as a repository of a wide array of formal documents including standard operating procedures, confined space entry procedures, process hazard assessment tools, process change authorization procedures and various checklists. Documents in the system are maintained through a predetermined review

process and signoff. The system maintains a revision history and generates notices for document review. Although it is available for use, and meets some of the requirements inherent in a knowledge management system, it is not universally used and there are no formal requirements that documents be stored in the system. There is no systematic approach to storage of documents and no standardized formats.

There have also been efforts to consolidate operating knowledge, and a project is currently underway in the Sulphide Leaching business area using the MTS Training system (MTS World Inc. 2011). This approach consolidates process operating information into a program of study which includes flowsheets, technical background, quizzes and other items in an on-line and paper document.

Within the Technical Support group there has been a long term document management effort that was initially based around a paper filing system with a master set of documents kept in the department filing cabinets. A subject numbering system was developed and expanded over the years to encompass the full range of technical and operating subject areas of Trail Operations. A file index of the folder numbering system provided the guide for a search of the available documents. Beginning in 2000 new documents were collected in an electronic format and stored in a general repository on a LAN drive. A full text search function used for locating documents on the basis of the title and content when available in text or word processing formats. Since 2008 there have been efforts to store documents in a LaserFiche™ (LaserFiche 2011) based system. Many of the electronic documents from the LAN storage area have been moved into the LaserFiche system; however there has been no attempt to add metadata to these items. Preliminary moves have been made to formalize this process and add a metadata requirement to the filing process, but this has not been fully implemented. At the current time there is expanding corporate support for SharePoint™ (SharePoint 2011) while an active support for LaserFiche has not been maintained in the face of Trail Operations IT retirements. These changes are undermining the document management effort.

In summary, there has been no guiding knowledge management strategy for Trail Operations. Over the last two decades there have been piecemeal efforts in various area of knowledge management, largely focussed on the storage of documents. This has largely gone on within Technical Support, and has made use of available technology which is not strongly supported. There is an absence of a vision of knowledge management that would help to define the path towards a fully functional knowledge management system.

2.3 Conclusion

The running of Trail Operations is becoming more complex as business, environmental and personnel changes increase. There is a growing need to become operate in a more disciplined and systematic way. The margins available due to differentials between feed stocks and products are shifting towards suppliers and customers. Increasing variability in feed materials and the processing of waste materials requires more flexibility, and a higher rate of adaptation. In every case, successfully addressing these challenges will be dependent on the ability to more effectively apply knowledge. Knowledge is the key component of a systematic response to change, and as changes intensify, knowledge becomes even more vital to viability.

It is clear that a systematic application of knowledge will be increasingly important to the success of Trail Operations. The combination of formal and informal mechanisms used in the past does not meet the needs of the future and the increased competitive pressures faced by the organization. The need to address challenges on a range of different fronts requires that knowledge management be recognized as a critical component of the response.

It takes a broad spectrum of knowledge to run an operation as diverse as Trail Operations. The effective functioning of the unit relies on sophisticated knowledge in many business fields, from human resources and accounting, to the technical underpinnings of the metallurgical processes. The scope of an integrated knowledge management system at this scale is considerable, and beyond the scope of this paper. Although the ultimate goal would be to create an enterprise wide system, there is considerable work to do to define the best way to handle the core operating and technical knowledge. To a certain extent it is separate and distinct from the more generic business functions that the operation shares with other Teck divisions and other companies. The technical aspects of this operation require a careful analysis of the knowledge management issues and a specially crafted response.

3: **Knowledge Management in Technical Organizations**

In order to tailor a knowledge management system to meet the challenges faced by Trail Operations it is important to have a basic understanding of the structure required to deliver on the promise of a more effective use of the firm's knowledge. This chapter presents a brief review of the concept of knowledge and knowledge management, and the key distinction between explicit and tacit knowledge. A generalized framework for a knowledge management system is proposed as a basis for the development of a solution for Trail Operations.

In order to embark on a significant change process within the organization it is imperative to clearly make the business case. This critical argument is addressed in the concluding section of the chapter which outlines the value proposition that a properly designed knowledge management system offers to Trail Operations. Significant gaps in knowledge management at Trail Operations were identified in Chapter 2. Together with the discussion of knowledge management features in the first sections of this chapter, they point to a number of ways in which a knowledge management system can contribute value to the operation. The general benefits of knowledge management are enumerated, followed by an analysis of where they will be found in the application of this strategy to the technical side of the operation.

3.1 Knowledge and Knowledge Management

The effective functioning of a company relies on the access to resources and their use in an efficient manner to achieve the goals of the organization. Critical components of this process are information and knowledge. The notion of knowledge is philosophically very complex, and there is no general agreement on the definition as it applies to the activities internal and external to the firm (Alavi and Leider 2001). It is beyond the scope of this paper to provide a comprehensive review of the concept of knowledge, and the various epistemological models that have been developed as the basis for knowledge management systems in the firm (Assudani 2005). However, it is important to provide a structure for the organization of the different components of knowledge as an aid in communicating the concept of knowledge and providing a logical basis for development of a system to manage it. As explained by (McCarthy and Gordon (in press)), this conceptual breakdown of knowledge is important because a major challenge to

understanding and practicing effective knowledge management is the fact that it is concerned with controlling something that is inherently unobservable.

A generally accepted model is based on a hierarchical framework that divides the continuum into data, information and knowledge (Twietmeyer, et al. 2008). This approach attempts to focus on the basic transformations through which knowledge is generated from basic observations. Observations of a system produce the 'raw' data. Data are discrete 'facts' which show an instance of a relationship between a number of variables. There are many types of data points, but in the process industries, a typical data 'point' would be an output condition relative to a number of given inputs. For example, this could be a furnace temperature for a given input of air and natural gas to a burner. A collection of data points of this nature may lead to a relationship or perceived pattern that shows how the furnace temperature changes as a result of variations in air and gas flows. Information is therefore the 'pattern in the data' or alternatively 'the message' (Twietmeyer, et al. 2008). In this context 'knowledge' is the 'meaning' of the information for the particular process or application in the sense that it is a "justified belief that increases an entity's capacity for effective action" (Alavi and Leider 2001). Alternatively knowledge can be considered 'actionable information'. The advantage of presenting the key components of knowledge in this form is that it is readily understood and applied to technical organizations where a significant emphasis is placed on the acquisition of data and the conversion to information and knowledge. It develops the idea of knowledge in a form that directly leads to a working definition of knowledge management.

Knowledge management can be considered "the identification and leveraging of knowledge for value creation". This goes beyond the natural process of knowledge generation and application which happens spontaneously within any organization with a defined set of goals. Thus, to a degree, the elements of knowledge management are necessary for the basic functioning of the organization. The recognition of knowledge management as a distinct organizational function has appeared within the last 20 years (Hansen, Nohria and Tierney 1999), and is an evolving field of study. Whether it becomes a formal discipline remains to be seen, but the perspective that it brings to the functioning of the firm has the potential to bring improvements to our traditional practices.

In characterizing the store of knowledge in an organization it is important to recognize at least two fundamental types of knowledge: explicit and tacit (Broadbent 1998). Explicit knowledge is knowledge that is available in a recorded or codified form, and can be transferred through a medium such as paper copy, e-mail or accessed in a database. Tacit knowledge is

knowledge that people have internalized and carry with them, and is most easily accessed through some form of personal contact, for example conversation or dialogue. There is some debate, and often confusion in the literature, about whether true tacit knowledge can be codified. If a strict definition is applied then there is a class of knowledge that is internalized, but cannot be codified and made explicit. For purposes of this paper the term 'latent knowledge' will be used to refer to internalized knowledge which can be made explicit.

3.2 Knowledge Management Approaches

There are a number of different knowledge management strategies, but they can be broadly broken down into two approaches: codification and personalization (Hansen, Nohria and Tierney 1999). Codification refers to the effort to capture knowledge in a database of some kind with the focus on the 'economics of reuse'. Electronic repositories can be structured to make searching and access relatively easy, and are therefore well suited to situations where similar problems are addressed or recurring problems are encountered. Existing information on the problem or task is a good template in developing a response to the current need. Personalization is a better strategy when deeper knowledge is needed to tackle an issues and a good measure of creative thinking is important to the task. Hansen et al. refer to this as 'expert economics', and it involves extensive use of latent or tacit knowledge. Although codification can be applied to convert latent knowledge to an explicit form, this cannot be done for tacit thinking or thought processes, especially when the purpose is the generation of new ideas and insights (Stewart 2008).

There is a useful parallel between these strategies and the general nature of problems encountered in the operating environment. In statistical process control a distinction is made between 'common cause' and 'special cause' variations. Common cause variation is within the normal statistical variation of the process and can be considered predictable. Special cause variations are due to unusual factors which result in unpredictable changes. In establishing a knowledge management system to address process deviations it is important to appreciate that control of a process within the realm of special cause variation requires a deeper knowledge coupled with the ability to develop creative solutions.

3.3 Knowledge Management Framework

The development of a knowledge management system for the organization requires a systematic approach to the key components of the knowledge management structure. As

described above, the objective of knowledge management is the identification and leveraging of organizational knowledge. These two aspects of the process are part of flow from knowledge creation to application as outlined in Table 3.1. Between the identification and leveraging there is the need to format the knowledge in a way that allows for the most effective capture, storage and access.

The first component is the inventory of knowledge that exists. This knowledge can be in any form, and it is important that the system have some means of tracking the inventory of available knowledge. The inventory is not static and evolves through deliberate action or by natural processes. Knowledge is created through normal business processes, including both production operations and technical development. As part of a knowledge management system there is a need for an 'agent' to recognize the appearance of knowledge and identify it as valuable to the organization. Often the agent will be part of this process, and inevitably is the person who is accountable for the production or technical process, as the case may be. The knowledge generated or retrieved is used for some purpose. Within the knowledge management system it becomes their additional duty to flag the knowledge item for capture.

The capture process depends on the type of knowledge under consideration. Generally, knowledge relating to a technical or production understanding can be recorded in an explicit form, e.g. a document or drawing. Knowledge of a new problem solving approach or methodology cannot be documented as easily, and will likely be retained as tacit knowledge. A properly functioning agent will make the effort to capture the knowledge in the most appropriate way. At a minimum, the agent should maintain some record of the appearance of knowledge even if there cannot be immediate capture. The capture process must respect the storage requirement, and the form of the knowledge capture should record the knowledge in a form that is most efficiently stored. The storage system must be designed for effective access to the knowledge once it has been placed in the system. To a degree the storage and access functions would be part an information technology (IT) subsystem (Alavi and Leider 2001).

The final and especially critical step in the management process is the transfer of the knowledge to the applications where it can add value. At one limit, when this step is essentially a passive process, the knowledge management system becomes really no more than a document management system making the explicit knowledge available to those that make the effort to search for it. In a well designed system the transfer process must be active, and contain mechanisms which promote the use of the contained knowledge.

Table 3.1 Knowledge Management System Components

Phase	Knowledge Management Component	Key Question	Purpose
Identification	Inventory	What knowledge is there?	Establish an inventory of all knowledge created, whether it is explicit, tacit or latent
	Agent	Who is accountable for the knowledge?	Required to identify the appearance of knowledge and the plan for its capture
Formatting	Capture	What means should be used to capture it?	Capture knowledge in the most appropriate form
	Storage	Where is the knowledge to be stored?	Store knowledge for ready access
Leveraging	Access	How is the knowledge accessed? and who can?	Make the knowledge as accessible as possible
	Transfer	How is the knowledge transferred to where it is needed?	Make the knowledge available where it can contribute to the creation of value

It is important to appreciate that the agent is plays a critical role in this system because there is a need to recognize the creation or presence of knowledge, and to decide on the appropriate method of flagging the information for the best access and transfer. The agent is therefore somewhat different than the other components, and is a role that must be taken on by people in the appropriate positions.

In summary, the design and implementation of a knowledge management system should be built around a framework which includes functions for the three key phases of the process: identification, formatting and leveraging. The form of these will differ for explicit and tacit knowledge, and it will not likely be practical to construct one structure that handles both in the same way. Care should be taken to design the system accounting for the attributes of the knowledge of interest and avoid applying a generic solution.

3.4 Knowledge Management Value Proposition

In general, the value proposition of knowledge management is based on what it offers for improvement in the following areas:

- performance (throughput, recovery, production)
- problem resolution (troubleshooting)
- identification of options for technical and production issues

- response time to technical issues (adaptability)
- reduction of rework
- enhanced ability to create new knowledge more quickly
- innovation

Each of these items applies in some way to the business challenges outlined in Chapter 2. An improvement in performance can increase profits in several ways. In the limit, the application of knowledge can optimize an existing operation and achieve a higher throughput or recovery without requiring any increase in resources. Knowledge creates value in this case by simply making better use of the existing resources, by increasing efficiency. When difficulties arise, the problem solving response relies on application of knowledge. In the absence of the appropriate knowledge the response can degenerate into almost random trial and error changes to process parameters. These can be very inefficient in coming to terms with issues in complex systems. Without the appropriate knowledge it is difficult to anticipate the implications of changes and interpret the resulting observations of process behaviour in the absence of a fundamental understanding of how the process operates.

A quicker response to technical issues not only addresses immediate problem resolution but also relates to longer term issues faced by the organization. For example, there are a number of impurity elements that come on to the property along with the valuable metals but make no net contribution to profits even if they end up being sold in one form or another. Often they represent a net cost to the operation. Arsenic is a case in point. As economic and market conditions change, technology advances and environmental regulations evolve, there is an impact on the optimal arsenic strategy. In the absence of a strong knowledge base that is updated regularly and easily accessible, it is difficult to respond in coherent manner. This issue is compounded as a function of personnel moves. Often the momentum towards addressing longer term issues with a strong technical component is disrupted with the movement of key personnel. Due to the nature of these issues they do not readily lend themselves to careful and systematic documentation, especially when there is a continuing and urgent need to manage short term issues at the same time. As a result, there is tendency for the knowledge gained to accumulate in a tacit form in the minds of one, or only a few, individuals. This is exacerbated by periodic needs to focus on short term problems that often postpone work on the medium and longer term issues. One solution is to have a separate group whose primary concern is long term strategy. However, there is a tendency in Trail Operations to rely on ad hoc teams assembled from existing departments. This has the advantage of drawing in people with very relevant experience, but incurs the costs

outlined above. Knowledge management can play an important role here if the system is structured to capture the knowledge as it is generated, and transfer it effectively when required.

Directly tied to improvements in response time is the degree of rework. Clearly, rework on a problem delays any response. If the knowledge or information required to solve a problem must be regenerated then additional time is required before action can be effective. Knowledge management offers the potential for a reduction in rework simply by identifying what was done in the past and providing access to it. This should include both explicit and tacit knowledge. Although necessary in the context of any particular issue where knowledge has been lost, rework fundamentally represents a waste of resources. Therefore a reduction of rework represents a productivity gain for the organization. There are secondary benefits that flow from this as well. The practice of rework can be demoralizing for personnel and raise questions about the effectiveness and competency of management. If carried further this can ultimately contribute to turnover and amplify the knowledge management problem.

Knowledge management can have the effect of enhancing knowledge generation. In the first place it highlights knowledge as distinct from information. In this way it helps the technical and operating personnel focus on the more enduring lessons that are learned as part of problem solving and project activities. Secondly, knowledge can assist in the interpretation of new data or information, and more effectively identify the path to new knowledge (Boisot and Cox 1999). For example, knowledge of patterns in experiments seen previously can help minimize the number of new experiments needed in the present round of tests. Thirdly, at a higher level, a knowledge management system allows for patterns to be detected in the knowledge creation process itself. This, in turn, offers the opportunity to increase the efficiency of knowledge generation. A simple example might be of when the required information or knowledge is best generated through lab scale test work, and when plant tests are really the only way to learn what is needed. The knowledge management system would allow for these cases to be assessed based on history, or help identify individuals with the appropriate tacit knowledge to make a decision.

The implementation of knowledge management is not without costs. However, a significant benefit can be obtained merely by recognizing that a systematic approach to information and knowledge storage is important. This attitude can promote minor changes in the practice of people which can make measurable increases to knowledge accessibility.

4: **The Knowledge Management Framework**

An assessment of the state of knowledge management in Trail Operations was reviewed in Chapter 2. As noted, there have been attempts to create pieces of what might make up such a system, but with no overall objective for the organization as a whole. As a result, there is a need to begin with a broad perspective and create a vision for the system. The structure of the system from that point can be then developed on the basis of the framework defined in Chapter 3 for specific aspects of the organizational knowledge base. This chapter develops the general approach to knowledge management from that perspective, and highlights where differing types of knowledge require distinct mechanisms to effectively fulfill each function. A sensitivity to these issues is important in order to avoid the temptation to apply a blanket solution to all of the knowledge in the organization. The framework is designed to guide implementation through a series of critical questions which help avoid the pitfall of assuming that all we dealing with is a need to write down a list of information about each process or plant.

In the discussion of each phase of the knowledge management system a brief review of the status of the components at Trail Operations is presented to illustrate the type of issues that need to be addressed at each level. The intent is to show how the framework raises the critical questions for a knowledge management system in a systematic and developmental way. A thorough analysis of each component is beyond the scope of this paper given the diversity of knowledge areas to address. The analysis presented here is intended to show how this approach would form the basis of a more thorough evaluation of the current state of knowledge management in the organization.

4.1 Vision

A following statement captures the essence of the long term vision of a knowledge management system:

The knowledge management system will drive the collection of knowledge created in the organization and transfer it when and where it can create value.

The idea is that system must independently drive the collection of knowledge as it is created through the activities of the technical and production departments. It must then capture

and store the knowledge in way that makes it readily transferable when the need or opportunity arises. The system should ultimately be an active transfer mechanism in the sense that it requires a minimum of special inputs from technical and operating personnel. This is an ambitious goal.

4.2 Identifying Knowledge: Inventory and Agents

The front end of the system is the knowledge inventory. This is generated as a result of the analysis of technical and operating information. Knowledge of how a process operates and how to control it is produced through this activity. It is important at this stage to recognize that knowledge is being created and to first note the existence of new knowledge. Knowledge creation is largely a human activity, and people are uniquely qualified to recognize the appearance of new knowledge, or knowledge re-created. It is therefore critical to the success of the knowledge management system that the people involved make the identification of knowledge a top priority. These people might be termed 'knowledge agents'. At a minimum they need to record the presence of knowledge if there is not the time to make a full account of it. Often, in the course of an investigation, study or problem solving exercise there is not the luxury of documenting each step as it is taken. However, a record of a major finding or conclusion can be a flag for future reference and identify the need for detail. In a technical project this need could be met by maintaining a list of documents that should be produced as a result of the work. Even if they are not written in the normal course of the project they can be generated when time permits. It is apparent that this approach to knowledge management requires an increased commitment of personnel time during the knowledge production stage.

It is important to review the drivers of knowledge management and ensure that the right incentives and audits are in place. The creation of knowledge should be recognized as a critical function by the organization. It is therefore important that individuals who generate knowledge maintain a list of their contributions to knowledge. Since it is difficult to impossible to determine the lifetime value of a piece of knowledge, there should be only a minimal effort by the individual in trying to make this assessment unless it is relatively obvious at the time. In some cases it may be possible to qualitatively mark the value and what it derives from. Where the knowledge is used to solve an immediate problem then there is more hope of quantifying a value, but even with the availability of all of the facts, it can become a problematic exercise. Most often the efforts of a team of people are involved and distinguishing the individual contributions is problematic, and easily counterproductive if not done very carefully. People should therefore track their contributions even if there is some redundancy. The main point is to highlight the importance the

organization places on knowledge creation and accessibility. The latter aspect becomes part of the list, and answers the question as to where the knowledge created resides. Its presence as 'tacit' knowledge is acceptable in cases, but this may flag the need for conversion to an explicit form. Generation of these lists and their maintenance helps to capture knowledge for the organization and, at the same time, gives individuals the opportunity to clarify their role.

The current approach to tracking projects with the Technical Support group at Trail Operations is to use the 'Objective Statement' or 'Project Charter'. This is summary of the objectives of the work, evaluation of the benefit, scope, project plan and risk management plan. It also serves as the document in which the monthly reporting on progress and changes to budget and project direction are recorded. A final section includes a listing of documents produced by the project. If properly developed at the beginning and maintained through the course of the project, this charter includes much of the relevant background information on the project and a chronology of the progress. The list of documents becomes a potential pointer to the knowledge generated. Unfortunately the Charters or Objective Statements are not well maintained unless there is active review of their content. As a result, the inventory of information and knowledge generated in the course of a project can become largely tacit, and reside internally in the project leader and co-workers. This situation is normally tolerable within the lifetime of a project, particularly if one person is the leader from beginning to end. However, in projects that extend over several years and see a succession of project leaders, this system breaks down, especially if previous project leaders are not part of the continuing team.

This system, as structured for knowledge management, has significant deficiencies although it is better than cases where projects are carried out on a largely ad hoc basis with little, if any, paper trail. The knowledge management approach to the issue of project knowledge would critically assess the mechanism for producing the knowledge inventory and identify the knowledge agents as recognized components of the project. More than a listing of documents actually written, the master project document would include a list of documents written as well as those that be necessary to fully document the results and conclusions of the work. A special effort would be made to also track 'lessons learned' as a way of providing knowledge to other project activities. In order for this to be done effectively there would be a need for two levels of knowledge agents. The primary agent is the project leader who is overseeing the work and in the best position to view the knowledge creation process that is going on, and make the linkages between the various activities. They would be accountable for maintaining an up to date project document list and a registry of lessons learned. However, given the demands on project leaders

there is a need to vet this process, and the secondary agent is the group leader to which the project leader reports. This level of supervision is accountable for maintaining the group knowledge inventory.

The knowledge inventory and agents form the basis of the knowledge identification stage of knowledge management. The critical linkage to reinforce is the activity of personnel in the creation and cataloguing of knowledge. This can be difficult to manage unless there is a clear perspective from the point of view of the knowledge management framework.

4.3 Formatting Knowledge: Capture and Storage

One of the roles of the knowledge agent is to determine the best form for the knowledge capture. Often this is some form of explicit codification in a document. The document is then stored in a repository that has the appropriate search functions so that the knowledge can be readily retrieved.

Information technology plays the key role in this area of the knowledge management system. Here there is a need to rely on the application of computer technology, both hardware and software to meet the objectives of the system. For this reason it is important to align the development of the knowledge management system with the available software options, unless a particularly strong case can be made for the purchase and support of a new product. As noted in Chapter 2, two options are currently available at Trail Operations: LaserFiche and SharePoint. At the moment there is strong support for developments using SharePoint while the maintenance of LaserFiche is declining. There are other a number of other tools offered by various firms that purport to host knowledge management systems. A full survey of these tools is beyond the scope of this paper, however, a large number of web sites are available which describe general and proprietary products. A select group of these companies are contained in the Appendix.

To a degree, this issue is moot. At this stage in the knowledge management initiative it would be difficult to mount a persuasive argument that a proprietary tool is required. This is especially the case given that SharePoint can be used for both knowledge codification and personalization (see Section 3.2). A new product would not only require purchase, but also support both internal and external. Without a strong presence in the corporate office it is unlikely that Trail Operations would feel inclined to take this on until there were demonstrated results. In light of this, two thrusts are recommended. First, a knowledge management system be built on the basis of an internally supported platform. This will demonstrate the potential which may

strengthen a case for the use of a specialized product. Second, the knowledge management initiative should be audited by an external consultant for coherency and completeness.

A significant amount of the knowledge generated in the work of Technical Support and plant business areas is documented in electronic documents, both word processing files and emails. Word processing files are easily stored in the project LAN directory, and with slightly more effort can be put into the LaserFiche repository. Emails are problematic since there is little effort made to store this information and knowledge in a central location for general access. Access is largely mediated through tacit knowledge of individuals who have had close involvement. When the names of these people are not readily available the knowledge is difficult to retrieve. Furthermore, even these individuals themselves may not be able to retrieve this from their own email program files. One of the issues that arises here is the choice of whether to use a formal document or simple email to capture the knowledge. Often expediency is favoured, resulting in explicit knowledge that has poor accessibility. There is cost in personnel time to make the capture process more effective for accessibility. However, this can be minimal if a copy of the email can be added to the general document repository.

The issue of storage is highlighted by the LaserFiche system currently in use by Technical Support. It has become a collection of many documents with a limited degree of structure. In addition, only a small fraction of these documents have associated metadata. Search functions are available for the full text of documents as well as titles. For documents created before the year 2000, paper copies are stored in filing cabinets in the Technical Support area. A numerical filing code was used to categorize these and copies are contained in corresponding file folders. Since 2008 there have been periodic efforts to scan groups of these documents into the LaserFiche system. This work is on-going. In addition to these repositories, numerous electronic files are stored in various LAN drives on the Trail Operations network. Technical Support has maintained the 'tdcommon' directory for over 10 years, and it contains a large collection of project, administrative, personal and process information, data and knowledge. To complicate the storage (and access) problem even further, there is a significant amount contained in personal computer drives and paper filing cabinets. It is clearly apparent that a large amount of knowledge has been captured and stored, but has a relatively low level of accessibility.

The lesson from a knowledge management perspective is quite simple: there should be a common storage system in which all of the information and knowledge can be easily accessed as appropriate. If this is not practical due to software or hardware constraints, then some sort of interface is necessary to make the access as simple as possible. It is acknowledged that this might

be preferable in certain circumstances where collecting all relevant knowledge in one particular place may not be feasible. For example, in the case of proprietary training systems it may be better to define an access path from a general SharePoint site. This is the approach used for on-line journals which the company subscribes to, where it is more efficient to access these sources indirectly.

This situation illustrates the difference between the two components of the 'formatting' stage of the knowledge management framework. Capture is concerned with the best form in which to put the knowledge to facilitate storage and access. There can be trade-offs in this area, where additional effort is required to capture the knowledge in a form that facilitates potential future access. How this type of problem is addressed is one of the issues that should be part of the knowledge management system design. Storage of knowledge is not necessarily as straightforward as it might first appear, especially when there are multiple sources of information and knowledge to manage.

Before leaving this area a couple of further points should be noted. The question of data capture and storage is important for both the technical and production organizations. Data is critical to the development of ideas and knowledge of process operation. Often it is necessary to revisit data to confirm past conclusions or to test new hypotheses. Access to data is vital for these purposes. Production and operating data is stored in large databases that are maintained independently of the knowledge management system. However, for Technical Support projects the data inevitably finds its way onto individual computers and the LAN drives. It is well mixed with the explicit knowledge and information. In these cases, co-locating project data, information and knowledge can have significant benefits in retracing the development path. However, the presence of a lot of data, if not properly organized, will compromise the ability to access the knowledge. The accumulation of many data files amongst the reporting files may have this effect. An analysis of data storage would be a recommended part of the development of a knowledge management system. The second point concerns the 'capture and storage' of tacit knowledge. As noted earlier, this is actually contradictory. However, the emphasis is more on the development of pointers within the system which guide access to sources of tacit knowledge, or more formal systems of tacit knowledge transfer such as communities of practice (Wenger and Snyder 2000). Decisions about these aspects of a knowledge management system should also be considered in the design phase.

4.4 Leveraging Knowledge: Access and Transfer

The final phase in the knowledge management process is the leveraging of knowledge for the creation of value. This is accomplished by two steps, access and transfer. Access is the process of retrieving knowledge from the system, and can be as simple as searching for, and finding a document. As noted in several of the cases cited above, the state of the current Technical Support system is not conducive to ready access. Access is compromised by the existence of several repositories, none of which have been carefully structured. Some of the knowledge is available only through personal files that are only accessible by one individual through their computer. In their absence, or without their cooperation, the knowledge is invisible to the company.

The raison d'être for knowledge management is the transfer process. Otherwise the system is in danger of becoming little more than document management. It is crucial that knowledge transfer become an active part of the system. There are several ways in which this should be done and can be divided into the generalized transfer of knowledge and targeted transfer. The former approach is traditionally given as training courses for operators and technical experts which communicate the background knowledge necessary to understand the operation and trouble shoot the processes. Classroom training and on-line tutorials are typical ways of delivering this content. The disadvantage is that it is, by its nature, not specific to any immediate needs, and can be inefficient in addressing and communicate knowledge for direct application in a given situation. However, there are relatively simple ways of scheduling this type of transfer to ensure that it is part of regular updating of personnel knowledge.

A small amount of generalized process knowledge transfer takes place for engineering staff when they join Trail Operations. As part of the training modules associated with employee inductions there is an overview of the process metallurgy and how the many processes interact. This introductory material is supplemented in each business area with technical detail, some of which is available through plant trainers and training systems. Beyond that, technical knowledge is transferred through the reading of technical file notes, and interactions with experienced personnel as driven by troubleshooting or project needs.

To be truly effective a knowledge transfer mechanism must be able to actively deliver the relevant knowledge in a timely fashion. There are no easy methods to effect this. A starting point however is the development of knowledge maps which allow for effective searching of the knowledge base. This is a first step in a more comprehensive program which ultimately aims to become an active system.

4.5 Application of Knowledge Management to Trail Operations

The role of knowledge management in the mining and metallurgical business has been recognized for some time (Ednie and Mottola 2002). Various companies have taken different approaches to manage knowledge, some investing more effort than others. As discussed in Chapter 3 it is important to pay attention to the type of knowledge of concern and tailor the approach accordingly.

The review of knowledge management issues in Chapter 2 suggested that there is a need for management of both explicit and tacit knowledge. There is an important need to ensure that standard operating procedures (SOP) and analysis techniques are available. As noted, there is a controlled document system in place which can be used for SOPs; however it is not used in a standardized way. Furthermore, it is not fully populated with the information and explicit knowledge of the organization. This material is necessary to operate and address the problems encountered within the normal operation of plant processes. There is also an important need for latent or tacit knowledge to respond to the process problems encountered due to special causes, and feed chemistry changes. This knowledge is more difficult, and in some cases, impossible to codify. Therefore the knowledge management system must address this need as well.

As a result, the knowledge management system for Trail Operations must include components for both explicit and tacit knowledge. It is important to recognize that one approach will not be effective for both. In addition, there is need to beware of the dangers of trying to place an equal emphasis on both (Hansen, Nohria and Tierney 1999). Hansen recommends that the system be designed around the core business purpose. However, this is likely not as critical in a situation where the roles of operations and technical support can be fairly clearly separated.

The framework of knowledge management framework points to the need to address several critical deficiencies in the existing situation. It is important that the development proceed with the intent that the system be more than a passive repository of information and documents. To this end it must have a clear overarching vision which reaches from knowledge creation to knowledge transfer. These are also the key areas where change and developments are required.

5: **Implementation Plan for Knowledge Management**

The implementation of a knowledge management system is a major undertaking for the organization because of the need for a substantial paradigm shift. It is therefore important that a systematic approach be used which defines a clear pathway for coherent development. The chapter begins with a review of the rationale for a structured change management approach. This is followed by an overview of a structured approach to organizational change based on the model proposed by (Kotter 2007). An analysis follows which addresses each of the steps in turn. The key aspect of each stage is described followed by the application to the knowledge management implementation plan for Trail Operations.

5.1 Knowledge Management Implementation Issues

A formal and comprehensive approach to knowledge management as a change process is required for several reasons. These include issues related to the both the knowledge itself, as well as the context within which the changes are being made.

In the first place, knowledge management has not traditionally been considered as a formal management task. As a result, the creation, capture and transfer of knowledge have been done on an ad hoc basis. There have been various attempts to address aspects of the issue, for example, the development of a training simulator for the new lead smelter (Babcock, et al. 1998), but there has not been a systematic approach across the property. The normal approach for unit operations has been to write a standard operating procedure (SOP) and file it in a document management system. The company culture has not supported a systematic approach to knowledge management in the past. Under these conditions is unrealistic to assume that any implementation will be able to grow 'organically' through the organization.

Second, the overall objective is daunting. There is a large amount of information and knowledge which is currently contained in a wide variety of explicit, latent and tacit forms. The implementation of a comprehensive system needs to be a coordinated effort to ensure that the appropriate standards are develop and comprehensively applied.

Third, the two factors discussed above suggest that there will be resistance to the program. In part, this will be passive in the sense that it is a cultural change, and requires that

people come to implicitly value knowledge and act accordingly. The concept itself is not likely to raise serious disagreement; however it will be more of an issue in achieving a demonstrated level of commitment and leadership from management. The magnitude of the task will likely provoke resistance unless appropriate resources are available to launch and sustain the effort. To a degree this arises because there are many other systems that need maintenance, and sufficient resources to meet existing demands are not available.

Fourth, it requires a new, more comprehensive view of knowledge. In order for knowledge management to take hold there is a need for clarity around the concept to avoid confused action, and to increase the visibility of the benefits. In particular, it is important to distinguish between data, information and knowledge so that the proper measures are taken to manage each component appropriately. This can be addressed, in part, by the process of education as part of the knowledge management system implementation, but would also have implications for the system structure.

Finally, another potential issue is the problem of 'knowledge hoarding' (Gilmour 2003). Employees will often be found to hoard information or knowledge as a means of promoting job security, or to demonstrate their value to the company. A knowledge management system must address this tendency in the corporate culture in order become effective.

5.2 Overview of Organizational Change

The process of organizational change is complex, and successful change management depends on attention to the important steps in this process. (Kotter 2007) recommends a path which begins with making the case for urgency, and continues through to institutionalization of the changes. The transformation process can be broken into eight stages as summarized in Table 5.1. It is important that the steps be taken in the order prescribed.

The first stage involves creating the sense of urgency, whether it flows from a threat or opportunity, or some of each. Either way, there is a need to make a convincing case that change is imperative, and the status quo will not sustain long term success. Once this argument has been developed to a level of sufficient credibility the next step is to form a guiding coalition which has the power to drive the change. This group then develops the vision for the change, in a form which captures the essential message in a succinct and emotional way. The vision should be easy to communicate and inspire people to participate in the change. At this stage there is also the need to plan the strategies that will effectively achieve the vision.

Table 5.1 Change Management Stages (Kotter, 2004)

	Stage	Description
1	Sense of Urgency	• Work from threats and opportunities • Need 75% of key decision makers convinced of the need for change
2	Guiding Coalition	• Requires line managers in a position to address obstacles • Should include 'outsiders' to balance the inertia of the existing hierarchy • Team effort required from the group
3	Vision	• Clear, concise articulation of the change • Elicits immediate understanding and interest
4	Communication of the Vision	• Constant, contextual communication of the vision • Use of all possible vehicles, including leading by example
5	Empowering Others	• Vision needs to motivate people to act • Coalition needs to monitor the process to help remove obstacles
6	Short-term Wins	• Need to be engineered • Help to maintain the sense of urgency • Recognize and reward those involved in the wins
7	Consolidation and Further Change	• Do not declare 'victory' too soon • Work from short-term and smaller wins to bigger accomplishments
8	Institutionalizing the Change	• Communicate the connections between the changes and improvements/successes • Work to ensure the next generation of leadership supports the changes

Communication of the vision by all means possible is the fourth step. The more radical the change, the more persistent and pervasive the communication required. The vision should help to explain the urgency as well as the path forward. It is best if there is some way to demonstrate the vision by example. As the change is rolled out, and specific activities are underway, it is important that everyone at all levels is supported through the process. The coalition should monitor the change process and ideally anticipate obstacles before they become serious issues. In any case, obstacles must be removed, and if this is done visibly by the coalition it helps to communicate the drive behind the program. 'Short term wins' are critical in demonstrating the commitment to the process, as well as demonstrating that the change is positive and beneficial. These wins should be visible evidence of performance improvements. Although this is step six in the overall process, careful planning for the wins should be part of the strategy development from earlier stages. The final stages work to accelerate the implementation of change, first by consolidating improvements and taking the change to new areas. Ultimately, the new structure becomes an integral part of the institutional mind set and culture. This may take a considerable period of time, and the coalition must continue to put energy into sustaining the change even after the program is superficially in place. In the case of major changes there is a need to ensure that succession planning is done in support of the long term vision.

5.3 Implementation Plan

The eight stage implementation plan is outlined below.

5.3.1 Urgency

The starting point for a change management plan is a sense of urgency. In the absence of this feeling, the inertia of the status quo impedes any attempt to move in a significantly new direction. Although knowledge management activities can be enhanced in, or grafted onto, existing departments they will not lead to the vital changes that are required in the culture unless they are seen as a part of imperative business action.

As discussed in Chapter 2, there are growing threats to the organization which require a response through knowledge management. Fundamentally, the need for a knowledge management system is driven by the need to sustain the business in the face of increased competition and significant changes in the workforce. The accelerating demographic change is a haemorrhage of vital information and knowledge critical to the organization. As these resources are lost we face increasingly unsustainable levels of rework and reinvention that cannot be afforded in a competitive environment.

An aid in establishing a sense of urgency is the ability to quantify the impact of knowledge management, and the lack of taking action. The development of metrics for knowledge is problematic, and raises a host of issues that cannot be easily addressed, for example the problem of measuring the store of tacit knowledge. However, an appreciation of the magnitude of the issue can be developed through a preliminary inventory of the knowledge required to operate. The use of numbers has a certain appeal to people, because it tends to give the impression of deeper understanding than actually exists, particularly to the scientifically inclined. The availability of a metric is also an important aspect of gauging the long term success of the program (Tiwana 2002). The maxim ‘you cannot control what you cannot measure’ has a certain validity in the context of the knowledge management issue.

The sense of urgency can be established in two steps. First, the scope of the issue should be outlined through a set of concrete examples which highlight each facet of the challenge. This would entail working through each of the items identified in Table 2.1, and providing a clear and poignant example. In each instance, the preference would be for a high profile case which was widely recognized in the organization.

5.3.2 The Guiding Coalition

The coalition behind a knowledge management change that covers the whole organization, and spans both the technical departments and production units must have leadership at the top. The coalition must include the General Manager, and have full senior management support. It is important that there be strong representation from Operations and Technical Services.

A number of initial projects are detailed below which are designed as 'quick wins'. Important roles for the coalition are support for these efforts through assignment of resources, and the removal of obstacles when they arise. With this in mind, the membership of the coalition should include people in positions to do this quickly and effectively. On this basis the coalition should consist of:

- General Manager
- Information Technology Manager
- Superintendent, Human Resources
- Manager, Operations
- Knowledge Officer

The General Manager is required to emphasize the importance of this to the organization. His direct involvement sends a strong message that this initiative has full senior management support. The involvement of the Information Technology group is vital to the implementation of an effective document management system for explicit knowledge. The creation of a knowledge bank which includes explicit and tacit knowledge is also part of the system and requires attention to personnel issues. It is important that there be participation of the human resources department to bring them along in the as part of the required cultural change. The main customers for the technical knowledge are the operating plants. There is a critical need for the Manager, Operations to endorse the project through direct participation. The proposed creation of knowledge maps is based heavily on the input from operators and Operations technical staff, and they must see a firm commitment from their management. Finally, there is need for the coalition to have a member which can actively coordinate the implementation. This individual would have knowledge management as their top priority and champion the program. He or she would be tasked with nurturing the individual seed projects in such as way that can ultimately be brought together in a unified system. It is important that this person should come from outside of the individual departments mention above in order to ensure that the new vision of the knowledge culture is sustained, and not absorbed into one of the prevailing mindsets. Creation of this position in the organization would also be an important endorsement of the initiative.

5.3.3 Vision

The vision is a guiding statement that captures the essence of the change. It needs to be clear and concise, and quickly communicates the scope of the change to the organization. It should be written to elicit immediate understanding and interest. The vision for knowledge management needs to be formulated by the coalition in a way which addresses the urgent issues, and inspires action.

The vision should be developed by the coalition as part of a session which focuses on the knowledge management initiative and charts the course of the initial phases of the program. This session would begin with an overview of the knowledge management issue as laid out in Chapters 1 to 4. This sets the stage for an articulation of the vision by the coalition. It is necessary that they undertake this exercise in order to ensure that they fully understand the depth of the change, and that they collectively commit to active support.

A general vision statement was proposed in Section 4.1 which speaks to the organization and transfer of knowledge for value creation. This might serve as a basis for development of the vision, which would include detail on how the system would best be structured for Trail Operations. Several components of the vision are necessary. It must provide inspirational motivation for action. At the same time, it must contain enough information so that employees can act with confidence on their own initiative.

The vision is captured in the following.

Knowledge makes the difference
Create – Save – Apply
Make the most of it

5.3.4 Communication

Communication of the plan should include the stages proposed to achieve the vision for knowledge management. This should be structured to highlight the components of knowledge management, and the impact of this approach on the ability of Trail Operations to meet its goals. Knowledge captured and made available for use must be seen as a productive activity of all employees. This message is a key part of the communication plan.

Regular updates on the progress of knowledge management initiatives should be made to employees. Along with this there would be invitations to contribute to the program, either through direct participation or contributions to the knowledge base.

5.3.5 Empowerment

The empowerment stage is critical to the success of the implementation. Employees must feel that they have the latitude to apply the vision to their everyday routine, and to propose changes which align with it even though it runs counter to the status quo. These ideas should be encouraged and exploited to move the process forward.

There is a need to clearly recognize the value of the work done in contributing to the knowledge management system. This must begin with recognition of individuals who create, and make the effort to capture knowledge. Where appropriate knowledge related objectives should be part of every employee's annual performance assessment process, and thereby factor into their annual compensation. This is an important way to communicate the value the organization places in knowledge management and reinforces the attention that is required for it to be effective.

All individuals would have a knowledge related objective that would preferably tie to one of the early knowledge projects. The emphasis would be on knowledge inventory, capture or transfer. One of the key components of the knowledge culture is the recognition of knowledge contributions, and this could follow from contributions to the inventory. There should also be some incentive to capture the knowledge. It is therefore important that knowledge infrastructure projects be part of the first phases. There needs to be places where the knowledge created and captured through individual efforts can be placed and organized so that it can be made universally accessible.

A significant emphasis should be placed on soliciting help in defining the most effect transfer processes. One approach would be to bring together groups to define how these can be made effective.

5.3.6 Short term wins

Short term wins are important in reinforcing the change in the early stage when there is incomplete knowledge of the program or acceptance in the organization. These give other people a chance to see the concrete form of the vision, and it therefore helps in the communication of the overall goal and plan. Successes early in the program also help to reinforce the team and provide opportunities to reward their efforts, and raise the profile of the endeavour.

A number of knowledge management project suggest themselves for early effort and success.

1. Knowledge metrics. As noted above, the quantification of the knowledge inventory and its use are problematic. However, the benefits of this would be several fold, if the scope were limited and clearly communicated. A means of characterizing the knowledge would help drive the recognition of the need for knowledge management, and reinforce the systematic nature of the program. It would be important to carefully structure and vet this before raising expectations too high.
2. Document management. An easily accessible and searchable document management system is a primary objective (Hansen, Nohria and Tierney 1999). This system should be built as a pilot project with the focus on a specific process or unit operation. All available information and knowledge on the process should be built into the system to illustrate the structure and retrieval methods. It would be desirable to make the interface as simple and intuitive as possible. This might be accomplished through some sort of graphical knowledge map (see below).
3. Knowledge bank. A knowledge bank is another step towards a comprehensive knowledge management system that can be taken, and later integrated into a larger structure. The idea here addresses the capture of knowledge, but also provides a basis of a locator of tacit knowledge. This bank is a database of lessons-learned (Greer 2008) and approaches to problem solving or project execution. Although it could contain pointers to documents, the concept is to provide a place to store higher level conclusions and recommendations. It would be important to carefully add metadata to increase the searching efficiency.
4. Knowledge map pilot project. The purpose of this project is to illustrate the structure that the knowledge management concept can bring to the organization of knowledge and demonstrate the power that more general access can bring. The point here is to communicate in a direct way that the knowledge is now more available than before. The vision is that anyone in the operation can readily, and intuitively, access the information and knowledge for all of the plant processes. The basic idea is to create an interface to a distinct unit operation, and graphically link all of the relevant process knowledge to this site. A potential case is the continuous drossing furnace (CDF) which has a significant profile in Trail Operations because of the critical role it plays in the functioning of a number of plants and its recent history of problems. As a result of this, a significant amount of information has been gathered and knowledge created which is readily available. This would be used to develop a fully populated map of the process and its operation.

5.3.7 Consolidation

Based on the success of earlier stages, the plan would be to implement the concept of knowledge maps across the property, and start linking them together. The use of a common format would facilitate the access for individuals if they moved from one area to another, and allow more time to be devoted to technical training rather than for the learning of a new system. It is at this stage that more emphasis would be placed on the transfer aspect of knowledge management to take full advantage of the knowledge repositories.

5.3.8 Institutionalization

The long term goal is knowledge management as a routine management process. The whole effort revolves around the creation and transfer of knowledge, both of which are centred in people. The knowledge management system, like a safety system, is only truly effective if all employees are engaged. The system can facilitate the process, but ultimately safety depends on the decisions and action of people in the field. Knowledge is created in the 'field' and is lost or remains there if people do not make the effort to retain and share it. It is therefore necessary to institutionalize the respect for knowledge, and emphasize the value that the organization places on it.

The incorporation of knowledge in regular personal and institutional objective setting is one way of maintaining the profile of this activity. There should be annual recognition of knowledge contributions.

6: **Conclusions**

The challenges faced by Trail Operations come from many directions. A common theme is the need to operate with more flexibility and efficiency. Given the increasing complexity of the business environment, new process and feed materials, and changing workforce demographics, one of the key resources to meet these challenges is organizational knowledge. To effectively use the available knowledge, and capture knowledge as it is created, a disciplined approach is required. This role can be fulfilled by a properly structured knowledge management system. The knowledge management system should be matched to the knowledge in the organization and the uses to which it is put. Thus, there is a need to understand the differences between explicit and tacit knowledge, and design the system structure accordingly.

The goal of knowledge management is the leveraging of knowledge for value creation. A systematic approach involves designing a system with three phases: knowledge identification, knowledge formatting and finally, leveraging of knowledge. Identification of knowledge requires knowledge agents to maintain an inventory of knowledge as it is created, and work for the capture of knowledge in the appropriate storage repositories. Access to the knowledge must be a simple as possible, but the key to knowledge management is the implementation of a transfer process which delivers the relevant knowledge to where it can contribute value to the organization.

In the case of Trail Operations, there is an increasing need to apply technical knowledge for process improvement and more effective troubleshooting of upset conditions. This knowledge is also important in adapting to new feed materials and developing strategies for the processing of non-traditional feed stocks. The benefits of knowledge management indicate a strong value for Trail Operations through an increase in the responsiveness to technical problems, a reduction in rework, and an increased speed of innovation.

A preliminary assessment of the state of knowledge management shows that Trail Operations is in a relatively underdeveloped condition. Components of the system exist in various areas but lack a coherency across the technical groups in the organization. Furthermore, there is little coherent vertical integration of knowledge management from the inventory to transfer mechanisms. A basic inventory of knowledge is maintained within individual Technical Support projects but these are not part of universal indexing system. Project and technical leaders

have roles as knowledge agents, but this is not identified as an explicit function. As a result, knowledge creation is not formally recognized as a key job function. This situation does not place the proper emphasis on the creation and application of knowledge. The capture of knowledge has been reasonably successful for a wide variety of activities including projects, fundamental process understanding and troubleshooting. However, the storage of this knowledge has been a challenge, exacerbated by the move from paper based filing to electronic documents. In each case there have been attempts to organize the process with variable success. At this point there is no comprehensive repository although some effort has been put into populating the LaserFiche system. The consequence of this is a lack of ready access to the available knowledge. Transfer of knowledge is largely based on traditional training methods and what can be picked up on the job.

Although the analysis of the state of knowledge management is incomplete it has highlighted the need for a more systematic approach, with attention to the fundamental aspects of the processes involved. This should be done as part of system design exercise. In order to proceed with knowledge management it is critical to recognize that this would be a major change for the organization. This includes not only the structure of the system itself, but also the need for a different cultural environment which embraces the value of knowledge. As such, the implementation of knowledge management system should be considered an exercise in change management. On this basis, a carefully planned program is recommended beginning with establishing a sense of urgency around the challenges faced by the operation and the vital role that knowledge management can play in meeting them. This is followed by the formation of a high level coalition which takes on the leadership of the initiative. Their work would begin with defining a vision and ensuring that this was communicated across the property. An important aspect of this planning is to target short term wins in order to give the program early momentum and foster general buy-in. Specific target include a universal document repository and a knowledge bank of tacit knowledge. It is also recommended that knowledge contributions are highlighted in individual performance reviews. Given the nature of the change there will be a need for the coalition and the organization as whole to make a long term commitment to the development of knowledge management.

The fundamental value of the knowledge management approach is to bring a new, more holistic perspective on a critical resource to the business unit. A recognition of knowledge as a distinct resource which can be managed in a systematic way is the first step in extracting maximum value for the organization.

Appendix

Select Web Based Knowledge Management Sites

Company	Web Site	Comment
APQC, Houtson, TX	http://www.apqc.org/	Productivity and quality improvements through attention to financial, human capital, knowledge and supply chain management as well as process improvement and measurement
Knowledge Management Resource Center (IKM Corporation, Atlanta, GA)	http://www.kmresource.com/index.htm	Information site on knowledge management issues
Innodata Isogen, Hackensack, NJ	http://www.innodata-isogen.com/	Knowledge management services with focus on IT

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