Knowledge Management for the Natural Gas Transmission Industry

The INGAA Foundation, Inc.

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Dedication

This white paper makes the case for Knowledge Management (KM) and the criticality of capturing knowledge, as it can be transient — usually via workforce turnover, but in other ways as well. That point was made poignantly clear to all of us here at Interliance Consulting, when, in the midst of writing this paper that she was passionate about, our coworker and paper author, Sharon Bergeron, passed away suddenly.

Sharon's knowledge base was tremendous, and we are thankful for her insight, research, and direction. We dedicate this paper to Sharon. We miss you.

Executive Summary

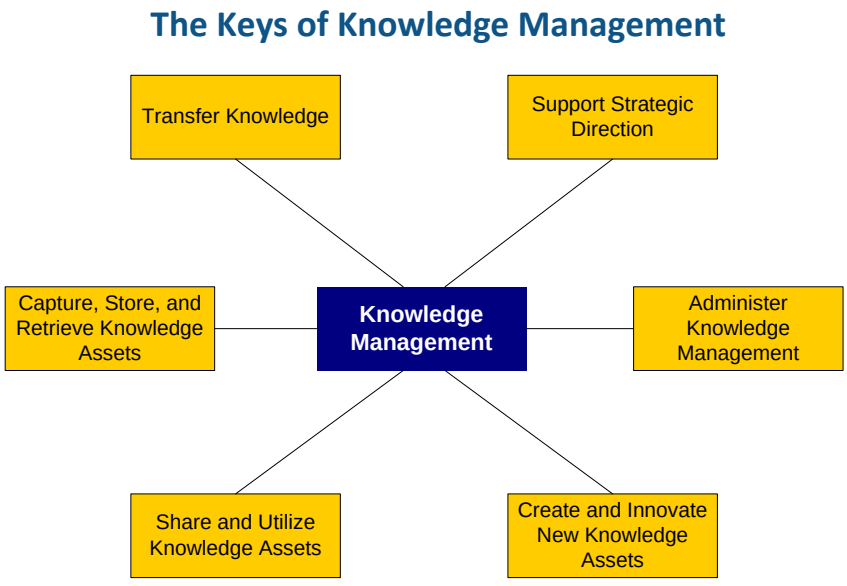
The natural gas industry and the people it serves would benefit if companies were to implement a more robust process to capture knowledge. Most companies – both inside and outside of the interstate natural gas pipeline industry – fail to "own" the "institutional" knowledge that is critical to company success such as data files, business histories, and business processes. Knowledge management is an important tool to support the safe and reliable operation of the North American natural gas pipeline industry, and companies must make a greater effort to retain employee knowledge.

The INGAA Foundation, Inc. commissioned the report "*Knowledge Management for the Natural Gas Transmission Industry*" to help natural gas transmission companies understand and successfully navigate the challenge of managing knowledge in the coming years. This report builds on the 2007 INGAA Foundation Workforce development study[1] that, among other things, recommended the development of actions to maintain company knowledge for training new employees, improving process and improving the quality of decisions. Knowledge assets become valuable to an organization when they can be accessed and utilized by in support of the organization's goals and objectives. To this end, it is necessary for the organization to have processes in place to identify critical knowledge, capture and store it, and retrieve it for use when needed.

This paper addresses the imperative for utilizing the capabilities of knowledge management in the natural gas transmission industry. This paper provides an introduction to knowledge management with a focus on developing a process for natural gas transmission companies to manage knowledge assets effectively. A brief summary of best practices and common knowledge management tools and techniques is presented, but the main focus is on "why to"(instead of the "how to") implement knowledge management. The case is made that a strong knowledge management program provides a path for achieving greater safety and efficiency in every organization and is especially critical to those experiencing significant growth and change, as is the case of the natural gas transmission industry.

Knowledge Management Background

Knowledge management is the strategy, processes, practices, methods and technology that enable an organization to create, maintain and leverage its individual and collective knowledge to achieve its goals. Below is a chart that displays graphically some of the keys of knowledge management.



[1] Securing our Future: Developing The Next Workforce - An Analysis Of Risk And Recommended Strategies For The Natural Gas Pipeline Industry, INGAA Foundation. July 2007. (F-2007-02)

Briefly, knowledge management involves: (1) getting people the right information at the right time so that they can perform and act competently (knowledge transfer), (2) helping people share information across boundaries in ways that will measurably benefit the organization, and, (3) producing new knowledge that leads to improved quality and service, intellectual and technological advancements, new products, capabilities, and processes/practices, and increased competitiveness and profitability.

Making the Case for Knowledge Management in the Natural Gas Transmission Industry

The natural gas industry is in the midst of a growth a cycle. A recent INGAA Foundation study[2] projected natural gas consumption in the U.S. and Canada will increase by an average of 1.6% per year through 2035. Total natural gas used across all sectors electric generation, industrial, commercial and residential—is projected to rise to about 110 Bcfd in 2035. U.S. and Canadian natural gas supplies are projected to grow by 38 Bcfd from about 75 Bcfd in 2010 to about 113 Bcfd in 2035. New infrastructure will be required to move natural gas from regions where the production is expected to grow to areas where demand is expected to increase. New supplies entering the interstate pipeline system may require significant investments in added pipeline capacity to handle the projected increase in natural gas transportation. As gas demand and production continue to grow, so will demand for pipeline services.

Along with growth the natural gas pipeline industry also must contend with a competitive market, greater public concern and increasing regulatory oversight. The safety and reliability of the natural gas industry has been safeguarded over the years in part, by a stable force of experienced professionals; men and women who are experts in pipeline construction and operations. This knowledge matters: studies show that experienced workers are more efficient, more reliable, and make significantly fewer errors than less experienced colleagues.

This critical asset could dissipate as older employees retire and exit the workforce. Unfortunately, many pipeline companies struggle to record and document fully the unique knowledge of their best employees before they leave. As a result, the natural gas industry is entering a period of rapid expansion, increased market competition, and heightened scrutiny. The risk is that the industry may not have the benefit of its collective knowledge.

The key to meeting this challenge is knowledge management, the process of capturing, storing and sharing knowledge within a company to assure high competence at all levels of the organization. Knowledge is more than employee skills; it includes everything the company needs to run its business successfully, including data files, business histories, past projects, technical documents, business processes, product data, trade secrets, etc. The goal of knowledge management is to make every decision, at every level, with the benefit of the full knowledge base of the company.

Making the Case for Knowledge Management

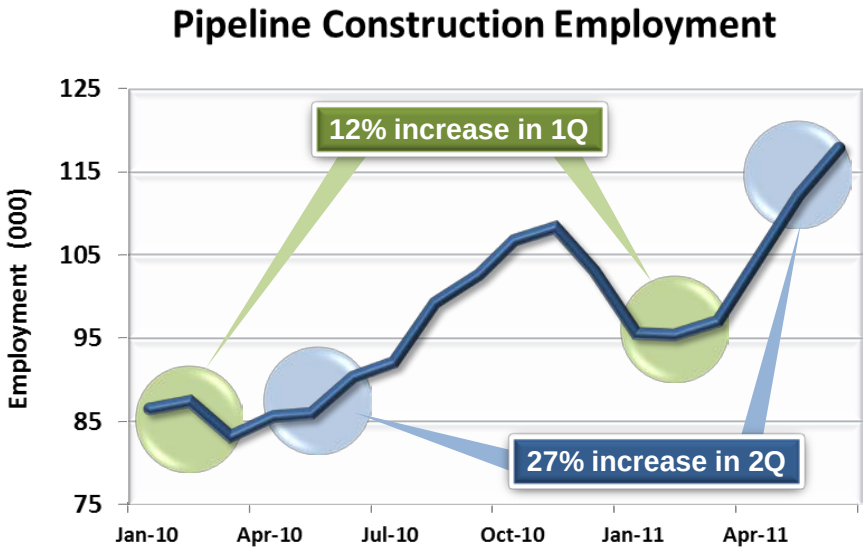
In 2007, the INGAA Foundation's study, "Securing Our Future: Developing the Next Workforce — An Analysis of Risk and Recommended Strategies for the Natural Gas Pipeline Industry,"[i] highlighted the growing challenge of an aging natural gas pipeline industry workforce and suggested that an industry-wide strategy will be needed in order to recruit new talent for the future. Until relatively recently the industry had a highly stable workforce and was afforded a rare luxury in low employee turnover, retaining employees and their knowledge within the company.

Pressures on the workforce in the natural gas transmission industry eased due to a slower economy. Turnover in the transportation and utilities industries has declined by 30% from 2005/2006 to 2010/2011, according to the U.S. Bureau of Labor Statistics (BLS). This has created a positive environment in the industry for recruiting and developing an adequate workforce. In addition, risks associated with knowledge losses due to retirement of skilled employees have likewise diminished.

[2] The INGAA Foundation, Inc. "North American Gas Midstream Infrastructure Through 2035: A Secure Energy Future." June 28, 2011. Executive Summary.

However, recent survey data show that this trend is changing despite the higher unemployment rates, and turnovers are expected to rise quickly. Over half of U.S. employers in 2011 reported difficulty finding new employees, up almost four-fold from just 14% in 2010. Workers themselves are much more willing to look or are now actively looking for new positions.

The U.S. Energy Information Administration is predicting that between 2010 and 2035 domestic natural gas production will increase from 5 Trillion Cubic Feet (Tcf) to 13.6 Tcf. Consequently, employment in oil and gas pipelines will continue to have a dramatic increase for the foreseeable future.. From the first quarter of 2010 to the first quarter of 2011, employment was up 12%; in the second quarter, it was up 27% over the same period in 2010.



This paper addresses the imperative for fully utilizing the capabilities of knowledge management in the natural gas transmission industry. A brief summary of best practices and common knowledge management tools and techniques can be found in the appendices, but the main focus of this paper is the "why to" instead of the "how to" implement a knowledge management strategy.

> *"Knowledge has to be improved, challenged, and increased constantly, or it vanishes." — Peter Drucker*

Say "Knowledge Management" to most business people today and they immediately think technology. Technology may be part of most knowledge management initiatives, but rather than dictating the concept of knowledge management, it is best used in an enabling role as one part of a comprehensive approach. Successful knowledge management is a complex mix of business processes, people, and technology. While supported by technology, successful knowledge management initiatives are not simply technological solutions. They are programs of wide-reaching cultural change that affect the organization in significant ways. Knowledge management projects can be organization-wide or local; high-tech, low-tech or no-tech; and all sizes in between.

While companies generally have very clear policies about managing physical and financial assets, and maintaining their workforce, the value and importance of knowledge assets can be overlooked. The risk employee turnover poses to the organization is the likelihood that some critical information may disappear without warning.

A company can greatly benefit from an inventory of its intangible assets. Intangible assets are in the form of relational capital (reputation and external relationships), structural capital (knowledge management

processes, codification of tacit knowledge, intellectual capital, and innovation capability), and human capital (capacity for skill development and creative problem solving). Linking the inventory to the organization's functions and tasks, along with an assessment of the quality of these assets, allows the organization to prioritize knowledge management projects.

Effective knowledge management is also critical to support the organization's governance, risk management, and compliance activities, which have a direct impact on the organization's bottom line and reputation.

A key to effective governance is access to relevant data for decision-making. Corporations today have access to unprecedented quantities of data, often overwhelming amounts. However, corporations often fail to aggregate and analyze the data to create usable knowledge that is a critical foundation for making informed decisions. Although appropriate technology is available, the missing elements are often skill, experience, and expertise to uncover the meaning from the data.

> *"If only HP knew what it knows it would make three times more profit tomorrow."*
>
> *— Lew Platt, ex-CEO, Hewlett Packard*

Risk management is dependent on effective knowledge management to allow the organization to identify, characterize, quantify, control, and mitigate unacceptable business risks as they relate to the organization's knowledge assets. Unsecured knowledge is quickly drained by the retirement of key employees. It may take years or even be impossible to recover some unwritten processes or best practices.

Regulatory compliance involves many areas of knowledge management. In addition to having the appropriate policies and procedures in place, compliance also requires having the necessary information and maintaining a skilled workforce. The costs of non-compliance, which can include problems such as business disruption, reduced productivity, fees, penalties and other legal and non-legal settlement costs, significantly outweigh the costs of compliance. A knowledge management program can be a linchpin for maintaining regulatory compliance.

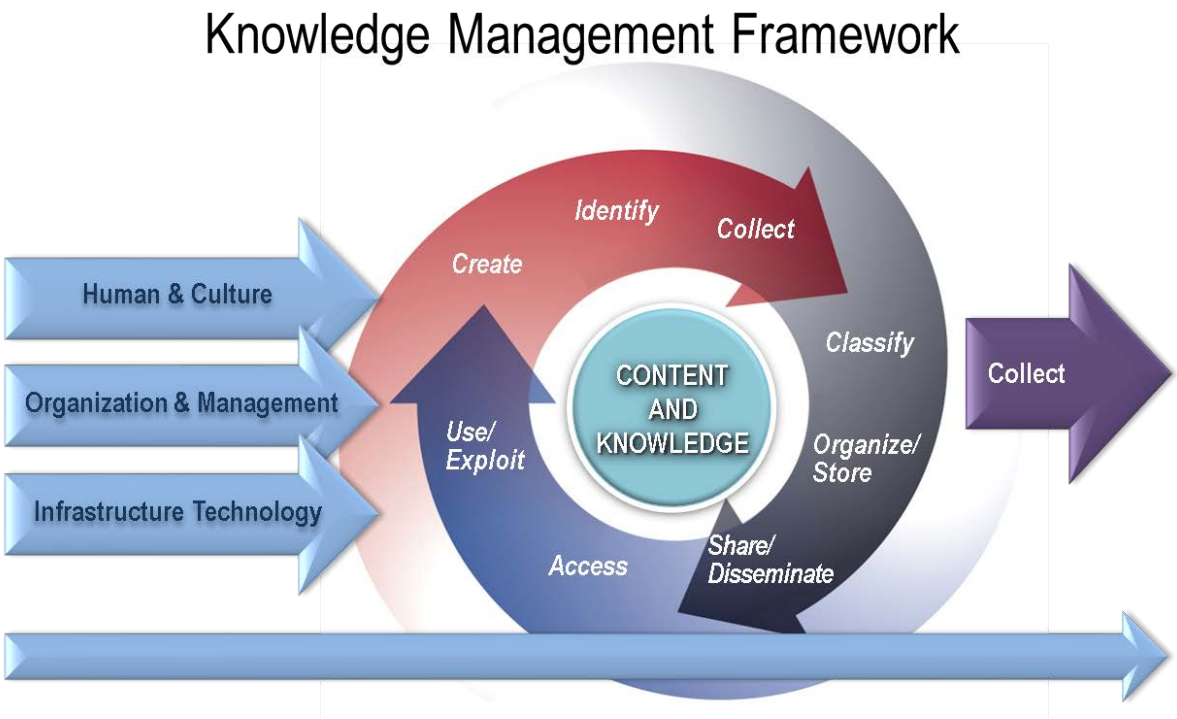
Implementing Knowledge Management — from 40,000 Feet

The first step in the process of implementing knowledge management is to build awareness that it is more than just an Information Technology (IT) system acting as a repository for documentation. Implemented properly, knowledge management is more of a strategy supported by technology that can show a quantifiable, and sometimes substantial, return on investment. The organization needs to recognize that its knowledge is as important, if not more important, than any fixed asset — thus removing any doubts that knowledge management is too expensive or limits the organization's flexibility.

Next, an organization must work to capture the knowledge contained within its walls and employees. Easily captured is existing documentation, followed by the intangibles of both the how and why employees do their jobs — both in the form of processes and best practices.

Necessary to all of this is a framework to house the knowledge. That framework needs to be flexible to allow for future growth, while at the same time being easily accessible to all. The ability to intelligently cross-reference captured data is critical to the success of knowledge management. When knowledge is linked by intelligent cross-referencing, the knowledge base can be utilized in a multitude of ways — from documentation to policy making, and from reference to training.

Of paramount importance is that the entire organization must realize knowledge management is dynamic. Once an initial knowledge capture has happened, it does not just "sit on the shelf" as a completed project. Knowledge management must be integrated into the everyday thought pattern of all employees. It serves as the enterprise reference, providing important history and valuable insight for guiding the organization into the future. This simple graphic illustrates the areas of input, and the continuous cycle of knowledge management, resulting in an output of overall value to the organization.



Obstacles to Effective Knowledge Management

In the past, IT vendors have used the term "Knowledge Management" to describe many tools that would not be considered knowledge management, such as portals or collaboration software.[ii] This led to confusion over the meaning of knowledge management and some distrust of the validity of the tools.

The American Productivity & Quality Center (APQC) has conducted several studies to determine the most common obstacles to companies implementing successful knowledge management.[iii] Four main areas were uncovered:

1. Failing to implement knowledge management to meet a business need and treating knowledge management as the goal instead of an enabler to the actual business goals and strategies.

2. Inadequate resources for rolling out a new knowledge management initiatives after they are proved out in a pilot phase. The real work comes after the pilot phase is done. As an example, Ernst & Young spends 6% of revenue on knowledge management systems.

3. Lack of a person charged with accountability for the organization's knowledge management activities, resulting in no enforcement of approved knowledge management initiatives, such as ensuring that project deliverables include adding to the organization's knowledge base.

4. Not selecting tools or implementation that fits the user's needs and the organization's culture and core values, or failing to develop and implement a plan to change the corporate culture to allow successful knowledge management.

This paper will address these obstacles in detail, as well as best practices for overcoming them.

Introduction

The INGAA Foundation 2008 Critical Skills Forecast[iv] built upon the INGAA Foundation 2007 workforce strategy study, Securing Our Future. The critical skills study forecasts the most critical skills for the natural gas pipeline industry workforce and provided the industry with a place to focus efforts to enhance skill development methods and materials for these vital areas. Of particular risk are specialized areas of the industry with limited numbers of practitioners — pipeline integrity engineers, reservoir engineers, project engineers/managers, and construction managers — who also have limited external training resources and require significant industry experience and are, therefore, particularly susceptible to retirement and non-retirement attrition.

One of the recommendations from the 2008 study was for companies to look to those employees who have key skills and knowledge to ensure those talents are captured and perpetuated within the organization. This reduces the risk of knowledge loss in key positions while also enabling new employees to develop expertise much more rapidly than by means of conventional on-the-job skill development.

Most organizations recognize they are not very effective at managing their knowledge assets. There is a tendency to value tangible assets more than intangible assets. Underrated knowledge is easily lost or given away, while efforts to create, maintain, share, or reuse knowledge are deficient. One of the biggest obstacles to effective knowledge management is organizations may not know what they know.[v]

Many organizations do not realize knowledge management is the critical enabling process that supports their operations activities and the critical activities of risk management and compliance. In fact, a key function in the risk management of an organization is the communication of knowledge that allows all involved parties to make informed decisions. Maintaining compliance and managing risks are possible only when the required knowledge is correct, complete, and accessible.

Knowledge assets become much more valuable to the organization when they can be accessed and utilized by the organization in support of its goals and objectives. To this end, it is necessary for the organization to have processes in place to identify critical knowledge, capture and store it, and then be able to retrieve it for use when needed.

> *"Knowledge has become the key economic resource and the dominant — and perhaps even the only — source of competitive advantage." — Peter Drucker, Management Consultant*

Knowledge Management in the Current Environment

Knowledge Management has become more important in recent years due to changing economic and business environments.[vi] The present environments include:

- Perception in advanced economies that knowledge is an important asset
- Increases in the number of people employed in occupations that rely on the creation and use of knowledge
- Interactions in communications and IT allowing new tools that facilitate knowledge management
- Advances in the research of knowledge management topics that facilitate the understanding of the importance of knowledge to an organization, as well as the types of knowledge and tools for capturing and using the knowledge efficiently
- More service and technology offerings from consulting companies in this area

This paper addresses the following:

- The relationship and impact of effective knowledge management on the implementation and management of risk management, and why this can have a direct impact on the organization's bottom line and reputation
- The extent attrition can increase the risk of knowledge loss in the industry and how effective knowledge management can help address and mitigate this threat
- The importance of knowledge management as part of the overall strategic planning for an organization
- How effective knowledge management can positively impact the long-term health of an organization and how to overcome obstacles to mounting successful knowledge management initiatives
- Who in the organization should sponsor this activity and what are the major elements to consider when embarking on this business practice
- The use and effectiveness of common knowledge management tools and their effect on the key underpinnings of the organization in terms of stabilizing business practices, enabling process improvements, and building the foundation for best practice management within the organization

Knowledge assets become valuable to the organization only when they can be accessed and used by the entire organization in support of its goals and objectives. To this end, it is necessary for the organization to have processes in place that identify, capture, and store critical knowledge, as well as the ability to retrieve it for use when needed. This study underscores the criticality of knowledge management in the natural gas transmission industry and recommends actions to secure the knowledge assets of this industry.

The Goal of Knowledge Management

The principal goal of knowledge management is to deliver outstanding business success through full and systematic use of an organization's knowledge by utilizing what the organization knows to deliver superior business results.

With a knowledge management process in place, you can:

- Make all successes repeatable and sustainable.
- Recognize when you make a mistake and never make it again.
- Never reinvent the wheel or duplicate an effort.
- Shorten the learning curve.
- Make every decision, at every level, with awareness of the full knowledge base of your organization.

Background

Knowledge management is the strategy, processes, practices, methods, and technology that enable an organization to create, maintain, and leverage its individual and collective knowledge to achieve its goals. It involves:

1. Getting people the right information at the right time so they can perform and act competently
2. Helping people share information across boundaries in ways that measurably benefit the organization
3. Producing new knowledge that leads to improved quality and service, intellectual and technological advancements, new products, capabilities, processes/practices, and increased competitiveness and profitability

> *"Knowledge management is a strategic, systematic program to capitalize on what an organization 'knows.' " — Ellen Knapp*

Several key sub-functions and processes must be successfully implemented to support the overall function of knowledge management. These functions are shown in the following figure and described in the subsequent text.

Knowledge Management — Key Functions

The purpose of a knowledge management strategy is to leverage and create the knowledge and capability required to align with the strategic plan. The strategic plan is reviewed to determine the organizational capabilities that should be created or maintained through knowledge management. A separate knowledge management vision and strategy are created to clearly identify how knowledge management will be used in alignment with the strategic plan and what it will accomplish (strategic objectives).

There are five primary functions within knowledge management:

1 - Capture, Store, and Retrieve Knowledge Assets

Knowledge assets become valuable to the organization when they can be accessed and utilized by the organization in support of its goals and objectives. To this end, it is necessary for the organization to have processes in place to identify critical knowledge, capture and store it, and then be able to retrieve it for use when needed.

The overall goal is to make knowledge readily accessible to those who need it and to ensure that the organization, and not individuals, owns the knowledge.

> *"In the end, the location of the new economy is not in the technology, be it the microchip or the global telecommunications network. It is in the human mind."*
> *— Alan Webber*

There are two types of knowledge:

- **Explicit Knowledge** is the formal codified knowledge documented in drawings, reports, papers, specifications, technical documentation, patents, formulas, books, manuals, written policies and procedures, and other forms of documentation.
- **Tacit Knowledge** is the informal non-codified knowledge that resides in people's heads, which can be difficult to capture and transfer.

Tools and methods need to be developed and utilized to support internal and external experts in capturing knowledge. Knowledge capture methods/tools can include specialized interview tools (e.g., appreciative inquiry, tacit knowledge elicitation tools), critical incident/lessons learned, knowledge mapping, research or action learning projects, white papers, and documentation.

2 - Share and Utilize Knowledge Assets

The organization needs to be able to share the knowledge among its members and, where appropriate, with other organizations. The goal is to disseminate the knowledge and make it useful to those who need it. Leaders should recognize the need to collaborate with others in the organization for knowledge sharing within and between functional areas. Typical knowledge sharing opportunities include:

- Acquiring knowledge to support the achievement of operational goals or individual performance objectives
- Finding opportunities to copy and adapt best practices from others in the organization
- Developing expertise in areas of interest to others in the organization
- Utilizing collective knowledge to improve functional and cross-functional processes

3 - Transfer Knowledge

Transfer knowledge is the process that involves identifying the knowledge and skills required for a given purpose, transferring the knowledge from one entity to another, and ensuring the transferred knowledge results in improved capability and performance. Without knowledge transfer, technology and process transfer will not occur, as knowledge transfer is the key to control of non-human systems.

The transfer of concepts, practices, routines, information, and theories is best accomplished with explicit transfer methods. These include self-study, courses and seminars, audio/visual models, e-learning, and decision-support tools. The development of judgment, troubleshooting, problem-solving, insight, intuition, and predictability is best accomplished through tacit knowledge transfer methods, such as mentoring, simulation, job shadowing, communities of practice, decision-support documentation (tools), online collaboration, and coaching.

Skill development requires different transfer methods, such as structured on-the-job training, apprenticeships, and role-playing. Other factors that affect the selection of knowledge transfer methods are cost effectiveness and reusability.

> *Knowledge Management seeks to fully understand and manage the knowledge required to achieve strategic goals and plans. It proactively acquires critical knowledge and addresses the knowledge requirements of the entire organization through maximum utilization of knowledge assets and tacit knowledge.*

Knowledge management provides the means to ensure that the organization owns, is able to use, and shares critical knowledge.

- **Strategic vision and strategy** — knowledge management must support the overall strategic vision and strategy of the organization.
- **Leadership and administration** — Successful knowledge management initiatives need to be supported by strong leadership and administrative roles.
- knowledge management **policies, processes, tools, and procedures** — Specific policies, processes, tools, and procedures need to be developed and implemented within the various organizations that address the what, why, how, and who of implementing knowledge management.

4 - Create and Innovate New Knowledge Assets

The identification of knowledge creation initiatives should occur as part of the knowledge management strategy (tied to the strategic plan). The overall goal is to identify and establish initiatives that support the organization(s) in meeting its strategic objectives and goals.

> *"Competitive success is governed by an organization's ability to develop new knowledge assets that create core competencies. While these exist in many forms, organizational learning is an integral feature of any learning organization that exploits its knowledge resources to generate superior performance." — Jonathan D. Pemberton*

Knowledge creation initiatives may focus on the following:

- Development of new internal capabilities
- Process re-engineering or design
- Engineering
- Product/service development
- Development of new best practices
- Development or improvement of new technology

5 - Administer Knowledge Management

An infrastructure must be developed to support the success of knowledge management from its launch and into the future. Governance for knowledge management occurs at two levels: centralized, where strategic decisions, policies, strategies, etc., are made, and decentralized, where the program is implemented. Knowledge management leadership should exist at all organizational levels even though it is a top-down program. Strategic initiatives occur at the centralized level, but individual managers organization-wide can promote knowledge capture, sharing, transfer, and creation initiatives at their level.

A high-level executive or manager should be assigned the responsibility for the organization's knowledge management activities, including strategic planning, project oversight, resource allocation, and communicating with leadership and the workforce about the need for knowledge management in the organization. Vanguard knowledge organizations are recognizing this by the creation of a Chief Knowledge Officer (CKO), who is responsible for implementing and directing the knowledge strategy and management systems.

The impact of not addressing an overall knowledge management effort in conjunction with knowledge transfer is while the knowledge transfer may occur initially, it may eventually be lost to the organization if the knowledge is not properly managed. Knowledge transfer needs to happen on a dynamic, on-going basis for a robust knowledge management system to thrive.

Key Function Outcome

When knowledge management is fully implemented, the impact to an organization is immense in terms of ROI. Companies recognize savings in terms of lower costs in compliance management, as well as increased profits from a knowledge base that allows them the mobility to pursue economic opportunity.

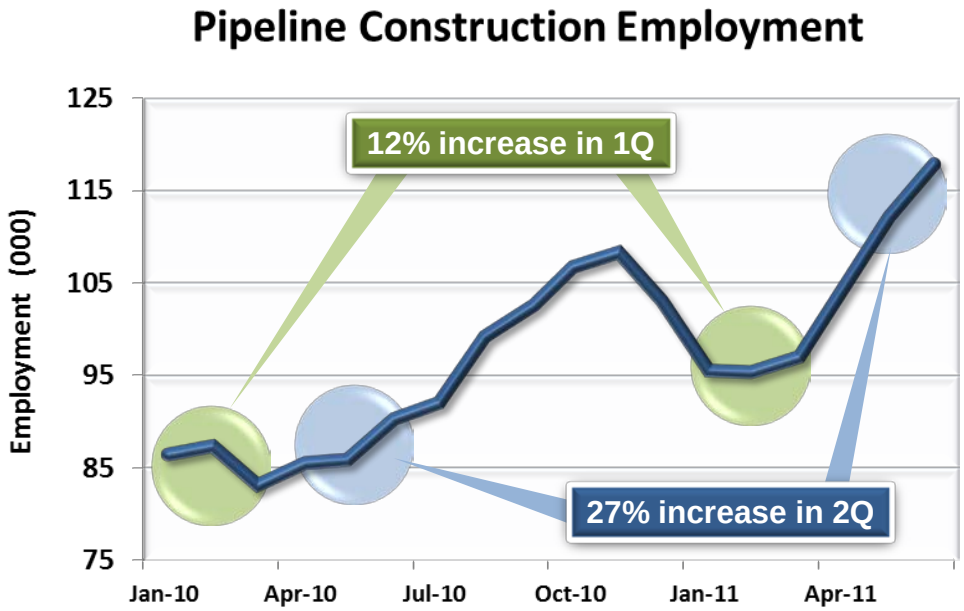
Workforce and Knowledge Management

Over the past few years, pressures on the workforce in the natural gas transmission industry have eased, mainly due to a slower economy. Likewise, turnover in the transportation and utilities industries has declined by 30% from 2005/2006 to 2010/2011, according to the U.S. Bureau of Labor Statistics. This has eased pressure in the near term on the industry for recruiting and developing an adequate workforce. In addition, risks associated with knowledge losses due to retirement of skilled employees have likewise diminished.

However, recent surveys are showing that this trend is significantly changing. Recent developments make it clear this lull in turnover and hiring pressures is quickly coming to an end, both from pressures within the industry and the result of a strengthening economy. While 14% of employers in 2010 reported difficulty in finding workers, in 2011 that jumped to 52% of employers.[vii] Workers themselves are much more willing to look, or are now actively looking, for new positions.

Pipeline Construction and Knowledge Management

The U.S. Energy Information Administration is predicting that between 2010 and 2035 domestic natural gas production will increase from 5 Trillion Cubic Feet (Tcf) to 13.6 Tcf. Consequently, employment in oil and gas pipelines will have a dramatic increase for the foreseeable future. Employment has already had a dramatic increase. From the first quarter of 2010 to the first quarter of 2011, employment was up 12%; in the second quarter, it was up 27% over the same period in 2010.

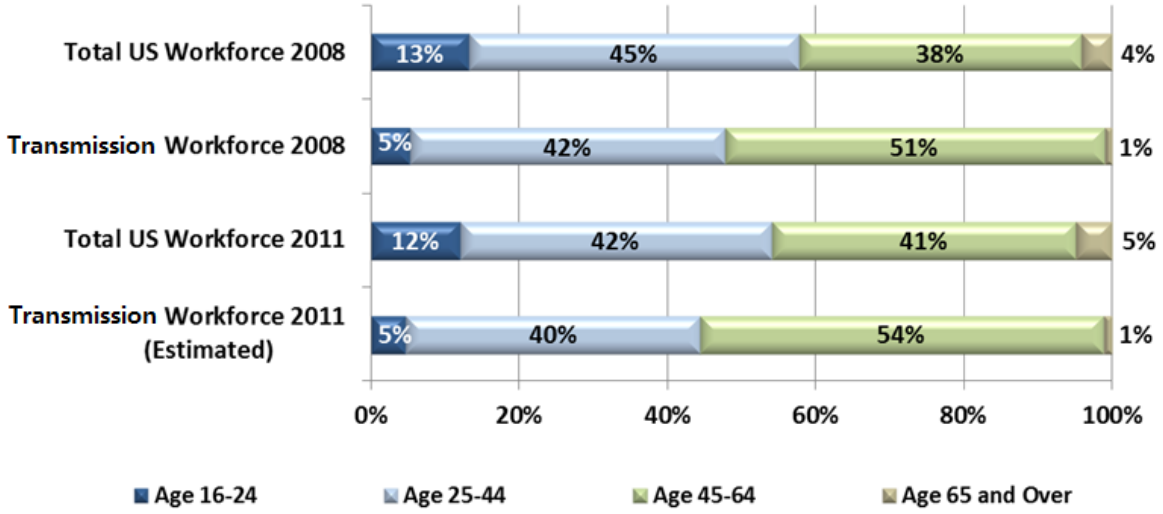


Recent surveys have shown that although the unemployment rate is still higher than in recent years, more people are planning to change jobs.[viii] Compared to 60% in 2010, 84% of employees surveyed indicated they planned to look for new jobs in 2011 based on a Manpower survey, and a third of employees are actively looking, based on a Mercer survey. These results are backed up by the fact that the number of employees voluntarily quitting in the U.S. increased 35% between January 2010 and May 2011.

The Manpower Talent Shortage Survey reports that the hardest positions to fill globally are technicians, sales representatives, skilled trades, and engineers, which have all been in the top-four hardest-to-fill

spots since 2006. Providing additional training to existing staff was the most common way companies reported working to overcome their recruitment issues.

The aging workforce is consistent with the BLS prediction: "Baby-boomer retirements will lead to excellent opportunities for qualified entrants" in the near term in the utility industries. The following chart of BLS data supports this for the most recent breakout of data between workers in the utility industries and overall.



Source: U.S. Bureau of Labor Statistics

The transmission workforce has significantly more workers approaching retirement age, but much fewer who work past age 65 than the overall U.S. workforce. Over the past three years, the average worker's age has increased due in part to economic pressures discouraging retirement. The present workforce in the transmission industries was estimated based on the relationship between the overall workforce and transmission workforce in 2008.

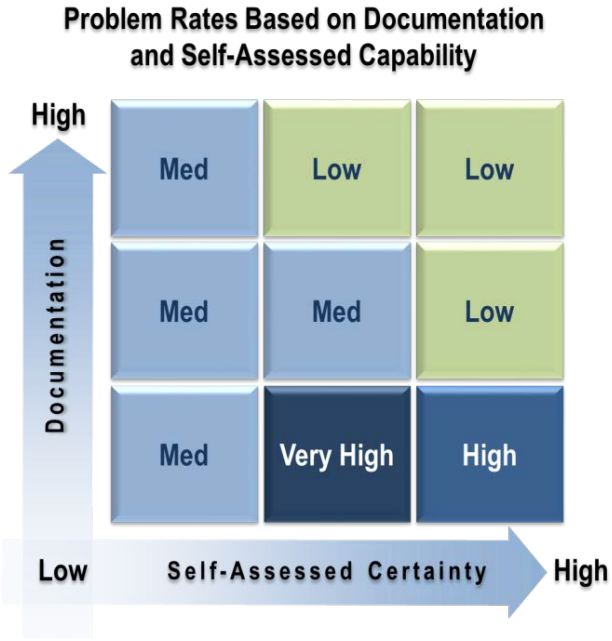
From the research in the 2007 INGAA Foundation Study[ix], "Securing Our Future: Developing the Next Workforce — An Analysis of Risk and Recommended Strategies for the Natural Gas Pipeline Industry" many managers report their organization's skill development and knowledge management efforts are not adequate and were concerned about impending retirements of "irreplaceable" employees. Some survey results were:

- Half of managers feel their company's knowledge management is insufficient to capture knowledge from retiring employees.
- Eighty percent of managers expected workforce issues to have a significant impact on the company capability within five years, with loss of knowledge the most significant impact.
- Over half of managers reported that present skill development for technical employees was inadequate.

Workforce surveys of employees in the pipeline transmission industries reveal there are a limited number of experts for select complex processes or types of equipment. Documentation in the form of standards and procedures is generally incomplete, resulting in the most experienced workers using their tacit knowledge and novice workers often completing tasks by trial-and-error.

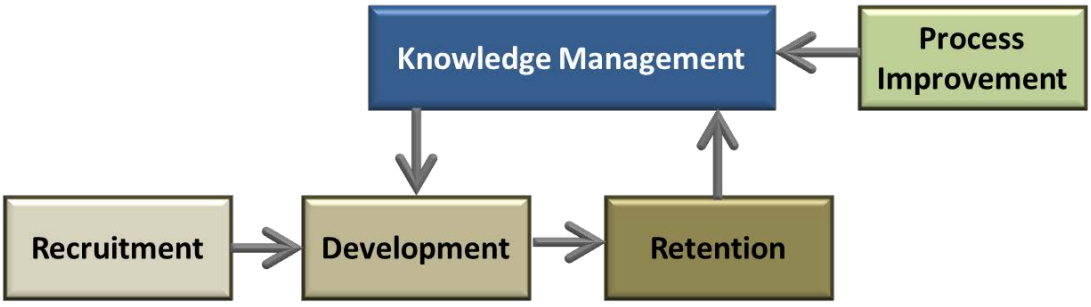
The consequences of not securing the organization's knowledge and not having it available for the next generation of workers risk compromising the organization's operational capability in several ways. Benchmarking has revealed employees with moderate knowledge and minimal documentation report experiencing the most frequent problems or errors in completing their tasks, reducing productivity through a slower pace of work and potential rework.

The following figure shows the reported problem rates, based on the level of documentation available against respondents' self-assessed certainty.



Carefully scaled and executed knowledge management initiatives minimize costs and improve the lead time for recruiting, new hire development programs, and supplemental training programs and reduce the attrition skill losses. This mitigates the increased error rates and loss of productivity due to slower learning rates that result from the common problems of tacit knowledge transfer where explicit knowledge has not been codified. This increases efficiency, accelerates worker productivity, reduces human errors, and formalizes institutional knowledge.

The following diagram shows the relationship of knowledge management to the workforce supply chain and where process improvements can enhance the organization's knowledge assets and, hence, performance.



Additionally, having a robust knowledge management process allows Operations to adjust the baseline requirements to allow for the available supply of new employees. That is, if there are fewer skilled applicants than required, having appropriate knowledge management tools available, such as adequate documentation for job responsibilities, standards for task completion, formal job shadowing, and mentoring programs, allows hiring lower-skilled workers and adding in-house skill development. In this case, additional lead-time should be allotted.

Recent Trends Affecting Knowledge Management

There are several recent trends that will result in significant operational risks for organizations that do not have adequate knowledge management processes in place.

- The U.S. workforce has been aging over the last three years, and a large percentage of the natural gas pipeline workforce is quickly approaching retirement age.
- Turnover has dropped over the past few years due to the economy, taking the focus off workforce concerns. However, due to the beginnings of an economic recovery, especially within the natural gas pipeline industry, recently there has been a dramatic rise in the number of U.S. workers who report they are considering or actively looking for new jobs.
- Four times as many U.S. employers are finding it difficult to fill positions in 2011 as compared to 2010.
- At least half of all natural gas industry managers surveyed reported their companies were not sufficiently prepared to stop knowledge loss in the case of a wave of baby boomer retirements.

Knowledge management is intricately linked to having an effectively functioning workforce and must be considered for both skill development and for capturing the organization's critical knowledge for both existing and future employees' benefit.

Risk Management and Compliance

Risk management and compliance are closely related activities and are aligned or even integrated in many organizations. Recently, it has become common to consolidate them to eliminate redundant processes and management.

Risk Management

Risk Management refers to an integrated "system" of policies, procedures, methods and tools used consistently to identify, characterize, quantify, control and mitigate unacceptable business risks. Its effectiveness is dependent on the competency and skills of organizational personnel responsible for risk management and leadership commitment to utilizing a consistent risk-management approach to support management decision making.

There are three main types of risk:

- Market
- Credit
- Operations

This paper focuses principally on operations risks.. System or process failures can result in illegal employment practices, illegal competition, breach of contract or allow internal or external fraud to go undetected. Other operational risks include loss or damage to physical assets and operational interruptions. Competitive advantage may be put at risk by unsecured knowledge of systems or intellectual property.

> *"…neglecting the management of intangible assets has the potential to destroy the value of tangible assets…" — Eduardo Longo*

The primary objective of risk management is to identify and seek to reduce the likelihood of a negative action occurring, and if it does, reducing its potential affects. An organization should put in place strategies to eliminate, avoid, minimize, transfer or share unacceptable risk based on its level of risk tolerance. These activities are dependent on a robust knowledge management process.

Risk Management in a Changing Environment

It is a myth that well-conceived risk management prevents flexibility.[x] Although risk management is sometimes viewed as a method for limiting changes through auditing and regulating, it actually allows organizations the ability to manage data in a sustainable manner. Viability in a changing environment is dependent on having a flexible organization that can take full advantage of all its assets, including knowledge. The rate of change today is almost outpacing the ability of organizations to adapt.

In some industries, notably healthcare and financial services, reporting requirements, privacy, and IT requirements are highly regulated. This has led to the development of specialized software products to help companies in these industries manage these tasks and track the number of violations that occur. However, organizations in most industries have access to unprecedented quantities of data, often overwhelming amounts.[xi] However, they rarely aggregate and analyze the data to create usable knowledge that is a critical foundation to making informed decisions.

Although appropriate technology is available, the missing elements are often skill, experience, and expertise on the part of the analysts to uncover meaning from the data. Consideration should be taken in:

- Understanding how the data is created and stored

- Understanding business needs
- Appropriate technology to handle, understand, and present data
- Statistical analysis tools and models to support decision making
- Communication skills

Another important role for knowledge management is to facilitate connections and communication.[xii] In the event of a merger or acquisition, voluntary attrition is always a concern. Organizations can help assure new employees of their place and worth to the blended organization by communicating their corporate culture and values. As knowledge management teams generally work across the organization, they are uniquely suited to help new employees understand how the organization works, where to find knowledge, what best practices will come from each organization, and which knowledge has not been codified. New employees can become engaged through knowledge sharing, knowledge transfer, and knowledge management team activities.

Compliance

Compliance can be simply defined as "meeting, adhering, and conforming to requirements." Those requirements can be either externally or internally driven. For example, regulatory agencies can establish laws, rules, and regulations with which an organization must comply. However, compliance can also be expected in response to policies, processes, and procedures that are developed internally. For example, if a procedure says, "must," "shall," or "will," it implies compliance is a requirement, not an option. Similarly, commercial contracts define terms and conditions (rights and obligations) with which an organization must comply in the course of business.

> *"It's not usually a big event like an oil spill that gets you into trouble. It's forgetting to submit an update report. One little error triggers a whole process that then uncovers other problems." — Stephanie Bertels, Compliance Researcher*

The Cost of Compliance

Maintaining compliance with regulatory entities involves several facets of knowledge management. It is a matter of having the appropriate policies and procedures in place, as well as having the required information and maintaining a skilled workforce. There are costs associated with compliance; however, the cost of compliance is trivial when compared to that of non-compliance.

Costs associated with incorporating compliance and regulatory policies, procedures, training, and monitoring include:

- Documentation and records management
- Business process management
- Remediation activities
- Internal and external security

> *"Reputational losses . . . dwarf regulatory penalties such that, intended or not, they are the primary consequence for a firm of a revelation of its misconduct."*
>
> *— John Armour, Oxford University Law Department Faculty*

In contrast, the costs of non-compliance can be much more significant, estimated at three times higher than the costs associated with compliance,[xiii] and can include the following:

- Fines or disgorgement penalties
- Accounting fees
- Drop in stock value with possible shareholder lawsuits
- Costs for investigations and legal fees
- Criminal charges and their defense
- Lost revenue
- Loss of goodwill and corporate reputation
- Costs to repair, replace, redesign and/or requalify and retest assets
- Bankruptcy, and the loss of the organization (ultimate cost)

A survey of 160 business leaders at 46 multinational organizations concluded the cost of non-compliance far outweighs the cost of maintaining compliance. The findings on average showed a cost of $9.4 million for compliance failures, which far outweighed the $3.5 million annual cost of maintaining compliance.

According to the survey, "Compliance costs are defined by the study as any activity organizations use to meet specific rules, regulations, policy, and contracts that are intended to protect information assets. Non-compliance costs are the costs that result when an organization fails to comply with rules, regulations, policies, contacts, and other legal obligations."

The survey's conclusion about conducting internal compliance audits: "While they are expensive, [they] offer the most comprehensive way to maintain compliance and, in the long run, reduce the cost of non-compliance."

Besides the $151 million in fines levied against Royal Dutch/Shell Group for overstating oil and gas reserves, both the chairman and the chief executive of exploration and production stepped down.[xiv] *Part of the settlement included spending $5 million to develop a "comprehensive internal compliance program"* [xv].

Non-compliance costs can be great. Pacific Gas & Electric Company (PG&E), a utility with transmission pipelines, faced fines of up to a million dollars per day for its failure to produce adequate records. The penalties were additive to revenue lost when PG&E was ordered to reduce pressure levels on some pipelines. The company negotiated a $3 million fine with the California Public Utilities Commission (CPUC) for its failure to comply fully with a CPUC order to provide pipeline safety records by a certain date.[xvi] PG&E was unable to locate all the records, some over 50 years old, and some of the records produced were deemed inadequate by the CPUC. As a result, the CPUC threatened PG&E with additional fines if it missed future deadlines to produce adequate records.

Is regulatory pressure increasing?

In the financial industry, the answer is a resounding yes.

In 2010, the various U.S. federal bank regulatory agencies imposed $671 million in civil fines compared to just $6 million in 2009,[xvii] *with the number of enforcements increasing as well. The year 2011 is on pace to be another record-setting year.*

The U.S. Environmental Protection Agency (EPA) is one government agency that takes steps to ensure that any cost savings associated with delayed or avoided compliance expenditures are disgorged and that non-compliance is more costly than timely compliance. The EPA uses a model to calculate the economic benefit of non-compliance, and then assesses a fine to capture the violator's savings. This ensures that it does not become an economic benefit to delay compliance.[xviii]

Across the board, the message is clear: "Compliance with rules and regulations is expensive. But the price of non-compliance is far worse: It can include prison, fines, firings, accounting overhauls, public censure, stock devaluation, and bankruptcy."[xix]

Pipeline Integrity, Operational Efficiency, and Safety

The safety and reliability of pipelines has become a social accountability issue. Pipeline owners must demonstrate and document the persistent integrity of their pipeline facilities. Easy access to clear data is also important.

> *"Most activities or tasks are not one-time events. Whether it's drilling a well or conducting a transaction at a service station, we do the same things repeatedly. Our philosophy is fairly simple: every time we do something again, we should do it better than the last time." — Sir John Steely Browne, BP*

Pipeline owners also must assess the risks associated with the operation of their facilities and take measures to mitigate the consequences of any failure. This is impossible to achieve without knowledge data, including specifications, hydrotest data, and engineering data. In connection with a major pipeline incident, PG&E was asked by the investigating body to produce over 50 years of records. Roughly interpreted, this would have resulted in 1.5 million records. As noted above, PG&E was unable to produce all of the requested records and some of the records produced were deemed inadequate,

Knowledge management — spanning the areas of engineering, operation, inspection, maintenance, HSE, and corporate communication — is crucial for pipeline integrity. The organization must collect and integrate lessons learned, and initiate improvements in order to contribute to the mechanical condition of the pipeline facility, its reliable operation, and the fulfillment of its delivery obligations. Without successful knowledge management, the reputation and business of the organization are at risk.

Effective knowledge management enables the organization to assess and mitigate pipeline risks to reduce the likelihood and consequences of incidents. Beyond detection and remediation of potential integrity concerns, the organization can build on a foundation of acquired knowledge in order to analyze risks and prevent incidents.

Knowledge management is a key component of the improved safety of pipeline systems. Effectively allocated resources can identify and analyze actual and potential events that can result in pipeline incidents. The spectrum of risks and risk-reduction activities available can be examined, and a structured method selected and implemented, in a comprehensive and integrated manner.

When knowledge management is applied to pipeline integrity, the organization benefits in many ways:

- Reduced and mitigated risk
- Incident prevention
- Process improvement
- Improved organizational efficiency

The costs of not managing knowledge can be significant, as described previously under non-compliance.

Strategic Planning and Knowledge Management

Strategic planning and knowledge management are closely linked, as they are each required for the other to be successful. Strategic planning should carefully consider the organization's assessment of its present knowledge and its competition in the assessment of the organization's strengths, weaknesses, opportunities, and threats (SWOT). One way of looking at this is by the use of a Johari window to identify different types of knowledge assets in relation to the competition.

Normal competition will occur in the area of common knowledge, while business development and growth may be facilitated by creating or acquiring knowledge in areas not presently known to the organization.

Understanding and categorizing those known knowledge assets allow the knowledge management team to advise the planning team where there are areas that can be improved or where gains can be made. Before developing a strategic plan, knowledge creation, in the form of a forecast of the business environment and internal situation, enables the planning committee to construct a strategy that actually addresses the future environment instead of the present.

Today's business environment can be characterized as "high velocity and hypercompetitive,"[xx] due to the increasing speed of technology development. This environment makes it even more important to develop and update an organization's strategic plans. The traditional decision-making model for strategic planning has been "what should we do?" This results in actions being taken, followed by results, and the accompanying new knowledge. This leaves companies with plans that address the present business environment, but don't consider future opportunities.

> *"It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change."*[xxi]

Critical to the strategic plan is the "what if" factor, or imagining a number of future scenarios and utilizing the corporate knowledge base to build solutions. Scenario building focuses on the process of knowledge integration over the outcome of the process. The scenario should consider the type, likelihood, and impact of direct and environmental factors:

- Direct factors — Suppliers, customers, competitors, public policy makers
- Environmental factors — Political, social, technological, economic

Strategic Planning Types

The next step in the process is to decide whether the organization wants to develop a conservative or a dynamic strategic plan, in relationship to its knowledge assets. A conservative plan would be developed that relies on the organization's existing knowledge set. That is, competencies determine the strategies. An alternative approach is a dynamic plan, where new opportunities are used to acquire new competencies via recruitment, skill development, mergers and acquisitions, or reorganizations.[xxii] Today's changing environment often favors companies that use a dynamic model for developing their strategic plans.

Conservative strategic planning is characterized by:

- Competencies that determine the strategies
- The organization's existing knowledge

Dynamic strategic planning is characterized by:

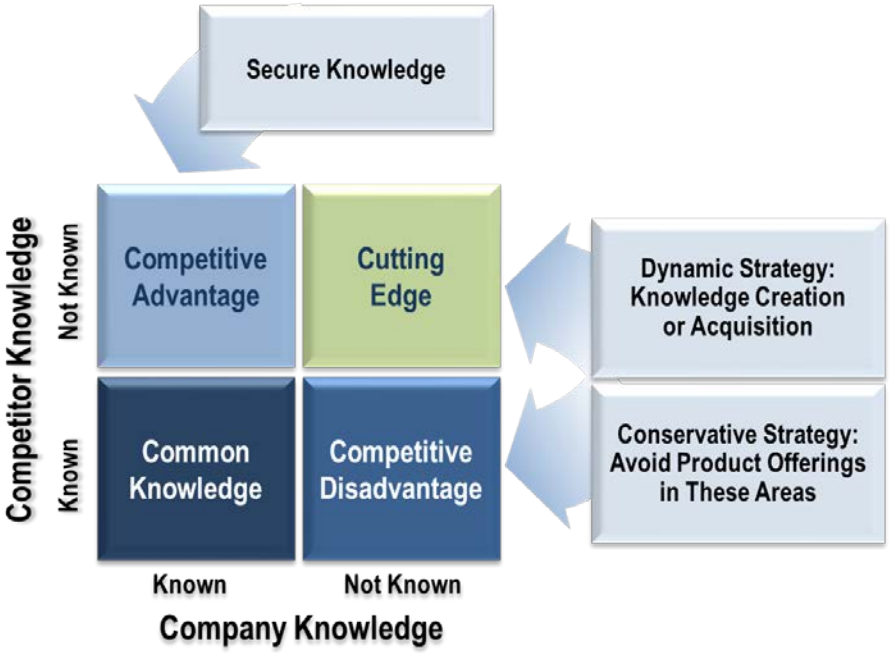
- Providing benefits in a changing environment
- New opportunities that are used to acquire new competencies
- Multiple methods for acquisition of knowledge and capability may be employed in the form of recruitment, skill development, mergers and acquisitions, or reorganizations

There are, however, some cases when a conservative model is more appropriate:

- The organization does not have the capability to develop new competencies.
- Competencies do not transfer easily.
- Costs for acquiring competencies are greater than the benefit they bring.

Once the existing knowledge assets have been identified, along with the appropriate type of plan, the specific areas of existing, missing, or unknown knowledge assets can be prioritized for KM initiatives.

Returning to the Johari window, these two approaches can be visualized, as shown below:



Integrating Knowledge Management with the Strategic Plan

Just as the assessment of the organization's knowledge assets was a critical component of the strategic planning process, the strategic plan is critical when selecting the best knowledge management initiatives. That is, knowledge management initiatives aligned with the strategic plan have a much higher chance of success and higher chance of a strong return on investment.[xxiii] Some features to consider are the proposed initiatives' alignment with:

- Company vision
- Business imperatives
- Economic performance
- Value in the industry

The existing knowledge assets of the organization should be quantified as a starting point to developing a strategic plan that takes advantage of the available assets as an input into the decision about what is the ideal offering of products and services. After the desired activities are defined, a comparison of the existing knowledge to the required knowledge will reveal any gaps or redundancy in the organization's knowledge assets. Quantifying existing knowledge assets is discussed in Appendix B — Self-Assessment.

The strategic plan must be based on the present assets of the organization, with knowledge assets being assets that can be frequently overlooked. The knowledge management plan is then based on the strategic plan and will affect the organization's knowledge assets.

Obstacles to Effective Knowledge Management

Previously, we discussed some obstacles to effective knowledge management:

1. Failing to implement knowledge management to meet a business need and treating knowledge management as the goal instead of an enabler to the actual business goals and strategies.

2. Inadequate resources for rolling out a new knowledge management initiative after they are proved out in a pilot. The real work comes after the pilot is done. As an example, Ernst & Young spends 6% of revenue on knowledge management programs.

3. Lack of a person charged with accountability for the organization's knowledge management activities, resulting in no enforcement of approved knowledge management initiatives, such as ensuring that project deliverables include adding to the organization's knowledge base.

4. Not selecting tools or implementation that fits the user's needs and the organization's culture and core values, or failing to develop and implement a plan to change the corporate culture to allow successful knowledge management.

As with any organization, and especially when dealing with knowledge, you must also factor in the human element.

Human Factors

In addition to companies' failure to select, plan, and fund projects adequately, human factors can also hinder successful project implementation. Often, people are reluctant to share information because they feel it makes them personally less valuable to the organization,[xxiv] or are afraid to share mistakes they have made.[xxv] Knowledge sharing is also more difficult in organizations that have not aligned individual's goals with the overall organization, are competitive or confrontational, discourage interpersonal communication, and overtly or covertly encourage individuals to seek power for personal gain.[xxvi]

Trust

Organizations must help employees become more trusting of new knowledge management initiatives by starting with small pilots to build familiarity and buy-in. In addition, projects should be allotted sufficient time to allow the building of beneficial interactions and sharing knowledge between project team members and other stakeholders. The focus should be on people over the technology. Organizations need to understand and counteract their own barriers through the proper choice of tools, communications, and, especially, encouragement to the working teams about the benefits of successful knowledge management implementation.

Communication

Transfer of knowledge is facilitated by regular communication and matching the backgrounds between trainer and learner. Organizations that have a strong understanding of their knowledge, are open to change, and encourage communication are most successful. These organizations have cultures that stress similarities between individuals, are task-oriented with shared goals, and have a mission to produce high-quality results with attention to detail.

Culture

A company's particular culture and organizational structure also affect the selection of appropriate knowledge management projects. Outside consultants are often used because of their expertise in planning and implementing knowledge management projects. However, any cultural or behavioral changes must be effected internally. Flatter organizational structures facilitate knowledge sharing within the organization and with vendors and suppliers. Pilot projects can also expose organizational weaknesses and give management measureable results to help guide larger projects. Different industries are more familiar and comfortable with knowledge management and knowledge sharing. IT companies often just consider knowledge management as management, since it is so ingrained in the culture of the organization.

Leadership

Misalignment of corporate and individual goals and a culture of competition that hinders two-way communications negatively affect knowledge transfer. Some common problems encountered in the implementation of new knowledge management projects include the failure to secure support from senior leadership and Subject Matter Experts required for the KM project.[xxvii] Where information technology is required, problems arise because of the prohibitive cost for new systems, information security concerns, or in allowing the technology to force a particular solution. Participants may also be reluctant to change or even reveal present poor practices. Finally, the lack of specific knowledge management objectives can also lead to underperforming projects.

Best Practices in Overcoming Obstacles

Case studies of knowledge management projects have uncovered additional obstacles that result from language or cultural differences, geography differences, and organizational cultures, especially when dealing with external contractors. There are a number of best practices, most specifically aligned with knowledge transfer, that have been employed to minimize these impediments:

- Closely manage client-vendor interaction and communications.
- Optimize and document processes before capturing or transferring.
- Prioritize knowledge projects based on gaps in required knowledge. For expediency, instead of a formal knowledge gap analysis, organizations can use data from surveys and/or focus groups of employees and senior management to uncover the highest-priority areas for action.
- Build a culture of trust within an organization that encourages internal and external sharing of knowledge. Reassure employees that their jobs are secure and will not be replaced by a vendor organization.
- Do not invest in overarching IT systems for knowledge management, capture, and transfer before the organization has fully developed its understanding of and needs for the knowledge.

When knowledge management was introduced in the '90s, it was originally heralded as a systems solution for companies looking to improve business processes. By solely relying on technology and not integrating a knowledge strategy, there was little ROI originally. Now, as the adoption curve for knowledge management has become larger and more sophisticated, companies are beginning to realize the value of an integrated, holistic approach and more are commencing implementation. These companies can build on the early adopter's lessons learned and best practices.

Implement metrics to track knowledge management progress toward reaching the stated goals to help the organization stay on track. Focus on process measures and the more traditional outcome measures. Outcomes include productivity, turn-around time, and cost, while process considers how people are performing the tasks, working collaboratively, and the health of the overall function.

The most significant obstacles to effective knowledge management initiatives are:

- Implementing knowledge management without tying it to a business need
- Allocating inadequate time or resources to the project
- No one in the organization with the designated responsibility of the organization's knowledge management
- Focusing on technology over business or human needs
- Company cultures that discourage knowledge sharing
- Attempting a large project before gaining experience with a pilot

Organizations that are cognizant of these pitfalls can then work to counteract them or at least acknowledge that they need to add additional resources.

Knowledge Management in the Organization

In many industries or smaller companies, it may not be necessary to appoint a CKO. However, the responsibility for ensuring that the organization's knowledge management activities are carried out properly must be assigned to a high-level executive or manager.

Knowledge Management Leadership Qualities

In addition to technical ability, great communication skills, business acumen, and tenacity are other desirable competencies in a CKO. As a good communicator and storyteller, a CKO should be able to form coalitions and present new ideas in an understandable way. Strategic thinking, a clear vision of the business mission and objectives, the ability to translate qualitative to quantitative information, and focus on the customer are other important characteristics.

The CKO (or personnel assigned the responsibility for knowledge management in the organization) needs to:

- Provide leadership and strategy
- Promote knowledge management
- Implement pilots
- Work toward institutionalizing knowledge management practices

The CKO communicates with stakeholders, other agencies, and industry partners, and is an integral part, if not a leader, of the strategic planning team. The CKO monitors metrics related to project outcomes to ensure that they enhance operations, benchmarks other public and private organizations, and works to reduce costs and time for product or service delivery.

The CKO should work to develop a positive culture that facilitates and promotes knowledge sharing and best practices, and measures and rewards individual contributions to knowledge sharing. As KM should be applied throughout the organization, the CKO maintains associations with all departmental stakeholders. This can be done, in part, by:

- Educating the organization about knowledge management practices
- Promoting knowledge management best practices
- Using effective IT tools
- Using knowledge storage methods

Obviously, this means the CKO works closely with the CIO as IT supplies the technology for the knowledge strategy to both be collected and disbursed. Another critical task is to educate the organization's leadership about knowledge management and its benefits.

Departmental Structure

The CKO manages the knowledge management department and provides the knowledge management resources to the organization. Managing the knowledge management personnel includes defining roles and career paths in knowledge management positions and facilitating department education.

These support personnel may include:

- Knowledge Architect, Knowledge Engineer
- Knowledge Asset Manager, Knowledge Officer, Information Archivist, Content Manager
- Human Resources and Training Manager
- Information technology support:
  - Chief Information/Technology Officer
  - Information Analyst, Architect
  - Systems Developer, IT Architect, Enterprise Portal Developer

Knowledge Management in the Industry — Executive Interview Results

Executive interviews were conducted with executives and managers in the natural gas transmission industry. The primary purpose of these interviews is to understand the perception of the criticality of knowledge management to the business and the level of risk due to the impact of expected knowledge erosion. The secondary purpose is to bring awareness and understanding of the impact of knowledge management on the operational effectiveness of the pipeline industry. The interviews covered the following areas:

- **Perception** — Important issues/challenges facing the industry, whether knowledge management is a named strategy for the organization, concerns over retirement attrition knowledge erosion, and skill gaps in the recruitment pool
- **Risk** — Knowledge as a material risk to meeting operating goals and knowledge management as a facet of the organization's risk management strategy
- **Actions** — General knowledge management activities in the organization, use of knowledge management in skill development, and other actions the organization/industry are presently taking to address knowledge management

Ten interviews were conducted with INGAA Foundation members in the following segments and job positions:

- Pipeline
  - Executive level, 3-4
- Construction
  - Executive level, 2-3
- Service
  - Executive level, 2-3

For a list of questions, see Appendix A — Executive Interview Questions.

Knowledge Management in the Industry – Interview Summary

Interviews with natural gas pipeline industry executives reveal that knowledge management has not been widely treated as a critical priority. However, executives recognize that changing workforce demographics and heightened regulatory oversight may soon render existing on-the-job training and other informal methods of knowledge management inadequate.

Losing critical knowledge assets poses a material risk to the organization's capability. The primary concern of industry executives was regulatory, which will affect the organization's ability to conduct the functions of risk management and compliance.

> *"Biggest challenge — regulation, regulation, regulation. You plan to build a pipeline and then while you are building, regulations are changing — so you can't plan for it as well as previously." – INGAA executive interviews, 2011*

Implementing a knowledge management practice allows organizations to know what they currently have in place for regulatory compliance and allows them to create knowledge events surrounding each project by gathering, sharing, and finally mobilizing the knowledge through all phases.

With effective knowledge management, companies can become more agile because executives, armed with more timely business intelligence and insights specific to the organization, are able to react faster to marketplace conditions and strategic opportunities.

Responsibility for knowledge management varies among organizations, and metrics for evaluating knowledge management have yet to be developed. During the course of the interviews, the following themes were reiterated.

Regulatory Challenges

Executives consistently identified regulatory compliance as among the industry's biggest challenges:

- "Regulatory is changing the business climate. Everything that goes wrong is now being examined."
- "Longer lead times, more costly due to the regulations and opposition from groups."
- "Biggest challenge — regulation, regulation, regulation. You plan to build a pipeline and then while you are building, regulations are changing — so you can't plan for it as well as [you could] previously."

Workforce Challenges

Executives recognize that a great deal of their organizations' knowledge resides only in the minds of workers:

- Employees "have been there a long time and have a great deal of knowledge. People are now more mobile and shifting jobs."
- "We are worried about having a mass exodus — that hasn't happened [yet] due to the economy."
- "People with that knowledge have the advantage."

Employees' potentially negative perceptions of a knowledge management program concerned some executives:

- "Don't call it 'knowledge transfer' — call it 'knowledge share' to show both ways rather than one way."
- "Call it 'knowledge sharing' because the company doesn't want the workforce to feel threatened that they are giving up knowledge."

Younger and newer workers create additional challenges for training and retention:

- "Motivation and work effort are different. New people are really bright — but different socially — 'what's in it for me?' as opposed to doing what it takes."
- "Pension and medical have changed in the last few years … so new people have no motivation to stay."
- "New people are challenging thought processes — *why* do something?"

Internal Responsibility

Executives' comments revealed no consensus as to which corporate function should take responsibility for knowledge management:

- "HR was delegated — but they aren't necessarily doing that."
- "Each area has created a process flow for their business."
- Who is looking at knowledge management in the organization? "ISO side does — with too many."
- How is the information being managed? "It is being managed department by department."

Metrics (Largely Not Developed)

Specific operational areas in some organizations have attempted to measure their knowledge management effectiveness. "For each operating area, we have developed a skill set manual including jobs and tasks." However, organizations largely have yet to develop meaningful metrics for evaluating their knowledge management:

- "Are we quantifying knowledge in the workforce? No."
- "Are there any metrics associated with knowledge management? As a total organization, we're not there. Experimenting on a departmental basis."
- "Maybe some individual measurements, but not corporate. One corporate goal is to have a workforce strategy — but it isn't quantified. It's just an objective — and needs to happen."

Future Crisis

Executives recognize that knowledge management deficiencies present an organizational risk. While the risk is not yet perceived as critical, some executives said the potential for a crisis exists:

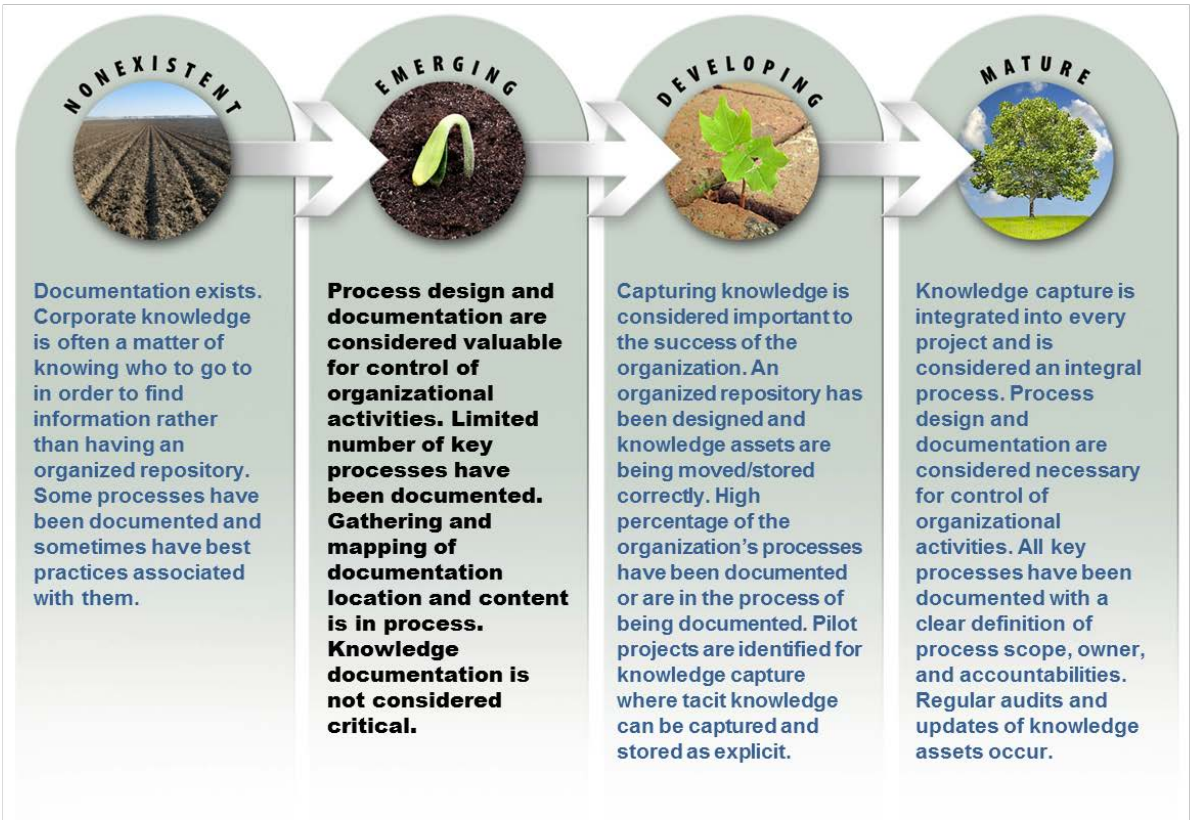
- "From a risk perspective — does knowledge management come on the radar screen? Because of regulation, you have to develop processes and procedures, so, therefore, it's a part."
- "Not a priority — may become a concern as energy companies brain drain them."
- "knowledge management is a material risk. It is going to significantly impact the bottom line within 5 to 10 years and the time to act is now because **it can't be solved on a short-term basis.**"
- "Even when there are best practices in place, they still are not backing it up with the processes — **house of cards ready to fall down**."
- "Not an awareness at executive level of knowledge management, but it is just a matter of time. **Will need a catalyst (catastrophic)**."

Best Practices in Knowledge Management / State of the Industry

The following graphics represent the various stages by key function for Knowledge Management. Each stage has a description of the state of the function for the company at that point. The last column, Mature, describes best practices. Black, bold text signifies the current status of the natural gas industry based on the executive interviews and observations of the companies.

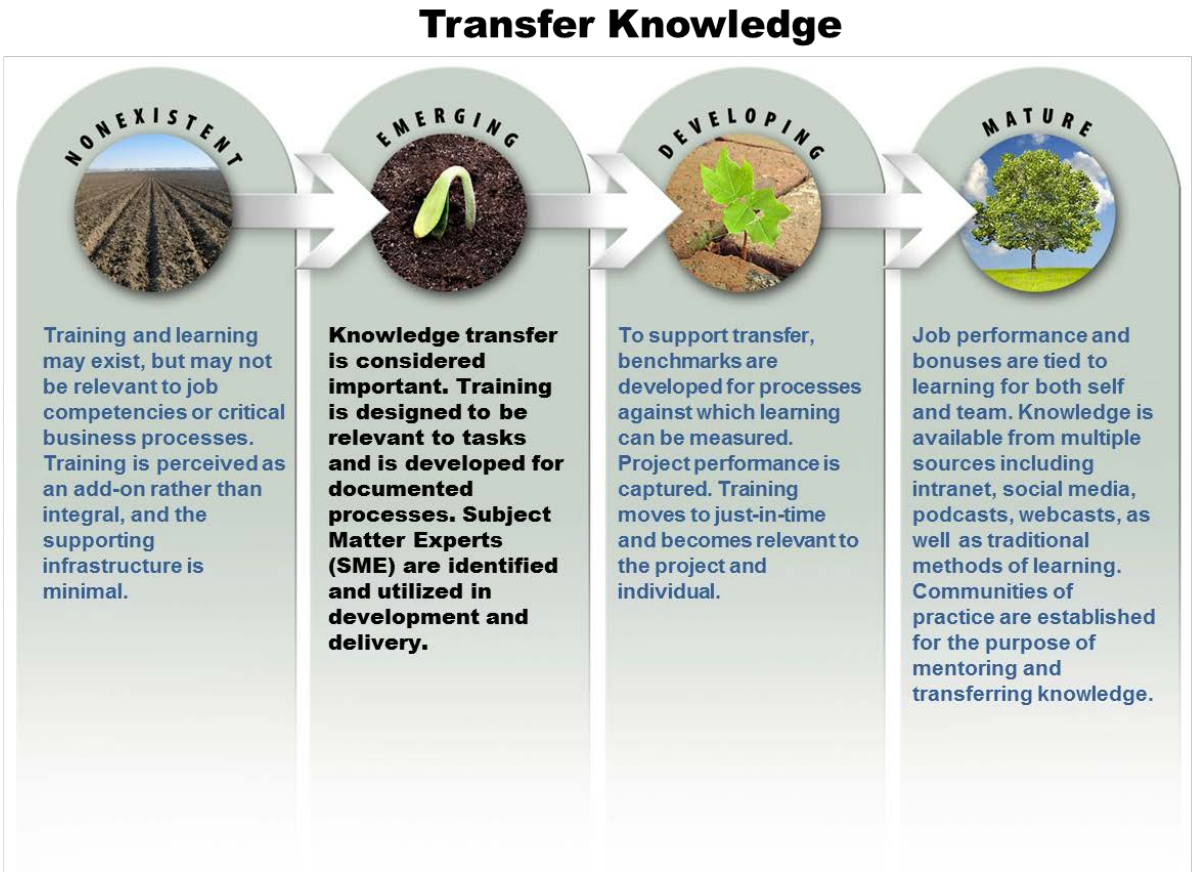
This first stage represents the gathering and availability of knowledge assets.

Capture, Store, and Retrieve Knowledge Assets



Next, we move to tasks and stages surrounding the function of sharing and using those assets

From there, the Transfer Knowledge function is addressed.



The fourth function, Create and Innovate New Knowledge Assets explores the new ideas and products that can spring forth from an established knowledge base.

Finally, knowledge has to be managed so that we don't return to the chaotic state of not knowing where the information resides.

Recommendations

The single greatest challenge to the pipeline transmission industry currently is regulation. Without "knowing what we know," organizations are running a huge risk of non-compliance and the tremendous associated costs.

Following closely is the brain drain that is on the immediate horizon due to employee attrition and an expanding workforce.

In order to mediate these, organizations need to formally implement a knowledge management strategy that will allow intelligent decision making in the most nimble fashion.

Survival of the Most Informed

To create this model, organizations need to have existing information readily available. Start with the simple — even a complete set of knowledge data on all existing assets and pipeline infrastructure represents a step forward for some organizations.

Have a simple, yet disciplined approach. While gathering existing information, create requirements for all new assets coming online to also meet the same knowledge requirements, thus backfilling knowledge repositories while building new knowledge — and avoiding the issues faced in tracing documentation of up to 50 years.

Learn how to obtain knowledge assets from those employees who are critical and who the organization may risk losing. Learn and share how they "just do it," in order to gain valuable insight into existing business processes.

Gather

Gathering knowledge assets is done on a continual basis, but it provides the jump-off point for all knowledge management activities.

- Document business processes and from them develop best practices, allowing the generational challenge of "why do we do it this way?" to improve the business by tasking the experienced workers to think through if this is the "best way" or just "how it's done."
- Business processes are at the core of the organization and knowledge management practice. They should include embedded controls that align with the risk profile.

Share

All the information in the world does an organization no good unless those with a need to know can access and understand it. This requires a cultural shift from the natural siloing of knowledge within units and individuals to that of an open, collaborative culture where sharing is not only encouraged, but expected.

Knowledge sharing is the organization's pipeline to growth. It is synergistic, as it allows both a transfer of information while increasing knowledge at the same time.

> *"Sharing knowledge is not about giving people something or getting something from them. That is only valid for information sharing. Sharing knowledge occurs when people are genuinely interested in helping one another develop new capacities for action; it is about creating learning processes." — Peter Senge*

Mobilize

Once information has been gathered and a cultural shift implemented, the area that will ultimately provide the greatest ROI can be robustly utilized. Knowledge mobilization allows an organization to take the available knowledge and place it into active service in order to provide benefit. Knowledge mobilization is closely tied to the strategic objectives of the organization.

Appendix A — Executive Interview Questions

Participating executives were interviewed about their perception of the criticality of knowledge management to the business and the level of risk due to the impact of expected knowledge erosion. Questions covered the following areas:

Perception

1. Think about the most important issues/challenges facing the natural gas transmission industry. What are the most critical issues in the short term? The medium term? The long term?
2. Is knowledge management a named strategy for your company? If not, is there a reason why KM is not viewed as an important issue for your company?
3. Is the cost of knowledge management a concern to your company? Is this cost viewed in light of the potential cost of not managing the company's knowledge?
4. Consider the issues of impending baby-boomer retirements and their potential impact on your company's knowledge assets. How important are programs addressing knowledge management for your company? These could be tools for capturing, storing, and retrieving knowledge; sharing and using knowledge; creating new knowledge assets; and managing the knowledge management function.
5. Is the present skill gap between the available pool of new hires and your company's needs a concern? Is the widening of this gap due to forecasted retirement demographics a concern?
6. Has your company considered the use of knowledge management for quickly increasing new hires' skill levels or for reducing the baseline skill requirements for new recruits?

Risk

1. Do knowledge management issues present a material risk to meeting your company's operating goals (profitability, growth, project deadlines)?
2. Are there other risks to the organization if knowledge is not managed?
3. Is knowledge management part of your company's risk-management strategy?

Actions

1. How far along is your company in developing and maintaining robust knowledge management activity?
   - — Recognition by the company senior management that knowledge management is a critical function
   - — Awareness of knowledge management, its impact, and future implications for both their area of responsibility and the company as a whole
   - — Piloting phase where some areas are testing new tools or processes for knowledge management
   - — Controlled deployment of knowledge management tools and processes across the organization

- knowledge management already institutionalized in the organization

2. Who is responsible for knowledge management in your company?
3. What are your observations of actions the industry or your company are presently taking to address knowledge management?

Overall

1. What information are you lacking that would help your company address these issues?
2. What actions should the INGAA Foundation take to help mitigate these risks on behalf of your company?
3. How do you rate workforce and KM on the following scale? (1-5 – 5 being best)
4. Do you feel your company will be able to mitigate operations risks successfully?

Appendix B — Self-Assessment

Knowledge Management Maturity

Organizations should begin by assessing their level of knowledge management maturity and implementation. At a basic level, the following five-point scale allows organizations to quickly gauge their level of KM maturity by considering their perceptions about KM, as well as actual implementation.[xxviii]

1. **Potential** — knowledge management is viewed positively and has some level of implementation. Knowledge assets have been identified.

2. **Encouraged** — There is a general understanding of the value KM brings to the organization. The culture is open to sharing knowledge and rewards that behavior. Knowledge assets have some level of management.

3. **Practiced** — knowledge management is part of the organization's standard processes, and there are ongoing KM initiatives. There is a central repository for knowledge assets with standardized classifications.

4. **Managed** — knowledge management enables the workforce to easily locate required knowledge and provides tools to sustain KM activities. Training in KM is provided, including change-management processes.

5. **Continuously Improved** — knowledge management tools and processes are pervasive in the company and reviewed periodically for continuous-improvement opportunities.

A more detailed method also considers the company leadership and culture.[xxix] Maintaining awareness and a positive perception of knowledge management includes:

- The organization has a general understanding of knowledge management.
- Knowledge assets are understood to be valuable assets.
- Resources are allocated for ongoing knowledge management skill development.
- KM is considered part of the organization's basic orientation training.
- Employees understand the benefits for practicing knowledge management.

The company culture can be a positive influence on the level of knowledge sharing and commitment to knowledge management principles and activities. Organizations that employ a vigorous approach to knowledge management generally share a robust corporate culture, including:

- People in the organization freely share knowledge and advice, and offer other support.
- Effective teams practice effective communications and knowledge sharing, including those with remotely located members.
- Capturing and disseminating knowledge is a company value.
- knowledge management principles, such as reusing and sharing knowledge, are valued and routinely practiced, while activities that work against them are discouraged.
- Change is understood to be necessary to the organization's future.
- Continuous improvement is valued.

In companies where knowledge management adoption has been successful, the company's top leadership and direct management are critical in championing and ensuring adequate resources for knowledge management activities. In these companies:

- The organization's leadership is committed to knowledge management and closely monitors ongoing activities.
- Rewards are given for positive knowledge management activities.
- knowledge management is an important part of the company strategy, and there is a vision for how it will be incorporated into the organization's activities.
- Future knowledge requirements are forecasted and plans developed to fill the expected gaps.
- There is a board-level position with responsibility for knowledge management.
- Metrics are defined and monitored for knowledge management activities and communicated to the appropriate workforce.
- knowledge management initiatives and activities have clearly allocated budgets, staffing, and ownership.
- Joint ventures and/or acquisitions are employed when needed to obtain necessary knowledge assets.

Finally, the organization should gauge how well it is performing the basic knowledge management activities to leverage its knowledge assets. Commonalities include:

- Critical knowledge assets are known, collected, and maintained.
- Employees can easily find and retrieve the information they need, and there is minimal duplication or rework resulting from missing knowledge.
- Technology to manage knowledge is applied as appropriate, including basic IT functions of document backup and recovery.
- Document management is practiced.
- Intellectual assets are protected legally.
- Clients have assets, as appropriate to company knowledge management tools.
- Best practices and lessons learned are captured and shared across the organization.
- Both formal and informal knowledge-sharing networks are in place.

Quantifying Knowledge Assets

Organizations possess four types of capital:

1. Financial capital can be in the form of monetary investments, real estate, or equipment.
2. Human capital is the workforce, exclusive of specialized knowledge.
3. Intellectual capital is intangible and includes explicit and tacit knowledge in the form of best practices, experience, and intuition.
4. Social capital is also intangible and describes the relationships, communities of practice, shared values, and internalized standards of the organization.

Understanding the relationship between tangible and intangible assets, or more importantly the impact intangible assets have on tangible resources and outcomes allows the organization to make the best resource allocation decisions in regards to the ideal level of investment.

The first step is to identify intangible assets. Intangible assets are in the form of relational capital (reputation and external relationships), structural capital (KM processes, codification of tacit knowledge, intellectual capital, and innovation capability), and human capital (capacity for skill development and creative problem solving).

The links between tangible and intangible assets are then estimated based on input from knowledge: creators, managers, and users. The same person may be responsible for one or more of these roles, which may change over time. The intangible assets are maintained and enhanced through the use of skill development and knowledge sharing. These methods should be chosen based on best practices for their appropriateness to the type of knowledge. The speed of skill development and ease of knowledge sharing are key factors in the efficient development of new intangible knowledge assets.

The basis for prioritizing resource allocation depends upon the perspective of the person interacting with the knowledge. Knowledge creators consider the speed of development, innovation, and access to knowledge-sharing methods. Knowledge managers are concerned with size and timeliness of the knowledge, its usefulness to the organization, and the cost and time for extraction. End users want to measure the usefulness, user-friendliness, and understandability of the knowledge. These metrics can all be assessed using a qualitative narrative scale, when quantitative measures are not available. Weightings can be used to combine metrics so priorities can be set for allocating resources among alternative knowledge assets.

The organization should continue to assess the relationships, measure the usefulness of the knowledge, and allocate resources accordingly. These steps allow continuous improvement of the KM activities and refinement of resource allocations. Understand that these steps will not be precise when dealing with intangible assets, but creating a baseline and ensuring future assessments are consistent allow the organization to understand the direction and quantity of change.

Appendix C — Best Practices

Project Selection, Planning, and Management

For organizations just starting out in knowledge management, selecting projects with a high potential for success is key to setting the tone in the organization for acceptance of future projects. For companies that are knowledge management novices, pilot projects should be based on knowledge processes that are an integral part of the workflow, instead of requiring users to step out of day-to-day routines to utilize the knowledge. Separate systems or processes for completing tasks and managing knowledge are more difficult to ensure that they get full planned benefits.

More mature organizations, in terms of knowledge management, tend to be more successful implementing projects that are outside of the day-to-day workflow. However, it is important to note that organizations just starting to use knowledge management need to begin with projects that readily assist in defining their knowledge management strategy and introduce KM concepts to their employees.

> *"Knowledge is sticky. Without a process, it will not flow." — Carla O'Dell*

Some factors to consider for selecting candidate knowledge management projects are whether they:

- Are core business areas that drive profitability
- Are able to be reused or expanded across the organization
- Fit within corporate culture, or are worth investing in changing the corporate culture to complete

Organizations have been implementing knowledge management projects for several decades. Even companies with significant experience in knowledge management still benefit from reviewing the current best practices before embarking on each new project. Be sure to select case studies and best practices employed by organizations that are getting the results the organization requires.

Project timing can be critical. When the organization is facing an important problem or opportunity that lends itself to a knowledge project, it is an ideal time for introducing knowledge management to the organization.

As part of the knowledge management project planning, define the following features of the organization that may influence the project output:

- Decision makers, stakeholders, and affected organizations
- Critical choices, motivators, and obstacles
- Budgeting for cross-organizational projects
- Definition of project success and evaluation criteria
- Impending changes in culture, technology, or other relevant features of the organization

Metrics

Knowledge management metrics should not be based on standard business measures, such as growth, profit, or sales, because they are unlikely to be solely influenced by knowledge management.[xxx]

Ford Motor Company, selected by APQC to acknowledge its effective knowledge management metrics, makes a practice of focusing on outputs and outcomes, instead of number of inputs, such as how many documents were stored or reviewed. The outcomes are in the form of the level use of knowledge that was developed in one part of the company by other parts of the company.[xxxi]

However, as a lagging indicator, outcomes and outputs should be complemented by leading metrics, such as awareness of knowledge management activities, uses for knowledge management, and the behavior as indicated by participation in knowledge management activities and skill development activities by both senior- and junior-level employees.

Metrics may change over time for both the overall knowledge management activity in the organization and for individual projects as they move from awareness and promotion to assessment and experimentation, to piloting, then to expansion, and finally, institutionalization. The piloting and expansion phases are most critical to the overall success, and, therefore, should have the most closely measured progress.

Metrics should measure activities, knowledge assets, organizational processes, and business outcomes. knowledge management tool selection and their corresponding metrics should also align with the organization's reasons for implementing a knowledge management project, such as:

- Capturing best practices and lessons learned
- Documentation of processes and procedures
- Organization of knowledge
- Knowledge auditing
- Employee development

An examination of IT knowledge transfer projects resulted in the following recommended metrics[xxxii]:

- Project performance in terms of cost, quality, and timely delivery
- Project outcome in terms of reliability, maintainability, and accuracy
- System implementation success in the installation, training, acceptance, and utilization of new IT systems
- Economic benefits to the client in the way of efficiency, enhanced profits, and the ability to meet business goals
- Human benefits in terms of satisfied users, positive environmental or social impact, and personal development

These metrics incorporate many of the elements of a Balanced Scorecard,[xxxiii] such as:

- Financial perspective
- Customer perspective
- Internal business perspective
- Learning and innovation perspective

However, these metrics do not include any leading measures. Adapting some of the Balanced Scorecard leading metrics to the measurement of knowledge management gives the additional metrics of:

- Customer satisfaction survey ---> End-user satisfaction survey
- Hours with customers ---> Hours of skill development
- Strategic information available ---> Explicit and tacit knowledge resources

Knowledge Transfer Basics

For conducting knowledge transfer, there are dozens of supporting knowledge transfer and management tools and techniques that could be employed. There are tools for organizing and developing knowledge (e.g., training plans and knowledge audits), capturing explicit knowledge (e.g., manuals, process flow charts, checklists, and decision support tools), capturing and transferring tacit knowledge (e.g., case studies, best practices, and scenario-based learning tools), and transferring tacit knowledge (e.g., communities of practice, mentoring, and job shadowing).

> *"People hoard their time and energy, not their knowledge." — Carla O'Dell*
>
> *KM processes and systems that save time and improve efficiency are more likely to be successful and have full support of the employees.*

Selecting the appropriate set of tools enables enterprises to create a customized and robust knowledge practice. Many researchers and scholars note that beyond selecting the appropriate knowledge transfer tools, the other key factors of success in planning and conducting knowledge transfer and management activities include:

- Build an understanding of the vision, strategy, and terminology by all stakeholders.
- Maintain support by senior management.
- Create social aspects of knowledge transfer and select first- and second-party project teams that have:
  - Prerequisite knowledge and skills
  - Mutual trust and respect
  - Good communication
  - Motivation
- Mandate and incentivize knowledge sharing.

Case studies of knowledge transfer have uncovered obstacles that result from language or cultural differences, geography differences, and organizational cultures. There are a number of best practices that have been employed to minimize these impediments:

- Manage client-vendor interaction and communication.
  - Establish formal communication structures with clearly defined communication counterparts and roles that help to transfer business and process knowledge.
  - Contractually require the vendor to maintain a stable project team to avoid disruption in communications.
  - Develop cultural competence by active and passive training methods for foreign suppliers (e.g., site visits, informal recreational events, and seminars).

  - Help integrated teams become cognizant of preferred styles for managing conflict resolution that may vary by culture from deferring to authority, regulations, or compromises.
  - Structure working sessions to ensure that vendors understand project requirements.
  - Conduct follow-ups to training sessions to reinforce the knowledge transferred and encourage the use of the new skills.
- Optimize and document processes before transferring.
  - Document business processes before beginning a capture or transfer process.
  - Standardize processes across business units to reduce learning time for employees moving within the organization.
  - For new ventures, or process improvement, it is desirable to model an existing successful operation, instead of starting from scratch with all-new business processes.
- Prioritize knowledge transfer in an organization based on gaps in required knowledge. For expediency, instead of a formal knowledge gap analysis, organizations can use data from surveys and/or focus groups of employees and senior management to uncover the highest-priority areas for action.
- Build a culture of trust within an organization that encourages internal and external sharing of knowledge. Reassure employees that their jobs are secure and will not be replaced by a vendor company.
- Do not invest in overarching IT systems for knowledge management capture and transfer before the organization has fully developed its understanding of and needs for the knowledge. These large IT systems often fail because the developers do not understand or address the needs, competencies, and culture of the organization.

Appendix D — Knowledge Management Tools and Techniques

> *"Of all the project management concepts, lessons learned from prior failures and successes is the most neglected." — K. Forsberg*

There are many tools and techniques and IT technology that can be considered part of knowledge management. These range from very basic task documentation to complex IT applications. The following list gives some examples of tools that would be appropriate to meet various business goals.

- Standardize operations
  - Process, policy, and procedure documentation
  - Standard tools, templates, and sample availability
  - Video demonstration of procedures or approved methods
- Share best practices
  - Posting of best practices
  - Communities of practice
  - Online collaboration or conference call forums
  - Social media
  - Links to external libraries/benchmarking organizations
- Prevent knowledge loss
  - Mentoring/job shadowing
  - Knowledge fairs/symposiums
  - Written scenarios
  - Performance support tools (process documentation, job aids, decision trees)
  - Action learning projects
  - Decision tools
- Increase efficiency
  - Searchable document repository
  - Databases and directories
  - Project notebooks
  - Just-in-time (JIT) training available via social media, podcasts, etc.

- Improve the quality or speed of decisions
  - Searchable document repository
  - Internal and external databases
  - "Expert" network/searchable personnel profiles
  - Search engines
  - Access to financial and performance data
  - ERP, CRM
  - Product/market/competitive information
  - Decision-making software

Tools for Compliance

IT can improve an organization's compliance posture by providing:

- Demonstration of compliance
- Responses to new and changing requirements
- Business agility in a regulatory environment

These can be accomplished by compliance management tools that do the following:

- Provide an adaptive repository for rules
- Monitor adherence to rules
- Alert Compliance Officers to problems
- Alert managers and employees as to new rules and training on those rules
- Analyze for trends and exceptions
- Assist Compliance Officers with formulating and monitoring proactive action plans

> *KM technology will only succeed if we put more emphasis on content and the people who develop, retain, and share that content. – Richard Combs*[xxxiv]

The 24/7 nature of IT enables it to vigilantly watch and alert Compliance Officers in a timely manner for indications of potential fraud, abuse, and error. The continuous monitoring enables tracking of action plans and remediation activities to ensure that they are following a course within necessary guidelines. This contributes to compliance and helps prevent unacceptable levels of risk.

IT tools help managers and officers to monitor and report on the overall status of assessments, testing, remediation, and certification activities. Completion of compliance tasks can be facilitated by guided workflows directing needed actions in the proper order. Violations of segregation of duties can be monitored and analyzed with the aid of IT tools that visually track the path of the violation, simplifying potentially complex duty roles.

The use of IT tools can also help minimize the costs of managing compliance over a variety of differing regions, regulatory agencies and policies, and business lines. A good database can reuse and divide elements as appropriate to achieve efficient use of resources.

IT tools can also employ the objectivity that can be lost when personnel are involved in transmitting information. This objectivity and subsequent data completeness allows the identification of exceptions and

trends that might be missed, as single data points alone might be dismissed when human subjective interpretation fails to see the big picture or to recognize the significance of an event.

IT tools can perform multi-criteria risk and cost analysis on a continuous or on-demand basis, enabling effective and agile response and planning to minimize both cost and risk.

While IT provides tools for compliance, IT itself needs to be managed for compliance. IT compliance regulations can cover issues from simple information security to protection of control systems. Data needs to be protected from unauthorized access, use, disclosure, destruction, modification, or disruption. Control systems can be a target for cyber-attacks — a breach of these systems could result in catastrophic outages or worse. The North American Electric Reliability Corporation standards for Critical Infrastructure Protection (NERC-CIP) include regulations pertaining to the implementation of adequate security and monitoring of control systems.

Various IT tools can be used for compliance with regulations in various spheres of pipeline business, with some tools integrating multiple capabilities into a unified package:

- Operations
- Production
- Technology security
- Information security
- Finance and accounting

Business Rule and Process Management Systems

A Business Rule Management System (BRMS) and a Business Process Management System (BPMS) can help with compliance issues. A BRMS is used to manage the business rules, including company policies and regulation requirements. These "business rule engines" define, deploy, execute, monitor, and maintain the variety and complexity of decision logic that is used by operational systems within the enterprise. A BPMS is used to manage business processes, providing visual and other modeling tools that promote the streamlining, automation, continual improvement, and agility to processes in the face of changing requirements. Some of these systems employ libraries of predefined policies to help transform formerly manual and detective controls into automatic and preventive controls.

The key steps to automating processes and rules to assist in compliance are as follows:[xxxv]

- Identify the regulated decisions and processes.
  - For process-associated regulations, identify the impacted processes and estimate how to automate them in a BPMS.
  - For decision- or rules-associated regulations with limited-allowed actions, identify the relevant processes and define for the BRMS.
- Use good source rule management to respond to changes in processes or regulations.

Root Cause Analysis

Oracle's Information Technology Service Management (ITSM) is a top-down, business-driven approach that enables the reactive and proactive management of IT services to ensure reliable service delivery. The Oracle Enterprise Manager (EM) proactively detects events that could lead to incidents through automated monitoring of its business applications. The Problem Management module categorizes underlying root causes with the use of diagnostic tools, such as correlation with records of recent changes or the characteristics of the most recent system command. Integrated event and change management data are also analyzed for trend analysis to aid in proactive longitudinal root cause analysis.

Risk Analysis

Risk indicators can be used to highlight areas of non-compliance and potential fraud, abuse, and error. Analysis covering multiple criteria can determine significance of risk and potential associated costs. Continuous tracking of action plans ensures that remediation activities are on course.

Corrective and Preventive Action

In corrective and preventive action (CAPA), recurring issues are investigated, root causes identified, and corrective/preventive actions implemented and evaluated for effectiveness.

Predictive Analytics

More advanced tools may use predictive analytics to adaptively improve diagnostic capabilities. In risk management applications, predictive models and decision tables are combined with rules to guide decisions that are governed by policy or regulation. In some financial sector regulations (e.g., BASEL II), analytics are required as part of demonstrating compliance, and through court rulings' consideration of the statistically likely impact of rules and processes.

Appendix E — End Notes

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