Who Moved My Knowledge?

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Knowledge is the most strategic asset in enterprise, the source of all creativity, innovation and economic value. – W.E. Halal[1]

ABSTRACT

The natural gas industry is faced with a growing crisis due to the loss of operational skills and knowledge resulting from the rapidly retiring Baby Boomer generation. Herein we will investigate the changing workforce demographics that are in play today, the fact that collecting more data is not, in and of itself the solution and explore potential actions that must be taken to stem the tide of knowledge loss. The author does not, nor cannot, propose specific solutions to the challenges, as they are beyond the scope of this paper. What is presented is a new way of looking at how we define and ultimately capture knowledge. This paper is a journey in thought, much like the journey that we as an industry must undertake, as no "shrink-wrapped" solutions to the challenge exist.

INTRODUCTION

The natural gas compression industry, whether gathering, midstream, transmission or local distribution, faces many challenges in today's market place. Growing demand, an aging infrastructure and a rapidly retiring workforce, among other pressures, are all converging to form an operating environment not previously experienced by this, or many other industries. As daunting as the challenges are in and of themselves, the combined impact on operations will serve to redefine how the natural gas industry operates in the future. Meeting these complex challenges requires new thought processes and approaches to capture, facilitate, deploy and leverage the unique knowledge inherent in the industry's workforce.

In the 1990's corporate America was fascinated with the promise that the dot-com boom and a strange concept referred to as *Knowledge Management* held for the future. So new and unique was this new realm that expansive wealth was built on nothing but dreams and expectations. In many cases, extensive wealth was built on nothing more than a simple webpage and a promising business case. We all know what happened to the dot-com's, but the prominence of *Knowledge Management* also faded away as people and corporations grappled with this slippery and hard to define resource. Although the value of knowledge is intuitively inherent, it is a vastly more difficult endeavor to capture and leverage this valuable resource.

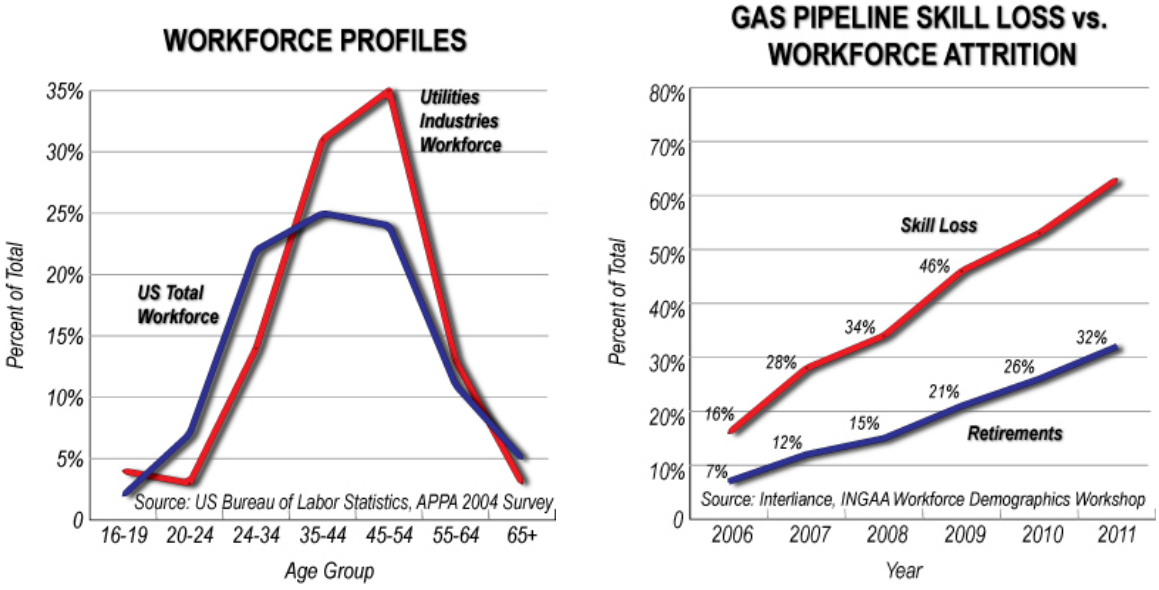
Capturing and deploying knowledge as a leveraged, ever-increasing resource requires a paradigm shift in our thought process as well as in our systems architecture. This paradigm shift must not only be applied to the computer systems that contain the vast knowledge of the industry but also to the hierarchical structure that is often applied to who, and more importantly, who is not a knowledge worker. Ensuring that knowledge is

kept whole, further developed and readily deployed requires imbedding the necessary tools throughout the industry's operating infrastructure from end-devices to intuitive, interactive user interfaces available to the entire workforce.

The tools to capture and deploy knowledge exist today as in no other time in history. Deployment, however, requires a paradigm shift in the way that knowledge is viewed. Gone are the days where there is power in closely held knowledge, either individually or as an industry. We now operate in a world wrought with acute economic pressures where the true power comes in the sharing, facilitation and expansion of knowledge through collaboration. The answers to the challenges that the industry faces lie in our ability as an industry to pool our collective knowledge regardless of corporate boundaries.

CHANGING DEMOGRAPHICS: *An unprecedented driver of change*

Born in the two decades immediately following World War II, the generation known as the Baby Boomers has driven change and technological growth known by few other generations. This generation, through shear volume of numbers, has changed the face of the country through pressures created by their needs and expectations. Between 1998 and 2008, the number of workers aged 45 and older will increase from 33 percent to 40 percent. Coupled with this fact is that over the same period, those workers aged 25 to 44 will decline from 51 percent to 44 percent, which will have a tremendous impact on all aspects of the United States economy. The U.S. Bureau of Statistics estimates a shortage of 12 million qualified skilled workers by 2010, rising to 20 million by 2020 in the United States[2]. Nowhere is this impact more acute than in the U.S. oil and gas industry where it is recognized to be reaching crisis proportions[3].

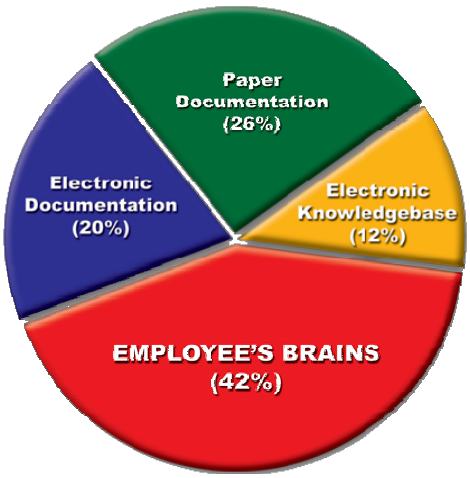


Twenty percent of employees working in the natural gas industry are currently eligible for retirement and another 35% will become eligible in the next 5-10 years.[4] When these employees retire, they will take with them their unique operational knowledge developed over careers spanning forty years. This employee base holds an estimated 80% of the industry's operational knowledge, including that which is considered critical knowledge.

In as little as five years, 63% of tasks will be at risk of being performed without a skilled worker available if immediate action is not taken to stem this loss of skills and knowledge[5].

The expected rate of retirement, either through workforce downsizing or voluntary means, precludes the passing on of knowledge gained through joint experience, guidance and hands-on training. It is possible to classically train the follow-on workforce in a classroom but classroom training is only one step in the devolution of knowledge. As the saying goes, "one learns by doing". There is no replacement for decades of experience and time has simply run out for recreating it. Most concerning is that where gaps exist in the training; the new generation of workers will be forced to "reinvent the wheel" as the existence of previous solutions is unknown to them.

If the loss of key industry skills through retirement induced attrition is not alarming enough, the location of the operating knowledge is extremely sobering. In a survey conducted by the Delphi Group, it was discovered that roughly 42% of the knowledge of an organization exists solely in the brains of their employees[6]. This 42% not only represents unique, undocumented, explicit organizational knowledge, but also the unique tacit knowledge that employees, from the custodian to the CEO, use in the daily execution of their duties. This critical knowledgebase goes home at night, "wins the lottery" and retires. In surveys specific to the natural gas transmission industry, it is estimated that we will see a 63% reduction in critical skills within the next five years. These skills are those that have been gained by a generation of operators, engineers and technicians over the 30-40 year span of their careers that allow for the safe operation of an increasingly aged infrastructure. Those who will replace them have not had the luxury of designing and/or operating the infrastructure for the past 40 years. They will be the generation, however, that must adapt a decidedly rigid infrastructure to the ever changing demands that are upon the industry today.



Source: The Delphi Group, After the Gold Rush

Knowledge Lost: *The Apollo space program*

> *I believe we possess all the resources and talents necessary. But the facts of the matter are that we have never made the national decisions or marshaled the national resources required for such leadership. We have never specified long-range goals on an urgent time schedule, or managed our resources and our time so as to insure their fulfillment. – John F. Kennedy Congressional Message, May 25, 1961*

With the closing of John F. Kennedy's Congressional message in 1961, the nation embarked on a historic journey to put a man on the moon within the decade. Many

thought the task impossible and simply science fiction. However, the nation did have a sense of urgency as in few other times in history. In the heat of the Cold War, the Russians were ahead in the space race and posed a serious threat to national security. Kennedy's historic call to the nation to pick up the challenge resulted in the largest, focused deployment of scientific and engineering knowledge in history. Through unimaginable challenges, grief and celebrated successes, Neil Armstrong was able to make that "giant leap for mankind" on July 20, 1969.

Society as a whole has benefited greatly from the advances given us from that decade and continues to do so today. After all, where would we be without Tang™, Velcro® and the ubiquitous microwave oven? Today, however, we could not pick up where we left off with the Apollo program that took us to the moon in 1969. The vast majority of the expertise that created that historic program, which seemed impossible when John F. Kennedy challenged the nation in 1961, was contained in the heads of individuals and is lost to the sands of time. To go again to the moon and beyond will require an entirely new generation, much of which was born after the last moon shot in 1973, to relearn all of the lessons learned and knowledge so painfully gained through adversity, loss and successes of the original pioneers.

The World Has Moved On: *It's not your father's pipeline anymore*

The "hard work" in modern technological advancement has been done by the G.I. Generation[i] and their progeny, the Baby Boomers. What was once done with a pencil and paper, steam tables, a slide rule and an in-depth knowledge of the underlying physics is now done by entering boundary conditions into a software application and pushing a button. In this process the innate relationships of the measured data to the physical symptoms is often lost. This is especially true in the operation of complex systems whether individual engines, or pipeline systems as a whole.

This is not to say that the advancement of knowledge in industry has come to an impasse. Quite to the contrary, we stand on the brink of an age where industry can advance at a rate that has been unknown in the previous generations. Generations X, Y and Z are not bound by the practices of the last forty years, nor do they suffer from technology phobia. They will, by their very nature, drive to the realization of intelligent, self-managing, self-optimizing systems through the implementation of neural networks and the precursors of artificial intelligence the basic elements of which exist today[7]. This move, however, must be supported and facilitated by the generation that has advanced and accumulated the base knowledge that must be imbedded in the applications of the future.

The economic drivers and expectations of today preclude this and future generations from spending the time necessary to fully immerse themselves in the fundamental physics, thermodynamics and mechanical relationships that drive the world around them. Not that these generations are incapable of forming the understanding, it is that the constraints and expectations placed on them with respect to time-constraints and productivity simply no longer allow the in-depth exploration of the fundamentals enjoyed

[i] The G.I. Generation was born between 1900 and 1924, with those born between 1911 and 1924 often referred to as the Greatest Generation, served in World War II and the Korean War and gave birth to the Baby Boomer generation (1946-1964).

by previous generations of engineers, technicians and scientists. The state of understanding also continuously evolves and grows empowering each successive generation. The Wright brothers toiled to understand the fundamentals of flight yet future generations simply made use of their findings. Today hobbyists and children alike deploy many of the basic principles that Wilbur and Orville struggled to understand without giving it a second thought. The same will also happen with those complex things that we are striving to understand today.

It is through the convergence of multi-generational knowledge, imagination and skills that we will advance the state of the art and ultimately the state of our understanding. This convergence must be actively cultivated, facilitated and driven to achieve the results that will sustain this and many other industries.

Data Overload: *The Information Age*

The Information Age began On May 24th, 1844. When Samuel Morse transmitted "What has God wrought" from Washington to Baltimore through a thin copper wire, in what was to become known as Morse Code, the means by which we share information changed forever. Since that time, the rate of data transmission has increased exponentially and today exceeds the capacity of the human brain to assimilate it at the rate that it is generated. It is only through the conversion of data into information and information into knowledge that we will make the next advances in enabling employees and businesses.

The Information Age has had immense benefit to both industry and society. It has, however, had negative impacts as well. We are now never truly disconnected from work or each other. We have become a nation addicted to 24/7/365 data. Yes, we are more productive but what happened to the dreams of the early and mid 20th century where technology would free us and give us more free time. Technology has freed us in many respects, but has chained us in many more. Additionally, much of the "information" that we receive is simply partially distilled data which simply overwhelms our ability to assimilate it into meaningful information. All too often we simply "check out" as the waves course over us.

Evolving Dependencies

Sitting here at 35,000 feet, somewhere over the American midwest, I don't have access to Wikipedia or Google™ and my usual routine of switching from writing to research when I need a fact or statistic is not available to me. And I'm not sure that I am okay with it! Generations Y and Z feel this seperation anxiety even more acutely than those of us who grew up in a "disconnected", non-digitized world. Those of us who remember library cards, party-lines and writting letters with pen and pencil can better adapt to "gaps" in our connectivity. Our children, who have grown up in a connected world, simply become disoriented when they can't text their friends for what feels like an eternity to them and only two hours to the "old folks."

It will, however, be these generations that give me back my Google whether I'm cruising at 35,000 feet, camping in Yosemite or sitting comfortably in the office. How dependent have you become?

Acceleration: *We are not the first to grapple with it*

When I was my children's age, a mouse was a fury critter that ate cheese and the phone was screwed to the wall. They do not remember the days before computers, Microsoft, the internet or the cell phone. To them, these enablers of modern life have always been there. Much as the fledgling engineers of Silent Generation dreamed of building faster

airplanes, those of the Greatest Generation dreamed of television and those of the Baby Boomer generation dreamed of going to the moon, the imaginations of Generations Y and Z will be spurred on by the "flipping of bits." Their innovations will make real the science fiction of today at an ever increasing pace. We are not the first generations to deal with this acceleration.

The speed at which America operated changed with the completion of the transcontinental railroad on May 10, 1869 at Promontory Point, Utah. Prior to that day, communication had moved at the speed of a horse as it had since before Roman times. In 1869, with the railroad and the telegraph that was beside it, a man could move at sixty miles per hour and transmit an idea or a statistic from coast to coast almost instantly[8]. Within a week of the completion of the railroad, the time that it took to travel from New York to San Francisco was reduced from four months, wrought with life threatening dangers, to seven days in the comfortable surroundings of a passenger train. The completion of the railroad enabled the expansion and industrialization of the country at a pace that was inconceivable to older generations, yet the younger generations embraced and adapted with unbelievable results, thus ushering in the industrial age.

KNOWLEDGE: *What can be consumed, but not depleted?*

> *Unlike capital, knowledge can't be used up. The more you dispense, the more you generate. - Ray Smith, former CEO of Bell Atlantic*[9]

Although it may sound like a riddle, it precisely describes what we call *knowledge*. This, however, is not to say *knowledge* is an intrinsically robust resource immune to distortion, destruction or loss. In the oil and gas industry, it is currently estimated that 60% of the experienced managers will retire by 2010.[10] What unique, operation critical knowledge will each of those employees take with them when they retire? Since it is only through the application of existing knowledge that new knowledge is created,[11] the loss of critical knowledge and skill through attrition jeopardizes the ability of the industry to continue to meet the operational challenges it faces; for knowledge lost must be rediscovered before it can be applied.

Knowledge is a unique and difficult resource to define in terms we can grapple with in the context of a hierarchical world. Knowledge can and is created by anyone and everyone at any level within an organization. Nowhere is this more evident than on the internet today. Knowledge is being collaboratively created and expanded upon by people from all walks of life at a rate that exceeds anything before it in history. The very inherent nature of knowledge is that it grows the more it is shared and when applied, it grows in power unlike any other resource.

Multiple definitions of knowledge exist and there is a continuous quest to define new ways to characterize something that is not easily understood. After all, how do you describe something that cannot always be easily written down or in some cases even conveyed verbally? Volumes have been written in an attempt to define what knowledge is. In many cases defining what knowledge is can be as futile as attempting to reduce human intuition to a series of process maps. Without getting caught up in the intricacies of what knowledge is or isn't, we can group it into two distinct classes, explicit and tacit, that allow us to more easily deal with the concept of knowledge.

Not all forms of knowledge are difficult to define and/or describe. These forms of knowledge are commonly referred to as explicit knowledge. It is explicit knowledge that can be readily converted to standards and processes such as design specifications and best maintenance practices. Saying it is readily converted is far from saying conversion is an easy process. Not all explicit knowledge is "created equal" nor should it be treated as equal or an organization runs the risk of homogenizing the very knowledge which makes it unique[12]. Serious thought and effort needs to be expended in determining what explicit knowledge has merit in being documented and ultimately codified for deployment to the people who need it.

The form of knowledge that often eludes our attempts to capture it is tacit knowledge. It is tacit knowledge that we all posses that cannot be easily converted to a physical form to be implanted into processes and standards. Tacit knowledge is what makes us unique as individuals. Tacit knowledge can be transferred, to some degree, through training and experience. Hence, tacit knowledge is often referred to as experiential knowledge or that which is gained through experience. From legends, parables and anecdotes told around tribal fires to the world-wide-web, mankind has struggled throughout time to pass tacit knowledge from one generation to the next. At the root of this struggle is the simple, inherent unreliability of human memory that, when coupled with our own unique interpretation and perspective, alters what has been received. This struggle is not always detrimental to the advancement of mankind. As with Einstein, Bohr or Galileo, the combination of interpretation, perspective and focused application of tacit knowledge can lead to changes in the way we understand and interpret the world around us.

We, however, are neither Einstein, nor Bohr or Galileo striving to explain the inner-workings of the universe, but an industry struggling against socio-economic factors that influence our workplace, our workforce and ultimately our future. Our struggle is one that involves capturing the unique tacit knowledge gained by an industry through decades of operation and converting that knowledge into an explicit form that can be distributed, grown and acted upon to guide our actions.

Changing Our Perception of Knowledge: *It's not what you may think*

Information is not knowledge. - Albert Einstein

Before we can deal with the difficulties of transferring knowledge from one human being to another, we must redefine our view of what knowledge is. Knowledge, once the domain of scholars and philosophers, has become the focal point of engineers, computer scientists and physicists as they apply the principles of heuristics, neural networks and artificial intelligence to solve increasingly difficult problems.

Our quest to understand, control and optimize the complex systems that we have developed, coupled with our attempts to understand their intricate interdependencies has lead to an explosion in the volume of data collected. However, the answers to our ever increasingly complex questions seldom, if ever, lie solely in the raw data itself. It is often assumed that data alone will bring knowledge and understanding, which is far from the truth. For the data to have meaning it must be organized and put into context. This combination of data and meaning provides us with information that can, in turn, be acted upon to solve problems and improve efficiency. If information is then processed within

its context and related to other information, thereupon expanding our understanding of the interaction of the variables that allow us to act precisely, then we have converted information into true knowledge that can be deployed and leveraged across the system.

In today's world, much of this conversion of data into information and information into knowledge occurs in the "gray matter" of experts. The results of this "conversion" are heavily influenced by personal circumstances, understanding and reference. As defined by Thomas Davenport and Laurence Prusak:

> *Knowledge is "information combined with experience, context, interpretation, and reflection. It is a high-value form of information that is ready to apply to decisions and actions."*[13]

More simply:

Data ≠ Knowledge

Data + Meaning = Information

Information + Experiential Processing = Knowledge

This definition of knowledge significantly increases the complexity of capturing, interpreting and deploying it for use. Although it may seem an impossible task to digitally create something that occurs in our brains today, we are on the verge of a new paradigm with regards to data, information and knowledge systems that will make this "conversion" a reality. Success, however, requires yet another shift in thought process. Knowledge can no longer be closely held as an advantage to the individual. This new world requires a great deal of trust and cooperation as the sharing and growth of knowledge through collaboration demands it. This responsibility takes us far beyond the *Knowledge Management* concepts of the 1990's. We are now charged with an even greater responsibility, *Knowledge Stewardship*.

THE KNOWLEDGE VISION: *A call to action*

> *Everything you can imagine is real. – Pablo Picasso*

In his 2004 paper, *A Vision for the Intelligent Pipeline System and the Role of the Intelligent Engine*, Chad Fletcher calls for a strong, clear *Knowledge Vision* to carry the pipelines into the future against the many challenges that lie ahead. Fletcher's *Knowledge Vision* called for the integration of knowledge and infrastructure thus allowing increased leverage of both people and compression hardware. Many things have changed since that call to action from both a technology and operational standpoint that bring these concepts closer to reality today than at any other point in history. Intelligent systems that blend knowledge and infrastructure are fast becoming a reality in industries around the globe. From a knowledge loss perspective, the level of urgency and need has increased dramatically for the natural gas pipelines. As illustrated thus far, the effect of workforce attrition and the subsequent skill loss caused by the retiring Baby Boomer generation has elevated the stakes for non-action. As an industry we are now playing a

game with much higher stakes and in Gene Krantz's famous words, "Failure is not an option".

The responsibility and challenges of *Knowledge Stewardship*, in this author's opinion, go far beyond any challenge previously faced by the natural gas industry. The projected rapid rate of knowledge and skill loss mandates immediate action to ensure the loss of critical operational knowledge and skills does not reach crisis proportions. It's not too late to embark on this journey, but the clock is ticking and time is running out. If we do not act immediately, with focused intent, we will be forced to retrace history rather than focusing on how to meet the many challenges that the future promises.

Many of the seemingly complex, enabling technology layers that exist within the knowledge infrastructure are being readily driven to non-differentiated commodity offerings through the influences of the mass markets. Telecommunications, data warehousing, even the dissemination of data have rapidly become commodity offerings available from multiple sources for a relatively small fee. It is the knowledge-rich layers, imbedded both in intelligent, application resident devices and application specific software that add true value. No longer is it sufficient to provide data alone in increased volume. That data must be acted upon to translate it into information, and then embedded knowledge applied to leverage resources to their maximum potential, thus providing tangible improvements in business results. This conversion of data to knowledge-rich, workforce enabling applications, whether facilitated and expanded internally or in conjunction with other companies facing the same acute pressures, will provide the foundation for *Knowledge Stewardship* within the industry.

Knowledge Stewardship: *It's not a shrink-wrapped solution*

The success of any technology deployment requires a clear definition of objectives and metrics against which to measure its success. It can be stated with confidence that the fractured deployment of technology alone will not gain the desires, or the business results, that are sought by companies throughout the industry. Unaligned technology and resources, whether people, assets or capital, simply burdens and frustrates those involved leaving the true potential unrealized as the expectation, and therefore success, was never clearly defined prior to deployment. Tangible results never come simply from the installation of software. The applications must be tailored to fit the needs of the user. This is especially true in the world of *Knowledge Stewardship.* There are no canned solutions that can simply be downloaded, installed or purchased of the shelf in a shrink-wrapped box. Converting the "wave of data" into usable knowledge that can be applied in the course of daily operations to make decisions and be acted upon, whether physically or autonomously, must begin with the human element and the capturing of the knowledge it holds.

The applications that make up the foundational elements of *Knowledge Stewardship* not only behave as organisms but require organic growth. This model is contrary to many of the current practices in place today that demand users follow a prescribed course of action and thought. The processes that currently drive daily operations, including system automation, mimic the relatively straight forward pneumatic systems that were successful in powering the industrial revolution. Knowledge based work follows a different, often indefinable path that is as unique to an individual as their fingerprint. The simplest example of this is watching over someone's shoulder as they navigate and use

a computer program. This exercise often creates a high level of anxiety and frustration in the observer as what they are seeing does not line up with their own "process," whether it is the speed of movement or the order in which commands are executed. Likewise, the infrastructure that enables *Knowledge Stewardship* must work for a wide array of individuals from managers to technicians and from experts to novices. It must accomplish this in a way that fits the needs of the individual or it will not be embraced.

Creating systems around the behaviors of individuals may sound like a tall order but it is that very essence the creators of Web 2.0[ii] applications are striving for and in many cases, have achieved. The developers of Web 2.0 do not try to impose any predetermined processes on the user. They are focusing on building the platforms and tools that allow the unique aspects of knowledge based work to materialize.

Web 2.0: *The enabler*

> *(The internet) shrinks time and distance, simplifies complex business processes, and enables more effective communication and collaboration. - Bill Gates*[14]

Still considered by many to still be in its infancy, the internet is undergoing a profound transformation that will ultimately have a significant impact on society as a whole. This transformation has seen the advent of collaborative applications that allow people to capture, distribute and share information like nothing before in history. Internet based applications such as wikis, blogs and search form the backbone of what has been labeled Web 2.0. The platforms that comprise this second generation of the internet go far beyond the original concepts that drove the dot-com era. These platforms, when strategically deployed, allow the collection of knowledge, organizational and individualistic, without actually focusing on the capture and management of knowledge as has been the traditional *Knowledge Management* goal. As noted by Andrew McAfee, "Current technologies are not doing a good job of capturing knowledge. New platforms focus not on capturing knowledge itself, but rather on the practices and output of knowledge workers."[15] These platforms, when integrated into the daily routines and work processes of employees, allow for the organic growth of collaboration within an organization and ultimately capture the knowledge that circulates within. But can we, as a structured generation, embrace these new concepts that often go against everything that we have been taught about how to go about our daily tasks?

Can I Google that?

It's become a part of many of our thought processes without even thinking about it and if you are part of Generation X or Y you think even less about it's significance. I'm talking about the ability to search a world of information by typing a few cryptic words into a simple box.

Ten years ago the abilities of today's search engines were unimaginable as they were struggling in their infancy. Whether looking for what is playing at the local movie theater or researching facts and statistics for a paper, search has become central to life in a world awash with information. Search, as we know it today, is continuously evolving. It is moving far beyond database query and is driving towards the basic elements of true artificial intelligence. As our vast knowledgebase grows we will become increasingly dependent on search to unlock its power.

Tell an engineer fresh out of school today to look for a file in the file room and you are likely to get a puzzled look and be faced with the question; "Can I Google that?" Which brings into question, is your information searchable?

[ii] O'Reilly Media first used the term "Web 2.0" in 2004 in describing the second-generation of internet based services that allow people to collaborate and share information.

Collaboration: *Convergence* and t*he Wiki way*

The most recognized wiki today is quite possibly Wikipedia, *the free encyclopedia that anyone can edit.* Wikipedia was launched on January 15, 2001 by Jim Wales and Larry Sanger in "an effort to create and distribute a multilingual free encyclopedia of the highest possible quality to every single person on the planet in their own language."[16] Based on Ward Cunningham's groundbreaking wiki technology, the very concept of an encyclopedia built collaboratively by individuals around the globe seemed a ludicrous and naive idea at the time of its inception. However, since its launch, Wikipedia's growth has been nearly exponential with more than 5 million articles in many languages, including more than 1,300,000 in the English-language version. Wikipedia ranks among the top 20 most visited sites on the internet and its popularity continues to grow[17].

Popularity aside, the question remains, is Wikipedia an accurate and reliable source of information? It is, after all, a collection of individualistic knowledge from around the globe and anyone can edit it at any time with no "real" control over they content that they are adding. The answer may surprise you. In a study released by the magazine *Nature* in December of 2005, the accuracy of 42 science entries were compared with the online version of the Encyclopedia Britannica. Each was found to have four significant errors while "reviewers also found many factual errors, omissions or misleading statements: 162 and 123 in Wikipedia and Britannica, respectively "[18]. Although not perfect, the results of the study show that the practice is feasible and does in fact work.

The principle of collaboratively creating and editing articles upon which Wikipedia is built leverages the very essence of knowledge work. If only one individual contributes to an "article", then that individual's experience, emotions and resulting viewpoint has the potential to significantly skew the level of accuracy. However, accuracy on a subject will naturally converge as more and more people collaborate, exchange views and come to a new understanding of the subject. The same can be said for any collaborative effort regardless of its focus. Imagine the power of the industry knowledge as a whole captured collaboratively and deployed within the workforce to move the entire industry forward in its understanding of the principles upon which it operates. Yes there are risks, but they are small compared to the risk of inaction.

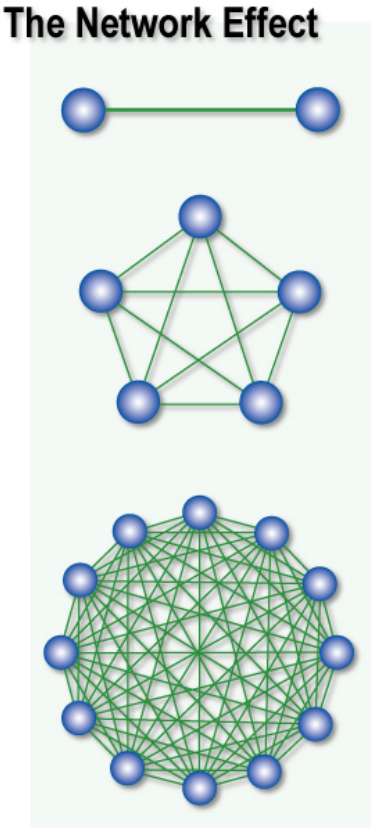
Organic Growth: *It has to be contagious*

Regrettably, the path ahead is not one in which we can simply engineer the knowledge infrastructure and then mandate that everyone "download" their collective know-how and begin collaborating. The steps forward must be taken one at a time. We must first learn to crawl before we can walk. In the face of adversity, such as that which the industry faces, the need to act immediately can be very acute. In realizing the *Knowledge Vision*, we must act with purpose and intent if we are ultimately to be successful. It is often stated that a journey begins with the first step and so it is true of the realization of the *Knowledge Vision*. We will be working within the very best, and worst, of the human element. It will be a messy business but what great achievements have ever been straight forward and without setback?

Many technology endeavors begin with good intentions only to fail due to the lack of acceptance within an organization. This lack of acceptance almost always stems from a

lack of engagement by the workforce. Linking databases and interfaces is easy when compared to the challenges of "integrating" the human element. Often employees are required to change their work habits and are told to follow a prescribed process unfamiliar to them. Compounding the problem, exploration and experimentation within the new platform is often discouraged if not outright censured. It is this "forced" change that leads to the failure of such technology deployments as the majority of people do not readily accept change. It is uncomfortable, requires thinking in new ways and people simply rebel against it. There is another way, but it will go far beyond many comfort zones of those who strive for control of the process and demand hierarchical structures.

Human Curiosity: *The ultimate fertilizer!*



Realizing the *Knowledge Vision* requires that another facet of the human element is leveraged to a very high degree. For the *Knowledge Vision* to succeed, human curiosity must be leveraged, encouraged and rewarded. As it is impossible to demand that anyone "download" their unique knowledge; the platforms that comprise the knowledge infrastructure must be readily accepted as a benefit to those who are expected to use them. The greater the level of acceptance, the greater the value will become and the faster the growth of the infrastructure. For knowledge platforms to be successful they must be deployed informally and allowed to take on a "life of their own" as employees experiment and explore the limits of their curiosity.

Ensuring success of collaborative platforms such as wikis requires incremental, informal deployments driven by the acceptance rate of the users themselves. The ability of the users to follow curiosities and experiment within the collaborative environment is an essential element of this success. The goal is to draw people to the tools, not force them into using them[19]. Drawing people to the tools requires initial content that elicits response, controversial or not, and is required to get people engaged as true power is achieved through the network effect[iii]. It is not enough to simply provide the "blank canvases" of a collaborative platform and demand their use as people will not be emotionally driven to engage in learning a new way of doing things.

A world in which employees openly collaborate and share their opinions to create knowledge that can be further leveraged defines the success of the knowledge infrastructure. Success, however, will come with unintended consequences that also demand a change in thought process. The very same platforms that give rise to the

[iii] First characterized by Robert Metcalf, inventor of Ethernet, Metcalf's Law state that the value of a network is proportional to the square of the number of users in the system (n^2). The exact mathematical relationship is debated but the overall impact of large numbers of users in a networked system is indisputable.

Knowledge Vision also give voice to the employees in ways that have never been available. It is as yet unknown if the new paradigm will be welcome. How companies deal with this delicate balance will determine the level of success they attain within the *Knowledge Vision*.

TAKE THE FIRST STEP: *There is no perfect strategy*

Unfortunately there is no "canned" solution to the problem of knowledge and skill attrition that we face as an industry. Despite what you may read in advertisements or what consultants may tell you, the solution to this problem cannot be downloaded, installed off of a disc or purchased in a shrink-wrapped box. There simply is no one-size-fits-all solution. Solutions in this realm are unique to each industry based on their needs. We must begin to build the infrastructure that will enable *Knowledge Stewardship* using the tools that are available to us today and do it without unnecessary complexity. We must take that first step.

The integration of databases from internet knowledge and collaboration platforms to engine control systems is a relatively easy concern. The complexity of the endeavor lies within the human element and our ability, or willingness, to embrace and participate in something that often goes against our very nature…the sharing of our own unique knowledge. The successful deployment of a knowledge infrastructure lies in our collective abilities to step beyond these natural, yet traversable, boundaries. We must start small to develop our understanding of *Knowledge Stewardship* and what is required to ensure success. If we strive to define the perfect strategy and/or solution before we act we will have lost our opportunity as the knowledge and skills will have been lost. There is no such thing as a perfect strategy or perfect solution. There is only action and inaction.

PERCEPTIONS: *The biggest hurdle may be ourselves*

Knowledge is haunted by the ghost of past opinion. - Author Unknown

In 1714, the British, through an act of Parliament, offered the *Longitude Prize* of 20,000 pounds sterling, to anyone who could accurately determine longitude. In the eighteenth century, the biggest problem facing the word of business was the inaccuracies involved with maritime navigation. This was especially true of Great Britain whose vast empire required reliable shipping.

> *"The Discovery of the Longitude is of such Consequence to Great Britain for the safety of the Navy and Merchant Ships as well as for the improvement of Trade that for want thereof many Ships have been retarded in their voyages, and many lost..." Parliament, in 1714, voted to offer a reward (£10,000 for any method capable of determining a ship's longitude within one degree; £15,000, within 40 minutes, and £20,000 within one half a degree) "for such person or persons as shall discover the Longitude."*[20]

John Harrison[iv], an English horologist (clockmaker), solved the problem by inventing a spring driven clockworks that could survive the rigors of sea travel. When presented to the Board of Longitude, comprised chiefly of astronomers, they refused to accept a solution devoid of celestial calculations despite repeated successful transatlantic sea trials spanning a period of 36 years. It was not until King George III came to his aid in 1773 that John Harrison, now 80 years of age, was able to collect his prize.

As in John Harrison's case, our ability to grapple with the changes that are upon the industry is often "haunted by the ghost of past opinion." Successfully dealing with the challenging realities of an aging infrastructure, a rapidly retiring workforce and changing market demands requires that we look forward with clear and open minds not bound to the practices of the past. Although the practices of the past 40 years have served us well, they are quickly reaching and/or exceeding their limitations. We must accept that many of these practices cannot carry us forward into these new and uncharted waters. Our perceptions of the past must not keep us from moving forward. We have a far reaching responsibility to share our accumulated knowledge with the future generations of engineers, technicians and operators who will inherit not only the infrastructure that we have built over the previous generations, but also the accelerating demands placed on that same infrastructure.

> *There are risks and cost to a program of action. But they are less than the long-range risk of comfortable inaction. - John F. Kennedy*

[iv] John Harrison is also credited with inventing the bimetallic strip thermometer and the caged roller bearing.

End Notes

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