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Field Project

Implementation Planning for the Introduction of Knowledge Management in an Aerospace Engineering Organization

By

Neil Hughes

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Herb Tuttle
Committee Chairperson

Andy Elliott
Committee Member

Heather McCain
Committee Member

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EXECUTIVE SUMMARY

The availability of information within an aerospace organization is required for engineers to perform activities. As information is considered, it's the experience of the engineer that allows information to become knowledge for use.

Knowledge sharing is critical within aerospace organizations to continually meet goals. Knowledge for personal use can maintain the organizational knowledge levels until people begin to retire, but the organization can't maximize the use of its knowledge without sharing.

The idea of Knowledge Management, or KM, was created to promote the sharing of knowledge by using IT enabled tools. KM allows for organizations to make the most of the information stored in databases: as well as knowledge stored within the minds of associates. KM takes many forms across different organizations. When KM provides the most benefit is when the organization allows the intended end users to be a part of the development process. Ideally, the result is an easy to use tool, or group of tools, that assists users in the storage and retrieval of pooled information to build personal knowledge.

Such an initiative must be comprehensively planned to limit the affect of road blocks that accompany the start of any such project. Getting the buy-in of stakeholders up front, as a part of the planning process, is paramount to the success of KM.

Based on the compilation of feedback from engineers at the aerospace company, as well as research in the field of study, this project aims to develop an implementation plan for KM at the company.

TABLE OFCONTENTS

LIST OF PRINCIPLE SYMBOLS AND NOMENCLATURE

CSF	Critical Success Factors
KM	Knowledge Management
KMS	Knowledge Management System
ITAR	International Traffic in Arms Regulations
OEM	Original Equipment Manufacturer
PLM	Product Lifecycle Management
SKMM	Strategic Knowledge Management Model

INTRODUCTION

At the start of this project, the primary goal was to identify an improved information structure to organize project information at a specific company that will be referred to in this paper as 'the company'. The company performs aerospace projects that can be both complex and lengthy. The intent is to provide exactly the right information to the right people at the right time: useful information. This was originally to be done by establishing a predefined and globally accepted network of folders within the Microsoft tool Windows Explorer. Finding information without going through a lengthy manual search process will save time by allowing the seekers to be more efficient in their duties, thereby reducing the frustration of being unable to find the information. The scope of this paper is focused on technical staff. The more efficient use of their time will benefit the organization, thereby increasing profitability. Additionally, that properly stored information would be useful to other associates within the company to provide more robust products by potentially using the past information to improve reliability and quality.

The methods to carefully sort information and use the simple tools that exist is at its core an information management challenge. During the research for this paper, it became clear that organizing the structure of project files alone was not enough to meet the goal of this paper. The goal is to provide useful information to exactly the right the right people at the right time.

Research in the field of Knowledge Management (KM) has provided some further guidance to meet this goal. Where information management stops, KM continues on.

Specifically, KM provides a methodology to improve the creation, storage, as well as retrieval for the sharing of information.

With that, the scope of this research project expands beyond that of just information management practices, and now includes aspects that will lead to identifying and implementing the principles of Knowledge Management at the company. Specifically for this project, KM will be introduced as it applies to the needs of technical staff at the company. Instead of providing a finalized structure or well defined KM tool, the short term focus of that goal will be to create a KM implementation plan for use at the company, based on the research shared within this paper. The plan will be laid out such that the key stakeholders can guide the process to identify and develop the tool(s) that will be the most useful at the company. Successful completion of this project increases the company's ability to meet the goals, financial and otherwise, by providing timely and useful information to its technical staff to more effectively perform their work.

At the company, information gathered throughout the life of a project is created, organized, and stored at the discretion of the person creating or saving it. There is little structure or oversight from the organization to provide standard formats or processes when it comes to information. Where any project file structure may exist at the company, there is no common understanding of what type of information is to be retained or where that information is to be placed. Over time, information that has been retained may or may not be found easily, if at all. Only people with the memory of having first created the information have a fair chance of locating it.

There have been previous attempts to come up with a specific structure, but none have provided the sought after benefits, or have been adopted as a department standard.

Although this may not have anything to do with how well thought out the structures were constructed, but the lack of success most likely was from a lack of training or buy-in during the development by the intended group of users.

Often a seeker of information, perhaps a new associate, does not know where to start a search. The hope is that there will be enough initial knowledge regarding file storage structure and technical understanding to pick up on a trail of bread crumbs that leads to potentially useful information. The series of folders that house all information must be systematically scoured thoroughly one by one to prevent information from being overlooked. This shotgun approach to finding documents may sometimes lead to informed decisions, but in many cases it will not. The result of these fruitless manual searches often means that a more senior engineer will be interrupted. The interruptions aren't good for anybody, especially when only enough information is transferred to the seeker to pick up the search again or to provide quick answers in a way that the seeker never really gains any knowledge themselves. The barrier to productivity that exists in the form of a hulking volume of unidentifiable electronic information requires context enabling tools to prevent such searches. Without context, information is unusable. With some contextual understanding of the information desired, the knowledgeable engineer at the company will be able to find useful information that helps build their knowledge even if the location is unknown or little is already known about the subject matter.

At the company engineering representatives are involved in every phase of new aircraft programs, and applying context to each piece of information that exists in a way that all can understand can be difficult to say the least. Working relationships vary within every department of the business unit, as well as with suppliers and customers, so the various kinds of personal knowledge bases that must be developed within each individual and will vary greatly from person to person. This diverse set of knowledgeable users can benefit greatly from customized access to information stored within the company. With there being several projects in process at a given time, in addition to the historical projects that have existed, there are as many kinds of saved files stored throughout the network. Often the documents within a program undergo an evolutionary process where the history must be maintained to provide an account of a design or document at any given time of its existence. Most of these historical files have the potential to be shared within cross functional teams comprised of individuals across the globe, as well as with regulatory bodies. To add to the list of documents that must be available for easy access, customers and suppliers also have their own related document packages that must be tied to those of the program. The flexibility required to store and reuse information of this complexity requires a better process than currently exists. Because of this, even with a common structure to follow for the repository of information, the need exists to assist in the search for finding useful information.

The need for available information of which to build the collective personal knowledge perhaps applies even more so to new hires, especially when compared to the lack of knowledge that exists in the people leaving relative to the people starting. At the company, the lack of explicit knowledge (documented knowledge) along with a structured training process makes it difficult for new engineers to build their knowledge base to allow them to become independently useful as engineers. There are several senior engineers with much tacit knowledge (personal undocumented knowledge) that can be identified as untapped resources of knowledge with the intent of turning the tacit into explicit information. Presently at the company the risk exists where the core competencies and favorable market share of our products, could easily be lost or diminished with the nearing approach of key employees retiring. This cannot be accounted for simply by increasing the number of new engineers, as it can take a year or two for new employees to gain a basic understanding of the processes required for the type certification of aircraft, and to become a significantly contributing member of an engineering team. Even then the technical knowledge base of a fully trained new hire is not typically comparable to that of a senior engineer with many years of experience.

Knowledge management tools can benefit the individuals and engineering teams of the company by making work within the complex and lengthy projects quicker, easier, and more efficient by providing useful information to the right people at the right time. Thereby there will be a positive impact on the effectiveness and the profitability of the company.

This paper continues with the literature review of KM, with a general description of KM, along with some historical information. Then we continue with the use of KM in the aerospace industry, while drawing parallels to the company that this project is intended for. The research portion of this paper focuses on the development of guidelines to assist in the planning and development of strategy for the implementation of KM within the company. It is recommended that future work, beyond that described in this paper, be used to establish a more detailed plan that is in alignment with company goals, available resources, and time table.

LITERATURE REVIEW

Knowledge

A basic understanding of what 'knowledge' actually is can be useful when trying to optimize its sharing by the associates of an organization. There is a difference between knowledge and information which will be discussed shortly. To recognize the differences will help to avoid the pitfalls of managing only the information within an organization, when knowledge is what is actually sought. As might be expected, managing knowledge is more difficult than information. Without the more comprehensive approach to retain knowledge, instead of information alone, decision making can potentially result in actions that are lacking one way or another. Additionally, over time core competencies may even be diminished or lost altogether as a result of focusing only on the retention of information. One author (Frey 2001) reflects on this as it relates to employees leaving an organization, "Whereas machines stay in the factory, mill, or mine, knowledge goes with the person."

To discuss the differences that exist between information and knowledge (Alavi 2001) states, "What is key to effectively distinguishing between information and knowledge is not found in the content, structure, accuracy, or utility of the supposed information or knowledge. Rather, knowledge is information possessed in the mind of individuals: it is personalized information (which may or may not be new, unique, useful, or accurate) related to facts, procedures, concepts, interpretations, ideas, observations, and judgments." The human aspect is primarily what distinguishes information from knowledge, and is also what makes knowledge management such a challenge. Moreover, it's the sharing of that information with others that allows them to personalize in their own way to build their own knowledge.

It is indicated by (Alavi 2001) that it is important to understand the different types of knowledge, so that specific means for handling each kind of knowledge and knowledge flow can be developed accordingly. He (Alavi 2001) identified and created a table with many kinds of knowledge to provide definitions and examples to differentiate them. The complete table can be found in the Appendix A of this report. The two types of knowledge that are discussed most frequently in this paper are 'Tacit' and 'Explicit'. The primary difference of these two types of knowledge can be described respectively as unrecorded versus recorded, as shown in the following Table 1 excerpt from the larger original Table.

Table 1, Knowledge Taxonomies and Examples

Knowledge Types	**Definitions**	**Examples**
Tacit	Knowledge is rooted in actions, experience, and involvement in specific context	Best means of dealing with specific customer
Cognitive Tacit:	*Mental models*	*Individual's belief on cause-effect relationships*
Technical Tacit:	*Know-how applicable to specific work*	*Surgery skills*
Explicit	Articulated, generalized knowledge	Knowledge of major customers in a region

The challenge with turning tacit knowledge into explicit knowledge is the time it takes to put it in a format that makes it shareable with others. According to (McMahon 2004) "…engineers do not wish to be burdened with the task of classification or the incorporation of metadata into documents. Classification will depend on our ability to identify suitable classification structures. It is suggested that, in the short term, universally applicable engineering classification schemes will remain elusive...” This indicates that people do not want to take the time to make the documents more searchable, or take the time to place the documents in a predetermined location.

It can be implied that the creators of information seek to retain their information so that they may build upon, or at least sustain, their existing knowledge level. It’s better yet if that information can be used to develop the knowledge of others as well. Information without the associated context or background that helps support the meaning that makes it searchable or the placement of it in a predetermined location cannot be found, and therefore it has no realizable value. It may as well not exist, and the expense of creating it can be considered a loss. Making the information shareable can't be placed solely on the creator of the information or it will not be as useful as it might be otherwise. It is a challenge inherent to all learning to make the available information useable with the required context needed for the personalization for others to retrieve, receive, and use it. Information with context is knowledge. The potential for use exists because of the personalized understanding that makes it applicable to a particular situation, at a specific time, and to a particular person. Much of knowledge management consists of finding ways to take the unrecorded tacit knowledge and make it explicit knowledge by recording it in a way that can be easily shared.

Knowledge Management Definition

KM provides guidelines for organizations to identify what procedures and tools to develop to assist in the sharing of knowledge among the targeted individuals and groups within an organization.

According to (Harvey 2005), "Improved knowledge management is fundamental to providing teams and individuals with increased access to others' knowledge, and therefore improving the collective ability to operate successfully in this void." Void in this case means to have a lack of tacit knowledge. Additionally, "… knowledge management is not simply about providing as much information to as many people as possible and as quickly as possible. It is about information context and optimisation of information to maximise knowledge where and when it is required." This is further stated by (Ribino 2009) as such, "The issue of how to better capitalize and disseminate tacit knowledge is one of the actual priorities in Knowledge Management."

One author (Frey 2001) states, "For practical purposes, knowledge management (KM) is a holistic cluster of sustainable, proactive, conscious, and comprehensive organizational and business activities that encompasses enterprise-wide processes, techniques, and professional practices and interactions." The activities as summarized by the author can be viewed as: identifying, collecting, indexing, and codifying.

Another author (Alavi 2001) offers the following about the various activities of KM, "At a minimum, one considers the four basic processes of creating, storing/retrieving, transferring, and applying knowledge."

Similarly, (Tat 2007) provides the following summary from that research on the topic of KM, "… the processes of acquisition, processing, transfer and application of knowledge are recognized by them all."

Knowledge Management can do the following (Harvey 2005):

- "Facilitate rapid identification of alternative decision makers, or subject matter experts (potentially in parent organisations or subsidiaries)."
- "Improve the quality, quantity, and accessibility of the information available to authorities and decision makers (and hence potentially increase their knowledge)."
- "Provide improved contextual information (e.g. the latest competency assessment and experience of the original designer can be made available to the approver of the design)."
- "Increase the likelihood that all relevant information has been considered."
- "Reduce preparation and review time, and in doing so 'free up' key people to be applied to approvals and certification."
- "Ensure that the key people are able to spend more time sharing knowledge and wisdom."
- "Facilitate retention of knowledge/skills of key employees."

No actions in KM are ultimately worthwhile if the organization as a whole does not benefit. This is indicated by (Frey 2001), "To sustain that business on an economic landscape with increasingly global dimensions, both formal (explicit) and informal (tacit) knowledge are becoming critical commodities as are the strategies, policies, and tools to leverage those knowledge assets at business, management, and operational levels."

While there is a common overriding theme of similar steps regarding knowledge storage and retrieval of documents among the varying views on Knowledge Management, not all tools from KM have to do with creating and utilizing a search engine type tool. There are other ways to get people in touch with one another's undocumented knowledge. As indicated by (Harvey 2005) it's often a matter of putting the seekers of knowledge in touch, directly or otherwise, with the subject matter experts.

Even the relatively low-tech way of putting people directly in touch with the right person will have some expense associated with the tools to make it happen. Without an organization providing the necessary culture and backing of resources, the KM effort is unlikely to succeed to its fullest potential. Many organizations require some level of initial justification for any expense in addition to later proof that the investment provided monetary returns. It is possible that the approach of thinking of knowledge as an asset may be enough for many organizations to support successful KM initiatives without the need for tracking complicated metrics that support the continuance of continual backing of company resources. Aligning KM initiatives with organizational goals can also help to provide additional justification for the full organizational backing of resources for ongoing KM initiatives. Often the initiatives that KM supports will already have existing indices that are easier to track than the ones in the largely subjective realm of personal productivity where in a non-repetitive work environment progress is not measured by how many items are created in a certain amount of time. Certainly as an engineer in an aerospace company, the thought making process can vary greatly within the same department and even for the same person from time to time depending on the circumstances.

KM in the Aerospace Industry

Aerospace, as an industry, has several challenges that make KM particularly beneficial for the organizations that develop knowledge management tools and related processes. Many of the challenges may not be unique to aerospace. Other industries may share one or more of the same set of road blocks for successfully retaining and utilizing useful information; they too could benefit from KM.

A handful of aerospace organizations have attempted to utilize KM, and document their findings. One author who did, identified some key challenges that are typical to their company, but it should be stated that they apply to the company as well. The challenges according to (Harvey 2005) are:

- "The dispersion of organizations, companies, operations, and suppliers"
- "The need for reorganisation and change to meet changing customer needs and business environments."
- "Demographic issues, particularly the ageing of the engineering and scientific population."
- "Complexity and interdependencies of systems requiring access to an incredible range of information and knowledge."
- "Safety and airworthiness assurance across a variety of regulatory environments."

Additionally, the aerospace industry is further characterized by the following challenges (Harvey 2005):

- "Technically diverse and complex systems that are dependent on a huge amount of data, information, and knowledge, and an increasing need for this to be shared."
- "Rigid compliance standards governed by design, maintenance, and operating regulations that not only ensure safety requirements are met but are essential for interface, functional, and operational compatibility."
- "Strong downwards pressure on prices and margins such that airlines fail or prosper on small changes in aircraft 'up time' or availability."
- "Design solutions and decisions that are critical to airworthiness and personnel safety."

One aspect of the aerospace industry that cannot be understated is the amount of effort required to show compliance with the safety inspired requirements established by regulatory authorities. As stated by (Harvey 2005), "The aerospace industry is regulated by a variety of agencies across a number of national and/or regional boundaries." Harvey further states that, "The intention is that safety be 'built into' the product through the application of accurate data, appropriate tools, and proven processes by trained and authorized people." This too is seen at the company where safety is proven by extensive testing and analysis. Both of which require a significant amount of documentation in order to validate the airworthiness of the equipment with the customers and regulatory bodies. According to the wisdom of a collection of proverbs and laws compiled by (Kerzner 2005), Douglas's Law of Practical Aeronautics states, "When the weight of the paperwork equals the weight of the plane, the plane will fly." This statement may sound like an exaggeration regarding the amount of report writing involved to validate aircraft safety and ultimately support Type Certification with the regulatory authorities, but it can be surmised that the amount of paperwork far exceeds the weight of some aircraft.

The use of KM can provide the tools needed for an aerospace organization to respond to the requirements of the regulation associated with safety. According to (Harvey 2005), "Although the process rigor that regulation brings to the industry appears to conflict with the flexibility required of, and sought within, the knowledge management-focused organization, it is potentially through improved knowledge management that regulations can be more flexibly applied."

According to (Jafari 2010), "Like other corporations, majority of aerospace firms are trying to outsource more and focus on their own core competencies." This undoubtedly is at least partially an attempt to share the expense of testing and documentation in support of the regulations. This feeds the massive requirement matrices that ultimately show compliance for the aircraft as a whole. The customer-supplier relationships that have always existed are being stretched further where the customer passes down to the supplier the responsibility of compliance for the equipment they provide. The sharing of knowledge with customers and suppliers can lead to pseudo partnerships, and KM can help in any way necessary as designed by the individual organizations in response to the regulatory oversight requirements.

Some additional perceived benefits of KM according to (Zawawi 2011) are:

- "Reduction of aircraft maintenance downtimes through knowledge sharing. Engineers will have broader knowledge base to perform their tasks and as a result the time needed to accomplish the task will be reduced."

- "Reduction or elimination of silo behavior in handling expert knowledge. Consequently, this will mitigate the impact of experts retiring."
- "Reduction of the learning curve of a new graduate or recruit to fully function as an aircraft engineer."

In the paper by (Zawawi 2011) the need for experienced engineers to make decisions is highlighted as such, "… freshly graduated or recruited engineers may require a lot of experience before they can fully function as an aircraft engineer." This may be true for any engineer in a manufacturing setting, but the differences that set aerospace aside as stated previously add to the amount of on the job training that must also be performed while learning how to become a working engineer.

One aerospace company (Jafari 2010) feels that KM can help them learn from their mistakes, but additionally, "… they believe that it can help them to learn from their achievements..." This approach lends itself to the idea of supporting the efforts of 'lessons learned' and 'best practices' that many companies claim to support, but often have no idea of how to implement. Lessons Learned as well as the sharing of best practices are essentially institutionalized ways for an organization to share what it sees as useful with those that have it available when they happen to need it.

The availability of knowledge and the sharing of it with the necessary training to later find it are critical to the success of a program when the introduction of aircraft can take several years before being able to obtain type certification and entry into service. Aircraft OEMs and their suppliers must coordinate the integration of several systems installed within the tightly constrained space of an aircraft: each with tightly controlled and fully documented compliance to regulations. A change to one piece of equipment may result in a change to another, and that evolutionary process lends to program durations that can last several years. According to (Harvey 2005), "The contracting and development of large aerospace projects typically takes place over many years, such that the implementation of a company's Intellectual Property may take considerable time to materialise." It is the experience of some particularly troublesome projects at the company for projects to require nearly a decade for completion. Perhaps the use of KM would allow for better control over the required specifications to ensure all requirements are fully understood up front, and ultimately met with only controlled change in scope.

Despite the length of many programs, as can be expected, the allotted amount of time is not of abundance for the projects in the critical path of tight schedules. Aerospace OEMs demand quality and performance of their suppliers, and often they do so with very aggressive schedules with the intention of beating the competition to market and perhaps even delivering aircraft that has already been ordered. Being unable to provide completed equipment that is lacking in quality or performance could result in an unsafe aircraft, and is therefore not considered. Being unable to meet all three legs of that triple constraint of quality, performance, and time, the schedule will often slide to allow the other two to be handled as needed. Aerospace airframe makers understand this as well as do their suppliers, but they certainly do not let on by providing unrelenting pressure to meet the original schedules despite the fact that the aircraft on the whole is evolving, as are the requirements. This is manageable with adaptive planning and extra work, but this results in less time for properly handling of undocumented knowledge for future sharing once a potentially outdated task is completed. As stated by (Harvey 2005), "As in any a project based, schedule-driven industry it is often difficult to find the time and inclination to create and share knowledge. This is because it is inherently difficult to place a value on this activity when a current project is behind schedule or there is an aircraft full of passengers awaiting an engineering decision to enable it to take off."

Unlike civil aircraft programs, military programs provide an additional level of compliance that makes knowledge storage and retrieval more difficult, or else risk a violation of the applicable International trade laws (ITAR). To violate these laws could result in jail time of the offender, and restricted operation for the company. Regarding this (Harvey 2005) states, "… the protection of information and technology over extended periods is usually given greater importance than sharing of knowledge." This causes a situation where specific knowledge cannot be shared, and must be stored in isolated areas. Knowledge management can provide the flexibility to assist in the compliance of the law, while still making the knowledge obtained by the organization as useable as it is allowed to be.

In summary, aerospace companies have much to gain from the use of Knowledge Management. According to (Harvey 2005) the aerospace industry can benefit from KM. He states, "Knowledge harvesting, the understanding, collation, dispersion, and exploitation of what the company already knows offers huge potential gains, particularly to large aerospace companies. The technical knowledge possessed by the tens of thousands of employees of these companies is incredible, and the ability to identify and access this knowledge globally and in real-time would represent a huge competitive advantage." The statement that indicates that large aerospace companies can benefit from KM potentially sells KM short, whereas all companies can benefit from better management of their in-house knowledge. The scope of KM is limited by only what the individual companies establish for themselves.

KM Requirements for Success

Knowledge Management is as much about managing the people as it is about the knowledge they retain. Therefore there is no one size fits all solution to what Knowledge Management has to offer, as people's needs will vary from one organization to another. A careful but flexible plan for the identification and implementation of KM should be established with the needs of the organization that is looking to begin a knowledge management system. With the proper backing of organizational resources, specific tools and processes can be developed by a team of well informed end-users along with technical guidance of IT.

Just as every individual has different needs and expectations regarding the knowledge they seek as well as retain, it can also be stated that every engineering company has similar organizational differences that will affect the implementation of a successful Knowledge Management program. According to (Holm 2006) there are four things that are critical to the success of creating a KM program. They are culture, knowledge architecture, IT infrastructure, and supporting services.

As (Holm 2006) further states that, "The cornerstones of any KMS are people, processes, and technology – all three aspects are needed to capture and harness the knowledge within an aerospace organization." In developing what he calls the "KM architecture" these views should be focused on to collect and integrate sources of information. It is intended that this will lead to good decisions based on the stored information and will facilitate the creation of knowledge.

Considering the company has much to gain by the use of Knowledge Management in terms of improved profitability, it is in the best interest of executive management to provide the culture and resources to help KM succeed. Being active proponents of KM is a key to knowledge management, and the support must be institutionalized in the organizational procedures to actively encourage the sharing of information. Without allowing engineers the time to perform the activities that leads to sharing of their knowledge (documenting, organizing, and storing the information) it is unlikely that others will benefit, and they may not even be able to retain it for their own personal use. As a result of this environment those seeking knowledge will be unable to perform their duties with the benefit of organizational knowledge. Even with the proper tools to make storing information relatively easy, engineers may have the mentality to hoard information and knowledge to build up their own personal worth. The IT solutions developed by KM practices can build bridges between people in an intelligent way that makes it easier for engineers to find the time to share, but unless some engineers are encouraged and perhaps even praised for sharing knowledge it's possible that the success of KM will be limited. Some authors have even recommended the promise of some kind of reward. It is believed that engineering management at 'the company' is actively seeking off the shelf knowledge management tools, so it can be assumed that the culture and support of engineering management exists to some level. What hasn't been proven yet is their willingness to incorporate the requests of the knowledge holders and knowledge seekers to maximize the usefulness of the off the shelf tools or the flexibility within such tools to meet the specific needs of the end users.

Researchers on the topic of Knowledge Management state the importance of the human aspect. According to (Tat 2007), "Of special importance is the fact that knowledge sharing between individuals must be cultivated as part of the organizational culture." Additionally, (Lipusz 2006) states, "Knowledge can only be preserved if the most important part of the system, the thinking human being is available as well." (Lipusz 2006) further states the importance of people, "A knowledge management project cannot be successfully executed without support of the owners of the knowledge, i.e. the experienced researchers. … Knowledge is a personal thing created in mind of an individual during thinking and experiencing in research and practice."

Convincing all individuals to share is not handled simply by effective IT tools. Sometimes it requires training of the people with knowledge as stated by (Harvey 2005), "Although there is often an organisational expectation that these people will share their knowledge through goodwill, this could be considered akin to the willingness of an executive to share his personal assistant or his budget. Furthermore, these key technical employees are often not 'people persons' and may also require training in communication and mentoring in order to maximise their effectiveness."

Training is also needed to ensure that all users are familiar with the newly established standard processes as needed to in the development of KM. Standardizing work whenever possible can reduce the complexity of the Knowledge Management tools, and make for more effective use of them. The need for routine is discussed by (Alavi 2001), "People may be unaware of what they have learned; moreover, even if they realize what they have learned from a project, they may be unaware of what aspects of their learning would be relevant for others. Without a systematic way routine for capturing knowledge, a firm might not benefit from its best knowledge being captured." According to (Zawawi 2011) process management will help to "…ensure better process management to overcome the KM challenges embedded in the organization's systems. … It includes systems to support explicit and tacit knowledge sharing."

Additionally, from the process point of view consider the following (Holm 2006):

- Capture – "In capturing knowledge, the goal is to look at what an organization can do to help people articulate knowledge that can be easily shared and reused, and supporting people in moving tacit knowledge to a more explicit state."
- Organize – "In organizing knowledge, the KM program should expect to organize information so that people can easily share it, find it, and use it once it is found, as well as structuring information in standardized ways for use by others."
- Develop – "In the process of developing knowledge, it is critical to refine knowledge so that it can be easily reused by others (such as others on a team, future teams, or in a discipline), and to select which knowledge will be most useful based on the question asked or the need defined."
- Distribute – "…the goal is to help people get access to knowledge, encourage people to use and reuse knowledge, and train people in how to use the KM tools."

Processes are also needed to maintain the integrity of the knowledge retained as stated by (Harvey 2005), "Ultimately, the quality of the decision is a function of wisdom rather than knowledge (i.e., the application of knowledge to a particular context). Thus there is a need to ensure the validity of the knowledge being applied."

With a good foundation of well comprised processes and effective training there are many forms that KM can take. Who should decide what is appropriate for the organization? According to (Holm 2006), "The "build it and they will come" mentality does not work in the deployment of content-rich, enterprise-wide systems and KM programs should be careful to be working toward specific requirements, rather than trying to deploy the latest "cool" technologies. This can easily be avoided by having users take an active role in order to keep content and context refreshed, accurate, and relevant."

Because "Saving knowledge is of key importance" (Lipusz 2006) and documenting information for later use is not always a priority, the tools used to save knowledge should be in a suitable form. Lipusz further states, "This form should be really suitable because it is not enough if they simply write down their ideas on a piece of paper. Methods and applications should be developed enabling researchers to conveniently and possibly automatically save their knowledge in a form that can be easily integrated in a knowledge management system." Additionally, "Further tools might be needed to integrate the already existing old or eventually obsolete set of information that needs most likely human interaction." This indicates that some effort should be placed on making new tools as simple as possible for the users and by the users, while seeing what can be done to improve the existing tools and information that still may be of use to build the knowledge of the organization.

Involving the users of knowledge is critical to the success of developing Knowledge Management systems because only they know how to relate to the very specific group of others with the same skill set. According (Alavi 2001), "…information is converted to knowledge once it is processed in the mind of individuals and knowledge becomes information once it is articulated and presented in the form of text, graphics, words, or other symbolic forms. A significant implication of this view of knowledge is that for individuals to arrive at the same understanding of data or information, they must share a certain knowledge base." The users need not be IT experts to contribute, but they must be able to communicate effectively in teams.

Successful sharing of information will vary from organization to organization, but in general there are some qualities that a successful KM program will exhibit. According to (Lipusz 2006), "Information should be continuously available at any time. The searching method should be simple, similarly to that of the internet search engines, and the system should provide no irrelevant hits. If there is no hit the system should recommend some experts who might help in finding the right answers. It is important that the system should provide answers within a reasonable time."

(Holm 2006) suggests some additional qualities and generic tools that might be used as a part of Knowledge Management:

1. Capturing tacit expertise – "Improving the quality, methods, and rate of capturing knowledge…"
2. Collaborative environments – "Improve collaboration and knowledge sharing with partners…"
3. Experts' directories – "Help people locate internal or outside experts…"
4. Interoperable libraries – "Cover authoring through archiving…"
5. Create an organizational "memory" of accessible documentation – "Create enterprise-wide archive for easy access to institutional information…"

6. Concurrent engineering – “Improve processes by providing standard design structures, policies and processes, and interfaces to help knowledge reuse.”
7. Web governance – “Policies for dissemination of information; procedures for publication and easy distribution; and creation of tools to support these, such as portals (customizable web gateways to an organization’s knowledge resources), content management, and search engines.”

In general (Holm 2006) describes what potential KM technology has to offer as such, “These include an environment for virtual teams to share, taxonomies for browsing, a robust search capability, standards for documentation, and metadata management.” This diversity of potential tools requires the consideration of the various stake holders to assess and determine what to attempt and how best to implement the KM tools as a team.

According to (Holm 2006) KM, or as applicable to that specific system “knowledgebase”, implementation can be summed up in 16 best practices that fall under the realm of four factor types (Human, Process, Technology, and Management). Many of these apply well to the implementation of KM at the company, and should be considered.

1. Human - Provide training about general knowledge management strategies and practices.
2. Human - Develop knowledge friendly organizational culture.
3. Human - Foster team spirit through team building activities: to enhance open collaboration.
4. Human - Make sure KM strategy is consistent with organizational beliefs.

5. Process - Establish accountability and measurement systems.
6. Process - Develop well defined procedures.
7. Process - Processes must be repeatable and consistent.
8. Process - Continuous quality improvement.
9. Technology - Select the right KM system.
10. Technology - Enforce standards on KM inputs.
11. Technology - Support integrated and remote sharing: global as well as local across various platforms.
12. Technology - Look for management reporting abilities of knowledge usage.
13. Management - Provide motivational aids and coaching.
14. Management - Develop clear corporate strategies on KM.
15. Management - Have a knowledge friendly organizational design.
16. Management – Have the commitment and participation of management.

The KM planning and implementation team at the company will have several factors to consider when determining what is desired and identifying what must be done to minimize roadblocks to success. The chapters that follow will assess potential actions associated with these activities as well as what structure they may follow to ensure a systematic approach is followed.

KM Implementation Phases/Stages

Knowledge management requires careful planning to ensure the users get an optimum tool and the investment of the organization is optimized. Ineffective use of resources made available to the KM team by the organization can hamper the positive results that KM has to offer, and potentially lead to the early end of a KM program. A successful Knowledge Management project, like many other company initiatives, can only be successful if the unique set of barriers that exist within the individual organization is addressed by careful planning and execution. Obtaining useful tools for the users that is developed by the users should not be mistaken for a fad initiative that the company will soon forget following roll out.

Many researchers on the topic of KM implementation have differing views as to what the most important areas are that require the majority of attention: whether it be the personal/professional side or the IT side. This undoubtedly has much to do with the fact that the people and organizations who have attempted to initiate KM have very different backgrounds, needs, and resources available for their respective KM programs.

According to (Zawawi 2011) the planning and strategy development of KM starts with the ability of KM leadership to "… drive the whole KM system toward business goals. … This is achieved by aligning the KM strategies with the business strategies." Aligning KM with business goals provides a good place to start.

Put another way, (Holm 2006) discusses the need for what he refers to as a 'knowledge architecture', that is described as "… a plan that an organization puts in place that relates the organizational goals to the KM activities, thereby ensuring that the KM program supports the basic business drivers." Furthermore, according to (Holm 2006), the guiding principles to creating a ‘knowledge architecture’, “…should be set forth to ensure that there are some consistencies in the knowledge management program that prevail over multiple leaders and priorities.”

This architecture described by (Holm 2006) addresses KM factors related to:

- People – “Focused on who the primary focus is on (employee, the public, partners) and who will help people share their knowledge and maintain tools and processes (the who).”
- Process – “Oriented on the way in which people do their day-to-day work in the organization (the how and why).”
- Technologies – “Ensures availability of the IT infrastructure and tools necessary to deliver the processes and services efficiently and effectively to the end users (the what and where).”

Regarding the development of a Knowledge Architecture (Holm 2006) indicates that only after all other aspects of the Knowledge Architecture are established should the system architecture be defined. According to (Holm 2006), “This is a layered approach that builds on already existing infrastructure and services. … KM technology activities should ensure that there is a high-level user interface via an enterprise portal or web sites that organize information via role, interests, and technical disciplines. In order to manage the knowledge of a large aerospace organization efficiently, it is critical to validate that certain technology stepping stones are already in place or to build them if they do not exist.”

Another paper on the topic of KM refers to the need to establish an SKMM Strategic Knowledge Management Model as a procedural way to plan for the implementation of KM. According to (Jafari 2010), the first step is 'Preparation Evaluation', which, as he states "… includes recognizing requirements, identifying resources and verifying commitment of management." In this initial step (Jafari 2010) also refers to other issues which must be taken into account, and this includes assessing the "…existing resources in connection with available information technology infrastructure, proficiency and time of personnel, and cost of professional aid if necessary." This hints that the implementation of a KM program may require skills that the organization may be lacking that are specific to KM, and the potential for outsourcing that expertise to assist the organizational team is a valid option. Obtaining the needed help early in the planning phase can help with the ease of the subsequent KM implementation. Unlike Holm, Jafari doesn't put as much emphasis on the input of the end user to ensure appropriately aligned tools are created.

The second step that (Jafari 2010) refers to with SKMM is 'Programming' which "Consists of assigning a leader and participators for SKMM workgroup; performing an evaluation about mission, vision and strategy; allocating objectives/CSF to SKMM perspectives, creating KM strategy map, recognizing indices and taking collective agreement about KM indices; and building execution program. While the SKMM workgroup is identified, an examination about the vision, mission, objectives, and strategies (include process or functional strategies) must be done." This step follows many typical steps that can be found across many disciplines that are used to start a project with a well informed team that is working toward common team goals. Not all organizations establish and perform work in teams as stated by Jafari in this step, but that way provides a highly structured format that assists in the communication and assignment of duties within the team.

The third step (Jafari 2010) refers to of SKMM is ‘Execution’ where it is stated that, “An obviously well-made program must determine organization’s information technology infrastructure, and also its abilities and restrictions.” Unlike Holm, Jafari begins talking about technology fairly early in the planning process: before the processes for the creation and storage of information are established. If technology resources will not be provided as a result of KM, then perhaps it is more important to determine what is available instead of what could be obtained under ideal but unreal circumstances. With that the processes then must be created to fit the technology capabilities available.

The fourth step (Jafari 2010) refers to of SKMM is ‘Incorporation’, where it is stated that, “It seems that communicating is the most important feature of the incorporation stage. In this stage, all participants in SKMM workgroup and the whole managers and personnel should be aware of the SKMM process. All responsibilities for collecting, entering and evaluating the data, and producing the reports should be communicated through this stage.” In this step Jafari places the emphasis on the training of the affected personnel of the new processes, instead of the way Holm recommends where the process are based on the how and the why people do their work.

The final step (Jafari 2010) refers to of SKMM is ‘Routine Function’ where it is stated that, “This stage is a continuous process and consists of regular data inputting, information evaluation, and reporting by way of standard procedures. Also, some other regular functions such as overall outcome evaluation and modification of the whole process take place during this stage.” This step allows for the ability to keep KM relevant after it's implemented by keeping the information accurate and to allow for improvement when needed to ensure ongoing success. This step may not be unique to KM, but like other improvement projects that organizations roll out, the continued success of the program is dependent on the amount of effort that is continuously put into it.

According to (Tat 2007) a starting point for the implementation of KM is as such, "There appear to be three key issues that need to be addressed by any organization wishing to improve its KM practice. The first of these is Awareness Cultivation. This concerns the level of understanding of the fundamentals of KM, its theories and importance. The second is Objectives Definition. This refers to recognizing and realizing the strategic importance of KM as a tool within the organization. The third is Actions Implementation, which concerns the formulation of a plan which will enable KM assets to be used to support organizational objectives." These first steps lay importance on the need to have an understanding of KM while considering the needs of the users as well as the goals of the organization.

A fourth stage was later added as a part of the lessons learned from the planning that falls between Objectives Definition and Actions Implementations stages (Tat 2007). "The Strategy Adoption Stage describes relevant strategic actions that can be adopted by organizations practicing KM. … These knowledge-intensive activities embrace innovative elements that enable practitioners to focus on translating the conceptual ideas of KM into a practical and working implementation programme." Unlike the other researchers who were more process and technologically focused, the original three steps of planning were lacking the detail of how to turning their ideas into useful tools.

Despite the fact that the steps by Tat don't provide as much detail regarding new processes or how to asses technological need as the other researchers previously discussed, there are aspects regarding the human and organizational side that the others don't consider.

A combination of the previously mentioned researchers planning methodologies can provide a good foundation for the planning of the KM implementation at 'the company'. One very important part of the planning methodology to be established for 'the company' will be to discuss the merits of various ideas for tools that may be of use. The next section discusses ideas of what should be expected of several technological solutions with examples for better understanding. All of the types have been used successfully in other KM programs, as compiled from the aforementioned authors. However, not all KM solutions apply to the needs of each organization, and it's up to the implementation team to determine which of the many options provide the potential for the best fit of the organization and their users based on need and available resources. Many of the options the KM implementation and planning team at the company will have available to consider are in the following chapter. Associated with these options that also must be considered are the procedural framework and system architecture available to support the KM tools to be developed.

KM Tools

The many kinds of tools that have been associated with KM range from technologically advanced to very simple with software that is readily available to many organizations with the need to purchase more. As such the involvement of IT does not necessarily have to take a major role in the development of new tools. Many will require the help of IT from early on. Regardless of the level of difficulty and expense in creating a new KM tool there is a common characteristic of which they should exhibit: to promote the sharing of knowledge.

On the relatively simple side of implementing KM, a single prepackaged user interface can minimize the upfront effort in creating a KM tool that is unique to the particular organization. One such tool SharePoint by Microsoft does have some limited customization available with little up-front work. According to (Mudd 2009) there is good and bad in the use of a standardized tool, "On the positive side of things is that Mechanical Engineering will be consistent with the rest of the company." "It reduces the amount of background work that must be done in the selection of a system, and it also means that the team will have the support of Information Technology for technical issues. What is a positive is also a negative, in the fact that the department will not have any input on the system they will be using." Like Mudd's organization, it has been found that 'the company' is also in the process of determining an implementation plan for MS SharePoint through IT. However, it's not clear how much involvement, if any, has been requested of the end-users to provide input. As stated previously, a custom KM family of tools created by the users and IT may take a fair amount of work, but the benefits are greater as well.

Regarding the customized solution to KM, as presented by (Frey 2001) there are two general knowledge management models. They follow the 'Codification' and 'Personalization' strategies. "Codification strategy refers to the approach by which knowledge is carefully extracted from people, codified into documents, and stored as knowledge objects or products in databases, from which it can be accessed and used easily by many staff within a given organization. People gain insight from documents. Personalization strategy, on the other hand, focuses on knowledge sharing via person-to-person contact. People gain insight from other people." 'Codification' requires a high degree of IT involvement, and 'Personalization' requires much less. Creative use of KM can help both aspects, but the tools may look significantly different between the two. Codification often is additionally referred to as being ontology or taxonomy based by other researchers.

The personalization aspect is further described by (Alavi 2001) as such "… to improve knowledge management, utilizing information technology implies attention not only to improving the individual and group level processes of knowledge creation and storage, but also to improving the linkages among individuals and between groups."

Additionally, (Alavi 2001) provides three generic applications of IT for knowledge management initiatives:

1. "…the coding and sharing of best practices…"
2. "…the creation of corporate knowledge directories…"
3. "…the creation of knowledge networks."

The previous three items are represented in the following Table 1 by (Alavi 2001) where the KM goal, or process, has associated ideas for IT involvement, "Table 3. Knowledge Management Processes and the Potential Role of IT"

Table 2, KM Processes and the Role of IT

Knowledge Management Processes	Knowledge Creation	Knowledge Storage/Retrieval	Knowledge Transfer	Knowledge Application
Supporting Information Technologies	Data mining Learning tools	Electronic bulletin boards Knowledge repositories Databases	Electronic bulletin boards Discussion forums Knowledge directories	Expert systems Workflow systems
IT Enables	Combining new sources of knowledge Just in time learning	Support of individual and organizational memory Inter-group knowledge access	More extensive internal network More communication channels available Faster access to knowledge sources	Knowledge can be applied in many locations More rapid application of new knowledge through workflow automation
Platform Technologies	Groupware and communication technologies			
	INTRANETS			

According to (McMahon 2004) "The two conventional ways of searching for information in electronic document collections are (i) using fully automated free-text retrieval search engines or (ii) by browsing information that has been manually organized into predefined (hierarchical) structures." Search engines alone can provide too little or too much information with little relevance, and browsing requires an existing understanding of what is being looked for. According to (McMahon 2004) a combination of "free-text-directed searching and browsing" can be used with "pre-organized information collections" for searching, "while removing some of the manual effort required to classify documents."The more manual effort needed to initially classify the documents, the potentially less complex the IT solution. People's resistance to the manual work required for the simpler IT solutions often makes the more complex IT solution more favorable for some instances.

According to (Ribino 2009) a knowledge management system can use different technologies:

1. "Document based: technologies for the creation, administration and sharing of different documents (such as doc, pdf, html and so on), managing the explicit knowledge of an organization."
2. "Ontology/Taxonomy based: technologies using representation and classification for knowledge representation. Knowledge concepts are frequently arranged in hierarchical structures, typically related by relationships. Such methodologies act on both explicit and tacit knowledge."
3. "AI based: using particular inference engines to resolve peculiar domain problems, the framework based on these technologies generally manipulates tacit knowledge (e.g. Knowledge-base system)."

For intelligent searching of knowledge the ontology based method comprises a large part of the attention given to KM initiative. Specifically, this has to do with storing pieces of information that allow for the search tool to optimize the results it provides. According to (Ribino 2009), "In computer science the use of the term "ontology" is derived from the previous use in philosophy, meaning the study of the "being", the fundamental categories of which it is composed and the relationships among them. An ontology tries to formulate an exhaustive and rigorous conceptual scheme of a particular application domain. Generally it is represented through a hierarchical structure which contains all the noteworthy entities, the existing relationships between them, the rules, the axioms and the specific domain constraints. Ontologies give an understandable meaning both to humans and to software agents. Given a domain of interest, the ontology explains the knowledge structure creating a syntax of domain terms, and shares it with all the people interacting with the given domain." This is in contrast to the document based approach that Ribino suggests in the sense where there is a structure that is established for explicit documentation. Ribino also mentions the AI or Artificial Intelligence approach where the tacit knowledge is the goal for sharing, which indicates the potential for KM tools that aren't particularly interested in documenting, or rather making the tacit into explicit knowledge.

The document based approach as introduced by Ribino and the classification schemes by McMahon can be further explained by (Sullivan 2008) where laws of stored information are referred to, so that information can be retrieved without the need for complex tools. "The laws are (1) the items must be stored in one place only, (2) the items must be uniquely named, (3) the items must be in a defined order, and (4) the defined order must match the users' search criteria. The dictionary is an excellent example of these laws. This example also provides a way for large groups of people to visualize the laws clearly at the same time." When the information being stored allows it this approach can be very useful by itself, but when coupled with specialized search tools the combination can be a more robust solution than either alone. This document based approach tends to be more of an information management solution where the goal to provide the right information to the right people at the right time may not be obtained by such a rigid methodology alone. When taking into consideration the complexity of aerospace projects information management has its place, but Knowledge Management provides some additional aspects to make it possible.

RESEARCH PROCEDURE

Based on the author's study of Knowledge Management and the personal experience with the company, a structure will be compiled for the implementation of KM at the company that highlights the proposed phases as well as the critical success factors that may occur during the KM process at the company.

Furthermore, a questionnaire shall be circulated to provide information from the intended users regarding their preferences for information and knowledge retrieval. This information is intended to provide an understanding of the level of interest at the company while providing specific insight that will help with the initial planning of KM.

The questionnaire seeks to obtain information from functional managers and senior engineers in the following ways:

- To find what people know about the benefits of sharing explicit and tacit information.
- To find out what people like about the current system.
- To find out what people would like to see in a knowledge management program.
- To find barriers (personal or otherwise) to the start of a Knowledge Management program.
- To find out if they would be interested in participating in a collaborative effort to implement a customized KM program at the company, if the company were to do so.

RESULTS

Assessment of questionnaire

The following provides the compilation and analysis of the completed questionnaires from high level engineers and their functional managers at the company. This information provides insight as to what an initial offering of a knowledge management system should consider to best meet the needs of the intended end users.

Of the eleven completed questionnaires, 14.9 was the average number of years of experience of the participants. The group has over 178 years of combined service in the aerospace industry. These people are among the most knowledgeable in the company's engineering group as a whole. The response to a knowledge management system was positive by all, but of course each person had different views and expectations of KM at the company. A summary with some analysis is provided in the following paragraphs.

When asked about the importance of different kinds of knowledge, the responses indicated that explicit knowledge (documented) was valued slightly more than tacit knowledge (undocumented) with scores of 4.5 and 3.8 respectively on a scale of 1 to 5 with 5 being the highest. Documented knowledge for engineers at the company provides the ability to provide many things: one of the most common kinds of explicit knowledge in the Product Engineering group is used as compliance to requirements of the customers as well as the FAA for projects.

When asked how important it was to share their knowledge with others the group, they indicated that it was important to them with an average score of 4.2. This could be out of necessity so that they themselves are able to find information, but it is also possible they recognize the benefit to the company.

When asked if they've had to consult other associates within the last month to help locate information, each of the eleven indicated that they had needed help. A KM tool will not remove the need to consult others, but it can help get the person to the right location quicker. Despite the need for help, the employees who responded to the questionnaire are as efficient as anybody in the company at finding information. If new KM tools can help the experienced, it can be assumed that less experienced associates would benefit relatively more.

When asked if they saw the benefit of retaining documented information beyond that which was required for project deliverables, all but one indicated that they did. There was no comment left to explain the diverging response. This question was intended to determine the scope for the initial implementation of KM with regards to the ancillary information used throughout the product development process and on into the rest of the product lifecycle.

When asked if they would be willing to document more day-to-day information if it was more automated they all said yes. This question also came with the condition that it would take additional standardization and procedures. More kinds of knowledge to retain and effectively retrieve potentially require changing the way that day to day business is performed.

They were asked how effective the existing retrieval tools and methods were. All rated about the same with scores ranging from 3.3 to 3.7. The existing tools and methods listed were Microsoft Windows Explorer project file structure, Microsoft SharePoint, and the KMS search tool in the Project Tracking multi-purpose tool on the intranet. To help locate other tools that exist at the company, that weren't known for inclusion of the questionnaire, they were asked to provide other existing options. They replied with the following tools: Teamcenter PLM software by Siemens; JDE document search; OneNote by Microsoft; saving of email; usage of Access type databases; and having good configuration management. These are additional KM options that can be evaluated as a part of a KM implementation team.

When asked if they had recommendations for how the existing tools could be more effective there were many responses. For the MS Windows Explorer project file structure it was recommended that there should be a standardized organizational structure with a method to appropriately title and name the documents. One person felt there was not much that could be done, while another provided a MS Windows Explorer path to where one could be found. Another person simple felt it would be more useable if it was organized better to be searchable. When asked about the newly offered SharePoint most hadn't heard of it, or did know of it but didn't know what to do with it. In one instance it was noted that SharePoint was used within some committees within the FAA. Many of these responses reflect the same concern that led to this research for the use of KM at the company. These comments validate the need to improve the management of knowledge within the company.

When asked to rate potential KM tools, the following results were obtained to show the level of interest. Table 3 shows the tools in the order of most interested to least interested. These are very generic types of KM tools that may be rated differently under different conditions.

Table 3, Questionnaire Summary of interest Level of Potential KM Tools

KM Tool	Average Response	Lowest Response	Highest Response
Inter-group Databases (departmental storage of information)	3.9	2	5
Knowledge Repositories (organizational storage of knowledge)	3.7	2	5
Workflow Systems (knowledge built into standardized work processes)	3.7	2	5
Knowledge Directories (faster access to knowledge sources/experts)	3.6	3	4
Learning Tools (information ready to assist just in time learning)	3.3	1	4
Electronic Bulletin Boards (informal knowledge storage/retrieval/transfer)	3.2	2	5
Discussion Forums (Q & A of peers on intranet)	2.5	1	4
When asked about other potential tools it was recommended that there be something utilized to assist with lessons learned reviews.			

When asked if they would be interested in participating in the development of Knowledge Management tools, they all replied, yes.

When asked how they felt the company may benefit from the implementation of KM the following was shared:

- Greatly, as we have no system in place.
- Clearly beneficial
- Meet planned ROI objectives. Faster project execution at reduced risk.
- No repeat of the same mistakes and or reduce development time
- The company has grown over the last couple of years and there are many new and junior members in the technical staff with little basic understanding of our products.
- There is a lot of wasted effort in double work or solving the same issues over. KM would make some engineering tasks more efficient.
- Slow the loss of important data as people retire or leave for other positions.
- Better transfer of tribal knowledge, and reduction of redundant work that has already been done. Improve overall effectiveness.
- Eliminate the risk of knowledge being lost and help to access information faster.

When asked which department should first be considered for the implementation of KM the indication was primarily in support of Product Development Engineering with some secondary recommendations for Manufacturing Engineering, Purchasing, and Testing. The case for Product Development to be first was made as such in one of the questionnaire responses, "Product engineering, because a lot of the knowledge to be archived would be of basic product information that could be used by other groups, such as manufacturing engineering and technical publications." Another questionnaire indicated, "Product Development – this is the key to all products both legacy and new production. Providing information that supports legacy products will help Liaison engineering be more effective and reduce the interruptions to new program engineers that used to support legacy products. Product knowledge is the key to maintain consistency and to maintain product integrity as people transition to different departments or new people are hired." It should also be indicated at this point that the majority of the people who responded to the questionnaire have strong ties to the Product Development group. The Liaison group handles the support of products after Product Development.

When asked which department most is at risk for losing knowledge that serves the core competencies of the company most indicated Product Engineering. One comment in support of Product Engineering was, "…primarily because knowledge and experience tends to be maintained on a per-project basis and there is little, if any, knowledge exchanged between projects." Another comment indicated, "A lot of product knowledge and" company "history is contained within a few people and they are moving closer to retirement. Also there are a lot of new engineers hiring into product development and understanding the past will help them to develop the future and not repeat the same mistakes or will help them to improve on the successes." A couple of people indicated Liaison Engineering, and one comment said, "At present it would be the Liaison group who has a great number of new employees not knowledgeable of the processes & procedures w/limited long term employees to fill the gaps."

When given an opportunity to provide additional comments regarding KM within the company there were a couple of parting comments for the researcher to consider. The first one said, “Knowing what someone should document will be difficult. Every person perceives info differently, so what I think is important/relevant, may not be to someone else.”

This will be a dynamic process, its never going to be perfect & will always be evolving, and we need to start somewhere. So don't get discouraged during the initial stages of development & implementation. Another said, “I would like to see us put this kind of system into practice.” Another said, “We do have access to commercial knowledge services (Nerac) and survey could benefit by knowing its effectiveness.” Another said, “Project success can be driven by using suitably experienced personnel during design reviews. Identifying and eliminating errors is a means of knowledge transfer.”

The results of this questionnaire can be used as a basis for further consideration and research amongst the KM implementation team members.

Critical Success Factors (CSF):

The following is a compilation of the literature review as well as personal experience with the company that aims to provide structure as well as discussion points within the team to promote a successful implementation of KM.

1) Supportive Organizational Culture
   i. Active proponents of KM
   ii. Encourage and Reward Knowledge Sharing
   iii. Provide Training and Necessary Resources
2) Know Your Knowledge
   i. Align Team Goals with Organizational Goals
   ii. Good Processes and Process Management (repeatable and consistent)
   iii. Standardization of Repeatable Work
   iv. Continuously Improve
3) IT Infrastructure / Technology
   i. Work Within the Existing IT Framework
   ii. Use Technology to Make KM Simple (while providing only relevant information)
   iii. Allow for Collaboration Across Regional Boundaries
   iv. Select the right KM tools
4) Supporting Services
   i. Maintain the Integrity of the Knowledge
   ii. Provide for the Means to Add Knowledge (historical and new)

5) People

    i. Be Active Participants in the Development of KM

    ii. Help maintain, Use, and Govern KM (hold all accountable for keeping KMS relevant and trustworthy)

Proposed Stages

The following stages provide a general set of guidelines to consider throughout the development and implementation of a knowledge management system at the company. It is merely a starting point for the KM implementation team to consider, and the actual steps and relative stages could easily change based on the goals of the team.

- ❖ Preparation
  - ➢ Establish a team structure with a leader and participants
  - ➢ Evaluate the team mission, vision, and strategy
  - ➢ Verify the commitment of management
  - ➢ Define organizational goals and roles and responsibilities
  - ➢ Cultivate awareness of KM fundamentals, theories, and importance
  - ➢ Establish team objectives that support organizational goals
  - ➢ Consider contracting KM professional assistance
- ❖ Evaluation
  - ➢ Define which department will be the first target for KMS implementation
  - ➢ Identify the proficiency and time availability of potential end-users
  - ➢ Identify the availability of existing tools and IT infrastructure
  - ➢ Evaluate existing tools based on team objectives
  - ➢ Identify and evaluate potentially new tools
  - ➢ Select the tool(s) to pursue, and create ideas for them
- ❖ Detailed Planning
  - ➢ Translate ideas into practical tools
  - ➢ Consider what metrics might be utilized

- Identify what new IT infrastructure will be needed
- Identify what standards and processes will support KMS based on day to day work (existing and new)
- Identify who will be required to support the implementation of a KMS
- Get the necessary approvals to allow work beyond the authority of the team

- Execution of Plan
  - Coordinate any IT related acquisitions
  - Revise or create standards and processes in support of the KMS
  - Assign responsibilities for the support of KMS with regard to the collecting, entering, and evaluating of information to be used within the KMS
- Incorporation and Routine Function
  - Offer the new KMS tools to the intend group
  - Provide training for new standards and processes
  - Provide training for new KMS tools
  - Promote the use of the new KMS tools
  - Periodically evaluate the KMS system and improve as needed

RECOMMENDATIONS AND SUGGESTIONS FOR ADDITIONAL WORK

Some considerations for future work, as a natural progression of this paper are as follows:

- The implementation team will need to further assess and develop the critical success factors based on their own experiences.
- The implementation team will need to assess the actions and build more detail into the stages laid out in this paper.
- More research that involves newer associates in the product development team regarding their unique needs of a KMS.
- A system to refine the KM tools as well as related processes will need further research.
- A system to provide ongoing maintenance and updates to the KMS structure will need further research.
- Metrics can be developed if desired to monitor usage of the KM tools, as well as provide a look at other measurable factors to determine the overall usefulness of the KMS.

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APPENDIX A

(Alavi 2001) "Table 2. Knowledge Taxonomies and Examples"

Knowledge Types	**Definitions**	**Examples**
Tacit Cognitive Tacit: Technical Tacit:	Knowledge is rooted in actions, experience, and involvement in specific context Mental models Know-how applicable to specific work	Best means of dealing with specific customer Individual's belief on cause-effect relationships Surgery skills
Explicit	Articulated, generalized knowledge	Knowledge of major customers in a region
Individual	Created by and inherent in the individual	Insights gained from completed project
Social	Created by and inherent in collective actions of a group	Norms for inter-group communication
Declarative	Know-about	What drug is appropriate for an illness
Procedural	Know-how	How to administer a particular drug
Causal	Know-why	Understanding why the drug works
Conditional	Know-when	Understanding when to prescribe the drug
Relational	Know-with	Understanding how the drug interacts with other drugs
Pragmatic	Useful knowledge for an organization	Best practices, business frameworks, project experiences, engineering drawings, market reports

APPENDIX B

Knowledge Management Questionnaire

Introduction:
The availability of information within an aerospace organization is required for engineers to perform activities. As information is considered, it's the experience of the engineer that allows information to become knowledge for use.

Knowledge sharing is critical within aerospace organizations to continually meet goals. Knowledge for personal use can maintain the organizational knowledge levels until people begin to retire or leave the organization, but the organization can't maximize the use of its knowledge without sharing.

The idea of Knowledge Management, or KM, was created to promote the sharing of knowledge by using IT enabled tools. When KM provides the most benefit is when the organization allows the intended end users to be a part of the development process.

Based on the compilation of feedback from engineers at the aerospace company, as well as research in the field of study, this project aims to develop an implementation plan for KM at the company.

This questionnaire is a very practical look at how ready this company is to use KM and understand its benefit.

This research is being performed with the guidance of and will be provided to the University of Kansas, School of Engineering, Engineering Management Program. The results of this research may be provided to the company in one form or another.

1. How many years have you been working as an engineer with an aerospace organization? _____

2. On a scale of 1 to 5 (with 1 being low and 5 being high) for the following kinds of knowledge, in general how important is it to you to have access to the team's collective knowledge in the following formats?
   a) Explicit (stored public documentation) _____
   b) Tacit (internally personalized without documentation) _____

3. On a scale of 1 to 5 (with 1 being low and 5 being high) in general how important is it to you to share your personal knowledge with others? _____

4. Within the last month have you consulted with another associate to help locate information that you know exists, but you can't get to it for one reason or another?
   YES / NO

5. Do you see the benefit of retaining documented information beyond that which is required for project deliverables?
   YES / NO

6. Would you be willing to document more day to day information obtained for future use it was more automated? This will take standardization of many things with new procedures and training.
   YES / NO

7. On a scale of 1 to 5 (with 1 being low and 5 being high) rate how effective you feel the following retrieval methods or tools are at locating information.
   a) Microsoft Windows Explorer project file structure _____
   b) Microsoft SharePoint _____
   c) KMS Search tool in Project Tracking _____
   d) Other ______________________________ _____

8. Do you have recommendations for how the following already in use at the company could be more effective?
   a) Microsoft Windows Explorer project file structure
   ____
   ____
   b) Microsoft SharePoint
   ____
   ____
   c) KMS Search tool in Project Tracking
   ____
   ____
   d) Other ______________________________
   ____
   ____

9. Of the following potential KM tools, rate on a scale of 1 to 5 (with 1 being low and 5 being high) how useful you feel each tool would be in building knowledge:
    a) Data Mining / Search Engine ______
    b) Learning Tools (information ready to assist just in time learning) ______
    c) Electronic Bulletin Boards (informal knowledge storage/retrieval/transfer) ______
    d) Knowledge Repositories (organizational storage of knowledge) ______
    e) Inter-group Databases (departmental storage of information) ______
    f) Discussion Forums (Q & A of peers on intranet) ______
    g) Knowledge Directories (faster access to knowledge sources/experts) ______
    h) Workflow Systems (knowledge built into standardized work processes) ______
    i) Other: ____ ______

10. Would you be interested in participating in the development of Knowledge Management tools?
    YES / NO

11. How do you feel the company may benefit from the implementation of KM?
    ____
    ____
    ____

12. Which department do you feel should first be considered for the implementation of KM?
    ____
    ____
    ____

13. Which department do you feel is most at risk for loosing knowledge that serves the core competencies of the company?
    ____
    ____
    ____

Do you have any other remarks or comments?

____
____
____
____
____
____
____

Thank you for your time.

Neil Hughes
Hughesn2@asme.org
(913)909-4587