Systems Leverage of Knowledge Management – Jerry Gaspar

Good morning and welcome to the INCOSE Avenue of the Saints Conference on Systems Engineering. It is a pleasure to be here with you this morning to talk about a topic that is a new, key enabler to Rockwell Collins business success as well as of personal interest to me … that being Knowledge Management.

As I considered all of the different systems topics that I could spend time sharing with you, none seemed as important in our aerospace industry and to our current business and economic environment as this one…. Knowledge Management. It is also a topic that perhaps you, the systems community at large, wouldn't normally spend much time thinking about however I will try to share with you this morning some of the reasons why we need KM and why it needs all of you.

Structured Knowledge Management is relatively new to me and to our company, but it is a significant part of our LEAN initiative at Rockwell Collins that has huge implications for improving how we all do our work in the future. So, I would like to share with you my thoughts on how KM will impact the future of business and specifically, the way we do our work in engineering, and in high tech development environments. But first, I would like to start us out this morning with some definitions to create a context for our discussion.

What is knowledge? According to Webster's Dictionary, knowledge is "the fact or condition of knowing something with familiarity gained through experience or association". Knowledge may be stored in individuals, or in organizational data bases, in processes, products, facilities or documents. It has two primary components. Explicit knowledge which is recorded and can be taught or read. The other is tacit knowledge which is gained by individuals through experience or personal know-how.

What is knowledge management? According to one definition it is the systematic process of finding, selecting, organizing, distilling and presenting information in a

way that improves an individual's comprehension in a specific area of interest, or, increases employees efficiency at problem solving or job execution. Specific knowledge management activities help focus an organization on acquiring, storing and utilizing knowledge for such things as dynamic learning, strategic planning, decision making, and reusing versus inventing. KM also protects intellectual assets from decay, adds to corporate intelligence and provides increased flexibility to hasten new invention, when appropriate or needed.

So why is the idea of knowledge management so important to business and industry in the engineering discipline and especially in the systems communities? First it is a key enabler to efficiency and effectiveness as we pursue the critically important system solutions within our industry where the needs are for impeccable and consistent quality in increasingly complex solutions, with targets for lower developed costs and shorter development cycle times. The second and more important reason to this group gathered here today is the very concept of knowledge management as an element or process within "a knowledge system." This knowledge system is in need of innovative solutions that can only be developed through the application of the systems domain skills. KM is a system, defined by customer or user requirements, information flows, processes, capabilities, tools and environments which all need to be integrated. This system needs to allow for better and more complete leverage of reuse and intelligent reapplication.

Allow me to digress.

Since humans walked on two legs, they have been working out methods for extending their learning to someone else other than by just story telling. Certainly hieroglyphics on cave walls worked to a degree, and even for quite a long period of time, but eventually, perhaps due to the difficulty in transporting cave walls, or a lack of desire in opening your cave up to just any other Neanderthal, humans began to work on symbols that could be put on something transportable, like tree bark, and they invented what we came to call alphabets, around 2100 BC in Egypt.

And work it they did, with many variants on these symbols. This technique allowed an explosion in knowledge sharing, and many inventions followed that facilitated this explosion; writing utensils, paper, printing presses, typewriters, carbon paper, copy machines, personal computers, internet, worldwide webs, even speechmakers etc. etc., all aimed at expanding knowledge.

Occasionally throughout history learning came in forms other than the written work. Related to our own industry – transportation for example, few people know that the original version of the wheel was square,
and then through knowledge sharing came a remarkable advance which provided for incredible improvements in the speed of transportation, the whip! There are many ways knowledge can be extended!! And sometimes it begs for a more elegant systems solution, instead of what might be viewed as a management solution.

Perhaps you don't think of information sharing broadly, but each of you likely speaks in the neighborhood of a dozen languages you use in learning and sharing information, English certainly, and maybe another tongue or two, but likely you use the language of numbers, of schematics, of programming, such as ADA, COBAL, C++, the language of time, language of music, Morse code, the language of color, language of maps, and on and on.

We will always have a thirst for knowledge as it is in our nature to want to do new things or to do things we already know, but better or faster. This is especially true of engineers as they seek to solve problems or create things. So lets look at some of the interesting facts about the system of knowledge and KM that need to be understood, managed or leveraged better for us to be more efficient and effective in our jobs and lives.

In the 1920's knowledge doubled about once every 30 years. 50 years later during the 70's knowledge was doubling every 7 years. Today, knowledge is said to be doubling every 11 hours. That means that by the end of my speech, there will be

9% more knowledge in the world than when you came in here! Although there is some doubt that those of you listening to my speech will have shared equally in this increase! Now we could debate the research and the numbers, but there is little to argue that this is creating an interesting systems problem.

Engineering half-lives are approaching 2 to 3 years in high-tech industries. In our industry, it is closer to 4 to 6 years, but it continues to decrease. Thinking about this in another way, how long does it take to become an expert as a systems engineer in your domain or in your industry? 3years?, 5 years?, 10 years? And how long does it take to loose it. And do we loose it one retirement at a time? Alan Mulally, President of Boeing Commercial Aircraft Division has said that they have to invent a new airplane at least every 11 years or they forget how. The investment of time and cost to gain the knowledge or skills directly or through your own experience is too great. The practicality is we will not be able to make this zero but we need to reduce it, through efficient ways to locate the knowledge, which then needs to be documented for intelligent reapplication and reference the expert or author. The goal is to not constantly force the relearning, or worse yet reinventing of how to do the same or similar things ourselves. Current data, however, suggests that that's exactly what we do.

The average number of hours PER WEEK that people spend gathering information was reported to be 10 - 20% of the work week, but further, 60% of employees spend more than one hour EVERY DAY duplicating work done by others. Think about the chain of events when someone reinvents something already done. This forces an amazing amount of rework through the entire development, such as "new" tests that are created and "new" test equipment or factory processes all generated to support a new version of someone else's design. The cost and inefficiencies all just build throughout the chain. At Rockwell Collins we also found that typically our technical community can spend 45 minutes to one hour looking for individuals who have or know how to get to information that they need. Northrop Grumman performed a study and reported that the average time consumed by their engineers each year searching for internal experts to help them

complete their work was 6 weeks. Those are stunning numbers, especially in an environment where we push disciplined processes, lean philosophies, and "working-together" as mantras for success. Whatever these numbers are for your business, they are too high. Not only are these costs too high to pay, but people don't enjoy working in an inefficient environment. People do not enjoy spinning their wheels, spending hours, days and weeks doing work they know could be done better if they had access to the knowledge they needed. Studies have shown that individual's morale follows and is proportional to the individual's productivity and perceived "added value," their level of contribution.

To look at another facet of the problem, let's further characterize the job and career status of the Engineering profession. We have workforce statistics that show in the US in 1988, we were at equilibrium with the number of new graduates from engineering schools at approximately 30,000 students. This matched the workforce demand, as approximately 30,000 new jobs were created through new growth and the need to replace positions for retirements and promotions out of Engineering.

Ten years later or 1998, the number of graduates from engineering schools had dropped to and leveled off at approximately 19,000 students. This drop was attributed to fewer people in the 18 – 22 age bracket – so fewer kids going to school, and of those fewer students, a smaller percentage were choosing Engineering as a career. So with 19,000 to meet demand of approximately 30,000 growing to 40,000 per year, well, we know the economics of that lack of equilibrium – higher salaries and signing bonuses, and we won't be able to get the work done.

Projections call for the number entering the field to remain steady at 19,000 per year, with demand for new engineers continuing to climb. It will only be through significant efficiency improvements, some which can be created with KM initiatives, that we can close in on this gap.

Now take that picture of new engineers and consider what is happening on the other end of the workforce. In total, there are 25 million people in this country between the ages of 50 and 60 in the workforce. Within the field of R&D, HALF are expected to be lost in the next 5 – 10 years. (HALF) With those who leave go decades of corporate knowledge, technical knowledge, and tacit knowledge that may never be documented and passed on. It is only through directed KM programs and initiatives that we have an opportunity to retain that knowledge with the workforces who are left to carry on.

Another example of why KM is so important in our profession is the difficulty of being an engineer and a generalist. Immediately after starting your first job you are inundated with the nuances of specific processes and technical knowledge that apply to that particular product or industry. You are also quickly introduced to the tribal customs of that culture which form the basis for how engineering is really done. The amount of specialized expertise required to design complex systems and solutions in today's environment requires engineers to be increasingly specialized in their own skill set. As a systems engineer with responsibilities for pulling together all of the specialized skill sets and disciplines to create a whole solution for the customer, you have an ever increasing need to know experts, lots of experts who know how to accomplish the work, and to perform to cost and schedule.

Now let's talk about how our tribal KM culture in engineering in typical technical companies has evolved. Our studies recently contain some interesting learnings. Fifty years ago the technical industries had open bays with minimal visual or aural barriers. This allowed for easy translation of information through conversations and unobstructed involvement. You could also find sources more easily and could easily monitor their availability. Then we moved to more isolated offices but kept a work-day structure that allowed for formal break periods, which allowed congregations of people to associate and share problems and knowledge. There was also the infamous water cooler which is the subject of books and jokes but in reality served us well as a forum for meaningful knowledge sharing. We tried to

complement this new environment with formal and informal mentoring programs to accelerate learning and networking.

Then we reached the mid eighties and the age of the "personal computer" which was a huge enabler of the creation of knowledge and greatly increased the speed and our ability to perform work. But I also believe pc's increased the difficulty of sharing knowledge. This was due primarily to a shift and reinforcement of personal independence, more ways to do things differently, and to create incompatible formats and unique or local data storage capabilities. This independence caused more work to be done in isolation and created more integration and life cycle issues across a development. The data storage issue meant, for example, that information I needed to know may be in your head or worse could be on your computer in your own filing system or worse yet in a wide variety of formats or applications on floppies that I could not use.

To combat this trend we started creating cross-functional teams to allow a better access to a broader array of talent. We also created physical collocation spaces and changed the teams to "concurrent development teams" to not only address information sharing but to also address the life cycle knowledge issue. Fortunately the newest development environments and computer/network capabilities have allowed more virtual collocation and wider involvement through integrated tools and shared data storage capabilities.

So here we are today with a design environment which has and requires a tremendous amount of knowledge and we keep creating more every day and have ever increasing needs for knowledge sharing. What is it that is driving this knowledge system so hard? Well, let me cite our own aerospace industry as an example.

There are many challenges in the Aerospace industry all of which involve the knowledge system and KM. This particular industry is being driven to develop more and more complex solutions and is challenged with more and more

requirements. The Future Combat System and Network Centric Warfare are great examples of this. Think a second about the extent of the mission capabilities required and involved in the battlefield operations today.

These systems have extreme needs for information of impeccable quality, availability, and precision. Think about the requirements for information sharing. There is a soldier or small group of soldiers that are working in close quarters with the enemy and are trying to coordinate their activities with artillery, tanks, naval ships and aircraft. All of these troops are using weapons, mission planning and communications systems which are leveraging GPS, satellite imagery, video and pictures from unmanned aerial vehicles, AWACS aircraft, and other troops. Think of the network capabilities necessary for sharing in real-time massive amounts of secure data in all the different formats and standards and then fusing the data into information and knowledge to assure that soldier can carry out his/her mission successfully.

No single team in existence has the domain knowledge to design and develop these systems. What is known, and what will be learned, as this develops, has to be shared among customers, competitors, and huge design teams. Obviously, Knowledge Management also has a significant Information Technology component to it, the big "C" word, collaboration. At the risk of offending the I.T. folks among this audience, I'm not going to go down that path. I only have 45 minutes!

Beyond just the difficult operating needs just cited, there are tremendous amounts of regulation and industry standards that apply to the product developments to ensure that they are compatible with the huge number of systems and environments that these products and solutions have to interface with. These products have extremely long life cycles with aircraft, weapons, and communication systems serving 25 to 50 years and operating many mission cycles through extremely harsh environmental conditions. They require the latest in technology to create initially, but then also need to be updated and infused with

technology upgrades on regular intervals for increased functionality and for obsolescence avoidance throughout their long lives. This industry now leverages technologies from the pace setters consumer industries like computer and telecommunications which are produced in high volumes and to different environmental standards. This industry has to deal with the extremely high costs and investments that are distributed over relatively low volumes. And just like in most industries in order to stay competitive there is a need to improve performance and quality of the end result, while reducing costs and cycle times. There also are increasing needs to partner and collaborate in new and different ways including with potential competitors. This complicates the knowledge sharing by introducing the element of security.

Global competition has also forced the industry to look to a global workforce and workplace. And the global workplace provides a set of unique challenges. It can be a difficult environment in which to work as systems engineers since, pulling together a system from teams that are not collocated in the same area of the building has caused inefficiencies and challenges for years. Now, trying to work with a design team that may be in different cities, time zones, and languages is a reality and a growing challenge. When pieces of engineering design are parceled out to different offices to take advantage of skill sets, and in some cases, economics, knowledge management for systems engineering becomes a harsh reality, not an option.

How do we survive? What will give us the competitive advantage to continue our long legacy of quality systems solutions for our customers?

Knowledge Management is about linking people to people and people to information so that we can think together for better technical and business results. KM is not about managing WHAT people know, but managing the environment – providing an environment that is conducive to people working together to share knowledge and solve problems.

I want to share with you some of the initiatives that we have developed and are employing at Rockwell Collins. However, I would contend that we have only developed some useful pieces of what an ultimate holistic approach will need.

As we bring in new engineers, or engineers new to our domain, we have put in place formal mentoring programs in a variety of functional areas, most notably engineering and operations. We have created "centers of excellence" where work can be done by highly specialized individuals, processes and tools that can support multiple businesses within the enterprise. This is a way to optimize and maintain critical skills and capabilities that can't be afforded by individual businesses and this concept also creates higher levels of efficiency through more common and consistent work. And not surprisingly, this COE concept has proven to be an excellent organizational construct for informal mentoring and what I call, spring training, that technique used to prepare new players to play the game effectively on opening day.

We have also created communities of practice which are forums for people to come together informally to share knowledge, solve problems, mentor and be mentored, and find better ways to meet the job requirements of better/faster/cheaper. These meetings are informal, practitioner driven, and practitioner led. Later in the conference, Lynette Freese will be hosting a workshop to discuss how we have made Communities of Practice work at Rockwell Collins. This has truly been a success for us and for many other companies around the world as a way to link experts to practitioners, link solutions to issues, and create a positive work environment for our employees.

Another component of linking people to information is our Electronic Book of Knowledge. Every company has intranets and access to the internet, most companies have libraries, every team has shared drives, and everyone could probably say that there is no shortage of data. But what we saw earlier with the statistics about how much time people spend sorting through all of the available data for the piece of information that they need indicates that more is not always

better. Rockwell Collins will continue to have the intranet, our Information Center or library, shared drives and hard drives full of data. The Book of Knowledge is an additional tool that houses our "best of the best" gold nuggets of information as determined by our experts. The Book of Knowledge has a taxonomy that was created by our engineers, designed in the ways that THEY would look for information, storing only the best of our documents, guidelines, lessons learned, and links to most useful sites, and in addition, using a taxonomy that is meaningful to the community at large, which will greatly reduce the amount of time people spend looking for information.

Another element in our system, is one where every engineer's skills and work experience is logged, to build a roster of enterprise-wide capabilities, and updated annually. This expert locator is critical in a design environment where so many specialized skill sets are required. Our expert locator system allows us to locate individuals across the enterprise with the right skills for the right job at the right time – whether that is for a quick consultation or a job assignment.

This tool also allows us to see at a macro-level what skills we have in abundance and which skills are at risk. We can now plan for emerging skills, we can plan for the expected loss of skills due to eligible retirement, and we can proactively train and mentor in areas where skill growth is needed. With a technical workforce in excess of 3,000 engineers, having one set of data with which to make informed decisions on our human capital gives us a competitive edge. Managing human capital as a critical asset has long been overlooked in business and KM places emphasis and provides tools to protect and nurture this investment.

One further element of ours, as well as your company's, I would guess, is the Intellectual Property disclosures and patent process. This turns out to also be one of the earliest methods of Knowledge Management and extension. The first patent laws were written not to keep secrets, but instead to encourage the exposure of new ideas so everyone could use them. The patent gave the inventor ownership and assured he/she could be compensated if it was a good idea, but it

put the idea in the public domain for everyone to learn from, and expand from there. My how successful those KM thoughts were, and the consequence was an explosion of ideas we like to call technology.

With these elements of the Rockwell Collins KM Program, we have described one particular, somewhat elementary system, what it is, what drives it, why we need to use it and how we have evolved elements of it. In essence we have created some of the conceptual thoughts and requirements of a system.

I would contend that even though most of what we have discussed today is becoming common knowledge, all of us have struggled with or been affected by the concepts and facts in some way. We all can identify with the need for KM. We also know that the capacity and capability to serve the need exists. What's missing seems to be our collect8ive corporate interest in fully serving the need. We know of no one who has developed a total system view. Hopefully some of you will apply your unique systems domain skills and capabilities to design system solutions to enable KM and the power of knowledge that could provide us with significant advancements in our development and support environments to provide effective solutions to our customers. If we don't use a systems approach to address the knowledge system then I fear we will end up with a situation similar to the one the INCOSE membership has dealt with in the past and is still dealing with in the area of requirements capture.

In closing, I believe that this conference represents an organization and a forum of people who can assist and support others to both understand and visualize the knowledge system, and then create solutions for meeting the requirements of the KM user communities of tomorrow. It will have to be an organization like INCOSE to create the critical mass to represent the need for a systems approach in order to consolidate the different needs, and users, and to create a common voice that can drive the solution creators to develop the tools and environments so KM can truly be leveraged to meet the growing demands. I would like to leave each of you with the challenge to work within INCOSE forums and your own companies and

industries to help build a knowledge system for the world with effective and efficient knowledge management, with new processes, standards, and tools in integrated environments.

Some thoughts on where you might begin are

- **keep leveraging knowledge for intelligent reapplication in your own work**
- **share best practices in forums such as this**
- **be succinct in describing the value you get in networking, in picking up knowledge and best practices, to help your business leadership understand these values**
- **keep thinking about system solutions, for example, one I'd like is a way to download knowledge from brain to brain without having to go through the eyes and ears would be good.**

After all if we on average only use about 3% of our brain, we could dump in one tremendous amount of info before having to defrag! Just a thought, but with this audience, everything is fair game!

So what's in it for you if you do work to expand this holistic system? Well, a number of you will be counted in that earlier group I mentioned, that group that will leave industry in the next 5 - 10 years. You will have left the place better for having been there. You'll have been a part of something highly successful. You'll have facilitated a path to lessen burn-out of the world's best and brightest, the ones who do all the heavy lifting in the tough systems architecture arenas. And you will have advanced the state-of-the-art that your sons/daughters will depend on to make their own mark, to build their own new knowledge.

Thank you very much for inviting me to your conference. I think we have time for about two questions.