The Future of Knowledge Management in INCOSE:

Moderator: Kevin Forsberg, The Center for Systems Management, USA
Panelists: Garry Roedler, LM Engineering Process Improvement Center, USA
Jack Ring, USA
Ralph Hodgson, TopQuadrant, Inc., USA
Hillary Sillitto, Thales Land & Joint Systems Division, UK
Raymond Jorgensen, Rockwell Collins, USA

Abstract

The goal of the Knowledge Management Working Group (KMWG) is to determine how technical INCOSE knowledge management needs are currently being met, and what the new state(s) should be. Input from the panel members, and most importantly from the audience for this panel discussion, will help shape the direction and future contributions of the INCOSE KMWG.

One of our panelists, Jack Ring, says, "I claim that the Future Direction of Knowledge Management in INCOSE is grossly under-conceptualized. Three concepts that may merit further dialogue are:

1) We could get on with developing and sharing knowledge about modeling stochastic systems, non-deterministic systems, agent-aided design and even generative/autocatalytic systems,
2) The engine for the G2SEBoK will be the next generation SE tool. Things like CORE, SysML-oriented tools, OpEMCSS, etc., become plug-ins,
3) The G2SEBoK should do more than talk ABOUT systems praxis. It should give examples of the work products. These should be real examples that are prompted by posing typical problems, then posting work products as proposed by participants.

Currently the final product from most INCOSE Working Groups is a printed document (which is also available in electronic form). Should this change?

Another panelist, Raymond Jorgensen, says: "Wiki technologies have provided an excellent forum for encouraging improved communication and sharing across the community. At Rockwell Collins, a Wiki environment is being used to encourage sharing best practices across the enterprise. Instead of different business areas publishing unique practices in stale "PDF" files on local networks, one enterprise environment is being used to host the collective enterprise knowledge of best practices in engineering. Similar techniques could be applied at INCOSE."

If a Wiki is so good, why did the SEHv3.1 Wiki lay dormant on the INCOSE web site for over two years? Is a Wiki suitable for the INCOSE environment? If so, who will control it?

Biographies

Moderator

Dr. FORSBERG has 27 years of industrial experience in Systems Engineering, Project, and Proposal Management, followed by 25 years of successful consulting to both government and industry. His experience ranges from research projects during a decade in the Lockheed Research Labs, to development projects, to full-scale production implementation. Since 1983 he has provided training and consulting to many organizations in more than a dozen countries.

Dr. Forsberg is chair of the recently formed (2009) Knowledge Management Working Group (KMWG). He was co-chair and co-editor for the SE Handbook versions 2a, 3.0, and 3.1. In 2002 he was one of the initiators of the INCOSE Committee on SE Certification, which began granting the Certified Systems Engineering Professional (CSEP) certifications in February 2005. He was a member of the nine-person Certification Advisory Group (CAG) for six years.

He is co-founder and current CEO of the Center for Systems Management. At Lockheed he was an early member of the Corona Project (mid-1950s), America's first successful satellite program. He is co-author of Visualizing Project Management, J. Wiley & Sons, (1996, 2000, 2005) and Communicating Project Management, J. Wiley & Sons, 2002.

His awards include the NASA Public Service Medal (1981) "in recognition of his outstanding technical and managerial contributions to the Space Shuttle Program"; the CIA Seal Medallion in recognition of his pioneering efforts in the field of Project Management (1998); and the INCOSE Pioneer Award, jointly with Hal Mooz (2001). He is an INCOSE Fellow (2006) and a Life-time Fellow, American Society of Mechanical Engineers (ASME) (1976).

Dr. Forsberg has a Ph.D. in Engineering Mechanics from Stanford University (1961), and a B.S. in Civil Engineering from Massachusetts Institute of Technology (1956).

Panelists

Garry ROEDLER is the Senior Program Manager of Systems Engineering (SE) at the LM Engineering Process Improvement Center. He is responsible for the development/selection of SE processes, assets, and training for the corporation towards an integrated set of SE enablers to aid program performance. This role also has responsibility for managing corporate councils for SE, Test & Evaluation and Specialty Engineering. Previously, he was the Engineering Process Integration Manager for LM Integrated Systems & Solutions, responsible for strategic planning of technology needs, process technology development and infusion, and process improvement. Prior to that, he chaired the LM Systems Integration Process Review Board, focusing on process improvement and achievement/sustainment of Level 5 CMM/CMMI objectives, including a world first to achieve Level 5 ratings in the SE-CMM.

Garry has over 29 years experience in engineering, measurement, and teaching and holds degrees in mathematics education and mechanical engineering from Temple University. Garry has been a technical leader in many areas of SE on programs and was the technical lead for various winning proposals. Other work includes leadership roles in various technical and standards organizations, including: US Head of Delegation and Task Group leader for ISO/IEC JTC1/SC7 Working Group 7 (SE and SW process standards), Practical Software and Systems Measurement Steering Group; INCOSE Corporate Advisory Board and Committees; INCOSE Delaware Valley Chapter co-founder, and IEEE Standards Assoc. Garry has worked on the author teams of several current standards, including project editor of ISO/IEC 15288, Systems Life Cycle Processes.

Jack RING has conducted action research regarding knowledge acquisition and diffusion at personal, small group and enterprise levels throughout his 53 year career. When software engineering became the focus in 1970 he was selected to lead the GE-wide software engineering workshop which grew to 2,500 participants in three years. Later he led development of advanced systems for tasking, collection, analysis and production of both classified intelligence and civil information clearinghouses. Then he applied these ideas to more than triple productivity and innovation in the planning function in Honeywell Large Computer Systems and the product development function in Edelbrock. He has been active in the knowledge management movement since 1993. He co-authored the INCOSE product, ConOps for a Systems Engineering Education Community, with Wayne Wymore and an INCOSE IS05 paper, Conceptual Design of an Environment for Systems Engineering Education, with Dr. Dennis Buede and Prof. Fred Bolling. Currently, he leads the INCOSE Motor Sports WG which intends to demonstrate how motor sports can accelerate SySTEM learning by youth world wide. Also he serves as co-chair of the Fellows Committee and the Autonomous System Test and Evaluation WG after having been co-chair, Intelligent Enterprises Working Group, 2002 ˆ 2007. He earned a BA, Physics, Emporia State University, Kansas, and continues formal education in systems, innovation and learning.

Ralph HODGSON is a co-founder and the CTO of TopQuadrant, Inc., a US-based company that specializes in semantic technology consulting, training, and tools. He combines expertise in semantic technologies with over 25 years of experience in business application development and deployment, consulting, software development, and strategic planning. Prior to starting TopQuadrant in 2001, he held executive consulting positions at IBM Global Services where he was a founding member of Portal Practice and Object Technology Practice. Prior to IBM, he was European Technology Director, founder, and Managing Director of Interactive Development Environments, which was an international CASE tools vendor. He is a lead Ontologist for the NASA Constellation Program Data Architecture and NExIOM. He is a published author and a frequent speaker at conferences. Recent books he has co-authored are Adaptive Information, published by John Wiley in 2004, and Capability Cases: A Solution Envisioning Approach, published by Addison-Wesley in July 2005.

Hillary SILLITTO graduated in Physics from St Andrews University in 1976, and started his career with Ferranti (now Selex) in Edinburgh as an optical engineer. He worked on many laser system projects, developed design, integration and test techniques for multi-spectral optical systems, led the optical design team for the UK's first airborne multi-spectral electro-optical pod (which involved successfully resolving several key issues and risks to transition new technologies into a production and in-service environment), and played a key role in developing the company's infra-red countermeasures business.

He moved to Thales Optronics in Glasgow in 1993, contributing to the strategy and early definition for many of the current generation of its products, and subsequently held appointments as Chief Systems Engineer and Chief Engineer. He was active in the international Thales Systems Engineering network, contributed to the development of the Thales Systems Engineering Method (SysEM), deployed Requirements Management and piloted UML system modeling techniques in Thales Optronics, and wrote a guide on Product Line Architectures.

Seconded to Thales UK Corporate in 2003-4 as Engineering Director Prime Contract Support, he made important inputs into major bids and programs including Soldier Systems, the Future Carrier, UAV and C2 systems, and led the development of the Systems Engineering part of the Thales Prime Contract Management Handbook and associated training. From 2005 to 2008 he was seconded to UK MOD as head of the Integration Authority, responsible for managing system-of-systems interoperability across the whole scope of the MOD's acquisition program and promoting the development of systems engineering skills and culture in the acquisition organization. He then became the Chief systems Architect for Thales Land & Joint Systems Division in the UK and on 31st March 2009 was appointed Systems Engineering & Architects (SEA) manager for the UK part of the division.

He has been a member of INCOSE since 1996. He contributed to INCOSE's Systems Engineering 2020 Vision, and presented 5 papers at INCOSE International Symposia from 1999 to 2009, winning a Best paper award in 2005. He was president of INCOSE's UK Chapter from 2004 to 2006. He was lead author of the UK Chapter's "Systems Engineering Annual State of the Nation" report published in June 2009, which aimed to baseline the national systems engineering capability, and played a key role in establishing effective INCOSE engagement with other professional bodies to move forward the systems engineering professional recognition agenda in the UK. He has submitted 9 successful patent applications, is a Thales Expert, a Chartered Engineer, a Fellow of the Institute of Physics, and a visiting Fellow at the University of Bristol. He was elected an INCOSE Fellow in 2009.

Mr. JORGENSEN is an advocate for system engineering excellence. His mission is to improve the effectiveness, efficiency, and communication of the discipline and practice of systems engineering – exploring practice improvements, revealing wasteful behaviors, encouraging appropriate use of tools & techniques, and improving the overall experience of each practicing system engineer. He is currently serving as a corporate knowledge resource for Rockwell Collins for system engineering processes, tools, and training. Previously, Mr. Jorgensen has held several positions as an avionic systems engineer working on flight deck applications used across a diverse community of aerospace customers. Mr. Jorgensen has been actively involved in INCOSE since 1996, serving as Heartland Chapter President, Treasurer (current), INCOSE Model-Based System Engineering initiative leader, former INCOSE Lean Systems Engineering Working Group co-chair, and former INCOSE Requirements Working Group co-chair. Mr. Jorgensen has published several papers at INCOSE symposia and continues to promote excellence in the application of the systems engineering discipline. He received a B.S. in Electrical Engineering from Michigan Technological University, a Master of Systems Engineering from Iowa State University, and is currently pursuing his PhD in Systems Engineering at Stevens Institute of Technology.

Kevin Forsberg:

Position Statement

The Knowledge Management activity within INCOSE is not an academic exercise to provide theoretical bounds on the “Body of SE Knowledge.” Rather it should be focused on providing resources with insight and guidance for the SE practitioner who faces daily challenges on active projects with real-life constraints of achieving technical excellence within tight schedule and cost bounds.

Every day one can read of projects in trouble because of issues traceable to failed SE. As Jared Diamond said, “One cannot just focus on the key to success in projects, but one must also avoid the thousands of individual causes of failure.” The Corona project, the first successful US satellite program in the 1950s, suffered 12 successive launch failures. Based on correcting painful lessons learned, the program went on to achieve an enviable record of 99% successful missions over hundreds of launches. The unfortunate reality in the 21st century is that we are re-learning the lessons learned in the Corona era, as witnessed in the multi-billion failure and cancellation of the Future Imagery Architecture (FIA) program in 2007. New challenges were faced and solved, but old failure sources were unfortunately recreated.

Our challenge is to present SE Knowledge in such a way that it is of interest to and accessible by people in all engineering fields and all business sectors. People from a wide range of industries such as pharmaceuticals, biomedical systems, as well as software development at companies such as Visa/Master Card and Google have all expressed interest in systems engineering. However the perceived bias for systems engineering as practiced in large government projects has been a barrier to creative interchange. This real or perceived bias must be dealt with.

The goal of the Knowledge Management Working Group (KMWG) is to determine how technical INCOSE knowledge management needs are currently being met, and what the new state(s) should be. The current focus of the Working Group is:

1. Identification of “all” areas of INCOSE’s *technical* knowledge needs, assets, and their management relevant to INCOSE membership and the discipline of systems engineering in general. Administrative and organizational knowledge management needs such as membership support, accounting, or web site maintenance are excluded.

2. Identification of INCOSE technical knowledge sources and stakeholders, whether internal or external to INCOSE. The Knowledge Management Charter and Concept of Operations (CONOPS) documents will be available on line on the INCOSE public web site.

3. Development of a comprehensive dictionary tailored to the needs of systems engineers and project teams. Several dictionaries exist already, including the one created by the ISO/IEC JTC1 SC7 Working Group 22. The challenge is that the existing documents capture multiple definitions without attempting to put a coherent structure to the definitions.

4. Establishment, in cooperation with the other INCOSE Working Groups, of the means to effectively manage and disseminate INCOSE's technical knowledge assets from creation through disposal. The panel will explore the appropriate balance of printed documents (such as the SE Handbook) and on-line products such as the SE Handbook wiki site (and why it was not being effectively used for SEHv3.1).
5. Examination of the shortcomings of previous INCOSE Knowledge Management efforts (Guide to the Systems Engineering Body of Knowledge [G2SEBoK], INCOSE Asset Product Library [IPAL], and the various editions of the INCOSE SE Handbook) and define a way to avoid their shortcomings.

The BKCASE Project, under the joint leadership of Art Pyster at Stevens Institute of Technology and Dave Olwell at the Naval Postgraduate School, is a significant three-year program initiated in the fall of 2009. BKCASE is the acronym for the Body of Knowledge and Curriculum to Advance Systems Engineering. The project scope for Stevens Institute and the Naval Post Graduate School is to define a Systems Engineering Body of Knowledge (SEBoK) and use the SEBoK to develop a Graduate Reference Curriculum for Systems Engineering (GRCSE, pronounced “Gracie”). For INCOSE the BKCASE project holds great promise, with the final product (BKCASEv1.0) due to be completed in the fall of 2012. This document certainly will heavily influence the next generation of the INCOSE SE Handbook version 4.0, and if appropriate, may in fact replace the SEHv4.0. At present the BKCASE team has 26 authors worldwide, and many are part of INCOSE as well. The final form of BKCASE has not yet been determined, and it may well include multiple links to on-line sources, it may be in a wiki form, and it may be a virtual document itself. We are open to suggestions from all interested parties.

Input from the panel members, and most importantly from the audience for this panel discussion, will help shape the direction and future contributions of the INCOSE KMWG.

Knowledge Management Position – Garry Roedler

Overview of Knowledge Management

Knowledge management (KM) includes the identification, capture, creation, representation, dissemination, and exchange of knowledge across targeted groups of stakeholders. The knowledge includes both explicit knowledge (conscious realization of the knowledge, often documented and easily communicated) and tacit knowledge (internalized in an individual without conscious realization) and can come from either individuals (through experience) or organizations (through processes, practices, and lessons learned).

INCOSE Motivation

INCOSE needs to understand and prioritize the knowledge needs of its stakeholders and build the framework, assets, and infrastructure to support the knowledge management for those needs. The motivation for INCOSE to do this is that KM can help:

- Information sharing across organizations
- Reduce redundant work due to not having the information needed at the right time
- Avoid “reinventing the wheel”
- Facilitate training, focusing on best practices
- Capture knowledge that would “go out the door” with retirements and attrition

The last item in this list is a major concern as we see a negative slope in the supply of systems engineers. As the percentage of experienced systems engineers retiring is increasing, it becomes even more important to capture the tacit knowledge that otherwise could be lost and then make that knowledge available to the developing systems engineers.

INCOSE needs to help facilitate the KM of SE practice in the large, providing mechanisms to manage the evolving SE Body of Knowledge as the premier SE technical organization. INCOSE’s role needs to include both the transfer of existing knowledge and the creation of new knowledge (where the discipline is evolving).

As the leading technical organization of SE, INCOSE needs to take the lead in developing an infrastructure that can be used across industry and academia to identify and organize the explicit SE knowledge and to facilitate the capture and documentation of the tacit knowledge of SE practitioners and researchers. This capability is needed as a complement to the work currently being supported to develop a guide to the SE Body of Knowledge (SEBoK). The Guide to the SEBoK will go a far way towards addressing the explicit knowledge in SE, but it stops far short of addressing the tacit SE knowledge.

Additionally, INCOSE needs to make the information useful to a diverse set of users. These users include:

- Developing new systems engineers
- Practicing systems engineers
- Systems engineering educators/trainers
- Systems engineering researchers

- Systems engineering managers

Enablers to Achieve the Objectives

A key to success in achieving the KM objectives is to identify and exploit the enablers for performing KM. Most of the enablers exist, but mastering their use is the challenge. INCOSE needs to be able to leverage approaches, technologies, practices and tools that the industry has found useful in facilitation of KM. These include:

- Discussion forums (email, wiki, blogs, etc)
- Repositories (assets, knowledge, etc)
- Communities of practice/expertise
- Decision support systems
- Collaborative technologies
- Video information exchange (storytelling, webinars, etc)
- Knowledge brokers/Expert directories
- Knowledge elicitation techniques (interviewing, observation, etc)

Many of these are being used within INCOSE today. The key is to provide a framework and infrastructure that supports using the right enablers for the right KM efforts, then work collaboratively with all parts of INCOSE.

The one common aspect of each user group of the knowledge is that they want to get to the information with the least amount of difficulty. This indicates a need to investigate the type of information each user group needs and how they want to access it. From this user information, the knowledge and assets can be organized through the appropriate use of a relevant ontology.

Princeton University's WordNet defines an ontology as "a rigorous and exhaustive organization of some knowledge domain that is usually hierarchical and contains all the relevant entities and their relations." Wikipedia defines an ontology as dealing "with questions concerning what entities exist or can be said to exist, and how such entities can be grouped, related within a hierarchy, and subdivided according to similarities and differences." The ontology can provide a concept model of the knowledge area defining the relationships between objects and the rules for the model. The ontology helps to determine and define a valuable knowledge organization system for the users.

Within INCOSE the development of the ontology needed to ensure highly useful knowledge information should become a primary objective of the Knowledge Management Working Group (KMWG) and INCOSE Technical Operations. It should help INCOSE to determine where to try to focus efforts for future work in a more strategic and deliberate manner. This need is broadly implied by the scope of the KMWG, but it needs to become an explicit objective.

As the need for SE Knowledge Management continues to grow, INCOSE needs to increase its work both within and beyond its boundaries to facilitate a common approach. The solution has several facets, many of which should be done collaboratively across the industry. The following summarizes some of the things needed:

- “Living” SE Handbook – The current approach to the INCOSE SE Handbook maintenance is the traditional linear document with updates spaced out over long periods of time. Although this creates a stable base, it does not allow for easily and quickly capturing advances and new information that could be valuable to practicing systems engineers. A moderated wiki would allow the necessary control to be maintained while allowing for a wider set of contributors to submit new information and improvements in a more dynamic manner.
- SE Body of Knowledge – The SE community has long been lacking a comprehensive guide to the SE Body of Knowledge that can evolve over time. INCOSE needs to influence and facilitate industry-wide and world-wide collaboration to define a guide to the SE Body of Knowledge. The SEBoK must include key references for knowledge areas with links and annotations about the reference. Currently, there is excellent work being done in this area and INCOSE is slated to work with IEEE to maintain the SEBoK.
- Searchable SE Database – For full impact this needs to be a collaborative approach that cuts across the key SE related technical organizations in industry to allow “one stop shopping” for information via proceedings, journals, articles, guides, competency models, and other assets.
- SE Competency Model – A common reference SE Competency Model is needed across industry to help drive the future development and assessment of systems engineers. There are several efforts in process that INCOSE should try to influence collaboration towards a single models that meets the various needs across industry.
- Interactive Information Sharing – to more fully harness the tacit knowledge, we need to establish appropriate communication mechanisms to address various dynamic information needs – mechanisms that connect people with questions to people with answers based on experience. These mechanisms include the things mentioned above, such as discussion forums, communities of practice/expertise, collaborative technologies, video information exchange, knowledge brokers/expert directories, etc.

No matter what projects are taken on to define and manage the systems engineering knowledge, we need to leave our previous comfort zone for documenting, disseminating, evolving, and maintaining the information. We can no longer afford to rely on slow-to-change linear documentation approaches. Often these are driven by antiquated financial models for selling products. INCOSE and the systems engineering community needs to learn to use the current and evolving communication technologies to springboard this effort. There is a strong need for more dynamic resources that leverage the whole SE community.

System Engineering
as Knowledge Production & Utilization

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1. The Systems Praxis

1.1 Knowledge Management

Professor Peter Drucker has said that knowledge cannot be managed because knowledge exists only in people's heads. Suppose, though, that the real objective is not management of knowledge but mutual exchange of knowledge among two or more people. Then consider W. Edwards Demming's warning that "it's the system" in which people are embedded that enables or obstructs achievement of any given objective. We can harmonize these views by agreeing that systems engineering practitioners must create and evolve a system that enables them to perform the work of systems engineering.

1.2 Requisite Knowledge

Increasingly, clients are facing problematic situations that are ever- higher in Extent, Variety and Ambiguity, E-V-A, than has been the case in the last several decades.

- **Extent** signifies the sheer quantity of cognates involved.
- **Variety** signifies the quantity of unique cognates, both temporal and semiotic.
- **Ambiguity** signifies the resultant uncertainty, due to vagueness and cognitive overload.

This means that systems practitioners must get beyond prescient design of deterministic systems. In turn, this means getting beyond INCOSE's current vision, standards, and handbooks and becoming proficient at initializing autonomous or intelligent systems that can cope with non-deterministic situations. INCOSE must aid and abet its members in becoming proficient at fomenting knowledge production and utilization whether in-project, in-career development, in-mentoring or whatever. Otherwise, INCOSE faces a rapidly declining future.

1.3 The Knowledge Diffusion Curve

Compiling a Body of Knowledge is not the answer. Knowledge has time value. Knowledge is different from all other resources. Exchange begets new knowledge. New knowledge obsoletes current knowledge. Often the knowledge that matters is subject to rapid and abrupt shifts. Knowledge turnover is the key metric. This manifests as velocity of knowledge promulgation throughout a systems project. In contrast, a body of knowledge invites rigor mortis.

Accordingly, knowledge production and utilization by a systems engineering workgroup includes not only the acquisition of new knowledge but also the recognition and remediation of inadequate, erroneous and irrelevant knowledge. Mutual error detection and correction is essential throughout the systems engineering workgroup and with their sponsors and customers.

1.4 KP&U Infrastructure Capabilities

For a system engineering practitioner, project, or community of practice to produce the desired effect the participants must have an infrastructure that enables knowledge velocity and vetting. Essential infrastructure capabilities are:

a. A clear, comprehensive Standard of Care.
b. A pervasive Quality ethic.
c. Means for shared meaning (sufficient set of concepts and signs precisely interrelated).
d. A Shared language (multi-media).
e. Mutual goal of co-learning and motivation for personal bests.
f. Information and decision automation (a learning environment).
g. A clinical approach to learning (see one, do one, teach one).

2. INCOSE's Problematic Situation

2.1 A Viable Value Proposition

Who's the customer? The customer for systems engineering is the systems development and deployment staff (the other 95% of a systems project). Those who pay the bill are sponsors.

How shall we serve? INCOSE has an identity crisis. Shall we focus on who we are, as in professional society, or focus on what we do, as in community of SE practice, or focus on what we know, as in ensuring maximum knowledge production and utilization among all members?

Measures of Effectiveness? INCOSE lacks a viable value proposition. Too long focusing on the value of SE instead of the worth of SE --- as a catalyst for maximizing the value add that our customers can achieve.

2.2 Optioneering

The future of knowledge management in INCOSE has several aspects;

a) The span of sponsor problematic situations,
b) the spectrum and level of individual knowledge across the various members,
    i. Sponsor domains, e.g., government, regulated industries, commercial industries, non-profit.
    ii. Systems Engineering methods, techniques and tools
    iii. Technologies including at least thermodynamics, informatics, biomatics, teleonomics, social dynamics, economics and ecologics.
c) the infrastructure (ways and means, including motivators) for knowledge exchange among the members, regarding;
    i. A method for rating member competencies and competency improvement options.
    ii. Method for member meaningful learning, preferably the clinical method, i.e., see one, do one, teach one.
    iii. project (infrastructure, metamodels, prediction markets),
    iv. reflection)

v. Member learning materials and tools
   Learning Management System
vi. Frameworks and Component libraries for sponsored projects
vii. Communities of practice (with mentoring)
viii. INCOSE administration

d) outreach projects to not-yet members of all ages.
e) knowledge regarding systems praxis has a half-life of less than 10 years.

In this sense we must make sure that the Future of Knowledge Management in INCOSE is not underconceptualized. For instance,

- the INCOSE Tech Vision 2020 must acknowledge high-Extent/Variety/Ambiguity situations.
- INCOSE must articulate a Standard of Care.
- INCOSE must include error detection/correction as an SE practice.
- INCOSE must support efforts not only to revitalize formal education but also to modernize formal education for high-Extent/Variety/Ambiguity problematic situations.
- INCOSE must acknowledge which methods, techniques and tools such as Model Based System Engineering, Model Driven System Design, Model Driven Architecture, Enterprise Architecture Frameworks do or do not respond to current Extent/Variety/Ambiguity challenges.

2.3 Measures of Effectiveness

The 7200 INCOSE members (and the approximately 600,000 who should become members) deserve three benefits;

a) The ability to produce systems models at 10 fold greater productivity and innovation than today.
b) The capability to learn from others with near-zero latency.
c) The ability to vet all propositions, principles and theories with respect to their effectiveness rather than having to conform to standards established by acclamation.

This indicates that INCOSE must

a. Devise a way of characterizing our field of discourse as the field continuously evolves. A taxonomy is not appropriate. Current ontologies are not sufficiently agile because autonomous systems generate new facets of their ontology.
b. Devise a way of encouraging knowledge sources everywhere to proactively register and share their knowledge with respect to an INCOSE field of discourse.
c. Devise a way of rewarding those who share their knowledge.

2.4 Intended Effect

ROKA: Return on Knowledge Assets. The INCOSE Knowledge Asset consists of the knowledge distributed across INCOSE members and all associates with which they interact. Return is determined by the exchange cycle time. Although most formulations of KM speak of a quantity, e.g., body of knowledge, the temporal value of knowledge makes Velocity of knowledge exchange the key ROKA factor. A second ROKA factor involves the interpersonal style of the participants. Interpersonal style determines whether ‘i’ participants generate the sum of participant knowledge, $K = \Sigma_i k$, the product of participant knowledge $K = \Pi_i k$, or a power of participant knowledge, $K = e^{ik}$

3. The Future of KM in INCOSE

The future of knowledge management in INCOSE may (probably will) determine the future of INCOSE.

3.1 Vision

Rather than the narcissistic "The world's authority on Systems Engineering." INCOSE would be well advised to adopt a service-oriented vision such as "Enabling people world-wide to cope with their problematic situations in a synergistic way."

3.2 Learning Environment

Members should see their own SE activities during a project as incrementally developing the knowledge states of customers and sponsors.
Key capabilities will include:
SEEC: The INCOSE product, ConOps for a Systems Engineering Education Community, describes INCOSE context and how members can derive maximum value of membership. It posits that five diverse learning environments are necessary for learning systems engineering. Meanwhile INCOSE continues to bother about only one, curriculum for SE courses at accredited engineering schools. This ConOps has not been followed up with any design exercise despite Terry Bahill's attempt to focus attention on it at IS07.
Clinical method: That maximizes learning by a See one, Do one, Teach one method.
Angels and Demons Game: or equivalent formulation of the way of assuring requisite variety in a non-deterministic situation or avoiding the situation.
INCOSE Scalable Architecture: An continually learning, heterogenous enterprise.
Others are described in [Ring 2004].

3.3 Example Relevant Technologies

For designing a KM infrastructure throughout an enterprise: Active Knowledge Modeling
http://activeknowledgemodeling.com/
For automating parsimonious participation in the bizarre bazaar: Web 3.0.
For actual KP/U during the fuzzy front end of projects
CMap http://cmap.ihmc.us to establish terminology
TopBraid™ to formulate an ontology
Systemigram, to describe logic/process
System Dynamics, to describe behavior
For designing and architecting systems by discovering the wisdom embedded in diverse viewpoints: The Handbook of Interactive Management.
To give all members access to INCOSE Learning Objects and track learning patterns: Learning Management System, LMS.
To give all members a way of navigating a personally relevant trajectory through the myriad learning objects regarding systemics and systems praxis.
To give system model users (developers, testers, etc.) on a specific project a way of navigating the inherent complexity of a larger scale system model: Learning Trajectory Navigator, LTN.

4. Further Reading

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Ring, J. 2004 Concepts Pertinent to the Future of INCOSE, Proceedings of INCOSE International Symposium 2004.

Ring, J. Design Science Aids the “Fuzzy Front End” of Systems Projects, *Integrated Design and Process Technology,* IDPT-2006, June, 2006, Society for Design and Process Science

Ring, J. Usage Case for a Learning Trajectory Navigator, INCOSE Track, IEEE Systems Conference 2010, San Diego, CA.

Jack Ring has conducted action research regarding knowledge acquisition and diffusion at personal, small group and enterprise levels throughout his 53 year career. When software engineering became the focus in 1970 he led the GE-wide software engineering workshop which grew to 2,500 participants in three years. Later he led development of advanced systems for tasking, collection, analysis and production of both classified intelligence and civil information clearinghouses. Then he applied these ideas to triple productivity and innovation in the planning organization in Honeywell Large Computer Systems and again in the product development function in Edelbrock. He has been active in the knowledge management movement since 1993. For INCOSE he co-authored the ConOps for a Systems Engineering Education Community with Wayne Wymore and an IS05 paper, Conceptual Design of an Environment for Systems Engineering Education, with Dennis Buede and Prof. Fred Bolling. Currently, he leads the INCOSE Motor Sports WG which intends to demonstrate how motor sports can accelerate SySTEM learning world wide, the Autonomous System Test and Evaluation WG after having been co-chair, Intelligent Enterprises Working Group, 2002 – 2007. He serves as Vice Chair of the Fellows Committee. He earned a BA, Physics, Emporia State University, Kansas, and continues formal education in systems, innovation and learning.

Ralph Hodgson

Position Paper:

The Constellation Data Architecture (CxDA) uses the NASA Exploration Initiative Ontology Models (NExIOM) ontologies for information types, structures, metadata specifications and data exchange. NExIOM provides common information models and vocabularies for administrative, governance, provenance, and associative metadata across different systems; and interoperability between system engineering tools and applications across the lifecycle of NASA activities. Within NExIOM, there are system engineering methods, tools and lifecycle ontologies that can inform how to provide ontological support for knowledge management (KM) initiatives at INCOSE. The position that will be put forward is that an ontological foundation for KM is key to establishing information models for shared understanding within communities of interest.

Future direction of knowledge management in INCOSE

Position paper by Hillary Sillitto

Introduction

Ultra-large-scale (ULS) systems will be interdependent webs of software-intensive systems, people, policies, cultures, and economics. (Northrop et al, SEI report on Ultra-Large Scale Systems)

Systems companies and acquisition agencies have the characteristics of Ultra-Large-Scale Systems, as the Appendix seeks to demonstrate. Complex systems are developed and operated by projects that are enterprises in their own right, spanning multiple systems companies. INCOSE itself is a complex socio-technical system, spans many systems companies and acquisition agencies, and its members are engaged in numerous project enterprises. Knowledge management within INCOSE has to deliver benefits in the context of the challenges set by this "problem situation".

The challenges

Each system development project is unique. Each has

- a unique purpose – to achieve some set of benefits envisaged by a complex set of stakeholders often with disparate cultures and agendas;
- a unique starting point, usually characterised by high levels of uncertainty,
- a unique trajectory, determined by the order in which critical decisions are taken, agreements made, resources engaged, relationships established and knowledge and understanding acquired, shared and used

And usually the "project enterprise" charged with delivering the project is also unique: a transient grouping of organisations and people brought together to pursue a common purpose while remaining attached to their parent organisation; while the system may be expected to outlive the "project enterprise" that created it, possibly by many decades.

The view of Systems Engineering presented by current standards and formalised handbooks is largely process-centric. The process models provide a useful shared reference model and language as a starting point for a systems project or business. Experience shows that as teams internalise these models they usually re-write them in their own words to suit local culture, language and circumstance. As a result, the same word may mean different things in different contexts; and different words are used in different domains to mean the same thing. The process models are "brittle", in the sense that they are subject to a variety of poorly understood failure modes; and it is very difficult for a project to establish ahead of time whether in adapting a systems engineering process model for its unique circumstances it has introduced changes that will prevent the process working the way it is supposed to.

This results in organisations developing adapted processes that they believe give them competitive advantage and therefore become proprietary. How then to set up a project enterprise involving collaborative working across multiple companies and agencies if each regards its process knowledge as a proprietary source of competitive advantage, and uses a private language that impedes communication with external stakeholders? What other aspects of systems engineering knowledge besides process are important for system success? Is there a "systems approach" that is more difficult to articulate but more important than process? What are the science and practice that underpin systems engineering?

My fellow panellist Jack Ring points out that knowledge creates value not from its existence but from its velocity and extent of diffusion. Unlike money, the same knowledge can be diffused to multiple recipients, and sharing can create emergent value that magnifies the benefit of the knowledge to all involved - as demonstrated by the open source software community.

However: even if “knowledge” is made available, that does not guarantee effective diffusion and assimilation. The way systems engineering knowledge is currently presented makes it difficult for people to understand its relevance to them and to their situation, and assimilate and exploit what is useful to them without becoming bogged down by much that is not. Much published systems engineering information lacks supporting evidence as to its value and range of applicability. Many Systems Engineering methods and approaches have been developed in specific cultures. Methods, language and behaviours that work in an “Anglo-Saxon Engineering” culture don’t always transfer readily to other regions, or indeed to other professional cultures in the “Anglo-Saxon region”. Few other companies have been successful in realising the benefits of the “Toyota way”. What does this mean for INCOSE?

The way forward

- We need to understand what we mean by “systems engineering knowledge”.
  - It has to be more than “systems engineering process assertions”.
  - It must be underpinned by evidence of maturity level and range of applicability.
  - It must extend to the underpinning science of complexity and human behaviours, and to the knowledge of how to assess a problem situation, that can make the crucial difference between success and failure in a systems enterprise.
- We need to understand what purpose we seek to achieve by managing it
  - And how we will know if we are being successful.
- We need to understand how our knowledge complements and synergises with that of other communities.
  - And then present it so that the added value is readily identified and realised
- We need to improve the language we use to make our ideas more widely accessible.
  - Most successful people have the gift of explaining complex ideas in simple language.
  - Much systems engineering writing does the reverse, hiding simple ideas behind complex language.
- We need to understand what knowledge our individual and corporate members are able and willing to share - with other members, and more widely.
  - INCOSE has already achieved a great deal by creating a shared language and understanding of systems engineering. This makes it much easier to set up complex collaborative systems projects than it was 20 years ago.
  - But when projects hit problems or approach critical decision points, participants are often banned from talking to the public or other stakeholders for fear of affecting competition outcomes or share prices, or prejudicing litigation. So just at the point when sharing would be most informative and possibly even most useful to participants and to society in terms of maximising system success, knowledge sharing may be positively blocked.
- We need to find ways of enabling faster knowledge sharing, and faster adaptation to context, within (as opposed to between) systems enterprises.
  - We often see inconsistent project outcomes within the same enterprise applying allegedly the same processes to similar classes of problem – perhaps because every project is unique in detail and the full range of factors that drive success or failure are not well understood.
  - We often find that teams are too busy with their own problems to spend time learning from other projects.
  - Lessons learnt within one project may be out of date by the time the participants finish that one and start the next.
  - Conversely, knowledge that was gained during development and deployment of a particular system, its design rationale and understanding of the problem situation needs to be managed throughout the system’s lifecycle.
- If INCOSE is to provide benefit to the entire systems community in the 21st century we need to create an environment and context where “those who share” benefit more than those who do not.

Summary

The opportunity exists for INCOSE to provide a learning environment in which systems engineering knowledge can influence and benefit a much wider range of people, communities and enterprises than happens at the moment.

In order to ensure knowledge diffuses fast enough for the activity to be useful, it seems inevitable that such a learning environment would need to be open source.

There are important questions about governance arrangements and “participation rules” for such an endeavour.

There is a plethora of issues concerning take-up and effectiveness of collaborative social networking systems – some of them work, some of them don’t, and how to make sure they produce intended benefits still seems to be a matter for research. So success is not assured.

Appendix: “Systems companies are ultra-large scale systems”

A typical international systems company might have the following characteristics:

Software intensive systems:
Various local, national, and worldwide, networks, running numerous applications, with variously constrained cross-connections
Numerous private networks and IT systems: within organisations, delivered to customers, shared with customer and supply chain, run on behalf of customers, connected to live operations
Move to cloud computing
Millions (100's of millions?) of lines of embedded code in 100's of thousands of delivered systems and products

People:
~50-100 thousand employees
~ 20 countries
>> 1000 sites (>1000?)
Thousands of external stakeholders

Policies:
At the level of the global corporation; within national entities; across international divisions; local to sites and business lines
Host nation security and IPR rules
Individual customer, collaborator, supplier IPR issues
Individual systems management policies
Industry domain standards - airworthiness, rail, space, maritime, vehicle, laser safety, - -
Internal R&T policies and product strategies

Cultures:
Functional: engineering, management, sales & marketing, commercial, operations, HR, - -
Customer: military, government, prime contractor; - -
Supplier: big companies, SMEs, universities, consultancies; service, product, sub-contract design, body-shopping, design-to-order, build-to-print, - -; risk sharing, fixed price, time and materials, - - differentiated, commodity
National: different national cultures have well-documented differences in value systems and behavioural norms that can either add value through diversity or impede due to incoherence.

Economics:
Multiple business models - programme, product, managed service, PFI, consultancy - -
Dependency on available funding (governments', shareholders’ and key customers’) for major projects and infrastructure investment

INCOSE IS2010 Knowledge Management Panel

The Future of Knowledge Management in INCOSE

Position Statement - *Raymond W. Jorgensen*

Knowledge Management - Basics

"Knowledge Management…linking people to people and people to information". This is the definition of knowledge management that we apply at Rockwell Collins, providing a vision for our corporate knowledge management strategies. Like other large organizations, we struggle with how to transfer knowledge from those who have knowledge to those who need knowledge, which becomes an ever greater struggle as the corporation becomes more global in operation.

A 2006 study by the American Productivity and Quality Center (APQC: www.apqc.org) revealed three major focus areas that corporations were investigating to improve their knowledge management capabilities:

- Increasing collaboration
- Transferring best practices
- Building better communities of practice (Knowledge Management in a Global Economy, APQC, Carla O'Dell, 2006)

Corporations are seeking better ways to encourage their employees to share their knowledge with one another! However, that same study showed significant barriers to be overcome:

- Getting people to participate – people are reluctant to share their knowledge (perceived as 'job security')
- Cultural barriers to sharing – the corporate culture creates it's own barriers to sharing knowledge (organizational structure, leadership "examples", entrenched processes, traditions)
- Too much focus on technology – seeking the "silver bullet"

As evidenced by the focus areas and challenges, a knowledge management system is not about the technology or tools, but rather the human social interactions that generate knowledge sharing. Tools and technology are enablers for knowledge management, but the real knowledge sharing occurs when people interact with one another to contribute and collaborate on topics of mutual interest.

At Rockwell Collins, we have several knowledge management initiatives in progress or under development to increase interaction and collaboration.

People to People Knowledge Sharing

- Communities of Practice: informal communities that gather together around a common theme, such as the System Engineering Excellence Community of Practice (514 subscribers) and the Project Management Community of Practice (560 subscribers)

  - Free Lunch – provided by corporate shared services
  - Time Charging – on your own time
  - LiveMeeting virtual connections as well as regional site gatherings
  - Leader and Regional Coordinators
  - Presenter and discussion Leader

- Expertise Location: subject matter expert location and skill identification
  - Skill Inventory (database)
  - Exploring improved ideas to help locate expertise and skills
  - Social networking possibilities

- Discussion Forums: topical resources to find answers from the experts
  - Moderators – keeping watch on the questions
  - Integration with knowledge library
  - All contributions encouraged to grow on-line knowledge library

- Professional Mentoring
  - Connecting those who seek knowledge with those who have knowledge
  - Mentee driven relationships – seek and pursue knowledge partners

- Rockwell Collins University
  - Learning environment with course curricula (role maps), instructor-led training, and computer based training
  - College of Engineering with faculty

The main purpose behind each of these initiatives is to decrease the distance between the knowledge seeker and the knowledge provider and break down the natural barriers and resistance to exchanging that knowledge.

People to Information Knowledge Sharing

- ETIpedia: a Wiki-based engineering library – one stop shop for all topics relating to engineering
  - Structured content with unstructured evolution
- ETIforum: a discussion forum fully integrated with ETIpedia to help users find answers faster
- TeamSpace: MS SharePoint site to encourage collaboration and teamwork
  - Portal for collaboration and working together
- eSearch: an enterprise wide search capability, helping find the information that you are seeking

The purpose behind these initiatives is to place the information as close to your fingertips as possible, decreasing the time it takes to find the information that you're looking for.

The Way of the Wiki

Central to Rockwell Collins' knowledge management is an environment wherein employees are encouraged to share their knowledge in practical and tangible ways within a Wiki environment called ETIpedia. ETIpedia is the engineering library, an evolving resource to share practical knowledge and contribute to our collective understanding of the best practices in engineering.

What is a "Wiki"?

A **wiki** (pronounced *WIK-ee*) is a website that allows the easy creation and editing of any number of interlinked web pages via a web browser using a simplified markup language or a WYSIWYG text editor. (Wiki - Wikipedia)

- A wiki invites all users to edit (contribute to) any page or to create new pages (articles) within the wiki Web site, using only a plain-vanilla Web browser without any extra add-ons.
- A wiki promotes meaningful topic associations between different pages by making page link creation almost intuitively easy and showing whether an intended target page exists or not.
- A wiki is not a carefully crafted site for casual visitors. Instead, it seeks to involve the visitor in an ongoing process of creation and collaboration that constantly changes the Web site landscape.

(The Wiki Way: Quick Collaboration on the Web, Ward Cunningham and Bo Leuf, 2001.)

By using an inexpensive Wiki engine, Rockwell Collins has successfully created a structured library of engineering practices for people, processes, and tools. Our library has been steadily growing as the engineering community contributes their knowledge of the state of the practice of engineering. Some of the benefits of the Wiki include:

- the Engineering Reference Source: migrating away from pockets of practices held in department shared drives or web-pages
- Up to Date and Reliable – information maintained by the user community, not just a select few 'experts'.
- Community Involvement and Contribution– not fixed in stone (or PDFs), but changes with the changing times or advances in "best practice"
- Structured – uses the foundation engineering process definition as the framework of article organization
- Threaded – simple cross references between articles; navigable threads between associated topics
- Collision and Confrontation – encouraging differing views to be expressed differently; not "one size fits all", but encourages folks to express variants of practice

Contributions to the Wiki, however, should never be anonymous. Contributors must login with their user account, and any changes that they make leave a trail of change breadcrumbs.

With a Wiki, however, there are many challenges yet to be overcome. A Wiki is not a silver bullet to knowledge sharing, but an enabler. Unfortunately, many potential participants in knowledge sharing are intimidated by Wikis:

- **Fear of New Technology** – "I don't know how to contribute", "This is too complicated"
    - The Wiki provides instructions for writing even the most simple, basic article. Best means to overcome fear is through education, "show and tell", and hands-on activities to break the ice
- **"Why bother?" Attitudes** – Many knowledgeable partners don't want to participate because they don't see the incentive or reward for divulging their "well kept secrets". Sharing knowledge takes time, which is a valuable commodity for overloaded engineers.
    - Promote the Wiki with both tangible and intangible rewards:
        - Provide recognition and awards for contributions – most new articles; most valued submission; and many others
        - Educate community on value of intangible rewards – increased corporate proficiency; increased opportunities; personal recognition as a subject matter expert
- **"Books" vs "Virtual Library"** – many potential contributors are still thinking that a "Book" needs to be written to capture valued knowledge. Without a binding or publication in a PDF format, it just isn't "real".
    - Demonstrate the Wiki as a library – not a book – of many articles threaded together; demonstrate ease of navigation between articles and ease of threading articles with links
- **Written in Stone (empowerment vs. authority)** – among the "process champions" of corporate culture, there are many who believe that only a select few hold the keys to "best practice", and many potential contributors refrain from sharing because they are not among the "select". Who has the "authority" to publish information?
    - Educate potential contributors about their own expertise and special knowledge
    - Encourage process champions to share their own wisdom – yet, be open to dissenting opinions or perspectives
- **Knowing Your Audience (or Not)** – oftentimes, contributors don't know how to effectively communicate their knowledge, and make common mistakes:
    - Creating the next novel – way too much information in one article
        - Keep articles short and to the point. Rule of thumb: no more than two display screens long. If need more, considering breaking content into multiple articles that are then threaded together with tactically placed links
    - Creating an article that is too general or of little use to the reader
        - Aid the reader to find useful content quickly. If needed, divide content between general and specific content in different articles and link them together.

INCOSE Knowledge Management

INCOSE has an opportunity to become a knowledge sharing hub of systems engineering, providing a virtual library and community of people to turn to for assistance in the application of system engineering principles. To enable more effective knowledge sharing within the INCOSE community and to reach outside to potential partners and future members, I propose the following knowledge sharing capabilities:

- iCommunity - a members area to share information about yourself – interests, projects, activities, expertise, connections – and discover new associates within the INCOSE community (similar to Facebook, LinkedIn, or MySpace community)
  - Your Personal Public Home page - Post your resume, biography, papers written, papers working on, special interests, etc.
  - Who's On-Line – indicators for on-line activity with
  - Instant Messaging capability – single select to activate on-line communication
- iSubscribe – Accessibility for both non-members and members
  - Provide member-only areas/ services, but …
  - Enable non-member subscriptions to search and test drive for free, explore for a fee, with potential recruitment to member status
  - Public space and private space managed together – seamlessly.
- INCOSEpedia – the systems engineering body of knowledge
  - Not just a handbook, but a library of knowledge – using the system engineering process as the structure to bind it all together
  - To be effective, Wiki needs structure, branding, and communication
  - ONE Library – not 30-50 small disconnected libraries (iConnect Wikis)
- iConnect – share information/ collaborate on development of new materials (existing)
  - Use to collaborate on development of artifacts or working group products that require more configuration control rigor
  - Products in iConnect joined to public Wiki pages

Information Management: Knowledge of System Engineering

The position presented within this paper describes a means to share knowledge of the system engineering process and best practices. Such an environment would enable the expression of competing theories, ideas, and diverse opinions, and creates an environment for collisions, which ultimately results in improvements to our collective knowledge.

Similar concepts may be applied to our system engineering knowledge of products (requirements, design, test, etc), but knowledge sharing of product definition is beyond the scope of this position paper (at this time).