Architecting the Enterprise: Is INCOSE up to the challenge?

Moderator: Dr. James N Martin, Aerospace Corporation, USA
Panelists: Dr. Stuart Arnold, University of Hertfordshire, UK
Jack Ring, USA
Brian White, The MITRE Corporation, USA
Richard Martin, USA

Abstract

The enterprise consists of much more than just hardware and software. Yet most SE literature deals with systems only composed of these technological components. This panel of experts in the domain of Enterprise Systems Engineering will draw from their experience to describe some of the special challenges in architecting the enterprise. They will recommend necessary changes to the SE discipline to enable better development and evaluation of enterprise architectures. Special methods and tools required at the enterprise level will be discussed. We will discuss the special nature of the "soft" elements of the enterprise: people, policies, practices, & procedures. We will also discuss some of the other elements not often dealt with by traditional SE: platforms, media, infrastructure, facilities, & (low-tech) equipment.

Biographies

Moderator

James MARTIN is an enterprise architect and engineer at The Aerospace Corporation developing solutions for information systems and space systems. Dr. Martin did graduate work at George Mason University in enterprise architecture and knowledge modeling methods and at Stanford University in engineering design. Dr. Martin led the working group responsible for developing ANSI/EIA 632, a US national standard that defines the processes for engineering a system. He previously worked for Raytheon Systems Company as a lead systems engineer and architect on airborne and satellite communications networks. He has also worked at AT&T Bell Labs on wireless telecommunications products and underwater fiber optic transmission products. His book, Systems Engineering Guidebook, was published by CRC Press in 1996. Dr. Martin is an INCOSE Fellow and for eight years was leader of the Standards Technical Committee. He recently received from INCOSE the Founders Award for his long and distinguished achievements in the field.

Following research into microwave systems at Roke Manor Research, **Stuart ARNOLD** developed his systems engineering skills over many years of international industrial experience working for Philips and then Thorn EMI in the development, manufacture and product support of professional, medical and defense systems. Subsequently, he moved into government service in MOD's Defence Evaluation and Research Agency. He returned to industry as a QinetiQ Fellow. In 'retirement' he consults on systems engineering and is the Royal Academy of Engineering Visiting Professor of Integrated Systems Design at the University of Hertfordshire. Stuart has been at the heart of the ISO initiative to internationally introduce systems life cycle management into business organization, being the founding Editor of ISO/IEC 15288 and its companion SE capability assessment model. Dr Arnold is a Chartered Engineer, is an INCOSE Fellow and represents INCOSE on the ISO team developing enterprise architecting standards. He holds degrees in Electrical Engineering, Optoelectronics and Engineering Systems.

Jack RING has designed and operated more then twenty five enterprises during twenty years with General Electric, ten years with Honeywell and twenty years coaching high tech startups and turnarounds. He was named Fellow of the International Council on Systems Engineering in 2003, co-founded and chaired the Intelligent Enterprises Working Group, 2002 – 2007, and co-sponsored, with James Martin, in 2008, a systems architecture workshop to address the extant confusion regarding architecture across several standards, guides and handbooks. Currently, he serves as co-founder of three startups, guides evolution of the Starshine Academy enterprise to a 5,000 campus chaordic network and serves as subject matter expert in test and evaluation of unmanned and autonomous systems for the DoD. He earned a BA, Physics, Emporia State University, Kansas, and continues formal education in systems, innovation and the practice of serving followers.

Dr. Brian E. WHITE was Director of the Systems Engineering Process Office (SEPO) at The MITRE Corporation from 2003-2009. He held a Corporate position and reported to MITRE's Corporate Chief Engineer. Dr. White's current professional interests are focused on applying complexity theory and complex systems principles to improving the practice of systems engineering in situations where the interactions of people (considered part of the system) dominate the technological issues. Dr. White is founding Co-Editor of a book series established in 2007 called Complex and Enterprise Systems Engineering with Taylor & Francis. He is co-editor and chapter contributor to a book, Enterprise Systems Engineering: Theory and Practice, and co-author (with Beverly Gay McCarter) of another (draft) book entitled Leadership in Decentralized Organizations; he is co-author (with Beverly Gay McCarter) of a chapter called Emergence of SoS, Socio-Cognitive Aspects for another T&F book entitled Systems of Systems Engineering: Principles and Applications that appeared in 2009. From 2005-2008, Dr. White was the International Council on Systems Engineering (INCOSE) Assistant Director for Systems Science and the founding Chair of the Systems Science Enabler Group (SSEG). He received Ph.D. and M.S. degrees in Computer Sciences from the University of Wisconsin, and S.M. and S.B. degrees in Electrical Engineering from M.I.T. He served as an Air Force Intelligence Officer, and for 8 years was at M.I.T.'s Lincoln Laboratory. Dr. White spent 5 years as a principal engineering manager at Signatron, Inc. In his 28 years at The MITRE Corporation, he has held a variety of senior technical staff and project/resource management positions. He was MITRE's Global Grid Architecture Project Leader for four years, and worked in the fields of digital communications and networking, satellite and radio communications, and modulation/coding for many years before that. During his professional career, Dr. White has published more than 100 significant technical papers and reports.

Richard MARTIN is President of Tinwisle Corporation in Bloomington, Indiana, USA, where he is responsible for the provisioning of information systems services focused on enterprise integration to companies in the manufacturing and distribution sectors. Prior to forming Tinwisle in 1981 he spent 15 years providing and managing the design and construction of automated research laboratory instrumentation at Indiana University. He is a senior member of the Society of Manufacturing Engineers, and member of IEEE, ACM and INCOSE. He served as a member of the INCOSE Intelligent Enterprise Working Group and is now a member of the Motor Sports Working Group. He participates in an active research program at Indiana University to formalize the architectural frameworks now in use for enterprise management and is the convener of ISO TC184/SC5/WG1 working on International Standards in the domain of Automation systems and integration – Architecture, communications and integration frameworks. His public service includes appointment to the Plan Commission of Monroe County, Indiana.

INCOSE IS10 Panel Position Paper

Architecting the Enterprise: Is INCOSE up to the challenge?

by
Stuart Arnold
s.arnold2@herts.ac.uk

Enterprises are an important class of system, yet they are just that: a particular type of system, with distinguishable and comprehensible attributes and characteristics. Certainly they sit at a level in a hierarchy of man-made system complexity that presents some very special challenges, but they are nonetheless still subject to the design and build conventions that have for over a half century progressively been absorbed into the discipline of systems engineering.

The crafting of system architecture has been an implicit constituent of systems engineering since its mid-C20th formulation as a discernable, business-oriented discipline; one that merged a system approach to engineering with many features of the management, resourcing and control of business enterprise. The intimate through-life interaction between a delivered system-of-interest – whether product or service – and the principle enabling system that facilitates this – the business enterprise – have been fundamental to the codification of systems engineering. The approach that has emerged means that the engineering mind is naturally attuned to being able to see these enabling enterprises in terms of systems engineering discipline; to approach an enterprise's architecture according to long held engineering design discipline.

However, there have been weaknesses in the evolution of mainstream systems engineering discipline that have not favoured enterprise design. It has not in general given due regard to the human component that directly or indirectly is present in most systems. Nor has the expression and organisation of the models that convey the many facets of complex system structure and its rationale been given the prominence deserved in systems engineering discipline. It has required advances in the human factors and business IT/software engineering disciplines to send strong messages, and thereby reinforce natural advancements already being pursued by the systems engineering community in these areas. The influence of all this has been to re-emphasise what already existed, what already was progressing, and so to stimulate a more disciplined interpretation of enterprise architecture within long-established and proven disciplinary principles and practice of systems engineering.

This re-profiling of inclination, method and means, rather than the introduction of a radical disciplinary paradigm shift, is enabling systems engineering to provide architecture design answers to the technological and human factors complexity of today's enterprises. Ultimately, the functional structuring and implemented conformations of enterprises remain subject to the design considerations customarily seen in systems engineering.

So, does systems engineering, and INCOSE as a major driving force in its evolution, offer advantage over other disciplines and practices in the arena of enterprise systems? Does it truly address the appreciation of need and opportunity, the design of architecture, and the resolution of the challenges present when architecting assets, people, IT, communications, environmental and social factors in order to create enterprises – whether they be industrial corporations, financial institutions, military force structures, social services or transportation industry. I believe so. I see no other integrated source of discipline, knowledge, skills and experience that is equal in its potential, its coherence or its capability to meet these challenges.

With time systems engineering has grown into an interdisciplinary subject able to tackle multi-technology solutions by following sound theory and empiricism that, combined, tackle complexity more effectively than other approaches. INCOSE has been instrumental, if not pre-eminent, in making this come about. It has not been as fleet of foot or as contrived as others in offering solutions to the daunting design of enterprise. It has migrated cautiously up the complexity scale from largely inanimate architecture to the ramifications of increasing self-determinism seen in enterprise architectures set in the space-time of global business dynamics, commercial vicissitudes and shifting social constraints. It has much yet to do, but it has a sound footing and it is learning from the disciplines that systems engineering naturally meshes with, so as to provide multi-technology solutions to multi-stakeholder demands. The achievement of this is far from complete and, as consumer expectations outpace engineering and management capability, it is unlikely to ever be complete.

At any level of system complexity and architectural challenge, there are techniques, methods and tools that favour successful outcomes – these act as the practical armoury of the domain specialist. INCOSE has for many years addressed the spectrum of application domains that variously equate to the creation and operation of enterprises. It has long addressed the design of complexity and the formulation of architectural structures, their implementation and their proving. It may not always have responded rapidly or positioned itself well in the disciplinary contest to establish jurisdiction over the multi-disciplinary arena of enterprise design and implementation.

Nevertheless, architecture principles, architecture description practice, well formulated system modelling conventions, and even capable accommodation of human factors and social issues, have now positioned systems engineering so that it can purposefully address and effectively influence the architecture of enterprises. The necessary system concepts and principles exist, and the requisite methods and tools are emerging, such that the boundaries of present-day systems engineering may be said to naturally encompass the challenges of enterprise architecture. INCOSE has a strong hand in the codification, communication, execution and professionalism of all this. It is up to the challenge, is already delivering and, yes, has more to offer.

Architecting the Enterprise: Is INCOSE up to the challenge?

by
Jack Ring
jack.ring@incose.org
3/21/2010

No. As indicated by INCOSE publications, adopted standards and strategic initiatives INCOSE does not accurately comprehend architecture or enterprise let alone the convergence method and stop rule for creating an enterprise architecture. INCOSE is unprepared to contribute to architecting enterprises that must thrive in an ambiguous situation. This indicates that INCOSE is not prepared to architect an enterprise that must perform non-trivial systems engineering. Likewise INCOSE is demonstrating an inability to architect the enterprise called INCOSE.

By enterprise I mean two or more human beings taking action with necessarily limited resources to serve customers. By enterprise I do not mean a set of computer programs as is often indicated in the literature and I do not mean a two dimensional checklist of some aspects of an enterprise as do enterprise architecture frameworks.

The intelligent kind of enterprise is even more relevant to this symposium. An intelligent enterprise continually measures its effects on its context and responsively changes a) to better serve its stakeholders and b) to conform to principles of systems and society [Ring 2007]. The key dimensions of an intelligent enterprise are extent, variety and ambiguity, EVA. Extent signifies the multiplicity of cognates. Variety signifies the number of unique cognates, both semiotic and temporal. Ambiguity signifies the observer's uncertainty in comprehending extent and variety due to obscurity and/or cognitive overload.

The principle of requisite variety tells us that the greater the variety of the enterprise situation the more change proficient an enterprise must be in order to sustain its effectiveness [Ring 2004]. This is important to the purpose of this panel because of all the enterprises that exist the kind that does systems engineering must exhibit higher levels of change proficiency than any other. The ability to architect a systems engineering enterprise is paramount.

An enterprise is a living system. An enterprise breathes, perspires, inspires, laughs, and co-learns. An enterprise is initialized by systemizing a set of frontal lobes --- the sources of abstraction, chunking, subsumption, intuition, induction, abduction, deduction, etc. An enterprise evolves according to members' ability to assess their situation and achieve appropriate changes. Enterprise effectiveness is determined by the interaction of a) member competencies, b) the methods and systems that facilitate and automate their information and choice making, and c) member enthusiasm for purpose.

By architecture I mean 'the arrangement of function and feature that maximizes an objective.' [Venturi]. As variety and ambiguity increase enterprise effectiveness becomes limited by the pattern of relationships. This pattern of relationships is called the enterprise architecture. In most cases the objective is expressed as the standards of acceptance for each of the enterprise measures of effect. Architecture is not the description of a system and is not the rules for arriving at the system or even for arriving at the architecture. Architecture is the result of decisions regarding function, feature, arrangement and proof or at least estimation that these suffice for acceptable effects.

Is INCOSE up to the challenge? Two facets of the question are relevant. One facet is whether INCOSE members are up to the challenge of architecting a sponsor's enterprise. A second facet is whether INCOSE is up to the challenge of architecting INCOSE. Both share certain fundamentals however, each presents unique aspects depending on the nature of the ensemble of frontal lobes involved.

The current recipe for SE as embraced by INCOSE (ISO 15288, ISO 15704, DoDAF, FEA, SEHandbookv3.2, etc.) is sufficient for many kinds of enterprises, e.g., evolving aerospace systems engineering from obese to lean to brittle or running a MacDonald's franchise in conformance to copious, externally provided rules. However, other societal problems and needs demand living systems [McDavid 1999a] that continuously learn and evolve. The current recipe for SE as noted above is not sufficient for enterprises, the claims of [Arnold and Lawson] notwithstanding. For example, intelligent enterprises are not bound by life cycles. Instead, this kind of system experiences growth episodes and may even morph. Worse, for higher degrees of extent, variety and ambiguity, the key dimensions of complexity, the likelihood of unintended consequences supersedes the likelihood of satisfying measures of effectiveness such that the systems praxis seeks Design for Prevention [Livingston 2010].

How shall we initialize a system composed of non-deterministic components (innovative humans) attempting to serve a non-deterministic problematic situation? Caution, linear thinkers need not apply. As [Warfield] warns, when linear thinkers encounter non-deterministic situations they experience cognitive overload then underconceptualize a solution. The last decade is dramatically marked by the invention of autonomous devices that help humans cope with non-deterministic problematic situations. This means that an enterprise that performs systems engineering of these autonomous devices and of systems of such devices must likewise exhibit autonomous behavior that is both necessary and sufficient but, in the interest of parsimony, not moreso.

The necessity challenge is to devise an enterprise architecture that enables the enterprise to fulfill commitments [McDavid 1999b]. The sufficiency challenge is to devise an architecture that enables the enterprise to adjust its gradients, rearrange its relationships and co-align its content as necessary, and in the right sequence, to serve a market that yields enough rewards to sustain enterprise purpose.

A clue is the classic game called NIM which starts with one or more objects in each of three or more piles and involves two or more players. Each player in turn can take any number of objects from a pile but only from one pile per turn. Players agree at the start that the winner is the player who takes the last object or the player who avoids taking the last object. A player can let the opponent decide who goes first. Those who understand NIM know that the objective is to be in control of the other player's choices. For any given configuration of objects an algorithm exists that will direct choice in order to sustain control. To those who do not understand the game it can be a frustrating experience.

A more recent formulation is a formal game called Angel and Demons [Ring, Pizzarello, Friesen, Davies]. To win the game an enterprise must exhibit the requisite variety that copes with any antics from its context and its internal people and automatons. Taking the enterprise as the Angel, two kinds of design decisions are key. One kind astutely cellularizes the enterprise. The second provides for orchestrating the cells (or making self-orchestrating cells). One real world example was the VISA Corp. [Hock]--- until Dee Hock retired. The recipe is clear [Ring 2004], featuring multiple, small (Starkermann) communities of practice, i.e., Chapters, sharing as a Council, all propelled by enthusiasm toward achievement of compelling purpose. The difficulty

is finding enough people with the strong desire to serve others and the courage to do so. Are you becoming one of these?

We must avoid thinking in the singular. An enterprise may be configured in two or more patterns of relationships (architecture) depending on the demands to which it is responding. These can be called modes of operation. An ideal architecture enables mode fast and confident mode switching. Given that the enterprise may be continuously learning then it is possible that an enterprise never executes the same process twice. Something is always different than before.

Is INCOSE up to the challenge? There are two facets to this question, one regarding the membership and the other regarding the leadership. Some members of INCOSE are catching on to the non-deterministic paradigm. Not nearly enough, fast enough, in light of societal demand [Ring 2009] but progress is evident. Leadership, largely from corporations and especially ones that are rules-following government contractors have not yet evidenced a transition toward the non-deterministic paradigm. The strategic initiatives, MBSE and SEBoK, and most of the Working Groups seem to be still addressing the deterministic, boundable paradigm. Further, INCOSE as an enterprise is far from chaordic [Hock] in form or behavior, the preferable means for change proficiency without unintended consequences. Lacking a compelling purpose, espousing a narcissistic vision and void of stated principles for member co-learning the enterprise INCOSE has not yet achieved certification as intelligent.

The INCOSE Intelligent Enterprises WG, 2002 – 2007 produced several insights into the gestation of intelligent enterprises [Ring 2007]. Subsequent work with actual enterprises and in response to the MBSE Grand Challenge clarified a framework of interacting capabilities composed of tailorable stem cells. This meta-enterprise can be initialized then self-evolve so as to maximize achievement of enterprise purpose.

One example of such intelligent adaptation is described conceptually by [Axelrod & Cohen] in which the cells are tailored to be genetic agents. At the risk of oversimplification their findings can be summarized as the interaction of twelve concepts. The following quote indicates how they interrelate. The numbers in parentheses indicate the twelve concepts. “Agents (1), of a variety (2) of types (3), use their strategies (4), in patterned interaction (5) across both physical space (6) and conceptual space (7), with each other and with artifacts (8). Performance Measures (9) on the resulting events drive the selection (10) of agents and/or strategies through processes of error-prone copying (11) and recombination (12), thus changing the frequencies of the types within the system, thereby changing the emergent characteristics of the system and creating a new gap relative to desired performance.” Their findings are consistent with the Goal-seeking System metaphor [Livingston] and give more insight into one way of implementing the ‘Gap = Goal – State’ convergence capability.

This points up the notion that an enterprise capable of adjusting, arranging and co-aligning must contain a model of ‘itself’ and be able to exercise ‘what if’ scenarios while responding to on-going stimuli. Further, a higher order enterprise that can not only make rules but also devise strategies must have a model of the neceasary and sufficient relationships among Effects, Capabilities, Competencies, Resources and functions.

The ultimate challenge is architecting an enterprise that performs systems praxis in high in EVA situations. The penultimate challenge is architecting an INCOSE that enables humans to accomplish a necessary and sufficient systems praxis.

Ideally the IS10 Enterprise Architecture panel will perturb the status quo sufficiently to spark a better enterprise architecture both in your next systems engineering project and among your council of systems engineering practitioners.

He who learns fastest wins.

References:

Arnold, S. and Lawson, H., 2006 Viewing Systems from a Business Management Perspective: The ISO/IEC 15288 Standard, *Systems Engineering Journal*, Wiley InterScience DOI 10.1002/sys.20006

Axelrod, R. and Cohen. M. 1999 "Harnessing Complexity: Organizational Implications of a Scientific Frontier" The Free Press/Simon & Schuster, 1999

Hock, D. 1999 Birth of the Chaordic Age, Barrett-Kohler

Livingston III, W. 1990 Friends in High Places, F.E.S. Publishing,

Livingston III, W. 2010 Design for Prevention, pre-publication manuscript, copy available from jack.ring@incose.org.

McDavid, D. 1999a, Discovering the User's Ontology In a Living Enterprise. *Proceedings of the ICSE1999 Conference.* International Conference on Systems Engineering, U. Las Vegas.

McDavid, Douglas, 1999b "A standard for business architecture description," *IBM Systems Journal*, 38, No. 1, 12-31, 1999.

Ring, J. 2004 Concepts Pertinent to the Future of INCOSE, *Proceedings of International Council on Systems Engineering Annual Symposium 2004.*

Ring, J. 2007 About Intelligent Enterprises: A Collection of Knowledge Claims, INCOSE-TD-2007-001-01 downloadable from http://www.incose.org/practice/techactivities/

Ring, J. 2009 Discovering a Strategy for Whole Systems Modeling, Proceedings IEEE Systems Conference 2009, Vancouver, B.C.

Ring, J., Pizzarello, A., Friesen, O. & Davies, B. 2010, System of Systems Readiness Assessment, *IEEE Systems Conference 2010*, San Diego.

Starkermann, R. 2003. Amity and Enmity, Editions als Carte, Zurich.

Venturi, R. 1996, Complexity and Contradiction in Architecture, NY Museum of Modern Art paper.

Warfield, J. N., 2002. Understanding Complexity: Thought and Behavior, available at www.jnwarfield.com

Position Paper – B. E. White
4 April 2010
For INCOSE 2010 Symposium Panel
Architecting the Enterprise: Is INCOSE up to the challenge?"

I think INCOSE has a considerable challenge in architecting the [systems engineering (SE)] enterprise, primarily because INCOSE seems to limit their definition to "the" Enterprise, which is interpreted only as *an organization*, according to [INCOSE SE Hndbk, 2010, p. 2, bottom]. To continually and successfully architect enterprises, one needs to take a very broad view of systems engineering, a perspective that includes people, particularly stakeholders whom one cannot often control but can usually only influence. Then one must draw upon several "complex" SE principles that rely more on creating attractive conditions, i.e., incentives, for enabling social and distributed/decentralized network interactions among people to facilitate the self-organization and evolution of attractive, and often profound, solutions. This contrasts with the more conventional systems engineering approach of sub-dividing the problem (reductionism), using work breakdown structures, risk management, and other rigid control techniques, and trying to force progress in a the top-down hierarchical fashion. However, do not despair, INCOSE can change over time provided a concerted effort is mounted to encourage and nurture a more complex systems engineering approach.

The best exposition of the need for a different mindset in approaching enterprise architecture, that I have seen recently, comes from [Bloomberg, 2010] of [ZapThink, 2010]. Here are some excerpts from this short article on the subject of complex systems engineering (CSE) vs. Traditional Systems Engineering (TSE).

> … SOA [Service Oriented Architecture] implementations must be complex systems in order to deliver on emergent properties like business agility. … we've expanded our treatment of Complex Systems Engineering (CSE) … Breaking away from the Traditional Systems Engineering (TSE) way of thinking is a huge leap for most technologists, as it shakes to the foundation how we think about architecture, not just SOA in particular, but even more fundamentally, the role IT [Information Technology] plays in the enterprise.
>
> ***Complex systems: Order from chaos in nature***
> Complex systems theory is especially fascinating because it describes how many natural phenomena occur. Whenever there is an emergent property in nature — that is, a property of a system as a whole that the elements of the system do not exhibit — then that system is a complex system.
>
> Everything from the human mind to the motion of galaxies are emergent properties of their respective systems. Fair enough, but those are all natural complex systems, and we're charged with implementing an artificial, human-made complex system. …. Making such a distinction between natural and artificial systems is basically a TSE way of thinking because it separates people from their tools. In a traditional IT system, people are the "users," but not inherently part of the system. In many complex systems, however, people aren't just part of the system, they are the system.
>
> In fact, any large group of people behaves as a complex system. For example, take a stadium full of people doing the wave. Each individual in the crowd decides whether or not to participate based upon the behavior of other people, but the wave itself has "a mind of its own" — in other words, the wave behavior is an emergent property of the crowd. Another example would be a traffic jam. An accident

in opposing traffic will slow down your side of the freeway every time, even though each individual knows that slowing down to look will cause a jam. You and hundreds of people like you can decide not to slow down to look in order to avoid creating a jam, but the jam forms nevertheless.
…

The enterprise as a complex system
Any human organization is, in fact, a complex system, including those unwieldy beasts we refer to as enterprises. Enterprises all have policies and managers and lines of control, but the overall behavior of the enterprise emerges from the individual behaviors of the participants in it. Furthermore, the emergent behaviors of corporations and governments may depend entirely on the people who belong to such enterprises, independent of technology. But when we do include technology in our enterprises, we can dramatically affect the emergent behavior of those systems, just as switching from cars to trains changes how traffic behaves.
…

Too often in the enterprise, people confuse complex systems with collections of traditional systems, which is just as big a mistake as confusing a parking lot full of empty cars with a traffic jam. In fact, architects are often the first to make this mistake. Of course, it's certainly true that some architects are too focused on the technology, leaving people out of the equation altogether, but even for those architects who include people in the architecture, they often do so from a TSE perspective rather than a CSE approach. But no matter how hard you try, designing better steering wheels and leather seats and the like won't prevent traffic jams!

Complex systems thinking and SOA
In traditional systems thinking, then, we have systems and users of those systems, where the users have requirements for the systems. If the systems meet those requirements then everybody's happy.
In complex systems thinking, we have systems made up of technology and people, where the people make decisions and perform actions based upon their own individual circumstances. They interact with the technology in their environments as appropriate, and the technology responds to those interactions based upon the requirements for the complex system as a whole. In many cases, the technology provides a feedback loop that helps the people achieve their individual requirements, just as brake lights in a traffic jam help reduce the chance of collisions.
…

The ZapThink take
If you still find yourself perplexed by this whole complex systems story, it might help to point out that complex systems aren't necessarily complicated. In fact, in a fundamental way they are really quite simple. Traffic jams may be difficult to understand, but individuals driving cars are not.
… the great thing about complex systems is that if you take care of the nuts and bolts, the big picture ends up taking care of itself.

For organizations who don't take a complex systems approach to SOA, however, the risks are enormous. As traditional systems scale, they become less agile. Ask any architect who's attempted to hardwire several disparate pieces of middleware together in a large enterprise — yes, maybe you can get such a rat's nest to work, but it will be expensive and inflexible. If you want to scale your SOA implementation so that it continues to deliver business agility even on the enterprise scale, then the complex systems approach is absolutely essential.

INCOSE should embrace the statement embodied by the [*italicized* and **bolded**] first sentence of the last paragraph above as applying to themselves! Further, and more importantly, INCOSE

should get serious about teaching the principles of CSE and developing methodologies for improving its brand of SE in that direction.

Another point to emphasize: Upon perusing some of the relevant literature, e.g., [White, 2009], [White, 2008], [SEPO, 2007], on the subjects, the principles of Enterprise Architecture (EA) and CSE have much in common. Here are some characteristics of EA espoused by [Gartner, 2010].

> … Enterprise architects must adopt a new style of enterprise architecture (EA) to respond to the growing variety and complexity in markets, economies, nations, networks and companies, … Analysts advised companies to adopt 'emergent architecture', **also known as middle-out EA and light EA**, and set out definitions of the new approach.
>
> "The first key characteristic of the emergent approach is best summarized as 'architect the lines, not the boxes', which means managing the connections between different parts of the business rather than the actual parts of the business themselves," … "The second key characteristic is that it models all relationships as interactions via some set of interfaces, which can be completely informal and manual – for example, sending handwritten invitations to a party via postal letters – to highly formal and automated, such as credit-card transactions across the Visa network."
>
> Gartner has identified seven properties that differentiate emergent architecture from the traditional approach to EA:
>
> **1. Non-deterministic -** In the past, enterprise architects applied centralized decision-making to design outcomes. Using emergent architecture, they instead must decentralize decision-making to enable innovation.
>
> **2. Autonomous actors -** Enterprise architects can no longer control all aspects of architecture as they once did. They must now recognize the broader business ecosystem and devolve control to constituents.
>
> **3. Rule-bound actors -** Where in the past enterprise architects provided detailed design specifications for all aspects of the EA, they must now define a minimal set of rules and enable choice.
>
> **4. Goal-oriented actors -** Previously, the only goals that mattered were the corporate goals but this has now shifted to each constituent acting in their own best interests.
>
> **5. Local Influences:** Actors are influenced by local interactions and limited information. Feedback within their sphere of communication alters the behavior of individuals. No individual actor has data about all of an emergent system. EA must increasingly coordinate.
>
> **6. Dynamic or Adaptive Systems:** The system (the individual actors as well as the environment) changes over time. EA must design emergent systems sense and respond to changes in their environment.
>
> **7. Resource-Constrained Environment:** An environment of abundance does not enable emergence; rather, the scarcity of resources drives emergence.
>
> Gartner said that enterprise architects must be ready to embrace the inversion of control. Where in the past, they controlled all EA decision making, they must now accept that that business units demand more autonomy. For example, they must understand that employees

demand that they can use their personal devices, there is increased integration with partners and suppliers, customers demand access to information using the technology of their choice, and regulators require more information.

"The traditional top-down style worked well when applied to complex, fixed functions – that is, human artifacts, such as aircraft, ships, buildings, computers and even EA software," … "However, it works poorly when applied to an equally wide variety of domains because they do not behave in a predictable way. The traditional approach ends up constraining the ability of an emergent domain to change because it is never possible to predict – and architect for – all the possible avenues of evolution."

In summary, those members of INCOSE pursuing seemingly impossible goals of achieving what may seem like miracles of mission capability improvements, both of the incremental variety as well as paradigm shifts, especially in the government acquisition area, need to change their mindset. They should learn more about systems science, complex systems, systems thinking, trans-disciplinary techniques of psychology, sociology, organizational change, etc., and apply their new-founded knowledge in their domain areas utilizing CSE/EA. To help create conditions conducive for this mindset to thrive within INCOSE, proponents should try to do better in overcoming INCOSE's resistance to change, particularly through building organizational trust.

References

[Bloomberg, 2010] Bloomberg, Jason, "Scaling SOA with Complex Systems Engineering," *ZapFlash*, 11 February 2010, http://www.zapthink.com/2010/02/11/scaling-soa-with-complex-systems-engineering/#comments; also, refer to http://blogs.zdnet.com/Gardner/?p=3502

[Gartner, 2010] "Gartner Identifies New Approach for Enterprise Architecture,"
Analysts Explore 'Emergent Architecture' at Gartner Enterprise Architecture Summits 2009 in London and Orlando, Egham, UK, 11 August 2009

[INCOSE SE Hndbk, 2010] Haskins, Cecilia, Editor, "Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities," INCOSE-TP-2003-002-03.2, INCOSE Systems Engineering Handbook v. 3.2, International Council on Systems Engineering (INCOSE),7670 Opportunity Road, Suite 220, San Diego, CA 92111-222, January 2010

[SEPO, 2007] "Enterprise Architecture and ESE [Enterprise Systems Engineering]: Defining the Discipline," Issue of Systems Engineering Process Office (SEPO) *Collaborations*, Vol. 5, No. 1, The MITRE Corporation, June 2007, http://www.mitre.org/work/sepo/

[White, 2009] White, B. E., "Complex adaptive systems engineering," 3rd Annual IEEE International Systems Conference, Vancouver, British Columbia, Canada, 23-26 March 2009

[White, 2008] White, B. E., "Complex adaptive systems engineering," 8th Understanding Complex Systems Symposium, University of Illinois at Urbana-Champaign, IL. 12-15 May 2008; http://www.howhy.com/ucs2008/schedule.html

[ZapThink, 2010] http://www.zapthink.com/

INCOSE IS10 Panel Position Paper

Architecting the Enterprise: Is INCOSE up to the challenge?

by
Richard Martin
tinwisle@bloomington.in.us
04/04/2010

Since many INCOSE members are actively engaged in "architecting enterprises" or at least parts of enterprises, the obvious answer to this question should be, "Yes it is". However, since two of the relevant terms, architecting and enterprise, have very diverse meaning for those same members, there may in fact be little demonstrable capability for the architecting of an enterprise as particular members conceive the challenge. Without agreement on the scope of these two terms the answer to the panel question is a qualified "Maybe in some limited situations."

This less than satisfactory answer results from several years of following INCOSE participation in International Standards preparation and discussions of system and enterprise architecture at annual symposium and workshops. Some individual members are well versed in the many aspects of architecting the enterprise but there is little evidence that a consistent and convincing role for INCOSE is emerging. The emphasis seems focused on engineering the pieces of an enterprise and some of their most prominent interactions rather than on the whole system that is the enterprise. And when the Handbook considers enterprise in an organizational context limited to procurement, there is much missing from the core of "architecting the enterprise".

The architecture of an enterprise evolves in a more or less continuous manner over the duration of that enterprise, although tending to arise most significantly in early stages of enterprise formation. Limiting enterprise to procurement is one sure way to avoid a continuing effort. But architecting is a continuous process within my concept of an enterprise context that goes well beyond buying things. The concepts of enterprise, life time, life cycle and life history need to be better understood and expressed within the domain of system engineering before architecting the enterprise can be meaningfully discussed and substantive guidance given to INCOSE members.

While the line distinguishing architecting from other design activities is often difficult to identify, glossing over the need to distinguish architecting, particularly as it pertains to enterprises, from detailed enterprise specification and sub-system design does little to further professional practice. Most INCOSE members engineer solutions to problems resulting in detailed analysis and design specifications. While enterprise architects must understand and be familiar with such detail oriented activities, their effort is more intentional and global with respect to the enterprise. The Model-Based System Engineering effort should enable a better understanding of and capability to perform architecting of an enterprise since most architecting is about abstractly modeling

something that may or may not yet exist and adapting that model as the thing evolves in operation to meet new opportunities and circumstances.

Much of the current enterprise architecture focus remains bogged down in the Information Technology domain of network infrastructure and its off-shoot of net-centric computing applications. What is now being called "business architecture", that is considered by many to be beyond the domain of Information Technology and therefore not "engineered", is in actuality very much a part of the whole enterprise. INCOSE member experience with risk assessment, cost analysis, and non-functional specification, particularly as they are brought into the MBSE activities, should enable more capability and guidance in aligning system engineering practice with business needs resulting in more fully architecting the enterprise.

The majority of INCOSE members seem to be engaged in systems engineering for hardware and software intensive systems. In contrast, the enterprise is a socioeconomic entity where the dynamics brought by human intervention are an essential driver of outcomes. Recently more human factors discussions have emerged in INCOSE, a hopeful sign, but the need to focus on the architecting process rather than the enterprise product is still largely missing. The customary hierarchies of system engineering are that of component and sub-component. The hierarchies most important to architecting the enterprise are the abstractions that form the modeling concepts and models capable of articulating the human interactions that comprise the enterprise.

In January of 2008 a special two-day session occurred at the winter workshop where about 25 INCOSE members participated in a series of small group discussions to focus on a set of questions posed by the conveners of two ISO working groups with responsibility for International Standards related to the architecting of systems and enterprises. While much good discussion and presentation of ideas occurred, no statement of position or guidance from INCOSE has yet appeared. In fact it is difficult to find any impact that this workshop effort has had on INCOSE or its membership. Clearly INCOSE has not been up to the challenge of communicating the input it received from its member participants at this workshop event.

INCOSE members have also been active participants in the revision efforts those same ISO working groups are now conducting for their architecture related standards. And while those members have provided useful input, they have not had much impact in driving the architecture description standard from its software-intensive systems orientation toward a more useful description of architecture in the enterprise context – another challenge as yet not met.