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Delivering Systems in the Age of Globalization

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Book of Abstracts

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keynotes

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The Big Shift: Innovation and Systems Engineering

Langdon Morris (Senior Partner - INNOVATIONLABS LLC)

Presented on: Tuesday, 08:00-09:30

Keywords.

Abstract. We all know that the world economy is undergoing a major transition and things are feeling pretty rocky these days, but we’re not so sure what we’re transitioning to. If you’re like most people this is something you think about now and then, and probably worry about too, since so many aspects of our lives seem uncertain and filled with risk. In this talk Langdon Morris will present a new explanation of economic change and describe what could well be coming for our future. He will then discuss the important role that we, the worldwide community of systems engineers, will play in dealing with some of the major opportunities and challenges that humanity faces. Thus, the key question that Langdon will address is, How will we cope with and succeed in a world that is becoming progressively more complex and more tightly interconnected, in order to create our preferred future?

Biography

Langdon Morris (Senior Partner - INNOVATIONLABS LLC)
Langdon Morris is co-founder and Senior Partner at InnovationLabs LLC, and leads the firm's global innovation consulting practice for a wide variety of clients in business, government, and the non-profit sector. His work focuses on developing and applying advanced methods in innovation and strategy to solve complex problems with very high levels of creativity. He is recognized as one of the world's leading thinkers and consultants on innovation, and his original and ground-breaking work has been adopted by corporations and universities on every continent to help them improve their innovation processes and the results they achieve. His breakthrough white paper, Business Model Warfare is a landmark in the field, and is used as a standard reference at universities and corporations worldwide. His book Fourth Generation R&D, coauthored with William L. Miller, is considered a classic in the field of R&D management, and his more recent books The Innovation Master Plan and Permanent Innovation are recognized among the leading innovation books of the last 5 years. Langdon is the author, co-author, or editor of ten acclaimed books on Strategy and Innovation, with editions in Chinese (traditional and simplified), Japanese, Korean, and French. (More book projects are on the way.)

Papers

Papers#107

A Framework for Concept and its Testing on Patents

Yaroslav Menshenin (Skolkovo Institute of Science and Technology) - y.menshenin@skoltech.ru
Edward Crawley (Massachusetts Institute of Technology) - crawley@mit.edu

Presented on: Thursday, 10:00-10:40

Keywords. concept; concept framework; concept theory; patents; model-based conceptual design; #Academia; #MBSE

Abstract. The development of a concept for a system is a key step towards creating the system's architecture. Most previous concept development approaches focus on the procedures for the conceptual design activity - the sequence of activities and tasks. Our work is motivated by the desire to move the activities executed in a Concurrent Design Facility more upstream, in order to include choices and trade-offs among potential system concepts in a digital environment. Therefore, the objective of this work is to develop a concept framework that can systematically represent the concept's constituents, their definitions and interconnections, such that it can be used in a computational environment. We propose a concept framework that is based on six assertions rooted in design theory, that lead to 33 entries in the framework. In order to test the completeness and utility of this framework, we have mapped eight selected US patents to the framework. Patents are a legally viable means for defending an invention, and therefore the patents must logically contain a description of the concept underlying the invention. For this small N study, we chose eight US patents that represent a broad spectrum of engineering systems and methods. The success of this mapping from patents to the proposed concept framework is a necessary condition to demonstrating the completeness and utility of the framework.

Papers#75

A Framework for Testability Analysis from System Architecture Perspective

Mahmoud Efatmaneshnik (UNSW-Canberra) - m.efatmaneshnik@adfa.edu.au
Michael Ryan (UNSW - ADFA) - m.ryan@adfa.edu.au
Sharaga Shoval (Ariel University) - shraga@ariel.ac.il

Presented on: Tuesday, 16:15-16:55

Keywords. Testability; Unit testing; Testing architecture; Markov chains

Abstract. In this paper, we study the effects of system architecture on testability. We present a probabilistic model of testability that enables us to study the relationships between system architecture and testability. A Markov Chain model is used to obtain the quality of system after test as a function of its quality before test and the test quality. In particular, we focus on the costs and benefits associated with the modularization for testability. We show that choosing the appropriate testing architecture through careful modularization can greatly enhance efficiency and effectiveness of system testing. The model is based on repetitive testing that means the test will be repeated after a fail test outcome.

Papers#128

A Framework for Understanding Systems Principles and Methods

David Rousseau (Centre for Systems Philosophy) - david.rousseau@systemsphilosophy.org

Presented on: Wednesday, 13:30-14:10

Keywords. General Systems Theory; GST; Systemology; scientific principles; Systems Philosophy; systems principles; #Academia

Abstract. Systems Engineering is increasingly challenged by the rising complexity of projects undertaken, resulting in increases in costs, failure rates and negative unintended consequences. This has resulted in calls for more scientific principles to underpin the methods of Systems Engineering. In this paper, it is argued that our ability to improve Systems Engineering's methods depends on making the principles of Systemology, of which Systems Engineering is a part, more diverse and more scientific. An architecture for Systemology is introduced, which shows how the principles of Systemology arise from interdependent processes spanning multiple disciplinary fields, and on this basis a typology is introduced, which can be used to classify systems principles and systems methods, This framework, consisting of an architecture and a typology, can be used to survey and classify the principles and methods currently in use in Systemology, map vocabularies referring to them, identify key gaps, and expose opportunities for further development. It may thus serve as a tool for coordinating collaborative work towards advancing the scope and depth of Systemology.

Papers#31

A fresh look at Systems Engineering - what is it, how should it work?

Hillary Sillitto (Sillitto Enterprises) - hillary.sillitto@blueyonder.co.uk
James Martin (Aerospace Corporation) - martinqzx@gmail.com
Dorothy Mckinney (ConsideredThoughtfully) - dorothy.mckinney@computer.org
Dov Dori (Technion, MIT) - dori@technion.ac.il
Regina Griego - griegor@sandia.gov
Eileen Arnold (ConsideredThoughtfully) - eparnold5@aol.com
Patrick Godfrey (University of Bristol) - Patrick.godfrey@bristol.ac.uk
Daniel Krob (CESAMES) - krob@noos.fr
Scott Jackson (Burnham Systems) - scott.jackson@incose.org

Presented on: Wednesday, 10:00-10:40

Keywords. Definition of Systems Engineering; Evolutionary systems; Paradigm shift; #Academia

Abstract. INCOSE's definition of SE was compared to the aspirations set out in SE Vision 2025 for SE as it ought to be to address modern challenges. Doing this led us to three fundamental realisations. First, while "20th century systems" were, for the most part, "deterministic" or nearly so, 21st century systems are on the other hand increasingly non-deterministic, adaptive or "evolutionary". Second, while "20th Century Systems Engineering Management" was implicitly based on a "command and control" paradigm, 21st Century Systems Engineering, to be successful, will usually need to use a more collaborative leadership paradigm. And third, that while 20th Century systems were largely "single systems", designed to "solve" specific problems, 21st Century systems are almost invariably networked, and are parts of complex extended enterprises with multiple, often conflicting, stakeholder objectives, that are intimately related to complex societal challenges. We used elements of Soft Systems Methodology (SSM) to understand the implication and consequences of the paradigm shift implied by these realisations. A revised strawman definition of Systems Engineering is offered for consideration by INCOSE, showing the changes that would be required to take these and related factors into account.

Papers#35

A Hybrid Liver-Candidate Transportation System to Improve Accessibility and Extend Organ Life in Liver Transplantation

Rajesh Ganesan (George Mason University) - rganesan@gmu.edu
Wen-Chi Hung (Univeristy of California, Davis) - wenhung@ucdavis.edu
Tzu-Yi Peng (Trendforce Corp.) - mel.peng@trendforce.com
Chun-Hung Chen (George Mason University) - cchen9@gmu.edu
Naoru Koizumi (George Mason University) - nkoizumi@gmu.edu

Presented on: Wednesday, 14:15-14:55

Keywords. Cold Ischemia Time (CIT); Liver transplant and Optimization; Simulation; UNOS; #Industry; #Healthcare

Abstract. In the USA, access to liver transplant is determined by the geographical organ allocation boundaries. The current allocation system involves a three-tier hierarchical boundary system consisting of Organ Procurement Organization (OPO), the United Network for Organ Sharing (UNOS), and the National (USA) boundary. The search for a matching candidate when a liver is available begins within OPOs and moves up to the UNOS and National levels. The boundary-based allocation system results in several issues such as geographical disparity in access, long system waiting times, liver wastages, high post-graft failure, and prioritization of less severe candidates that live close to a transplant center over more needy ones from farther away. The paper investigates the conflict between attempts that reduce geographical disparity and those that optimize organ life (results in geographical disparity) through the application of Modeling and Simulation (M&S) to System Engineering. To resolve the above conflict, the paper presents the system architecture of a new hybrid liver-candidate transport system instead of a liver-only transport system, and uses discrete event simulation to model and validate the new system.

Papers#55

A Novel “Resilience Viewpoint” to aid in Engineering Resilience in Systems of Systems (SoS)

Demetrios Joannou (Loughborough University) - d.joannou2@lboro.ac.uk
Roy Kalawsky (Loughborough University) - r.s.kalawsky@lboro.ac.uk

Presented on: Wednesday, 10:00-10:40

Keywords. Resilience; Resilience Engineering; Systems of Systems; Systems Engineering; Model-Based Systems Engineering; Architecture; Architecture Frameworks; #RisksComplex

Abstract. Designing evolutionary systems to meet stakeholder expectations on safety, reliability and overall resilience is of great importance in an age of interconnectivity and high dependency systems. With incidents and disruptions becoming more frequent in recent years, the requirement for systems to demonstrate high levels of resilience given the economic, political and temporal dimensions of complexity, resilience is of great significance today. Systemic resilience is of high importance at the global level. Therefore, the role of the system engineer and architect is becoming more demanding due to the need to consider requirements from a broader range of stakeholders and to implement them into early conceptual designs. The early modeling process of all systems is common ground for most engineering projects, creating an architecture to both understand a system and to design future iterations by applying model-based processes has become the norm. With the concept of systems-ofsystems (SoS) becoming common language across multiple engineering domains, model-based systems engineering techniques are evolving hand-in-hand to provide a paradigm to better analyse current and future SoS. The intrinsic characteristics of the constituent systems that make up the SoS make the challenge of designing and maintaining the reliability and resilience of a systems extremely difficult. This paper proposes a novel viewpoint, within an architecture framework (based around DoDAF, MoDAF and UPDM) to aid systems architects explore and design resilient SoS. This is known as the Resilience Viewpoint. Much of the research in the area is focussed on critical infrastructure (CI), looking at telecommunication networks, electric grid, supply networks etc, and little has been done on a generalizable tool for SoS architecture analysis, especially using existing modeling languages. Here, the application of the ‘Resilience Viewpoint’ is demonstrated using a case study from an integrated water supply system of systems, to portray its potential analytical capabilities.

A successful use of systems approaches in crossdisciplinary healthcare improvement

Julian Johnson (Holistem Ltd) - julian.johnson@holistem.co.uk
Fran Beck (NHS) - fran.beck1@nhs.net
Gary Smith (Airbus) - gary.r.smith@airbus.com
Alan Harding (BAE SYSTEMS) - alan.d.harding@baesystems.com

Presented on: Wednesday, 10:00-10:40

Keywords. systems thinking; process improvement; healthcare; NHS; conceptualisation; systems of systems; #Industry; #Healthcare

Abstract. UK Healthcare is facing many different trends: a changing demographic of an ageing and ‘frail’ population; increasing numbers of the population living with at least two long term conditions; improvements in medical care and interventions which can treat a larger number of conditions; continued budget pressures and raising expectations. Healthcare is a complex socio-technical system, and to identify and devise interventions with clear net benefits is a challenge: we see a classic ‘wicked problem’. The outcome from three INCOSE-facilitated multi-disciplinary workshops was a coherent prioritised work programme, with buy-in from all stakeholders, and traceable back to original issues and opportunities. This presentation will explain the context, the engagement from INCOSE, the nature of the workshops and techniques applied, and the outcomes. The developed programme supports the Shropshire and Telford NHS Sustainability and Transformation Plan (STP). Arguably the biggest ongoing challenge remains handling complexity and coherence across multiple stakeholder perspectives.

Papers#165

Adaptive Cyber-Physical-Human Systems: Exploiting Cognitive Modeling and Machine Learning in the Control Loop

Azad Madni (Viterbi School of Engineering, University of Southern California) - azad.madni@usc.edu
Michael Sievers (Viterbi School of Engineering, University of Southern California) - Michael.Sievers@usc.edu
Carla Conaway Madni (Intelligent Systems Technology, Inc.) - CMadni@intelsystech.com

Presented on: Wednesday, 14:15-14:55

Keywords. cyber-physical-human systems; mutual adaptation; machine learning; Internet of Things; cognitive limitations; human-technology integration; #Automotive

Abstract. Cyber-Physical-Human (CPH) Systems are purposeful arrangements of sensors, computers, communication devices, and humans to perform tasks that achieve specific mission objectives. These systems typically allow other systems, devices, and data streams to connect/disconnect as needed during mission execution. The roles of humans in CPH systems are quite varied. In adaptive CPH systems, humans collaborate with the cyber-physical elements to jointly accomplish tasks, and adapt to changing contexts to accomplish mission goals. Mutual adaptation based on prior knowledge, cognitive modeling, and online machine learning are key characteristics of adaptive CPH systems. This paper presents key challenges in realizing adaptive CPH systems. It discusses learning and adaptation, as well as human and CPS roles in adaptive CPH systems. It offers a functional (reference) architecture to inform and guide the development of adaptive CPH systems. It concludes with a discussion of research needed to advance the state-of-the-art of adaptive CPH systems.

Addressing the Sub-Saharan African Corridor Dilemma - A Systems Methodology

Nic Cloete-Hopkins (Wits TCSE) - nic.cloete-hopkins@wits.ac.za
Beatrys Lacquet (Wits TCSE) - beatrys.lacquet@wits.ac.za

Presented on: Thursday, 10:45-11:25

Keywords. Systems; Systems Engineering; Systems Thinking; System Dynamics; System of Systems / Super-System; Viable Systems Model; Freight Transportation; Economics; Sustainability; #Industry

Abstract. This paper explores the freight transportation system-of-interest as an enabler of the Sub-Saharan African (SSA) super-system. It does not offer a 'magic bullet' solution to reduce the complexity of freight transportation, but rather allows the reader to concentrate on the 'big picture' or 'systems view of the world' taking account of multiple perspectives in problem solving, decision making and/or contingency planning. It notes the need for the freight transportation in 'transforming our world'; thereby providing a consistent enabler towards all the United Nations Sustainable Development Goals (2030) and the aspirations set out in the African Union's Agenda 2063: The 'Africa We Want' in developing a sustainable SSA super-system. Unfortunately, as highlighted by the economic and trade indicators, the system elements and their functions need to be reviewed to bring about sustainable development. That is the desired emergent properties of the SSA super-system rather than having unforeseen and unwanted emergent properties like the economic downturn not forecast in 2010. It was projected in The Economist's article, based on IMF 2010 forecasts that from 2011 to 2015 'the average African economy will outpace its Asian counterpart.' These indicators relevant to trade and logistics for SSA were compared with the following Comparative Analytical Groups: Emerging and Developing Asia and Europe, and Major Advanced Economies (G7). Key features that emanated from this paper include an imbalance in gross exports by product category in these groups as is seemingly incentivised by the pit-to-port layout and structure of the freight transportation system in SSA. Furthermore, there seems to be a lack of functional and interface definition between parties identified in the Viable Systems Model developed from the various viewpoints from the architectural framework. The Viable Systems Model, in context of the systems paradigm provides an integrated systems methodology for an integrated system in addressing the SSA Corridor Dilemma' or is it an Opportunity? The systems methodology provides an integrated approach to a given situation. By adopting the systems methodology, one could potentially reinforce a common understanding, vision, goals and objectives and work across boundaries of all kinds, creating fertile environments not only for one stakeholder, but across all stakeholders within the containing environment. It is a proposed mind-set about an integrated SSA super-system.

Papers#34

An Analytic Model of Success for Information Technology Decision Making

T.M. Clemons, III (George Mason University) - tclemons@gmu.edu
KC Chang (George Mason University) - kchang@gmu.edu
Sean Tzeng (George Mason University) - sean.tzeng@outlook.com

Presented on: Tuesday, 16:15-16:55

Keywords. ITIL; IT; Decision Making; Bayesian Network

Abstract. To assist managers in monitoring the progress of their IT programs, we propose a Bayesian Network stochastic model, the IT Decision Management System (ITDMS), to simulate the evidence observations, complex interrelationships, and the dynamic/temporal relationships. Based on the the Information Technology Infrastructure Library (ITIL)® The model aligns the sub-process of each ITIL Phase in a Bayesian structure measuring status to provide the decision maker a measurement of the likelihood of program success during that phase of the program.

Papers#171

An Austere SoS Integration Assurance Methodology

Stephen Cook (Shoal Engineering) - stephen.cook@shoalgroup.com
Mark Unewisse (DST Group, Department of Defence) - Mark.Unewisse@dst.defence.gov.au

Presented on: Tuesday, 15:30-16:10

Keywords. Systems of systems engineering; Integration and interoperability; System assurance; #Government

Abstract. This paper outlines the development of a Program Integration and Interoperability Assessment (Program I2A) methodology. The methodology underpins integration and interoperability (I2) assurance through a system-of-systems engineering assessment approach used to undertake Program capability design, realization and management, and examination of the key artefacts. A scorecard approach was designed for the Program I2A. The methodology was tested on a complex Defence capability (Integrated Air and Missile Defence) and from the lessons learnt it was refined to generate the Program I2A methodology described in this paper. A notable feature of the methodology is that it inherently facilitates the delivery of a force that will be joint and integrated by design. In particular, it provides senior decision-makers with evidence to gauge the effectiveness of the emerging Program and force-level (SoS) approaches. In doing so it lays the foundations for a mechanism to facilitate the cultural changes needed to establish a joint-by-design approach to delivering integrated force capabilities.

Papers#91

An Empirical Case Study of Problem Structuring in the Use of Generic Architectures

James McLean (MOD - Defence Equipment & Support) - james_mclean_85@hotmail.co.uk
Dawn Gilbert (MOD - Defence Equipment & Support) - dawnpgilbert@gmail.com

Presented on: Monday, 15:30-16:10

Keywords. Case Study; Generic Architecture; Problem Structuring; #Government

Abstract. An empirical case study is presented which details a problem structuring activity facilitated by the United Kingdom (UK) Ministry of Defence (MOD) Internal Technical Support - Systems Engineering Team with the UK MOD Generic Vehicle Architecture (GVA) team. The body of literature reviewed identified an absence of specific guidance, or description of practical experience, in applying generic architectures to manage system change. The problem structuring activity allowed the GVA team to better understand the nature of the problem they faced, and to identify a means to effectively progress the issue. This case study is offered for consideration as the description of the problem situation may resonate with the reader, and to provoke thought on the methods used in selecting systems engineering methods to use in practice.

Papers#53

Application of a System Engineering Framework to the Subsea Front-End Engineering study

Siv Engen (University College of Southeast Norway) - siv.engen@gmail.com
Kristin Falk (University College of Southeast Norway) - Kristin.falk@usn.no

Presented on: Monday, 10:00-10:40

Keywords. Early-phase needs; System Engineering Framework; Modelling and arcitechture; Subsea industry; Oil and gas industry; #Industry

Abstract. This article applies formal system engineering methods in early-phase concept studies in the subsea oil and gas industry to identify early-phase
needs, and reduce late-phase design changes. The oil industry is changing, demanding more cost efficient, flexible, and modularized systems. In
order to improve their offering, suppliers within this industry are turning towards the systems engineering domain. To better understand the problem, we investigated the engineering processes at the supplier, went into details of technical project reports, and interviewed main stakeholders at the supplier. Based on our research we propose to adjust the early phase of the project execution process for the company, and adapt to a system engineering framework. At an early stage we recommend using unformal models to communicate decisions and to set up a foundation for applying more formal models in the later phases. A case study from field development illustrates the new process and methods. Some of these systems engineering methods have already been adopted in the company to improve the front-end engineering studies.

Papers#102

Application of the Model Based Systems Engineering Approach for Modern Warship Design

Massimiliano Manfredi (Fincantieri) - massimiliano.manfredi@fincantieri.it
Lucio Tirone (Aster) - lucio.tirone@aster-te.it

Presented on: Tuesday, 10:00-10:40

Keywords. Whole Warship; Warship Design; Naval Vessels; MBSE; NAF; #Government

Abstract. Modern surface combatants (hereafter considered as “systems-of-interest”) must accomplish a wide variety of missions, ranging from merely military, patrolling and constabulary roles to civil defense ones: the operational scenarios are much more complex than just a few years ago, and require that the whole warship is defined through deep configuration analyses, capable of simulating the effective theatres and leading towards the definition of the best fit for purpose solutions. This paper describes the Model Based Systems Engineering (MBSE) approach employed by Fincantieri for the definition and analysis of the whole warship level architecture, starting from mission analyses, and generating NATO Architecture Framework (NAF) based engineering views to describe the response provided by the system-of-interest, represented – in this specific case – by the new first line Anti-Submarine Warfare (ASW) surface combat units for Royal Australian Navy’s (RAN) SEA5000 program. Many benefits derive from the implementation of the MBSE/NAF approach (such as the continuous traceability among the different domains of the architecture, the optimization of communications between customer and supplier, and a solid support for the verification of the Whole Warship performance), as discussed in the following chapters, and summarized in the conclusions.
The system offered to RAN strictly derives from a consolidated system of success, which is currently employed by the Italian Navy (Marina Militare Italiana – MMI) in inter-forces NATO missions: Fincantieri has in fact identified the Italian FREMM (European Multi-Mission Frigate; Italian: FRegata Europea Multi-Missione) ASW class frigate as the optimal reference ship, which can be suitably tuned to achieve the goals intended by the customer in the new operational environment.

Papers#72

Applying Systems Engineering Early

Allison Ruggiero (MTA New York City Transit) - aarugg@gmail.com
William Gleckler (MTA New York City Transit) - William.Gleckler@nyct.com

Presented on: Thursday, 11:30-12:10

Keywords. processes; Concept of Operations; Functions-based Systems Engineering; Concept Definition; Requirements Engineering; system requirements development; #Academia

Abstract. Applying systems engineering early-on in the project lifecycle results in better understanding of the problem space, definition of solution concepts, and business impacts when using a User-Centric and scenario-based operational analysis approach for Concept of Operations (ConOps) document development which provides a stronger foundation for system requirements development. Additionally, implementing a functions-based approach for system requirements provides a clearer definition of the functions to be performed by the new system to satisfy the business and stakeholder requirements.

Anonymous-Agency Systems Engineering has identified a need to shift the focus from detailed, product-centric design to a broader system viewpoint by developing guidelines describing how to perform Stakeholder and Operational Analysis, develop ConOps documents, and apply a FunctionsBased Systems Engineering Method. This paper describes the systems engineering methods applied during Concept Definition and Design Phases on three project case studies, circumstances under which they were applied, lessons learned and benefits of their application.

Papers#167

Architecting Disruptive Digital Product-Service Systems

Anand Kumar (Tata Research Development and Design Centre) - anand.ar@tcs.com
Doji Samson Lokku (Tata Consultancy Services Ltd) - doji.lokku@tcs.com
Swaminathan Natarajan (Tata Consultancy Services) - swami.n@tcs.com
Kesav Vithal Nori (IIIT Hyderabad) - kesav.nori@gmail.com

Presented on: Wednesday, 16:15-16:55

Keywords. Disruptive systemsDigital TechnologiesCustomer experienceDigital product-service systemsArchitectureDigitizationDigital TransformationDigital Reimagination

Abstract. Currently, the context in which systems are architected, developed, delivered and experienced has changed. Advances in digital technologies are leading to revolutionary productservice systems and changing the landscape of businesses. Increasingly, such Digital product-service systems are at the forefront of globalization. Their proliferation has been substantial considering the rate of adoption by the masses. These systems have transformed social interactions, customer relationships, and have reshaped the ability to access and leverage information for the benefit of the stakeholders. They deal with products, services and interconnected, global systems that interact with multiple role players across multiple geographies, addressing multiple concerns of stakeholders across multiple disciplines by utilizing digital technologies in a dynamic and challenging environment while providing near real time response and rich customer experience. The challenge for the architects of these systems is to consistently and repeatedly disrupt the status quo without compromising on the quality of the offering and the value delivered to stakeholders. In this paper, an approach to architect such disruptive systems is presented. As an exemplar, the architecture for a digital product-services system that enables senior care is illustrated in this paper.

Papers#83

Architecture Design of Nuclear Power Plants Systems through Viewpoints-based Systems Analysis

Juan Navas (Thales Corporate Engineering) - jnavas.research@gmail.com
Philippe Tannery (Framatome) - philippe.tannery@framatome.com
Stephane Bonnet (Thales Corporate Engineering) - stephane.bonnet@thalesgroup.com
Jean-Luc Voirin (Thales Technical Directorate) - jean-luc.voirin@fr.thalesgroup.com

Presented on: Wednesday, 14:15-14:55

Keywords. Nuclear Power Plants; Nuclear Engineering; Systems Engineering; Model-Based Systems Engineering; Arcadia; Capella; #PowerEnergy

Abstract. This paper presents a method to perform the architecture definition and design of Nuclear Power Plants (NPP) systems. This method is based on the viewpoints concept and on an existing Model-Based Systems Engineering (MBSE) approach that was tailored to address the complexity factors of NPP engineering, progressively guarantee the comprehensiveness of the design and facilitate the safety assessment. This paper also provides an illustration of how this method was applied to define the architecture of a Nuclear Island system, provides valuable findings for the designer organization regarding the deployment of MBSE approaches and presents their key benefits and future improvement actions.

"Changing the Acquisition Game": Alleviating Unreasonable PM-SE Constraint Risks

Charles Wasson (Wasson Strategics, LLC) - wsle@cpws.net
Colin Neill (The Pennsylvania State University) - cjn6@psu.edu
Heidi Hahn (Los Alamos National Laboratory) - hahn@lanl.gov
Allison Weigel (Toray Composite Materials America, Inc.) - Allison.Weigel@toraycma.com
Tony Lindeman (Jacobs Technology, Inc.) - tony.lindeman@nasa.gov

Presented on: Monday, 14:15-14:55

Keywords. Project Management; Strategic Technical Management; Systems Engineering Effectiveness; Systems Acquisitions; #Government

Abstract. Poor project performance is often attributed erroneously to PMs and SEs that must perform in an environment characterized by:
1 Inadequate proposal preparation and analytical due diligence in understanding the user's problem space and operational needs.
2 Unrealistic proposal assumptions and contract constraints – such as overly aggressive schedules and inadequate funding.
3 A Source Selection Evaluation Process that is overshadowed by a highly competitive "Acquisition Game" of perceptions, influence, persuasion, and potential conflicts of interest.
4 Project Management and Engineering "stovepipes" that limit understanding of each other's roles, accountabilities, and their respective contributions.
5 Contract "requirements creep" by the Acquirer with an expectation or Developer accommodation without appropriate contract cost modification.
6 Deficiencies in Engineering and Systems Engineering due to outdated educational and competency paradigms.
As a result of unreasonable and unrealistic constraints by the "game" conditions, no one really wins - the User, the Acquirer, the Developer, or supporting subcontractors and vendors. Indeed, upon contract award, the project conundrum becomes: "Good news! We won the contract … Bad news. We won the contract!" Project Managers and Systems Engineers are then burdened with the impossible task of achieving contract financial, technical, and schedule "stretch" objectives in which they may have had little opportunity for input.
This paper explores each of these conditions, through illustrative examples from a range of business domains and industries perspectives, along with potential opportunities for improvement so that, fundamentally, the game itself is changed – changed to one that can be won.

Papers#123

Barrier Analysis of an Aviation Safety Assessment Model

Seungwon Noh (George Mason University) - snoh2@gmu.edu
John Shortle (George Mason University) - jshortle@gmu.edu

Presented on: Tuesday, 13:30-14:10

Keywords. Aviation safety; Barriers; System safety; #RisksComplex

Abstract. In a highly reliable system, barriers can be used to reduce the risk of high consequence events. This paper identifies and evaluates barriers within a large safety model of the National Airspace System. The model contains thousands of nodes, so a heuristic procedure is proposed to automatically identify candidate barriers in the model. A case study of a single accident scenario is presented to show how the heuristic works and then subsequently how component elements of each barrier function are identified. An overall analysis is presented showing the distribution of barriers throughout the model and their overall effectiveness. No obvious trend is identified relating the number of barriers to the rarity of a given accident scenario.

Papers#20

Breaking Casandra's Curse: Understanding Unsafe Mental Models to Build a Safe Systems Engineering Culture

Duncan Kemp (UK MOD) - duncan@17media.co.uk
Meaghan O'Neil (Bigfoot Biomedical) - meaghan.oneil@gmail.com

Presented on: Tuesday, 10:00-10:40

Keywords. Safety; Systems; Mental models; Culture; #RisksComplex; #Healthcare

Abstract. Modern safety management practice is a robust and generally effective discipline. Most modern accidents in complex systems are due to poor safety culture undermining a robust safety management approach. This paper examines the challenge of improving safety culture in the design, development and operation of complex systems. Based upon the authors' experience in defence, aerospace, transportation, information services and healthcare, this paper describes 18 mental models that can undermine the organisations safety management system.
The paper describes 5 underpinning factors that lead to these incorrect mental models. It also describes an approach to persuading key decision makers to adopt a safer approach.

Papers#146

Case Study: Agile Systems Engineering at Lockheed Martin Aeronautics Integrated Fighter Group

Rick Dove (Paradigm Shift International) - dove@parshift.com
William Schindel (ICTT System Sciences) - schindel@ictt.com
Ken Garlington (Lockeed Martin) - kennie.e.garlington@lmco.com

Presented on: Monday, 15:30-16:10

Keywords. agile systems engineering; information debt; process instrumentation; system of innovation; ASELCM pattern; Agile System Engineering Life Cycle Model; #Government

Abstract. The Lockheed Martin Aeronautics Integrated Fighter Group (IFG), in Fort Worth, Texas, was motivated to move to an agile system engineering (SE) development methodology by the need to meet urgent defense needs for faster-changing threat situations. IFG has and is tailoring a baseline Scaled Agile Framework (SAFe ®) systems engineering process for a portfolio of mixed hardware/software aircraft weapon system extensions, involving some 1,200 people in the process from executives, through managers, to developers. Process analysis in October 2015 reviewed two years of transformation experience, updated in this article to 2017 status. Notably, the SE process is facilitated by a transformation to an Open System Architecture aircraft-system infrastructure, enabling reusable cross platform component technologies and facilitating faster response to new system needs. The process synchronizes internal tempo-based development intervals with an external mixture of agile/waterfall subcontractor development processes. This article emphasizes the manifestation of agility as the purpose and outcome of an embedded system of innovation, and introduces concepts of information debt, process instrumentation, and a preliminary systems integration lab for early customer demonstrations and discovery of potential difficulties.

Papers#104

Case Study: Application of DoD Architecture Framework to Characterizing a Hospital Emergency Department as the Intended Use Environment for Medical Devices

Robert Malins (Eagle Summit Technology Associates, Inc.) - rjmalins@eaglesummittech.com

Presented on: Wednesday, 10:45-11:25

Keywords. healthcare; medical devices; architecture frameworks; usability; interoperability; #Industry; #Healthcare

Abstract. This paper presents a case study by the Biomedical-Healthcare Model-Based Systems Engineering (MBSE) Challenge Team in response to inputs received during workshops held at the 2015 and 2016 INCOSE International Workshops. At IW2015 and IW2016, the Challenge Team held workshops, including clinicians and systems engineers, to assess potential contributions of systems engineering, and MBSE, to clinical operations. At these workshops it was claimed that clinical operations were too complex to be modeled with existing MBSE tools from defense and aerospace. It was further claimed that there would be very limited value to MBSE products. Based on these claims, the MBSE Challenge team undertook several case studies to evaluate the ability of MBSE tools to represent clinical operations and to address problems relevant to healthcare. This paper describes the outcomes of applying one MBSE tool, the DoD Architecture Framework, to characterize clinical operations as the intended use environment for medical devices.

Papers#38

Communicating Requirements - Effectively!

Louis S. Wheatcraft (Seilevel) - louw@reqexperts.com
Michael J. Ryan (UNSW Canberra) - m.ryan@adfa.edu.au

Presented on: Tuesday, 14:15-14:55

Keywords. communication theory; communicating requirement; writing requirements; requirements; text-based requirements; Agile; #Healthcare; #Automotive; #PowerEnergy

Abstract. Requirements are the language we use to communicate stakeholder needs for a system of interest to developers, designers, builders, coders, testers, and other stakeholders. Increasingly, there is debate about which means (form and media) of communications is best for communicating requirements and sets of requirements. As part of this debate, one means of communication (such as diagrams, use cases, or text-based) is often advocated (with a lot of passion in many cases) over the other means of communication. Which side is taken in the debate depends on the specific idea or concept being communicated together with the domain, culture, people, and processes used within the specific organization. Consequently, there is no single "best" means of communication that applies to all the various types of requirements. Each means of communication has its strengths and weaknesses depending on which message is being communicated, who the sender is, who the receiver is, the needs of the receiver, and the filters used by both the sender to encode the message and the receiver who must decode the message. This paper goes back to the basics of communication theory to address this debate and concludes that, while each means of communication has value, no single means is sufficient to clearly, completely, and consistently communicate all of the various types and categories of requirements. Each of the means advocated represent a visualization (graphic or text) of the system from a perspective based on the intent of the message being communicated. With this viewpoint, rather than focusing on a single type of visualization, a set of visualizations is needed to effectively communicate requirements. This set of visualizations needs to be based on an underlying, integrated data and information model of the system of interest.

Papers#37

Composing Complex Capability: The Stakeholder Driven Development Framework

Les Vencel (VCORP Consulting) - ljv@internode.on.net
Elizabeth Sweetman (Defence Science and Technology Group) - elizabeth.sweetman@dst.defence.gov.au
Norman Lante (GovernIT) - norman.lante@dst.defence.gov.au

Presented on: Thursday, 10:00-10:40

Keywords. Composing Complex Capability; Systems Thinking; Multi worldviews; Multi methodologies; #RisksComplex

Abstract. The National Security and Intelligence, Surveillance and Reconnaissance Division (NSID) of the Defence Science and Technology Group (DST Group) is involved in the research, development and fielding of program strategies to grow complex capabilities in support of Integrated ISR. More recently, NSID has developed a framework of ideas, stratagems and methodologies aimed at composing complex capability. This framework, termed the Stakeholder Driven Development Framework (SDDF), allows incremental growth of complex capabilities in a measured and balanced manner; "measured" in terms of having a regard for progressive and stable growth of realisable aspects of the complex capability and "balanced" to reflect the risk based facilitation processes between stakeholder priorities and program complexities. It is based on a set of foundational principles that provide the rules of practice for complex capability development. The SDDF utilises systems thinking, is tightly coupled with stakeholder interaction and comprises progressive cycles of analysis, synthesis and assessment. It analyses the problem space from different worldviews, thereby providing a more comprehensive understanding from which to select a mix of methodologies to synthesise solution options. The aim is to deliver stakeholder mediated and facilitated candidate solutions.

Creating and Applying A3 Architecture Overviews: A Case Study in Software Development

Anders Viken - anders.viken@hotmail.com
Gerrit Muller (HSN-TMN-NISE) - gerrit.muller@gmail.com

Presented on: Tuesday, 10:45-11:25

Keywords. A3; Architecture Overview; software development; #Government

Abstract. We observed in our company that the commissioning phases of projects were inefficient when it came to effort, measured in hours. In order to meet this challenge, the management team decided to create a software program that would enable shipyard engineers to perform software changes by themselves directly in the automation systems. By enabling shipyard engineers, the goal is to save valuable person-hours on each commissioning phase.
The A3 report is a tool that can be used in most problem-solving situations. It can be used both as a way of structuring thinking and as a tool for communication and learning. After Toyota's success of using it as a tool for problem solving and report writing, many other domains have adopted the A3 report as a structured problem-solving approach.
In this study, the author explains how A3 reports can facilitate validation and communication during system design of a software program. During software development, the project team used the A3 reports when discussing the software internally and with stakeholders. Observations recorded during this study indicate that the A3 report is a valuable tool for sharing ideas and capturing feedback, both in planned and spontaneous sessions. This study also explains how the format of the A3 report can encourage reading and writing of documentation in hectic industrial settings.

Papers#115

Creating Decision Guidance for Applying Agile System Engineering

Ron Lyells (Honeywell - Retired) - rlyells@aol.com
Rock Angier (IBM - Retired) - rangier@mindspring.com
Bob Epps (Lockheed Martin Corporation- Retired) - repps999@aol.com

Presented on: Tuesday, 14:15-14:55

Keywords. Agile; Guidance; Decision Guidance; Agile SE; OODA; #Industry

Abstract. Systems teams, development projects, and organizations, who are involved in product development, are often faced with the question as to whether they should adapt agile systems practices into their programs and processes. In trying to answer this question these groups are almost immediately confronted with the problem of determining what is motivating the decision, where should agile principles be applied, and how much agility is necessary. There are several interrelated systems involved in this inquiry and the development of a proper understanding around these considerations is not a trivial exercise. A method of inquiry and decision making that is in itself agile and that can produce actionable results needs to guide the development of this understanding. The purpose of this paper is to present work accomplished to date on the definition, prototyping, and evaluation of a decision guidance system to help a development team or organization achieve a necessary understanding that can lead to useful actionable decisions regarding agile adoption.

Papers#178

Decomposing Complex Problems Using Influential Attribute Network Graphs

Garret Fitzpatrick (Shell TechWorks) - gfitzpatrick@shelltechworks.com
Ian Monk (Shell TechWorks) - imonk@shelltechworks.com

Presented on: Monday, 11:30-12:10

Keywords. complex systems; problem definition; business analysis; visualization; graph; influence diagram; #Industry; #PowerEnergy

Abstract. The deployment of new technologies and processes within established value chains requires a thorough understanding of the complex interactions between the existing system's behavior, structure, and the economic driving factors behind them. Recognizing these interactions and their effects within the system is a critical first step in defining the right problem to solve. Influential Attributes Network (IAN) graphs can be used as pictorial depictions of system relationships and have proven to be a valuable tool for communicating to stakeholders the critical factors that are driving often ambiguous problems. For large, complex projects these graphs help to break problems into smaller, more manageable pieces and focus technology development teams on the highest impact areas. IAN graphs also help to examine how potential solutions can address original requirements and communicate traceability from system architecture decisions back to underlying economic conditions. Ultimately, this tool helps the architect reduce ambiguity, employ creativity, and manage complexity.

Delivering Better Projects on Time by Ensuring Requirements Quality Upfront

Eduardo Vaz (QRA Corp) - eduardo.vaz@qracorp.com

Presented on: Tuesday, 11:30-12:10

Keywords. Requirement analysis; Natural language processing; Requirements engineering; Automated tools; Project efficiency; QVscribe; #Automotive

Abstract. As systems and projects become ever more complex due to multiple and distinct stakeholders, growing user demands, stricter regulations, and rapidly increasing integration and automation, the number and criticality of requirements also grows rapidly. The number of errors due to poor, ambiguous, and inconsistent requirements are becoming unmanageable and are leading to dramatic costs overruns and systemic delays. This paper investigates the cause and effects that errors in natural language requirements have in a projects' timelines and costs and how an emerging class of automated requirements analysis tools based on computational natural language processing can be harnessed by domain experts at the onset of the development lifecycle for them to retake control and ensure successful projects on time and on budget.

Papers#147

Deploying a Systems Engineering Approach to Enhance a Global Business within a Dynamic World.

Stuart Yeo (Siemens) - stuart.yeo1@siemens.com

Presented on: Wednesday, 13:30-14:10

Keywords. Deploy; Systems Engineering; Practical; Document; Example; #PowerEnergy

Abstract. The value of Systems Engineering is truly realized once we integrate Knowledge Management with Systems Architecture. This gives efficiencies of scale enabling engineers that are unfamiliar with the product to become effective in a faster timeframe. Using lean and agile techniques helps eliminate duplication of data in multiple documents, minimizing the effort to keep product documentation up to date. Historically System Engineering has been seen by many as a big bang approach with a significant overhead prior to initiation. This paper discusses some approaches that integrate business continuity with a phased migration to a Systems Engineering approach.

Papers#44

Developing a Configure-to-Order Product in the Subsea Oil and Gas Domain

Ole Kaare Ulsvik (University College of Southeast Norway) - olek.ullsvik@gmail.com
Kristin Falk (University College of Southeast Norway) - Kristin.falk@usn.no

Presented on: Monday, 13:30-14:10

Keywords. Systems Architecting; Modularization and Standarization; Lean Product Development; Configure-to-Order; #Industry

Abstract. This paper explores a configure-to-order strategy in the subsea oil and gas industry. A major supplier in the industry is investigating standardization and modularization of their systems and products to shorten delivery times and reduce cost. Consequently, changing from an "engineer-to-order" to an "configure-to-order" strategy.
We have studied part of the Subsea Production System, namely the subsea hydraulic control system and a new product development project as a basis for our research. The new product development project was our case for developing a standardized and modularized design that meets various customer needs. Applying the systems engineering framework together with lean product development principles helped us define a process to decide product specific variants of the new product through a configurator.
Results from our research show that we could configure the product based on functional requirements if the engineers consider modularity during product design. The research gives strong indications that the subsea oil and gas industry can achieve significant reduction in cost and time associated with design, documentation and production of the new product by using a Configure-to-Order strategy.

Papers#127

Developing Case-Based Costs Estimation: A Recursive Approach and Case Study

Haifeng Zhu (Unted Technologies Research Center) - zhuhf@utrc.utc.com

Presented on: Thursday, 00:00-00:00

Keywords. Cost analysis; Complex systems; Life-Cycle management

Abstract. Today many complex systems are built starting from certain prior products. Traditional cost estimation methods assuming products are built from scratch and using simple methods such as linear regressions can lead to significant errors. This paper studies the switching costs, the costs of developing a new product that is built based upon a previously developed product. It presents a series of systematic study results including its concept, properties, an estimation method, and operation principles. Our approach is an automated method that is able to minimize manual efforts. It can leverage historical data, acquisition information, existing cost models, commercial costing tools, and Expert Judgments (EJ). An HVAC (Heating, Ventilation, and Air Conditioning) system design example case was used to demonstrate our approach.

Papers#127

Developing Case-Based Costs Estimation: A Recursive Approach and Case Study

Haifeng Zhu (Unted Technologies Research Center) - zhuhf@utrc.utc.com

Presented on: Thursday, 08:00-08:40

Keywords. Cost analysis; Complex systems; Life-Cycle management

Abstract. Today many complex systems are built starting from certain prior products. Traditional cost estimation methods assuming products are built from scratch and using simple methods such as linear regressions can lead to significant errors. This paper studies the switching costs, the costs of developing a new product that is built based upon a previously developed product. It presents a series of systematic study results including its concept, properties, an estimation method, and operation principles. Our approach is an automated method that is able to minimize manual efforts. It can leverage historical data, acquisition information, existing cost models, commercial costing tools, and Expert Judgments (EJ). An HVAC (Heating, Ventilation, and Air Conditioning) system design example case was used to demonstrate our approach.

Papers#41

Developing conceptual smart training system for advanced plant design and FEED engineers based on a tailored systems engineering process

Dae-Geun Hong (POSTECH) - dghong@postech.ac.kr
Chang-Woo Park (Seoul National University) - cwpak@snu.ac.kr
Suk-Hwan Suh (POSTECH) - shs@postech.ac.kr
Hwal-Won Suh (POSTECH) - hwsur@postech.ac.kr
So-Yeon Kang (Yonsei University) - ksy1124@yonsei.ac.kr

Presented on: Monday, 16:15-16:55

Keywords. Smart Training System; Plant Engineering; Plant Design; FEED; Education Program; Systems Engineering; #Industry

Abstract. Global engineering market has been growing by an average of 17% per year, and is expected to reach $415.2 billion by 2015. With drastic expansion of the engineering market, competition between companies to win engineering contracts is becoming increasingly fierce. However, Front End Engineering Design (FEED), currently dominated by a few advanced countries, creates the highest added-value in the in plant construction industry. In the domestic plant engineering industry, it is difficult to acquire its own technology capability and experience due to lack of experience and shortage of experts in advanced design fields such as basic design and FEED. To achieve competitiveness with the advanced countries, it is necessary to establish smart training system for advanced plant design and FEED engineers. So, this study aims to propose the tailored systems engineering approach for developing a plant design education system for plant designers and FEED engineers, and to apply the proposed approach to a Korean case study, Smart-PETS that learns design knowledge based on educational content and experience based on design stage for chemical plant.

Papers#92

Development Concepts of Smart Service Systembased Smart Factory (4SF)

Heeje Lee (Pohang University of Science and Technology (POSTECH)) - zed@postech.ac.kr
Joongyoon Lee (Pohang University of Science and Technology (POSTECH)) - jlee2012@postech.ac.kr

Presented on: Wednesday, 14:15-14:55

Keywords. Smart Factory; Smart Service System; Manufacturing System; System Architecture; Model Based Systems Engineering; #Industry

Abstract. The concept of Smart Factory, a new paradigm in manufacturing industry, has emerged and is expanding exponentially. This shift is apparent in new IT such as Cyber Physical Systems (CPS), Artificial Intelligence (AI), and Cloud Computing. Varieties of Smart Factory architecture applying these technologies are already widespread. However, most of the widespread architecture only define manufacturing levels from Level 0 (Physical Processing) to Level 4 (Business Logistics Systems) and specify services that are provided between them. These technical specifications do not guide the development processes and do not provide the architecture to implement Smart Factory infrastructure within existing factory. In this paper, we propose Smart Service System-based Smart Factory (4SF) architecture that can be utilized without major changes to existing systems by using "add-on" concepts of Smart Factory. Furthermore, we applied Systems Engineering process to enable system design based on requirements in manufacturing industry using an operational, system and technology model. Finally, these concepts were applied to a steel plate plant to show practical potential of Smart Service System-based Smart Factory.

Papers#157

Discovering Career Patterns in Systems Engineering

Nicole Hutchison (Stevens Institute of Technology) - nicole.hutchison@stevens.edu
Sergio Luna (Stevens Institute of Technology) - sluna@stevens.edu
Matthew Partacz (Stevens Institute of Technology) - mpartacz@stevens.edu

Presented on: Tuesday, 13:30-14:10

Keywords. systems engineers; career path; patterns; #Academia

Abstract. Systems Engineering is a discipline where multiple roads merge. Individuals from different backgrounds and career starting points become systems engineers either by education or practice, however, their paths cross when implementing similar practices which are those of Systems Engineering. The Helix project seeks to understand what makes systems engineers effective and why. In order to achieve this objective, the team reviewed information from 364 systems engineers, peers of systems engineers and their leaders and managers. The data consists of more than 6000 pages of interview transcripts, 270 hours of audio, systems engineers' resumes and curricula vitae (CVs). With such extensive data available, the team relied on statistical analysis and text mining techniques to discover patterns related to the growth and development of systems engineers in their careers. This article presents preliminary findings on Systems Engineering career paths, primarily focusing on position and education.

Papers#143

Engineering Cyber-Physical Swarms with Collaborative Modelling

Ken Pierce (Newcastle University) - kenneth.pierce@ncl.ac.uk
Georgios Zervakis (Elsevier Limited)
Carl Gamble (Newcastle University) - carl.gamble@ncl.ac.uk
John Fitzgerald (Newcastle University) - john.fitzgerald@ncl.ac.uk

Presented on: Wednesday, 13:30-14:10

Keywords. cyber-physical systems; collaborative modelling; co-simulation; swarms

Abstract. A major challenge in the engineering of cyber-physical systems (CPSs), such as swarms of autonomous UAVs, is the need for engineers from multiple disciplines to collaborate as early as possible in the design phase. Model-based design is a well-established systems engineering technique, but separate disciplines often have separate formalisms, tools and even vocabularies. An emerging approach is to combine individual models from these domains into holistic system models called collaborative models (or co-models), which can be analysed through, for example, co-simulation. This paper reports on the application of the INTO-CPS tool chain, which supports such a collaborative modelling approach, to the design of a swarm of UAVs. Three engineers were involved in the modelling process, and were able to produce component models in familiar tools which were then integrated and analysed as a holistic system model using INTO-CPS.

Papers#158

Enhancing Automated Trade Studies using MBSE, SysML and PLM

Pawel Chadzynski (Aras Corp.) - pchadzynski@aras.com
Barclay Brown (Raytheon Company) - barclay@barclaybrown.com
Patrick Willemsen (Aras Corp.) - pwillemsen@aras.com

Presented on: Thursday, 10:45-11:25

Keywords. MBSE; PLM; RFLP; SysML; tradestudy; #Automotive

Abstract. One of the critical tasks of Systems Engineering MBSE methodology is execution of Trade Studies. Trade Studies are key to identifying the best-in-class architectural and realization alternatives. These studies often rely on physical characteristics of the available system elements represented by the “P” in the core system elements called RFLP (Requirements-Functional-LogicalPhysical). Such realization alternatives are not always easy to find for the Systems Engineers and often require tedious manual definition of the implementation elements in a system model. That information, however, often already resides within the enterprise design data and product configuration platforms – most likely a PLM (Product Lifecycle Management) system. This paper discusses how a proper integration between system model authoring tools (e.g. SysML) and PLM, can interactively and in real-time deliver all relevant “P” information of the RFLP core used in trade studies and therefore save Systems Engineers a significant amount of time, eliminate incorrect assumptions, and maximize reuse.

Enhancing the Academic Portfolio - Systems Engineering Research & Teaching for Universities

Mario Kossmann (AIRBUS) - mario.kossmann@airbus.com

Presented on: Monday, 10:00-10:40

Keywords. Systems Engineering Research; Systems Engineering Teaching; Academic Portfolio; Domain Ontology; SE Courses and Degrees; Ontology Web Language; Protégé; SE Research; SE Teaching; Semantic Web; #Academia

Abstract. Many universities across the globe have well established Systems Engineering (SE) courses and academic degrees, covering continuous professional studies for both the industry and the public sectors, undergraduate and postgraduate programs including research degrees at master and doctorate levels. Some universities even have world-class reputation for the excellence they demonstrate in SE research & teaching. However, there are still many universities worldwide that offer courses in traditional fields of Engineering but not yet in SE, let alone specific SE degrees or qualifications. Given that SE is essential for the development and in-life support of systems, even more so with the increasing levels of complexity of today's and tomorrow's systems and Systems of Systems (SoS), it seems urgent and important for such universities to consider an extension of their academic portfolio. This paper briefly discusses the justifications for explicitly including SE in the curriculum of Engineering focused universities, and provides insight into one possible way of enhancing the successful establishment of SE as part of the academic portfolio – via developing and maintaining an SE domain ontology. The generic ontology 'SERaT4Ac' (SE Research and Teaching for Academia) that is specified in the 'ontology web language' (OWL) is presented and specific aspects of the ontology are explained using typical examples. This proposed domain ontology represents an integrated model of what a university should consider and manage over time regarding their SE related activities. It could (and would have to) be instantiated for the context of a given university to directly help them extend their academic portfolio; but it may also be useful for universities with a well-established SE curriculum.

Envisioning Systems Engineering as a Transdisciplinary Venture

Hillary Sillitto (Sillitto Enterprises) - hillary.sillitto@blueyonder.co.uk
James Martin (Aerospace Corporation) - martinqzx@gmail.com
Dorothy Mckinney (ConsideredThoughtfully) - dorothy.mckinney@computer.org
Dov Dori (Technion, MIT) - dori@technion.ac.il
Regina Griego - griegor@sandia.gov
Eileen Arnold (ConsideredThoughtfully) - eparnold5@aol.com
Patrick Godfrey (University of Bristol) - Patrick.godfrey@bristol.ac.uk
Daniel Krob (CESAMES) - krob@noos.fr
Scott Jackson (Burnham Systems) - scott.jackson@incose.org

Presented on: Wednesday, 11:30-12:10

Keywords. Re-visioning SE; SE for complex systems; SE Principles; #Academia

Abstract. We envision that Systems Engineering (SE) can be transformed into a truly transdisciplinary discipline – a foundational meta-discipline that supports and enables collaboration between all the disciplines that should be involved in conceiving, building, using and evolving a system so that it will continue to be successful and fit for purpose as time passes. SE can be applied in different ways depending on the situation and how well current SE process patterns are matched to the problem in hand. We identify four elements of this new transdisciplinary framework: SE Tenets; SE Approach; SE Process; and SE Toolbox. We suggest that the use of SE then needs to be considered in three domains: problem space, solution space, and transformation space that helps us along the development-delivery-evolution trajectory. We propose twelve SE tenets and show how they should be applied in these three domains. We perceive that even though all elements of the current SE Process can be justified in terms of the twelve tenets applied to these three domains, the current commonly used, standardized SE Process is not suitable for all situations requiring an SE Approach or an application of the SE Tenets. We claim that the framework presented in this paper can act as a unifying structure that facilitates the evolution of Systems Engineering from the current focus on a "standardized" process model suited to a particular class of problem, to a more agile and capable "transdiscipline" that will provide an enabling construct for more successful collaborations that can better deal with a wider range of complicated, complex and chaotic problem situations.

Envisioning Systems Engineering as a Transdisciplinary Venture

Hillary Sillitto (Sillitto Enterprises) - hillary.sillitto@blueyonder.co.uk
James Martin (Aerospace Corporation) - martinqzx@gmail.com
Dorothy Mckinney (ConsideredThoughtfully) - dorothy.mckinney@computer.org
Dov Dori (Technion, MIT) - dori@technion.ac.il
Regina Griego - griegor@sandia.gov
Eileen Arnold (ConsideredThoughtfully) - eparnold5@aol.com
Patrick Godfrey (University of Bristol) - Patrick.godfrey@bristol.ac.uk
Daniel Krob (CESAMES) - krob@noos.fr
Scott Jackson (Burnham Systems) - scott.jackson@incose.org

Presented on: Thursday, 00:00-00:00

Keywords. Re-visioning SE; SE for complex systems; SE Principles; #Academia

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Papers#144

Evolving Model-Based Systems Engineering Ontologies and Structures

Warren Vaneman (Naval Postgraduate School) - wvaneman@nps.edu

Presented on: Wednesday, 10:45-11:25

Keywords. Model-Based Systems Engineering (MBSE); System Modeling language (SysML); Lifecycle Modeling Language (LML)

Abstract. Model-Based Systems Engineering (MBSE) is a mysterious concept that means many different things to different stakeholders. MBSE was envisioned to manage the increasing complexity within systems, by replacing traditional document-based system engineering with a model-based approach. However, more than a decade after MBSE was introduced, many systems engineering efforts still default to a “document-like view” rather than integrated, “virtual,” representation of the system. This paper suggests a revised definition for MBSE which supports system design and analysis, throughout all phases of the system lifecycle, and through the collection of modeling languages, model-based processes, structures, and presentation frameworks used to support the discipline of systems engineering in a model-based or model-driven context. To realize this definition, and an environment where the system is virtually represented, the long-sought ontology must be attained for better definition and structure within MBSE. This paper explores how current MBSE methods can be extended to include an ontology.

Papers#100

Experience from Introducing Systems Engineering in an Academic Environment Using an Industry Training Course

Erik Herzog (SAAB AB) - erik.herzog@saabgroup.com
Asa Nordling-Larsson (SAAB AB) - Asa.Nordling-Larsson@saabgroup.com
Jad El-Khoury (KTH) - jad@kth.se
Martin Törngren (KTH) - martint@kth.se

Presented on: Monday, 13:30-14:10

Keywords. Teaching and Training; Introducing Systems Engineering; #Academia

Abstract. Training and educating Systems Engineers is a key activity for any organization developing complex heterogeneous systems. Ideally, the regional/national academic community will provide courses and education programs facilitating for the needs of industry and society. However, Systems Engineering is not a traditional academic subject and despite the growing academic interest in the subject there are many regions with no dedicated academic courses and programs in the subject.

This paper presents experience from introducing Systems Engineering via a capstone project course in a mechatronics master’s program at the Royal Institute of Technology (KTH) in Sweden. System engineers from industry give an industry-developed Systems Engineering course, as part of a capstone course. We believe that the approach is novel and can serve as a mechanism for introducing Systems Engineering to both students and lecturers in the academic world, who have no previous exposure to the subject. Moreover, student feedback indicate that having lecturers with industrial experience was highly appreciated, making the activity a worthwhile branding investment for industry as well.

Papers#138

Exploration of the Complex Ontology

Dean Beale (University of Bristol) - db15900@bristol.ac.uk
Theo Tryfonas (University of Bristol) - theo.tryfonas@bristol.ac.uk

Presented on: Thursday, 11:30-12:10

Keywords. Complex; Complexity; definition; ontology; lexicon; chaos; emergent; theory; #RisksComplex

Abstract. The Oxford English Dictionary (OED), the established definition of words in the English language, is at odds with other definitions of complexity proffered by Complexity Theory. This variance is likely to cause confusion in the delivery community. The incorrect classification of a project between 'complicated' and 'complex' is considered by some to be a major source of project failure; implying that resolving this issue is critical to successful system development. This paper explores the definition of complexity by assessing definitions from various sources and by conducting a survey of over 100 delivery professionals. The results demonstrate the extent of the confusion and have informed considerations on how to resolve this. This paper recommends that the definition is either defined at the start, or that the term is avoided by using its component parts. This paper proposes supporting an emerging definition that resolves many of the issues, if adopted widely.

Papers#25

Extending Formal Modeling for Resilient Systems Design

Azad M. Madni (University of Southern California) - Azad.Madni@usc.edu
Ayesha Madni (University of Southern California) - amadni@usc.edu
Michael Sievers (University of Southern California) - Michael.Sievers@usc.edu
Edwin Ordoukhanian (University of Southern California) - ordoukha@usc.edu
Parisa Pouya (University of Southern California) - pouya@usc.edu

Presented on: Wednesday, 13:30-14:10

Keywords. Resilient Systems; Formal Methods; Model-Based; #Industry; #Automotive

Abstract. Resilience is a much-needed characteristic in systems that are expected to operate in uncertain environments for extended periods of time with a high likelihood of disruptive events. Resilience approaches today tend to employ ad hoc methods and piece-meal solutions that are difficult to verify and test, and do not scale. Furthermore, it is difficult to assess the long-term impact of such ad hoc 'resilience solutions.' This paper presents a flexible contract-based approach that employs a combination of formal methods for verification and testing and flexible assertions and probabilistic modeling to handle uncertainty during mission execution. A flexible contract (FC) is a hybrid modeling construct that facilitates system verification and testing while offering the requisite flexibility to cope with non-determinism. This paper illustrates the use of FCs for multi-UAV swarm control in, partially observable, dynamic environments. However, the approach is sufficiently general for use in other domains such as self-driving vehicle and adaptive power/energy grids.

Papers#8

Formalizing Requirements Verification and Validation

Ronald S. Carson (Seattle Pacific University) - ronald.s.carson@gmail.com
Robert A. Noel (The Boeing Company) - robert.noel@boeing.com

Presented on: Tuesday, 15:30-16:10

Keywords. Requirements validation; Verification; Validation; #SEFundementals

Abstract. The Verification and Validation of requirements are formalized using decomposition and set theory to yield four elemental criteria, verifiability, feasibility, necessity, and sufficiency, which are derived from definitions of requirements "verification" and "validation", and "correct and complete" requirements. These criteria are mapped to the fourteen characteristics of requirements in the INCOSE Guide to Writing Requirements. Requirements parent-child relationships are established for the verification and validation (V&V) criteria at multiple levels of a system architecture, from user needs to component requirements. Using these V&V criteria during the requirements development process would enable improved first-pass success and less rework caused by revisiting missing, incomplete, incorrect or unnecessary requirements.

Papers#140

Framework for Mission Engineering Competencies

Nicole Hutchison (Stevens Institute)
William Miller (Stevens Institute) - wmiller@stevens.edu
Hoong Yan See Tao (Stevens Institute)
Dinesh Verma (Stevens Institute)
Gregg Vesonder (Stevens Institute)

Presented on: Tuesday, 10:45-11:25

Keywords. mission engineering; systems of systems; competencies; #Academia

Abstract. Mission engineering is the application of systems of systems (SoS) engineering in an operational context. The focus is on execution of the mission and this can often require interoperability across an array of heterogeneous systems. This paper presents research resulting in the identification of the critical skills required to successfully accomplish and shepherd mission engineering. The competency model presented herein uses the grounded theory methodology and leverages the Helix methodology. It is based on a combination of interviews with mission engineers together with research in the open and seminal literature. Subject interviews and open source literature cover 1) mission engineering definition and organizational support, 2) identification of competencies and gaps, and 3) future vision. There is an overlap in mission engineering and systems engineering competencies with important differentiation in 1) governance, 2) foundational math/science/general engineering skills, 3) operational concepts, 4) interpersonal skills, 5) and leadership skills.

Papers#59

How Many Systems Engineers Does It Take To Change a Light Bulb?

Andy Nolan (Rolls-Royce plc) - Andy.Nolan@rolls-royce.com
Judy Nolan (Rolls-Royce plc) - Judy.Nolan@rolls-royce.com
Andrew Pickard (Rolls-Royce Corporation) - Andrew.C.Pickard@rolls-royce.com
Richard Beasley (Rolls-Royce plc) - Richard.Beasley@rolls-royce.com
Timothy Pruitt (Rolls-Royce Corporation) - Timothy.C.Pruitt@rolls-royce.com

Presented on: Tuesday, 15:30-16:10

Keywords. Estimation; Wisdom of Crowds; Judgment

Abstract. This paper transposes lessons learnt in cost and schedule estimating over to Systems Engineering. Systems Engineering, like estimating, is reliant on the experience and judgement of the individuals developing the system. But how effective is judgement and can we trust it?
Often Systems Engineers will not have enough data and must rely on their judgement. But humans are notoriously bad at judgement because they suffer from emotions, biases and egos.
However, since the early 20th century, it has been known that the collective judgement of a crowd can often be better than the judgement of many of the individuals within the crowd. Systems Engineering benefits from independent reviews, brainstorming and other group based techniques. We know that “many heads are better than one”, but how many heads?
Although we all use judgement in most of our work and life, we have a low opinion of any conclusions based entirely on judgement. Based on a study of 3,760 guesses, this paper draws some useful conclusions for when to use judgement, when to use a crowd and how to determine the optimum crowd size when using judgement in Systems Engineering.
Although the paper refers to the judgement of numerical values, the findings described in this paper apply to any group based activities in Systems Engineering.

Papers#116

Implementing the United Nations Sustainable Development Goals for the Systems Engineering of Multinational Corporations

Ian Brooks (University of the West of England) - Ian.Brooks@uwe.ac.uk
Mario Kossmann (Airbus) - mario.kossmann@airbus.com
James Longhurst (University of the West of England) - James.Longhurst@uwe.ac.uk
Mohammed Odeh (University of the West of England) - Mohammed.Odeh@uwe.ac.uk

Presented on: Thursday, 08:00-08:40

Keywords. Sustainable Development Goals; Requirements Engineering; Ontology-driven methods; Systems Engineering; Sustainability; #Industry

Abstract. The United Nations Sustainable Development Goals (SDGs) were adopted in 2015 by 193 countries. They can be characterised as sustainability ‘requirements’ for the global system. This paper provides a vision of how Multinational Companies (MNCs) are likely to experience the SDGs and their implications for Systems Engineering (SE) of the Enterprise. The SDGs do not have the status of international law and may be implemented differently in different countries over the period to 2030. MNCs will face choices about how they wish to comply today in anticipation of future requirements. Thereby, they also have the opportunity to avoid systems sustainability failures later on. This paper presents an initial approach to implementing the SDGs in the form of business requirements. The research will pave the ground for the development of a systematic framework for the adoption, monitoring and assessment of the SDGs in an SE context.

Incorporating Variability and Reuse into System Architecture Models - Principles and Challenges

Robert Malone (The Boeing Company) - robert.l.malone@boeing.com
Brittany Friedland (The Boeing Company) - brittany.a.friedland@boeing.com
John Herrold (The Boeing Company) - john.r.herrold@boeing.com
Ronald Houde (Mannarino Systems and Software) - ronald.houde@mss.ca

Presented on: Monday, 10:00-10:40

Keywords. Systems Engineering; Model Based Systems Engineering; Product Line Engineering; Variability and Reuse; #Government

Abstract. Great economies are achieved in the design, production and support of corporate Product Lines if available features and components can be shared across Products and across Product Lines. Incorporation and effective management of Product variability and component reuse within System Architecture models can improve the chances of successfully designing and deploying Product Lines. This paper introduces some principles for incorporating feature-based variability and reuse within System Architecture models, and also some challenges that must be overcome to allow the effective management of Product Line design models.

Papers#46

INCOSE Working Group Addresses System and Software Interfaces

Sarah Sheard (CMU Software Engineering Institute) - sheard@sei.cmu.edu
Rita Creel (CMU Software Engineering Institute) - rc@cert.org
John Cadigan (Prime Solutions Group, Inc.) - johncadigan@psg-inc.net
Joseph Marvin (Prime Solutions Group, Inc.) - joemarvin@psg-inc.net
Leug Chim (Defence Science & Technology Group) - leug.chim@dst.defence.gov.au
Michael E. Pafford (Johns Hopkins University) - mepafford@verizon.net

Presented on: Tuesday, 10:00-10:40

Keywords. Software engineering; Interfaces; INCOSE; Organizational conflicts; Process conflicts; #Industry

Abstract. In the 21st century, when any sophisticated system has significant software content, it is increasingly critical to articulate and improve the interface between systems engineering and software engineering, i.e., the relationships between systems and software engineering technical and management processes, products, tools, and outcomes. Although systems engineers and software engineers perform similar activities and use similar processes, their primary responsibilities and concerns differ. Systems engineers focus on the global aspects of a system. Their responsibilities span the lifecycle and involve ensuring the various elements of a system—e.g., hardware, software, firmware, engineering environments, and operational environments—work together to deliver capability. Software engineers also have responsibilities that span the lifecycle, but their focus is on activities to ensure the software satisfies software-relevant system requirements and constraints. Software engineers must maintain sufficient knowledge of the non-software elements of the systems that will execute their software, as well as the systems their software must interface with. Similarly, systems engineers must maintain sufficient awareness of the software to enable early identification and resolution of software risks and issues driven by other system elements. Thus, to enable continued progress in creating and sustaining capability in complex, interconnected systems, systems and software engineers must commit to improving the interfaces between their disciplines, to aligning and integrating their terminology, processes, methods, and tools.

Recognizing the need to improve the system engineering-software engineering interface, INCOSE approved the charter of the System and Software Interface Working Group (SaSIWG) in 2017. At its initial meeting at the INCOSE International Symposium 2017 (IS 2017) in Adelaide, Australia, the SaSIWG derived working group objectives from lists of brainstormed systems and software issues. This paper documents the interface issues elicited, grouped into seven categories, along with system-software interface use cases identified by SaSIWG members. The interface issues and use cases expose questions for the SaSIWG to prioritize and respond to. The paper concludes with a summary of the SaSIWG's plan to respond to these questions and strengthen the interface between the systems engineering and software engineering disciplines.

Papers#50

Information Technology Governance through the Complex System Governance Lens

Joseph M. Bradley (Patrona Corporation) - josephbradley@leading-change.org
Ralph T. Soule (Soule Research) - ralph.soule@gmail.com

Presented on: Wednesday, 15:30-16:10

Keywords. governance; information technology; complex system governance; system theory axioms; reference model; #RisksComplex

Abstract. As the field of complex system governance (CSG) continues to emerge, definition of organizations that reflect the principles of complex system governments can be imagined. We briefly review the progression of research on complex system governance, beginning with the conundrum posed by Rittel and Weber for current research in the field. A high level over view of the Complex System Governance Reference Model (Keating and Bradley (2015)) is provided to ground the following analysis. We next apply principles of CSG identified by Keating and Bradley (2015) to an exemplar Information Technology (IT) system of systems (a complex system) that is part of a larger industrial enterprise. This application of the Reference Model continues with a discussion of gaps in the espoused governance model of the US Navy system for software acquisition and maintenance. The paper concludes with suggestions for further research. This paper is part of a sequence on the development, design and maturation of Complex System Governance.

Informing the delineation of input uncertainty space in exploratory modelling using a heuristic approach

Enayat A. Moallemi (The University of New South Wales (UNSW AU)) - e.moallemi@gmail.com
Sondoss Elsawah (The University of New South Wales (UNSW AU)) - s.elsawah@adfa.edu.au
Michael J. Ryan (The University of New South Wales (UNSW AU)) - M.Ryan@adfa.edu.au

Presented on: Tuesday, 10:00-10:40

Keywords. Exploratory modelling; Uncertainty; Simulation; Scenario discovery; Decision making; #Infrastructure

Abstract. Exploratory modelling is an emerging approach which can address the challenge of model-based decision making in dealing with input model uncertainties. Exploratory modelling samples from an input uncertainty space and generates extensive computational experiments to analyse possible model behaviours in an output solution space. The way that the input uncertainty space is delineated influences the results of exploratory modelling and its computational cost. In this article, we show the statistical significance of the implication of the size of an input uncertainty space on the resulted output solution space. We also propose a heuristic approach which informs the delineation of input uncertainties by screening the relevant model behaviour in the solution space. An illustrative example of an aircraft fleet management system is used to demonstrate the implementation of our approach in practice. We conclude that the delineation of input uncertainty space can be a way to control simulations in exploratory modelling and to enhance the efficiency of the exploration process and the confidence of the final results.

Papers#99

Instant-Expertise in Failure Causation: Developing and Presenting a Network of Causes and Recommendations Extracted from Past Failures

Diane Aloisio (Purdue University) - dsorens@purdue.edu
Karen Marais (Purdue University) - kmarais@purdue.edu

Presented on: Tuesday, 10:45-11:25

Keywords. systems engineering; project failure; failure cause; interactive network; #RisksComplex; #PowerEnergy

Abstract. Systems engineering failures like schedule slips, budget overruns, and other setbacks, occur often and can be costly, but the literature provides little guidance on why these failures occur or how to prevent them. In our previous work we argued that systems engineering failures are manifestations of similar underlying problems, and thus leveraged literature on the theory of accident causation, as well as the many accident investigation reports, to understand better how and why project failures occur and potential ways of preventing these failures. We developed a database of over 900 examples of failure causes and over 600 examples of remedial actions. In this paper, we detail our process for building this database into an interactive network-based solution aid that anyone experiencing problems in their project or organization can access. The interactive solution aid provides the user with "instant expertise" in accident causation and remediation because it provides users with summaries and simplifications of the causes and remediation measures from the failures we studied.

Papers#137

Integrating a Model-Based Systems Engineering and Model-Based Product Support Approach for Affordable System Sustainment

Steve Kwon (Booz Allen Hamilton) - kwon_steve@bah.com
Kimberly Page (Booz Allen Hamilton) - Page_Kimberly@bah.com
Kevin Weinstein (Booz Allen Hamilton) - Weinstein_Kevin@bah.com

Presented on: Thursday, 08:45-09:25

Keywords. Model Based Systems Engineering; Sustainment; Affordability; Model Based Product Support; #Industry

Abstract. Systems engineers and product support managers often approach building the “best” or “right” system from different perspectives. Systems engineers focus on technical solutions that meet system requirements and maximize capabilities, while product support managers focus on optimized sparing levels and reduced supply chain delays. These tendencies lead to design decisions that do not optimize system readiness over the system life cycle. As programs evolve to deliver systems in today’s budget constrained environment, several are adopting model-based engineering approaches. The emphasis in acquisition is often to capture system requirements and architecture definition through a model-based systems engineering (MBSE) approach. There is a significant opportunity to integrate model-based product support (MBPS) practices with MBSE through concept and development to enable a decision support capability that effects optimized sustainment costs and demonstrates impacts on system readiness in design trades.

Papers#71

Integrating Safety and Reliability Analysis into MBSE: overview of the new proposed OMG standard

Geoffrey Biggs (Tokyo Institute of Technology) - geoffrey.biggs@aist.go.jp
Andrius Armonas (No Magic Europe) - andrius.armonas@nomagic.com
Tomas Juknevicius (No Magic Europe) - tomas.juknevicius@nomagic.com
Kyle Post (Ford) - kpost1@ford.com

Presented on: Wednesday, 15:30-16:10

Keywords. model-based systems engineering; safety-critical systems; reliable systems; standardisation; #MBSE; #Automotive; #Healthcare

Abstract. Model-Based Systems Engineering (MBSE) is gaining popularity in organizations creating complex systems where it is crucial to collaborate in a multi-disciplinary environment. SysML, being one of the key MBSE components, has a good foundation for capturing requirements, architecture, constraints, views and viewpoints. It allows linking different types of models that come from different engineering disciplines. However, inherent safety and reliability aspects of a system are not addressed by the SysML language. A new group at the OMG has been created by industry experts in this area to address these aspects in a new standard. In this paper, with the intent to get feedback from the systems engineering community, the members of the newly formed group present the current state of the Safety and Reliability Analysis Profile for UML submission, which extends the SysML language with the tools for modelling safety and reliability aspects. This paper also explains the value users get from taking a model-based approach to safety and reliability analysis and integrating it into the MBSE toolkit. Open issues and challenges are also discussed.

Papers#45

Integration of Parametric Cost Estimation with System Architecture - It's a dirty job but someone has to do it!

Barry Papke (No Magic) - bpapke@nomagic.com
Gan Wang (BAE Systems) - gan.wang@baesystems.com

Presented on: Wednesday, 14:15-14:55

Keywords. MBSE; COSYSMO; Parametric Cost Estimation; SysML; System Architecture;#MBSE

Abstract. The rapid adoption and advancement of Model Based Systems Engineering (MBSE) methods and tools opens up new avenues of systems engineering practices. One of them is cost estimation. As a key enabler for affordability analysis and budgetary decision making, cost estimation is an essential component for all system development and sustainment efforts. However, cost estimation is typically a separate endeavor from the design and development effort, creating a professional “chasm” between the worlds of systems designers and of cost analysts, causing a disconnect between the system as designed and the cost and effort required to build it.
This paper describes an approach to “tightly” integrate the existing practice of parametric cost estimation with the system architecture development process by leveraging MBSE and SysML to enable repeatable and efficient estimation of system development cost, and to allow system cost and affordability to be incorporated into the “digital thread” of the design while improving the efficiency and effectiveness of the cost estimation process. By expanding our previous work (Papke, Wang and Pavalkis 2017), this paper describes a new concept of operation (CONOP) for system development, enabled by the integrated SysML and COSYSMO modeling environment, that effectively connects the cost baselines to the technical baselines throughout the project life cycle. This new CONOP presents another step towards “pulling the digital thread” by making affordability and economic analysis an integral part of the system architecture.

Papers#162

Introducing Cost Models to Conceptual Tradespace Exploration

E. Alex Baylot (US Army ERDC) - alex.baylot@usace.army.mil
Drew Kelley (US Army ERDC) - drew.kelley@usace.army.mil
James Richards (US Army ERDC) - james.richards@usace.army.mil
Deanna Hardin (US Army ERDC) - deanna.hardin@usace.army.mil

Presented on: Monday, 10:45-11:25

Keywords. Cost Analysis; Surrogate Modeling; Engineered Resilient Systems; Computational; Modeling; #Government

Abstract. Over 70% of lifecycle cost (LCC) for a system design is determined during the conceptual phase. Currently for a US Department of Defense (DoD) Capabilities-Based Assessment (C-BA) or an Analysis of Alternatives (AoA), the cost analysis is performed on a small set of chosen designs based on performance/attribute metrics. Ideally, it would be better to explore the cost versus performance trades on thousands, if not millions, of designs before the down-selection to reveal the more affordable designs.
A goal of the DoD Engineered Resilient Systems (ERS) Program is to create a capability that links cost and performance models for early concept exploration. ERS leverages advances in computer science and computing power to create a tradespace framework to couple performance and cost model results. Integrating cost analysis into early tradespace development aligns with the evolving DoD policy to formally include cost earlier in the acquisition timeline.

Papers#17

MBSE Applicability Analysis in Chinese Industry

Lu Jinzhi (KTH Royal Institute of Technology) - jinzhl@kth.se
Wen Yuejie (China Academy of Space Technology) - wenyuejie@126.com
Didem Gurdur (KTH Royal Institute of Technology) - dgurdur@kth.se
Liu Qi (Suzhou Tongyuan Software and Control Technology Company) - liuq@tongyuan.cc
Martin Törngren (KTH Royal Insititute of Technology) - martint@kth.se

Presented on: Wednesday, 11:30-12:10

Keywords. MBSE Applicability Analysis; Chinese industry; MBSE; tool-chain; tool-integration; #MBSE; #Automotive

Abstract. Model-based systems engineering (MBSE) is an emerging technique widely used in current industry. It is a leading way expected to become a next-generation standard practice in the systems engineering. Fundamental tenets of systems engineering can be supported by a model-based approach to minimize design risks and avoid design changes in late development stages. The models can be used to formalize, analyze, design, optimize, verify and validate target products which help developers to integrate engineering development, organization and product across domains. Though model-based development is well established in specific domains, such as software, mechanical system, electric systems, its role in integrated development from system aspect is still a big challenge for current Chinese industry. In this paper, a survey from volunteers who related with MBSE is taken by questionnaires. The purpose of this survey is to highlight the usage and status of MBSE in current Chinese industry and address roughly the understandings of MBSE concepts among system developers in China based on the answers about usages, advantages, barriers, concerns, trends of MBSE, particularly the perspective of tool-chain development.

Papers#163

Military Supply Chains in a Connected World

Matthew Hause (PTC) - mhause@ptc.com
Christopher Heath (PTC) - cheath@ptc.com
Brent Baker (PTC) - hbaker@ptc.com

Presented on: Tuesday, 16:15-16:55

Keywords. Logistics; Supply Chain; MBSE; IoT; SoS; Digital Twin; #Government

Abstract. Net-centric warfare is a military doctrine or theory of war pioneered by the United States Department of Defense in the 1990s. It seeks to translate an information advantage, enabled information technology, into a competitive advantage through the robust computer networking of well-informed geographically dispersed forces. The internet of things (IoT) allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. The Supply Chain Operations Model (SCOR) is the DoD solution for process documentation which is an IoT that now connects assets, processes, people, and resources. IoT systems cannot be built in a vacuum and their success will only be realized through application of modern day systems engineering processes, methods, and tools. For the engineering of a system of systems as complex as the military supply chain, they will be essential.

Papers#12

Mitigating Integration Risks in Complex Systems

Marc F. Austin (US DoD) - mmfaustin@gmail.com
Cheyne Homberger (US DoD) - cheyneh@umbc.edu
Virginia Ahalt (US DoD)
Erin Doolittle (US DoD)
George A. Polacek (US DoD)
Donald M. York (Engility Corporation) - dsrsb@verizon.net

Presented on: Tuesday, 14:15-14:55

Keywords. system; development; complexity; integration; interface; readiness; assessment; Bayesian; probability; metrics; maturity

Abstract. In the Age of Globalization, integration is one of the primary areas of risk for today's complex system development programs. Integration failures continue to be one of the main reasons for unsuccessful system deployments. The Integration Readiness Level (IRL) is a new system metric developed to measure the integration maturity between two system components. IRLs, in conjunction with Technology Readiness Levels (TRLs), form the basis for determining the readiness of a system for deployment. The IRL represents the systematic analysis of the interactions between system components and provides a consistent comparison of the maturity between integration points. IRLs provide a means to reduce the risk involved in maturing and integrating system components in complex environments. We first present a methodology for determining the integration readiness of a system and its components and then describe the construction of a Bayesian network model for assessing IRLs. The IRL Bayesian network model provides a mathematical method to consistently combine and validate the judgment of experts assessing integration and increase the confidence in the determination of the integration readiness of a system and its components.

Papers#173

Model Based Tradeoffs for Affordable Resilient Systems

Marilee Wheaton (The Aerospace Corporation) - marilee.j.wheaton@aero.org
Azad M. Madni (University of Southern California) - azad.madni@usc.edu

Presented on: Monday, 11:30-12:10

Keywords. MBSE; Tradeoffs; Affordability; Resilience; #Government; #MBSE

Abstract. Affordability and resilience are two non-functional requirements that are increasingly needed in 21st century systems. Since these attributes act in tradeoff fashion, a tradespace definition and evaluation framework is needed. This paper presents a model-based approach that builds on two core capabilities: a framework to define the space system environment, and an analytic tool to set up the tradespace within the framework for tradeoff analysis with what-if assumptions about the future space system environment.

Papers#82

Model-based Assessment of the Submarine Support System

Sondoss Elsawah (University of New South Wales Canberra) - s.elsawah@unsw.edu.au
Michael Ryan (UNSW Canberra) - m.ryan@adfa.edu.au
Lindsay Gordon (Australian Defence Force) - lindsay.gordon2@defence.gov.au
Rod Harris (UNSW Canberra) - r.harris@adfa.edu.au

Presented on: Tuesday, 11:30-12:10

Keywords. system dynamics; model-based assessment; modular; #Government

Abstract. Submarine support systems are large-scale, geographically-distributed, and complex. In this paper, we describe the development and use of a modular system dynamics modelling approach for analyzing the dynamic behavior of submarine support systems, exploring decision options, and assessing their long-term effects on the system's performance. We present a proof-of-concept model to demonstrate the utility and flexibility of the methodological approach we have undertaken. The proof-of-concept is developed using a class of the Australian submarine support system. It is constructed and validated based on expert knowledge and historical data about the fleet performance. The paper gives an overview of the modelling approach, model design, selected sample investigations, and a discussion of the benefits of such a strategic analysis tool.

Papers#133

Modeling Cyber Threats with SysML

Mathew Curreri (Lockheed Martin) - matthew.r.curreri@lmco.com
Amrose Kam (Lockheed Martin) - ambrose.kam@lmco.com
Carl Hein (X-SIM LLC) - chein@cxsim.com

Presented on: Wednesday, 16:15-16:55

Keywords. SysML to Simulation; Cyber Modeling; Threat Analysis; #MBSE

Abstract. Advanced Persistent Cyber Threats (APCT) jeopardize all seven layers in the Open System Interconnect (OSI). Scalable Modeled Based Engineering (MBE) methodologies can address APCT by leveraging industry standard SysML techniques by automating threat assessment for a multitude of operational scenarios. This paper provides a use case demonstrating how SysML can be combined with simulation to improve cyber defenses.

Papers#119

Modeling the Sociotechnical Dimensions of Urban Resilience: Community-level Microgrids

Tom Mcdermott (Georgia Institute of Technology) - tom.mcdermott@gtri.gatech.edu
Molly Nadolski (Georgia Institute of Technology) - molly.nadolski@gtri.gatech.edu
Dorraine Duncan (Georgia Institute of Technology) - dduncan42@gatech.edu
Madeline Clowse (Georgia Institute of Technology) - Madeline.Clowse@gtri.gatech.edu

Presented on: Thursday, 10:00-10:40

Keywords. sociotechnical systems; microgrids; human capital; model based systems engineering; #Industry; #Infrastructure

Abstract. INCOSE Vision 2025 states an imperative to apply systems engineering to help shape policy in relation to social systems and identifies a number of societal grand challenges, including energy security and sustainability. The document further states a future where “the addition of a formal systems approach helps decision-makers to select cost effective, safe, and sustainable policies that are more broadly embraced by the stakeholder community.” (INCOSE, 2014) This paper discusses a series of models that combine technical aspects of urban community microgrids with economic and policy drivers. Together these efforts explore systems engineering methods that capture a social systems approach to technology driven trades. Specifically this work discusses models that allow stakeholders to analyze the impacts of the implementation of a community-level microgrids on the energy burden of residents (a social variable). Microgrids have been proven to provide resilience for communities during shocks to the electrical system, such has hurricanes and grid-wide black outs; however, better understanding is needed on the actual impact of microgrids on the energy burden of community residents. While this research explores whether or not the benefits of microgrids can extend to the household level by assessing their impacts on the cost of energy, the goal is to provide a policy model which will act as a valuable decision aid for future, more sustainable and resilient, energy infrastructure policy.? Initial research indicates that community scale?microgrids?with attachment to a central urban grid are economically feasible and can benefit community resilience,?but Atlanta specific policy constraints related to regulated utilities must overcome. Our work interprets all the economic, policy and social elements as an essential set of factors operating in a dynamic ecosystem.

Papers#141

Perspectives on Managing Emergent Risk due to Rising Complexity in Aerospace Systems

Dianne DeTurris (Cal Poly State University, SLO) - ddeturri@calpoly.edu
Andrew Palmer (Cal Poly State University, SLO) - ampalmer@calpoly.edu

Presented on: Monday, 10:00-10:40

Keywords. aerospace engineering; complexity; systems thinking; stakeholder-focused engineering; emergent risk; model-based systems engineering; agile development; perspective; engineering systems; cynefin framework; risk management; systems science; organizational science; complex adaptive systems; #RisksComplex

Abstract. Managing complexity in the aerospace industry is essential for effective development of modern engineered systems. Preventing emergent risk while maintaining cost and schedule discipline is the main objective for addressing uncontrolled self-organization due to complexity. Emergent risk can be quantified by viewing systems from multiple stakeholder and design perspectives to more accurately assess unforeseen behaviors. Methods for dealing with complexity that come from the systems, organizational and complexity science perspectives are considered and transposed into an aerospace context. This survey highlights commonalities between complexity management methods, systems design models, and elements of systems thinking that can be used to predict and prepare for emergent behavior in the system. Using new points-of-view in design gives practicing engineers more information with which to view and manipulate system properties. Ultimately, the solution for managing complexity lies in multidisciplinary collaboration in order to solve problems that span multiple academic domains.

Practice over perfection; A case study in building an in-house Systems Engineering Capability

Duncan Kemp (UK Ministry of Defence) - duncan@17media.co.uk
Megan Shenton (UK Ministry of Defence) - Megan.Shenton625@mod.gov.uk
Vince Adams (UK Ministry of Defence) - Vincent.Adams100@mod.gov.uk

Presented on: Thursday, 08:45-09:25

Keywords. Systems Engineering; Internal Consultancy; Kotter; Cynefin; High Energy Teams; Culture; Capability building

Abstract. This paper describes a case study in building an in-house Systems Engineering capability from concept through to delivery within a large asset owner operator. In a 12 month period the capability grew from an idea to a team of 19 delivering $1M of savings to the organization. The paper describes the growth of the team over four phases: (1) problem understanding and approach; (2) proof of concept (initial recruitment, operation and benefits delivery), (3) establishing the team and franchising the model to other disciplines; (4) further growth and embedding the model into the organisation's make/buy model. We describe the factors that contributed to the achievement of the team success including: a clear understanding of the systemic barriers to building an in-house SE capability; the use of Kotter's 8 step change process; a clear focus on delivering value to key stakeholders; the use of simple management processes and tools; and, the development of the right culture and selection of the right people. Finally, the authors identify some key lessons that might be applicable for others.

Papers#6

Professional Development of Student Engineers Using Design Thinking

Heidi Ann Hahn (Los Alamos National Laboratory – LANS LLC) - hahn@lanl.gov
Valerie J. Lawdensky (Los Alamos National Laboratory – LANS LLC) - vlawdensky@gmail.com
Lia C. Meirose (Los Alamos National Laboratory – LANS LLC) - liacmeirose@gmail.com
Hannah D. Mohr (Los Alamos National Laboratory – LANS LLC) - hdmohr@vt.edu
Haley B. Turman (Los Alamos National Laboratory – LANS LLC) - hturman@lanl.gov
Sandra J. Zimmerman (Los Alamos National Laboratory – LANS LLC) - szimmerman@lanl.gov

Presented on: Monday, 14:15-14:55

Keywords. Design Thinking; Professional development; Qualitative data collection and analysis; #Academia

Abstract. Future Female Leaders in Engineering (FFLIE) Program participants at Los Alamos National Laboratory were tasked to provide a design solution that would help the Bradbury Science Museum meet its educational outreach mission, using the principles and practices of Design Thinking (DT). The DT project aimed to improve the students' skills in the areas of project planning, problem definition, qualitative data collection and organization, problem solving, and product life cycle planning to prepare them for leadership roles on future technical projects. The instructional content used in the program is summarized at the outset of each section of the paper. How the students implemented the phases of Design Thinking and the resulting products are also described, using excerpts from the final project report they prepared. Throughout the project, the design team learned how to effectively brainstorm, communicate with others, gather needed information through interviews, analyze the information, and work as a team to finalize ideas. Prototyping and testing showed that the design solution they proposed is feasible and should help students in the targeted grade levels develop an interest in science.

Papers#15

Property Model Methodology: A Landing Gear Operational Use Case.

Patrice Micouin (Micouin Consulting for Innovative Systems Engineering) - pm@micouin-consulting.com
Pascal Paper (AIRBUS Helicopters) - pascal.paper@airbus.com
Louis Fabre (AIRBUS Helicopters) - louis.fabre@airbus.com
François Guérin (MathWorks) - francois.guerin@mathworks.fr
Thomas Razafimahefa (AIRBUS Helicopters) - thomas.razafimahefa@airbus.com
Roland Becquet (AIRBUS Helicopters) - roland.becquet@airbus.com

Presented on: Monday, 16:15-16:55

Keywords. Discrete Continuous and Hybrid Systems; Model-Based Systems Engineering; Simulation-Based Systems Engineering; Specification Model Validation; Design Model Verification; Zig zagging process; #Government

Abstract. Relevant for engineering a wide range of technological systems, Property Model Methodology (PMM) is applied in this paper to the development process of a helicopter function in the frame of the ARP4754A/ED79A. After a short presentation of the method, the case study is presented: "to retract and to extend airborne the landing gear system". Then, each stage of the PMM development process is illustrated by examples from the case study: (1) Modeling the top level requirements specification, (2) Validating the requirements specification by proof and simulation, (3) Modeling the architectural design, Refining the top level requirements into requirements specified to the different subsystems contributing to the function and Modeling the terminal subsystems detailed designs (4) Validating the requirements specified to the contributing subsystems by proof or simulation, (5) Verifying the design models by simulation and finally (6-8) Verifying physical implementations by test on the basis of all validation and verification scenarios accumulated throughout the development. At end, lessons learnt and industrial perspectives are summarized highlighting how PMM is a methodology adapted to the challenges facing to systems engineering by the globalization of development processes and showing how PMM can provide a powerful conceptual framework to support digital continuity within globalized Design Organizations. Modeling, simulation, proof and test generation activities are supported by the MATLAB and Simulink products.

Papers#52

Quantitative Resiliency Analysis and Modeling of Microgrids

Myron Hecht (The Aerospace Corporation) - myron.hecht@aero.org

Presented on: Wednesday, 10:45-11:25

Keywords. resiliency; microgrids; SysML; Critical Infrastructure; Electrical Power; Measures of Performance; Measures of Effectiveness; #RisksComplex; #Infrastructure; #PowerEnergy

Abstract. Electrical power generation, transmission, and distribution are among the most vital of the critical infrastructure services in modern society. While electrical grids in developed regions of the world are highly reliable, they are to cyberattacks, extreme weather, electromagnetic pulses, and other extreme natural phenomena and malicious events. Microgrids are generally recognized as a means of increasing resiliency of electrical power. However, a specific quantitative definition of resilience and the appropriate measures of performance and effectiveness have not yet been established. Without these quantitative measures of performance and effectiveness, it is not possible to assess how much resilience a microgrid has or what enhancements or corrective actions are necessary to enable it to reach a specified level of resiliency. This paper proposes such quantitative resiliency measures, sets forth approaches for modeling and evaluating them, provides application examples, and shows they can be encapsulated within SysML models.

Papers#69

Reading Further Between The Lines – Recent Developments in the UK MOD Acquisition Requirements & Acceptance Tube Map

Ian Gibson (Jacobs) - Ian.Gibson@jacobs.com
Andy Price (Jacobs) - andrew.price@jacobs.com
Samantha Williams (UK Ministry Of Defence) - Samantha.Williams952@mod.gov.uk
Ian Blake (UK Ministry of Defence) - Ian.Blake873@mod.gov.uk

Presented on: Monday, 13:30-14:10

Keywords. Acquisition System; Acquisition System Guidance; Requirements; Acceptance; Test; Evaluation; Tube Map; P3M; CADMID; MSP; Programme Management; #Government

Abstract. How do you visualise a very large complicated problem? With a very large complicated diagram obviously! But what if the diagram used a familiar notation that needed little or no explanation? What if the subject matter could be carved up into distinct interwoven threads that would be easily recognised by the reader? Welcome to the MOD Acquisition Requirements & Acceptance Tube Map. The authors have been engaged in a task to rewrite the UK Ministry Of Defence (MOD) Acquisition System Guidance intranet site for Requirements, Test, Evaluation and Acceptance. Whilst the task has resulted in a major overhaul of the guidance, it has been underpinned by a novel depiction of parallel threads of Requirements; Test, Evaluation & Acceptance; Portfolio, Programme and Project Management (P3M); and Solution Development - running through the parallel interrelated lifecycles of Programme Management (based on the Generic Capability Model) and Project Management (based upon the CADMID lifecycle – Concept, Assessment, Demonstration, Manufacture, In-Service, Disposal). This has taken the form of an underground "tube map" with lines representing stakeholder communities, minor stations representing technical activities, callout boxes for work products, and interchange stations representing review points.

Papers#120

Reducing Project Cost Growth Through Early Implementation of Interface Management

Magnus André Nilsen (University College of Southeast NO) - magnus_nilsen91@hotmail.com
Kristin Falk (University College of Southeast NO) - Kristin.Falk@usn.no
Tom Arnfinn Haugen (TechnipFMC) - Tomarnfinn.haugen@technipfmc.com

Presented on: Monday, 10:45-11:25

Keywords. Interface Management; Systems Engineering; Project Execution; Mitigating project cost growth; System responsibility; Management of change; #Industry; #Infrastructure

Abstract. This paper presents and analyzes quantitative data on Interface Management in the oil and gas domain from a subsea contractor point of view. To develop subsea oil and gas fields four to seventeen contractors collaborate via Interface Management to ensure that the technical parts fit prior to implementation and integration. This research has both analyzed quantitative data from seven large projects, and investigated the topic in depth using interviews. The results prove that late involvement of contractors contribute to project cost growth during project execution. The detailed analysis of a reference project showed that almost one third of the contractor's contractual changes were due to supply gaps toward other contractors. Early implementation of Interface Management could help mitigating this, and ensure project execution within predicted cost and schedule parameters.

Requirements Management or Assurance Management? Keep the data integrated!

Richard Beasley (Rolls-Royce plc) - Richard.Beasley@rolls-royce.com
Iain Cardow (Rolls-Royce plc) - Iain.Cardow@rolls-royce.com
Andrew Pickard (Rolls-Royce Corporation) - Andrew.C.Pickard@rolls-royce.com

Presented on: Tuesday, 13:30-14:10

Keywords. Requirements Management; Assurance Management; Requirements; Evidence; Definition; Verification; REDV; #SEFundementals

Abstract. The successful development of complicated and/or complex systems is facilitated by the application of Systems Engineering. The System Engineering technical processes create a lot of information, which is subject to change during system development. This information must be appropriately managed and change controlled. Beyond the basic configuration management of selected documents the elements in these, including individual Requirements, Evidence, Definition and Verification (REDV) information, must be subject to configuration management and change control.

This paper reviews how this information should be managed as a whole, and so there should not be a focus on “merely” requirements management. Dick and Chard (2004)’s “requirements sandwich” and Scheithauer and Forsberg (2013)’s “Assurance V model” are combined in this paper into a REDV information management process. The types of information, the linkage to the technical processes that produce the information, how information changes during the iteration and integration activities in system development are described. This approach to the information management is recommended as a progressive assurance management process. This will ensure information is joined up (so the system remains a whole) and is integrated with the system development plan (particularly the design iterations).

Papers#77

Reverse engineering a legacy software in a complex system: A systems engineering approach

Maximiliano Moraga (University College of Southeast NO) - moraga.max@gmail.com
Yang-Yang Zhao (University College of Southeast NO) - yangyang.zhao@hbv.no

Presented on: Wednesday, 16:15-16:55

Keywords. Legacy software; reverse engineering; complex system; CAFCR; #RisksComplex

Abstract. In a complex system, a legacy software as a component is determined by various factors beyond its own capability. Lack of knowledge that shaped software, which is often the case of a legacy software, can prohibit appropriate maintenance and development to comply with the system needs. To reverse engineering legacy software for a fit with the overall system of interest is a daunting task. Existing techniques of reverse engineering are mostly from a purely technical point of view and for the single discipline of software engineering. Thus, this paper aims for an approach to properly reverse engineer the reasoning behind the legacy software developments in a complex system. By jointly apply the CAFCR model and the reverse engineering, a roadmap is created to guide incremental developments of legacy software in a complex system, which benefits both the maintenance of existing implementation and realization of new functionalities for improved system performance.

Papers#47

Risk Management Limbo: How Low Can You Go?

Casey Medina (Studio SE, Ltd.) - caseymedina@yahoo.com

Presented on: Monday, 10:45-11:25

Keywords. Risk; Control; Resilience; Risk Management; Compliance; ISO 14971; #RisksComplex; #Healthcare

Abstract. Risk management standards and regulations are evolving and becoming increasingly stringent. This paper describes a methodology for evaluating the effectiveness of risk control measures that draws from existing work on system resilience. System resilience principles are reduced to a set of questions that can be easily understood to ensure adequate application of the principles. This paper describes a method for determining when appropriate risk reduction has been achieved. This paper presents a method that can be applied consistently across projects, companies, and industries to enhance the effectiveness and efficiency of risk mitigation efforts.

Papers#156

Safety Analysis in Early Concept Development and Requirements Generation

Nancy Leveson (MIT) - leveson@mit.edu

Presented on: Tuesday, 11:30-12:10

Keywords. Early Concept Analysis; STPA; Safety; #RisksComplex

Abstract. This paper shows how a new hazard analysis technique, STPA (System Theoretic Process Analysis), can be used to generate high-level safety requirements early in the concept development phase that can then assist in the design of the system architecture. These general, system-level requirements can be refined using STPA as decisions are made. The process goes hand-in-hand with design and the rest of the lifecycle as STPA can be used to provide information to assist in decision-making throughout the development and even operations phases. STPA also fits into a model-based engineering process as it works on a model of the system (which is also refined as design decisions are made) although that model is different than the architectural models usually proposed for model-based system engineering today. The process promotes traceability throughout the development process so decisions and designs can be changed with minimum requirements for redoing previous analyses. Finally, while this paper describes the approach with respect to safety, it can be applied to any emergent system property.

Papers#76

San Diego, We Do NOT Have a Problem! SE Leadership in the Construction Industry

Oliver Hoehne (WSP USA) - hoehneom@pbworld.com
Jennifer Russell (Garver USA) - JLRussell@GarverUSA.com

Presented on: Wednesday, 11:30-12:10

Keywords. Construction; Leadership; Communication; Change Management; Design Criteria; Acquisition; Procurement; RFP; #RisksComplex; #Infrastructure

Abstract. Problem Statement. Construction holds the dubious honor of having the lowest productivity gains of any industry. The Economist reported recently that more than 90% of the world's infrastructure projects are either late or over-budget. Even the sharpest of tech firms are not immune from this affliction. Apple's new headquarters in Silicon Valley, for instance, opened two years behind schedule and cost $2B more than budgeted (Economist, 2017). While many US sectors including agriculture and manufacturing have increased productivity ten to 15 times since the 1950s, the productivity of the construction industry remains stuck at the same level as 80 years ago, according to the McKinsey Global Institute (Barbosa, 2017).
Root Cause(s). The construction industry has become less likely to reinvest in productivity. Volatility in demand for construction, extensive fragmentation of construction companies, and slim margins lead to a tendency to defer improvement investments. Often projects have more than a dozen subcontractors, each keen to maximize profit rather than collaborate to contain costs. The result is an industry that mostly ignores tools that might improve productivity (Barbosa, 2017). A variety of factors account for poor productivity and cost outcomes: poor organization, inadequate communication, contractual misunderstandings, poor short-term planning. Contractors and suppliers identify misaligned contracts as the most important root cause of low productivity (Barbosa, 2017).
Possible Solution(s). Examples of innovative firms and regions suggest that acting in several areas simultaneously could boost productivity by 50 to 60 percent. Many of these actions translate directly into Systems Engineering activities, including rewiring of the contractual framework, rethinking design and engineering processes, improving procurement and supply-chain management, and introducing holistic project-operating systems into infrastructure megaprojects (Barbosa, 2017).
Systems Engineering Challenge(s): Most individual construction industry players lack both the incentives and the scale to change the system, resulting in industry that is literally not willing and not able to make changes to improve productivity. Systems engineering attempts are commonly met with a firm "San Diego, we do NOT have a problem, we have always done it this way!" The true systems engineering challenge is therefore to nudge industry players towards "being willing and able" to make changes by applying organizational change management skills while cautiously introducing systems engineering elements. This paper demonstrates how systems engineers – despite the identified obstacles – can be successful in identifying systems engineering opportunities, and using influence and leadership to drive change from within construction projects, as illustrated by two real world construction megaprojects.

Papers#153

SE Management is Not SE Core Competency: Time to Shift this Outdated, 60-Year-Old Paradigm

Charles Wasson (Wasson Strategics, LLC) - wslse@cpws.net

Presented on: Wednesday, 10:45-11:25

Keywords. ABET; System Engineering Competency; Groupthink; Paradigm; Systems Management; SE Management; Engineering Management; SE Standards; SE Processes; Engineering Education; SE Textbooks; System Complexity; MBSE; CMMI; ISO 15288; CSEP; INCOSE SE Handbook; SE Competency Framework; SE Core Knowledge; SE Application Experience; INCOSE Vision 2025; #Academia

Abstract. In the early 1950's the development of large, complex systems encountered two major challenges: (1) traditional Engineering methods were inadequate for coordinating and communicating designs and changes across multiple disciplines; and (2) projects were incurring unmanageable technical failures, cost overruns, and schedule slips. Exacerbating these challenges were growing conflicts between management and the engineers and scientists performing the engineering. These two challenges manifested themselves in the form of a "management gap," which emerged due to management frustrations with engineers and scientists' inability to articulate how the engineering process was performed, and (2) a "technology gap," which emerged due to engineers and scientists' frustrations with management's inability to understand how engineering was performed and the new technologies being implemented.
Central to these issues was the threat to the prevalent 1950's management paradigm of exercising authoritative control over subordinates by planning, organizing, staffing, directing, and controlling the tasks engineers and scientists performed. Corrective action solutions were urgently needed. Rather than solving the challenges, government as the acquirer of large, complex systems, decided to regain authoritative control over its contractors. As a result, the concept of Systems Management was introduced and mandated via a series of Systems, SE, and Engineering Management process standards. Over the past 60+ years, the emerging field of Systems Engineering (SE), which originally focused on answering a key engineering question "Will the system work – i.e., 'be fit for purpose' when realized? (Ring, 2017) shifted to "did we follow our processes?" Projects corrected a "management" problem while neglecting the "engineering" question. As a result, projects continue to exhibit systemic performance issues. It is time to shift this outdated Systems Management paradigm and reestablish SE core competency as the "engine" for correcting SE contributions to project performance issues that seem so intractable.

Papers#56

Setting Priorities: Demonstrating Stakeholder Value Networks in SysML

Matthew Sease (Cummins, Inc.) - matthew.sease@cummins.com
Brian Smith (General Motors, Corp.) - brian.t.smith@gm.com
Daniel Selva (Cornell University) - ds925@cornell.edu
James Hummell (MBSE Solutions, LLC) - jhummell@MBSE.Solutions

Presented on: Wednesday, 13:30-14:10

Keywords. Stakeholder Value Networks; Stakeholder Analysis; Stakeholder Prioritization; Model Based Systems Engineering; Systems Architecture; #MBSE

Abstract. Graph theory is used across systems science and engineering to obtain insights about the structure of complex systems. For example, in Stakeholder Value Networks (SVN), graphs are used to model stakeholders and their value exchanges. Centrality measures can thus be used to help the systems engineer prioritize among stakeholder needs. SVN have documented utility across multiple applications. The purpose of this paper is to demonstrate a relatively simple technique to codify an SVN within a Systems Modeling Language (SysML) based tool. Such a technique enables the prioritization of stakeholders to permeate the entire system model.
The authors constructed a SysML model of a fictitious enterprise to demonstrate the SVN method. Stereotypes and tag values were used to visualize the data created during the SVN analysis. The output of the SVN was propagated to additional system elements such as Stakeholder Needs, System Goals and System Functions. These were created by stereotyping standard SysML elements. In addition to integrating SVN with SysML, the authors show how the SVN can provide input for a trade-off analysis.

Papers#42

Synchronizing Systems Engineering and Implementation in Lean-Agile Programs

Robert Maione (Techna Systems Inc.) - rmaione@technasystemsinc.com
Mark Wilson (Strategy Bridge International, Inc.) - mwilson@strategybridge.com

Presented on: Tuesday, 11:30-12:10

Keywords. Agile; Agile Development; Lean; Lean-Agile; Development Strategy; Mission Value Threads; #Industry

Abstract. In traditional system development programs, high-level statements of capability and mission needs are elaborated and functionally decomposed, and then systematically allocated to discrete program segments or subsystems. Functional decomposition continues to be a classic systems engineering technique to define and manage the development of large systems, but this approach can create issues in systems that are being developed using Lean-Agile methods. Lean-Agile developers typically adopt a “time box” perspective, where the goal is incremental delivery of system capability on a predictable schedule. In other words, Lean-Agile developers may adopt a development rhythm with increments of rapidly evolving capability delivered every 10-12 weeks, while the SE team stays focused on the progress of the overall system as it was originally planned and defined. This divergence of both pace and perspective can lead to misunderstandings between systems engineers and developers or worse, disconnects between what the systems engineers think the developers are building and what developers are actually building.
Communication suffers when Lean-Agile developers and program systems engineers operate in separate organizational “silos” instead of working together as a cohesive team. Day-to-day implementation decisions with potential impact to overall system capability can become buried within lower level engineering and development documents that are hard to synthesize to support timely program decisions. In our work with large programs employing Lean Agile development strategies, we discovered an approach that maintains systematic collaboration between developers and the SE team. In our approach, we explicitly measure and communicate incremental delivery of value using a new level of abstraction that we call Mission Value Threads (MVTs). MVTs directly link system requirements and their associated SE artifacts to Lean-Agile development team backlogs and design documentation. This paper describes how to use MVTs to manage value delivery while fostering better collaboration between developers and systems engineers.

Papers#103

System Engineering Strategies for Coastal Flooding Mitigation

Kim McEligot (George Mason University) - kmceligo@masonlive.gmu.edu
Peggy Brouse (George Mason University) - pbrouse@gmu.edu

Presented on: Thursday, 11:30-12:10

Keywords. Coastal Flood Mitigation; Systems of Systems; Resilience; Model Based Design; #Industry; #Infrastructure

Abstract. Coastal flooding is a significant economic hazard. Multiple mitigation measures may be complementary or counterproductive. This paper identifies the applicability of System Engineering techniques in the development of a coherent mitigation policy at the community level. Current mitigation design practices are described, improvements are identified and a model-based approach is recommended. An integrated computational fluid dynamics and agent based modeling framework is proposed to conduct cost-benefit analysis of public structural mitigations and other options.

Papers#155

System Lifecycle Handler — Spinning a Digital Thread for Manufacturing

Manas Bajaj (Intercax) - manas.bajaj@intercax.com
Thomas Hedberg (National Institute of Standards and Technology) - thomas.hedberg@nist.gov

Presented on: Thursday, 11:30-12:10

Keywords. Digital Thread; Manufacturing; Model-Based Systems Engineering; Model-Based Engineering; Product Lifecycle Management (PLM); Application Lifecycle Management (ALM); Computer-Aided Design and Manufacturing (CAD/CAM); Cyber-Physical Systems; Open Standards; Graphs; Simulations; #Infrastructure; #Automotive

Abstract. Transforming the manufacturing economy from paper-based information flows to a seamless digital thread across geographically distributed supply chains has the potential to reduce cycle time by 75% and save manufacturers $30 billion annually. The “Digital Thread for Smart Manufacturing” project at NIST 1 is developing methods and protocols for completing a digital thread running through design, manufacturing, and product support processes. In this paper, we present a proof-of-concept System Lifecycle Handler (SLH) software environment being developed for the digital thread initiative. The SLH provides services to build, manage, query, and visualize the digital thread by connecting heterogeneous artifacts ranging from requirements and system architecture to PLM/CAD/CAM and simulation models to machines and sensor data streams. The SLH software environment leverages the Syndeia platform, and exposes its capabilities via a web dashboard and standard REST/HTTP API.

Papers#114

Systemic Intervention for Complex System Governance

Charles Keating (Old Dominion University) - ckeating@odu.edu
Polinpapilinho Katina (National Centers for System of Systems Engineering) - pkati001@odu.edu
Ra'ed Jaradat (Mississippi State University) - jaradat@ise.msstate.edu
Joseph Bradley (Leading Change, LLC) - josephbradley@leading-change.org
Richard Hodge (DrRichardHodge.com) - richard@drrichardhodge.com

Presented on: Thursday, 10:45-11:25

Keywords. Complex Systems; System Governance; Systemic Intervention; #RisksComplex

Abstract. Complex System Governance (CSG) is an emerging field with potential to enhance capabilities for design, execution, and evolution of complex systems. CSG offers a theoretically grounded, model informed, and methodologically driven approach to more effectively deal with complex systems and their problems. However, initial CSG applications have identified multiple impediments to systemic intervention to deploy this new and novel field. In this paper we examine the nature, implications, and response strategies to more effectively deploy systemic intervention in support of CSG. Following a brief introduction to CSG, four primary objectives are pursued, including: (1) identification of major forms of systemic intervention for complex systems in general and a corresponding classification schema, (2) presentation of a dynamic and tailored approach (CSG-Entry) to improve prospects for introductory systemic intervention for CSG, (3) results from an initial application of CSG-Entry in a field setting, and (4) suggestion of lessons learned from initial applications of CSG-Entry in relationship to systemic intervention. The paper concludes with examination of future development directions for systemic intervention to advance CSG performance.

Papers#54

Systems Engineering Quick Check

Sven-Olaf Schulze (UNITY AG) - sven-olaf.schulze@gfse.de
Daniel Steffen (UNITY AG) - sven-olaf.schulze@unity.de

Presented on: Tuesday, 14:15-14:55

Keywords. Quick Check Systems Engineering; Maturity; ISO15288; ISO29110; Industrial experience; SME; #Academia

Abstract. It is not possible to make a clear statement whether the ongoing globalisation in the context of system development holds more opportunities or more risks for companies. However, it is undisputed in this context that the system development projects have become and will continue to gain immense complexity in the context of increasing economic interdependencies. Considering the possibilities of the Internet of Things with the multitude of networked, autonomous systems, it quickly becomes clear that the complexity of system development will take on even greater dimensions in the future. The companies have recognized that they can only rise to this challenge with Systems Engineering and that they only can survive on the market of "Systems-of-Systems" by applying interdisciplinary development methods. For this reason the "SE Quick Check" was developed, a pragmatic instrument with which product development in companies can be analysed and tailored in order to lay the foundation for the introduction or targeted optimization of individually coordinated Systems Engineering. As shown in a variety of applications in companies, the approach can be used to determine an SE maturity level and an individual SE target in the shortest possible time. Based on this, measures can be defined and implemented directly to achieve the SE target image.

Systems Engineering, Data Analytics, and System Thinking: Moving Ahead to New and More Complex Challenges

Ron S. Kenett (The Neaman Institute) - Ron@kpa-group.com
Avigdor Zonnenshain (TECHNION) - avigdorz100@gmail.com
Robert Swarz (WPI) - rswarz@wpi.edu

Presented on: Thursday, 10:00-10:40

Keywords. Data Analytics; The Fourth Industrial Revolution; Systems Thinking; Internet of Things; Industry 4

Abstract. During the last decade, industries in advanced economies have experienced significant changes in their engineering and manufacturing practices, processes, and technologies that have the potential to create a resurgence in their engineering and manufacturing activities. This phenomenon is often referred to as the Fourth Industrial Revolution or Industry 4.0, and is based on advanced manufacturing and engineering technologies, such as massive digitization, big data analytics, advanced robotics and adaptive automation, additive and precisions manufacturing (e.g., 3-D printing), modeling and simulation, artificial intelligence, and the nano-engineering of materials. This revolution presents challenges and opportunities to the systems engineering discipline. For example, virtually all systems will have porous and ill-defined boundaries and requirements. Under Industry 4.0, systems will have access to large types and numbers of external devices, and to enormous quantities of data, which have to be analyzed through data analytics. It is therefore the right time for enhancing the development and application of data-driven and evidence-based systems engineering. One of the trends in data analytics is the shift from detection to prognosis and predictive monitoring in systems testing and maintenance using Prognostics and Health Monitoring (PHM). Also, it is proposed to practice evidence-based risk management as a more effective approach for managing the systems' risks.
System properties like reliability, safety, and security are very important systems attributes. So, it is proposed to integrate such 'ilities' into the systems engineering processes by introducing modern methodologies based on data analytics and systems theories. Modeling and simulation are going through impressive developments in this era. It is imperative for the systems engineer to exploit these advancements for system design, operation, and demonstration. Companies which are striving to introduce the advancements of the Fourth Industrial Revolution may apply the maturity level assessment tool proposed in this paper. We therefore provide here a context, an assessment tool and a roadmap for enhancement in system engineering designed to meet the challenges of industry 4.0.
The paper also evaluates the INCOSE VISION 2025 with a critical view to see if it meets the challenges and opportunities of the Fourth Industrial Revolution.
Finally, it is suggested herein that systems engineering needs a new model which we refer to as 'the double helix.' This model emphasizes the tight connection that systems engineering must have with applied systems thinking, as well as the new properties and processes, such as data analytics, security, safety, reliability, risks, and resilience, that must be integrated into the process. Following an introduction, the paper includes 13 sections that map different aspects of challenges for systems engineering in the context of the Fourth Industrial Revolution. The roadmap this presents is designed to provide both researchers and practitioners with a practical agenda for addressing emerging Industry 4.0 challenges and opportunities.

Systems Interface Management with MBSE: from Theory to Modeling to Reality

Matthew Hause (PTC) - mhause@ptc.com

Presented on: Wednesday, 10:00-10:40

Keywords. Interface; MBSE; SoS; UAF; SysML; Interoperability

Abstract. Systems interoperate using interfaces. They exist between capabilities, organizations, people, systems, people and systems, systems and nature, systems of systems, and so forth. Interfaces are used to support both system to system communication as well as supporting the complete set of enterprise goals. Interfaces are where the most interesting things happen. And where most things go wrong. This paper addresses system interface-management issues and the benefits of Model-Based Systems Engineering (MBSE) approaches. An initial focus will be placed on interface information content that needs to be addressed at each level of system decomposition – from external stakeholders to system boundary to eventually, system component- to-component. The focus will then shift to interface management to model-based and functional/logical design practice. It will also cover system interconnection and communications, how they change, operate and evolve over time to implement mission goals and to satisfy stakeholder needs. Finally it will look at physical systems and the connection to PLM/CAD domains.

• Defining stakeholder goals and required capabilities
• Interface definition with MBSE
• Functional Architecture Interfaces
• Logical Architecture Interfaces
• Physical Architecture Interfaces
• Allocation across cross cutting views
• How behavior drives interfaces which drive behavior
• Defining interaction requirements
• Implementing effective and testable interface specifications
• Traceability throughout the architecture
• Service Oriented Architectures.

Papers#58

Technology Readiness Assessment for the Nuclear Weapons Program

Glenn Bell (National Nuclear Security Administration) - Glenn.Bell@nnsa.doe.gov
Srinivasan Venkatesh (TechSource, Inc) - srini.venkatesh@nnsa.doe.gov
Caroline Bruns (TechSource, Inc.) - caroline.bruns@nnsa.doe.gov

Presented on: Monday, 16:15-16:55

Keywords. readiness level; assessment; nuclear security; calculator; #Government

Abstract. Technology development is typically the process of developing and demonstrating new or unproven technology, the application of existing technology to new or different uses, or the combination of existing and proven technology to achieve a specific goal. Technology development associated with a specific acquisition project for nuclear weapon typically should be identified early in the project life cycle and its maturity level should evolve to a confidence level that allows the project to establish a credible technical scope, schedule, and cost baseline. Projects that perform concurrent technology development and design implementation may run the risk of proceeding with an ill-defined project baseline.
In the climate of declining federal budgets and increased budget scrutiny, it is prudent to determine—as early as possible within a program schedule—the viability of technologies, and the ability of those technologies to support a specific project as well as the overall U.S. nuclear deterrent mission.
This paper describes the approach and tools used within the nuclear weapons programs for assessing the maturity of technologies and their readiness for insertion into the project design and execution schedule.

The Cynefin Framework and Technical Competencies: a New Guideline to Act in the Complexity

Davide Fierro (INAF) - davide.fierro@inaf.it
Stefano Putino (INAF) - stefano.putino@gmail.com
Lucio Tirone (Aster S.p.A.) - lucio.tirone@aster-te.it

Presented on: Tuesday, 11:30-12:10

Keywords. Cynefin Framework; Technical Leadership; Systems Engineering; Management Strategies; Decision Support Systems; Uncertainty; #Academia

Abstract. The current socio-economical context is affected by extremely challenging factors such as the macro-economic crisis, the globalization of markets, the exponential growth in the complexity of systems, the continuous evolution of technologies and the criticality of requirements subject to rapid and sometimes uncontrollable evolution.
In such a competitive landscape the role of the future leaders gets essential. They shall be able, by means of a holistic, methodologically structured and flexible approach, to drive their programs through the implementation of the complex changes which are strategic to preserve the competitiveness. Such new leaders must be endowed with both strong technical skills, continuously trained in the key reference standards, and soft skills, useful for the strategic understanding of the evolutionary processes expressed by the markets and for the improvement of the complex relationships efficiency with the relevant stakeholders.
The development and implementation of optimized technical-managerial solutions is therefore essential, vital for the “feasibility” and competitiveness of front-running projects, and cannot succeed without a contextual analysis of the reference scenarios.
In this context the Cynefin Framework, an interpretative model of the different levels of the systems complexity, ranging from order to disorder, can provide a very effective support.
The goal of this paper is to develop a multi-faceted and comprehensive vision of the problems in the various domains of complexity, “contextualizing” the most effective management approaches and “soft and hard” skills of the leader.
The paper benefits of the input received during various sessions of the second Cohort of the INCOSE Technical Leadership Institute, where precious insight and feedback has been collected, especially from the TLI coaches, Patrick Godfrey, Michael Pennotti and Don Gelosh.

Papers#48

The Fundamental Nature of Resilience of Engineered Systems

Timothy L.J. Ferris (Cranfield University) - Timothy.Ferris@cranfield.ac.uk
Scott Jackson (Burnham Systems Consulting) - jackson@burnhamsystems.net
Eric Specking (University of Arkansas) - especki@uark.edu
Gregory Parnell (University of Arkansas) - gparnell@uark.edu
Edward Pohl (University of Arkansas) - epohl@uark.edu

Presented on: Wednesday, 16:15-16:55

Keywords. ResilienceSystems EngineeringCapability

Abstract. We take the position that an engineered system is a means to enable user capability that provides value to stakeholders and address the question of the fundamental nature of resilience of engineered systems. Therefore, resilience is concerned with the behavior of the system in the face of a disruption, in particular emphasizing the management, through system design of the system behavior and operational capability under disruptive conditions, which include adverse events outside the operational envelope of the system and conditions in which parts of the system have been damaged. We provide a definition of engineered resilience and show an approach to measure engineered resilience. By taking a philosophical approach to the understanding of resilience, we are able to show where resilience fits in the overall task of engineering systems and how this view provides coherence across the various aspects of resilience which is not otherwise provided.

Papers#26

The Implementation of a Business Intelligence Platform to Leverage the Army Logistics Support Command's Balanced Scorecard - A Case Study

Raul Rodriguez (ISDEFE) - RRODRIGUEZ@ISDEFE.ES
Pedro Diaz-Osto (Spanish Army) - pdiaosto@gmail.com
Alberto Sols (Universidad Europea de Madrid) - alberto.sols@usn.no

Presented on: Tuesday, 10:45-11:25

Keywords. Business Intelligence; Balanced Scorecard; Defence; Army; Logistics; Support Command; #Industry

Abstract. Many complex organizations struggle to optimize the use of their assets and resources. The Logistics Support Command of the Spanish Army was aware, about a decade ago, of a number of inefficiencies that had a negative influence on the effectiveness of the weapon systems that it had to sustain in their operational lives. In order to improve the management of its allocated resources, it decided to develop and implement a balanced scorecard and a business intelligence platform. The job was performed with the support of ISDEFE (Engineering Systems for the Defence of Spain) the systems engineering firm of the Ministry of Defence. The systems approach led to a successful implementation of the needed platform, which substantially enhanced the effectiveness and efficiency of the Logistics Support Command. This paper shows what was done, and how. This case study of applied systems engineering enables the issuing of a number of recommendations for organizations that plan to develop similar business intelligence platforms, as a mechanism to becoming more competent and successful at the managing of their resources.

The Importance of Project Management in the System Integration, Verification and Validation Process

Christoffer J. Røsegg (University College of Southeast NO) - christoffer_j_r@hotmail.com
Kristin Falk (University College of Southeast NO) - Kristin.Falk@usn.no

Presented on: Monday, 14:15-14:55

Keywords. Project management; Root cause analysis; Complex system; Schedule; Planning; Integration; Verification; Validation; Test; #Industry; #PowerEnergy

Abstract. Suppliers to the oil and gas industry are experiencing an increased pressure from customers to deliver products at a lower cost and shorter schedule. One of the most costly single activity in packaging a Complex System is the process of system integration testing, verification and validation (test phase). In the researched Company this process has also proven to be a bottleneck. Symptoms are accumulated units ready for test, projects that are not put through, and delayed completion of projects.

This paper analyzes the testing process. The initial objective was to identify what impacts the testing schedule. We analyzed the testing process using root cause analysis methods. Our research identified that several issues occurred, both prior to and in the test phase. However, only a few of the issues have a significant impact on the test schedule. This project shows how crucial project management is for complex systems. It also gives an insight to how the company can successfully manage the system integration, verification and validation phase.

Papers#164

The Oil and Gas Digital Engineering Journey

Matthew Hause (PTC) - mhause@ptc.com
Steve Ashfield (Nova Systems) - steve.ashfield@novasystems.com

Presented on: Monday, 15:30-16:10

Keywords. Oil and Gas; Digital Engineering; Digital Thread; IoT; MBSE; Digital Twin; #Industry

Abstract. Model-based systems engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. The INCOSE Integrated Systems Engineering Vision 2025 [INCOSE, 2014] describes how future systems engineering tools will facilitate systems engineering practices as part of a fully integrated engineering environment. A shift towards an integrated, digital engineering environment enables rapid transformation of concepts and designs to digitalized virtual prototypes and then to physical prototypes through the application of additive manufacturing technologies, such as 3D printers and the digital twin in operations. This capability enables engineers to rapidly and continually assess and update their designs prior to committing costs to production hardware.
Implementing this vision will require an integrated suite of tools, technologies, and standards to support the full systems engineering and product lifecycles from requirements to design to implementation and maintenance. MBSE models are digital and executable, and using an MBSE simulation engine, they can shift risk towards early stages of project development as the asset can be tested before it is built. In operations, IoT technologies enable companies to capture and leverage information about a product's performance during operation – with the potential to dramatically improve existing and future products. Service Lifecycle Management (SLM) solutions combine IoT platform technology with service solutions. This integrated closed loop systems engineering toolset applied to the Oil and Gas Industry will ensure success of the Digital Engineering Journey. This paper will describe this Digital Engineering Journey using a Coal Seam Gas example.

Papers#60

The Systems Engineering Incompetency Framework

Richard Beasley (Rolls-Royce plc) - Richard.Beasley@rolls-royce.com
Andrew Pickard (Rolls-Royce Corporation) - Andrew.C.Pickard@rolls-royce.com
Andy Nolan (Rolls-Royce plc) - Andy.Nolan@rolls-royce.com

Presented on: Tuesday, 10:00-10:40

Keywords. Competency; Incompetency; Framework; #Academia

Abstract. The INCOSE Competency Working Group has invested significant effort in defining a Systems Engineering Competency Framework. This is important in that it allows Engineers to assess their level of competence in the different Systems Engineering skills and see where further training or on-the-job experience may help them become more effective Systems Engineers. The assumption is that competency starts at zero and improves with experience and training. This paper looks at the opposite side of the coin; what happens if a competence is not just absent, but if a reverse "incompetence" is present. Does this spell disaster for a program or for development of an effective product? Is it possible to train someone in an incompetency? What can Engineers do to avoid developing a "Systems Engineering Incompetency"?

Papers#24

Towards Purpose to Function Transition: A systematic approach

Zelin Liu (COMAC) - collin524@163.com
Zhongyan Qian (COMAC) - qianzhongyan@comac.cc
Busheng Wu (COMAC) - wubusheng@comac.cc

Presented on: Thursday, 10:45-11:25

Keywords. purpose; function; scenario; requirement; #Academia

Abstract. In the initial stage of design, capturing user's purposes and transforming them into functions is crucial for wider range selection of design solutions. However, few researchers have distinguished the concepts of purpose and function. The purpose to function transition is still largely an experiences-based process by designers in early design stage and there is still lack of formal approaches or any standard in this field. Therefore, this paper firstly provides a philosophical understanding of purpose and function, tries to clarify their differences, and then proposes a scenario-based systematic approach to facilitate their transition. In this approach, the transition is conceptualized as a stepwise process and scenarios are integrated in such process for elaborating the initial needs. A case study will also be discussed to demonstrate the proposed approach.

Papers#129

Towards Solving MBSE Adoption Challenges: The D3 MBSE Adoption Toolbox

Mohammad Chami (Bombardier Transportation) - mohachami@gmail.com
Aurelijus Morkevicius (No Magic Europe and Kaunas University of Technology) - aurelijus.morkevicius@nomagic.com
Aiste Aleksandraviciene (No Magic) - aiste.aleksandraviciene@gmail.com
Jean-Michel Bruel (IRIT, University of Toulouse) - bruel@irit.fr

Presented on: Thursday, 08:45-09:25

Keywords. Model-Based Systems Engineering; Adoption Challenges; Toolbox; Modeling

Abstract. Increasing competition drives organizations to continually seek ways to improve the quality of their products and services, time to market and pricing pressures. Model-Based Systems Engineering (MBSE) promises many benefits to solve document-based engineering problems. However, the journey of MBSE adoption relies on several human, financial, organizational and technological factors. Organizations that decide to adopt MBSE must be aware of those factors. This paper outlines the MBSE adoption experience of a series of projects and presents an approach to support and guide organizations in overcoming MBSE adoption challenges.

Papers#117

Use of a Multidisciplinary Design Optimization Approach to Model Treatment Decisions in Oropharyngeal Cancer

Robert Aarhus (George Mason University) - raarhus@gmu.edu
Edward Huang (George Mason University) - edwardhuan@gmail.com

Presented on: Wednesday, 13:30-14:10

Keywords. Multidisciplinary Design Optimization; Shared Decision Making; Oropharyngeal Cancer; #Industry; #Healthcare

Abstract. A potential Systems Engineering (SE) contribution to the healthcare discipline is in modeling the influence of interrelationships found in long-term clinical decision-making dynamics. Shared decision-making (SDM) is an increasingly important practice used to navigate challenging issues in the selection of appropriate therapies. We have employed a Multidisciplinary Design Optimization (MDO) approach to formulate a prospective SDM model addressing treatment pathways for patients diagnosed with oropharyngeal cancer (OPC). While routine SDM is usually a collaboration between physician and patient, chronic and serious illness requires a longitudinal approach that coordinates action and decision space between multiple independent entities and represents a complex engineered system (CES) focused on successful treatment outcomes. We discuss an example that illustrates the trade-offs between functionality and longevity that is often seen in OPC, and outline our efforts in augmenting SDM practices to reduce regret and recognize the diversity of patient preferences.

Papers#113

Use of TRL in the systems engineering toolbox

Kjersti Bakke (HSN) - kjersti.bakke@gmail.com
Cecilia Haskins (INCOSE) - cec-has@online.no

Presented on: Tuesday, 13:30-14:10

Keywords. Technical Readiness Level; Technical Readiness Assessment; Limitations of TRL

Abstract. Technology Readiness Level (TRL) is used to evaluate the maturity of the Critical Technology Elements (CTE) in a project or program and indicates an assumed level of the remaining technical risks for each independent technology. This paper presents results of a literature review exploring the diversity of definitions applied to TRL. Survey results explore whether and how TRLs are used. Based on these results the authors assess to what degree TRL evaluations are suitable for organizations without separately trained and skilled readiness assessment personnel.

Papers#174

Using Board Games as Subject Matter for Developing Expertise in Model-Based Systems Engineering

Matthew Corrado (Georgia Institute of Technology) - mattcorrado98@gmail.com
Kathryn Trase (NASA) - kathryn.trase@nasa.gov

Presented on: Monday, 10:45-11:25

Keywords. Model Based Systems Engineering; Systems Modeling Language; Learning; Adoption; #Academia

Abstract. As more organizations transition from traditional document-centric systems engineering to a model-based approach, many are challenged to train their staff in new languages, tools, and methodologies, while managing the expectations of stakeholders and their expected model outcomes. In particular, challenges associated with learning a new modeling language and developing skills in the ‘art’ of modeling present organizations with formidable obstacles to realizing this transition. This paper hypothesizes that systems engineers may more readily learn how to correctly model with SysML, and develop intuition about the art of modeling and using patterns, if their learning references a commonly and thoroughly-understood subject, such as a board game. This paper presents a case for the use of board games as subject matter for new modelers. It demonstrates the concept with a sample model of Hasbro’s popular board game, Monopoly, and discusses the limitations of this approach and potential adaptations that may broaden the applicability of the learned skills to projects. Finally, results from a small feasibility assessment and concepts for more formal study to evaluate the hypothesis are presented.

Using Force-Field Analysis as Part of Systems Engineering Strategy to Achieve Goals

Clement Smartt (Georgia Tech Research Institute) - clement.smartt@gtri.gatech.edu
William Casey (ELG) - bill.casey@elg.net
Susan Ferreira (University of Texas at Arlington) - ferreira@uta.edu

Presented on: Thursday, 08:00-08:40

Keywords. strategy; force-field analysis; enablers

Abstract. This paper provides an overview of Force-Field Analysis (FFA) and how to employ it within a defined systems engineering strategy framework to help achieve systems engineering goals. The systems engineering strategy framework has previously been introduced; it includes a high-level model and a set of classes and attributes to facilitate systems engineering strategic decision-making. However, no specific methods have been presented for how to use that framework to help achieve goals. FFA provides such a method, considering enablers and barriers related to achieving a goal. A strategist uses FFA to identify actions an organization can take to address the defined enablers and barriers. An example is provided to illustrate the use of FFA in the context of a systems engineering organization.

Papers#136

Using Systems Theory to Address Complex Challenges to International Spent Nuclear Fuel Transportation

Adam Williams (Sandia National Laboratories) - adwilli@sandia.gov

Presented on: Tuesday, 14:15-14:55

Keywords. Systems theory; Complex systems; Interdependence; Hierarchy; Emergence; #RisksComplex; #Infrastructure; #PowerEnergy

Abstract. Simply looking at a world map suggests new, more complex set of risks and threats will challenge successful international spent nuclear fuel (SNF) transportation operations. Whether related to multimodal transfers of SNF casks or inconsistency in multijurisdictional control measures, international SNF transportation represents a clear example of new threats and risk stemming from a multifaceted, globalized operating environment. In response to recent work out of Sandia National Laboratories (SNL) suggesting that new, system-theoretic analysis techniques better ensure safe, secure and safeguarded international transportation of SNF, this paper explores the ability of basic systems theory concepts—interdependence, hierarchy and emergence—to better understand and address these complexities in system analysis.

Papers#21

Using the Cognition Cockpit Platform for the Systems Engineering of a Local Health Care System in Cameroon

Mario Kossmann (AIRBUS) - mario.kossmann@airbus.com

Presented on: Wednesday, 11:30-12:10

Keywords. Systems Engineering; Health Care; Education; Health Care System; Charity Project; International Development; Cameroon; Africa; Sustainable Development Goals; #Industry; #Healthcare

Abstract. All projects that are concerned with developing complex systems are potentially very challenging; yet charitable, i.e. not for profit, international development projects often have additional obstacles to overcome due to the geographical distance between the various stakeholders of the project; cultural, national and legal boundaries including multiple languages; uncertainty regarding the available budget and resources throughout the project life cycle, including the availability of needed volunteers; as well as a lack of the necessary infrastructure in terms of electricity, roads or telecommunications, if the focus of the project lies in developing countries. This is true not only for the Project Management activities of such projects but also for the related Systems Engineering activities.

Using the example of a charity project that is concerned with the development of a local health care system in a deprived region of Cameroon, this article illustrates and reports on the use of the ‘Cockpit’ platform of the US based Cognition Corporation to enable key Systems Engineering activities of the project. The aim of this paper is to share the experience made with the applied Systems Engineering approach and the supporting platform; and thereby offer relevant insights to practitioners who are involved in similar development projects.

Papers#126

Utilization of Goal Function Trees for Robust Requirements Definition

Marc Gethers (University of Alabama in Huntsville) - mg0045@uah.edu
Dr. Dale Thomas (University of Alabama in Huntsville) - dale.thomas@uah.edu

Presented on: Tuesday, 10:45-11:25

Keywords. Goal Function Tree; Nominal; Off Nominal; Robust Requirements; Reduce Ambiguity; #MBSE

Abstract. This paper describes the implementation of the Goal Function Tree (GFT) for an Unmanned Aerial Vehicle (UAV) in a Systems Modeling Language (SysML) environment which tracks nominal and off nominal goals for a successful flight of a UAV. The utility of the GFT enables the traceability of the system's goals and requirements to perform a successful mission scenario. Definition of nominal goals reduces ambiguity about mission success and can be followed more easily by the customer. Furthermore, the Goal Function Tree can also track and implement corrections if the measurements for success are deviating through the use of off nominal functions. The GFT's off nominal functions create a new set of functions and goals that attempt to mitigate a failing attribute instead of the other methods that only defined failure. This methodology creates a set of procedures for an operator or system when action is needed, thereby identifying more robust requirements as compared to traditional requirements development based only on nominal mission scenarios. The advantage of the SysML environment enables the legible traceability of the overlapping of goals of various structural and behavioral system objects, the execution of functions, and implementation of stereotypes which classifies the interactions between objects.

Papers#7

What Can You Learn About Systems Engineering by Building a Lego™ Car?

Heidi Ann Hahn (Los Alamos National Laboratory) - hahn@lanl.gov

Presented on: Monday, 11:30-12:10

Keywords. mission assurance; system development project life cycle; professional development; #Academia

Abstract. Los Alamos National Laboratory's (LANL's) Future Female Leaders in Engineering (FFLIE) Program brings female engineering undergraduate students to the Laboratory for summer internships, which include a technical work assignment and a specialized eight-week long professional development course. During their first year, FFLIE students receive training on LANL's Mission Assurance (MA) Program, which involves the integrated application of systems engineering (SE), project management (PM), and engineering quality and rigor (QA) to ensure mission success. The instruction is organized around the system development project life cycle and emphasizes activities and artifacts associated with the various life cycle phases. A home improvement project (adapted from Braakhuis, Janssen, Koudenburg, de Liefde, Malotaux, Rens, and Stevenson, 2010) is used in a series of table-top exercises throughout to illustrate various points. The training culminates with a project - building a car for a Lego™ Derby race - on which the students exercise the skills they have just learned in the classroom instruction. This paper briefly reviews the instructional content, with an emphasis on the activities and artifacts exercised in the Derby project; provides lessons learned; and concludes that there's a lot one can learn about SE by building a Lego™ Derby car if the experience is properly structured! Overviews of FFLIE students' learnings about requirements, measures of performance, trade studies, and verification and validation are provided.

What do we mean by 'system'? - System Beliefs and Worldviews in the INCOSE Community

Hillary Sillitto (Sillitto Enterprises) - hillary.sillitto@blueyonder.co.uk
James Martin (Aerospace Corporation) - martinqzx@gmail.com
Dorothy McKinney (ConsideredThoughtfully.com) - dorothy.mckinney@computer.org
Dov Dori (Technion University/MIT) - dori@technion.ac.il
Regina Griego - griegor@sandia.gov
Eileen Arnold (ConsideredThoughtfully.com) - eparnold5@aol.com
Patrick Godfrey (University of Bristol) - patrick.godfrey@systems-thinking.co.uk
Daniel Krob (CESAMES) - daniel.krob@cesames.net
Scott Jackson (Burnham Systems) - jackson@burnhamsystems.net

Presented on: Wednesday, 14:15-14:55

Keywords. System Worldviews; Beliefs about systems; Systems Science; #Academia

Abstract. The System Definition Survey issued to INCOSE Fellows in December 2016 revealed at least five radically distinct worldviews on Systems within a relatively small, but moderately representative, part of the INCOSE community. We describe and analyse the survey results, and comment on differences between the responses from the Fellows and the responses to a similar survey issued to the System Science Working Group a month later. Then we discuss how the different worldviews on 'system' revealed by the surveys map onto different areas of the set of system definitions described in a previous paper. We conclude that all the worldviews identified offer useful perspectives for systems engineering, and that Systems Engineers need the flexibility to adopt different worldviews for different situations, or at least to act 'as if' different worldviews are true in different situations.

Key Reserve Papers

Key Reserve Papers#166

A Conceptual Model of Systems Engineering

Swaminathan Natarajan (Tata Consultancy Services Research) - swami.n@tcs.com
Anand Kumar (Tata Research Development and Design Centre) - anand.ar@tcs.com
Subhrojyoti Roy Chaudhuri (TCSL) - subhrojyoti.c@tcs.com
Kesav Vithal Nori (IIIT Hyderabad) - kesav.nori@gmail.com
Viswanath Kasturi (International Institute of Information Technology) - viswanath.itthyd@gmail.com
Venkatesh Choppella (International Inst. of Info. Technology Hyderabad) - choppell@gmail.com

Keywords. Foundations of systems engineeringView mappingsRelationship between systems and knowledgeIntegrating domain ontologiesReasoning about systems engineering practiceGenerative formulation of mechanistic systemsFour worlds model of systems engineering

Abstract. Systems engineering is widely perceived as an empirical discipline, with a need for theoretical foundations that can facilitate reasoning about practice. This is an attempt to help build such foundations by systems-theoretic inquiry into the nature of the relationship between knowledge and engineering. We conceptualize this relationship in terms of four worlds: the real world, the world of systems models, a world of aspect knowledge, and a world of wholes knowledge: knowledge that indicates how aspects come together and also how wholes relate to each other. This leads us to a generative understanding of systems engineering: synthesizing aspects to develop blocks; and generating the network of blocks that form a system, through recursive performance of three activities: decomposition, dependency closure and refinement. The problem of systems engineering practice involves augmenting this core with the concerns of problem formulation, design of the supporting ecosystem, and the need for closing gaps between the model world and real world. We derive some initial confidence in the validity and value of this strawman model by examining its ability to explain some aspects of current systems engineering practice, and the insights it provides into how we can integrate system modeling across knowledge domains.

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A Game-Theoretical Framework for Coordination in Requirement-Based Engineering Design

Soodabeh Yazdani (George Mason University) - yazdani.soodabeh@gmail.com
Edward Huang (George Mason University) - edwardhuan@gmail.com

Keywords. Game TheoryTeam CoordinationRequirement-Based Engineering DesignComplex Systems

Abstract. Requirement-based engineering design is a common practice that provides a definition of what is the desirable design solution. However, requirements define what constitutes the acceptable design from what is not, and provide a little guidance on the best design solution. Requirement-based engineering with team coordination, on the other hand, allows design teams to exchange resources to best manage their resources. This may lead to the better design outcome. This paper investigates the benefits of coordination in requirement-based engineering design. We apply game theory to formulate mathematical models of design problem with and without team coordination and demonstrate the mathematical framework on an illustrative example. The results indicate that we may not always get the system-wide best performance in the requirement-based engineering design while coordination among design teams can reduce the total cost of the system. Also, the numerical results capture the relation between team's effort level and system's cost coefficient.

Key Reserve Papers#145

A Pilot Study to Determine MBSE Utility for Process Modeling of Complex Interfaces

Clark Owens (NASA) - skip.owens-1@nasa.gov
Alexandra Dukes (Purdue University) - dukesa@purdue.edu
Shaun Daly (NASA) - shaun.m.daly@nasa.gov

Keywords. MBSESysMLModelingOperationsVerificationInterface

Abstract. Modeling a full system or a complete interface between systems in a MBSE environment is a very large task and not all organizations will benefit enough from using MBSE to offset the effort that is required to do this. Completely modeling a system or interface is not necessary to evaluate the utility of MBSE for a specific application or organization. The first step in any new and ambitious endeavor is to first demonstrate its utility. A small pilot can be executed over a short period of time that only models small portions of a system or interface and, if structured properly, this pilot can successfully demonstrate the utility of MBSE for an organization before having to invest a larger amount of resources to fully implement and deploy MBSE. This paper documents one such pilot that was conducted for NASA's Launch Services Program Integration Engineering organization in the hope that this example will lead the way for others to take a similar "one step at a time" approach. This paper does not present a process for conducting a MBSE pilot, as a generic process would have very little value to the community due to the amount of tailoring that would be required to apply it to a different project.

Key Reserve Papers#139

A Systems Approach towards Developing a Diagnostic System for Complex Robots

Rahul Krishnan (Worcester Polytechnic Institute) - rkrishnan2@wpi.edu
Shamsnaz Virani Bhada (Worcester Polytechnic Institute) - ssvirani@wpi.edu

Keywords. DiagnosticsSysMLRoboticsTroubleshootingFault Detection and Diagnosis

Abstract. Present day robots are highly complex systems. Most robots perform tasks that are timecritical in environments where human intervention may not be possible. When a failure occurs in such situations, diagnosing it can be a major challenge. To tackle this, a methodology to develop a diagnostic system using a systems approach is presented in this paper. The use of SysML diagrams as a tool to understand system behavior is highlighted. Finally, this methodology is used to build the diagnostic system of a complex humanoid robot.

A Systems Engineering Assessment of Emergency Disconnect System from the User Perspective

Marianne Kjørstad (University College of Southeast NO) - marianne.kjorstad@usn.no
Kristin Falk (University College of Southeast NO) - kristin.falk@usn.no

Keywords. socio-technical systemshuman interactionautonomy

Abstract. This paper assesses the decision-making process for activation of the Emergency Disconnect Systems (EDS) on offshore rigs in the oil and gas domain. The industry strives to evolve to a higher level of autonomy. At the same time, the standards and regulations are falling behind. The objective of this paper is to investigate the knowledge gap in engineering requirements for a future autonomous decision-making system. We have interviewed key personnel with operational experience from Dynamic Positioning (DP) rigs operating on the Norwegian Continental Shelf (NCS), and a specialist engineer from a global supplier of offshore workover systems. The standards currently applied to design the EDS, are mainly providing procedures. To evolve to a higher level of autonomy, we suggest that designers consider the socio-technical elements and relations of the EDS. The ISO9241-210 standard can contribute with a human-centered design approach as a supplement to the existing engineering approach.

Key Reserve Papers#142

A Tailoring of the Unified Architecture Framework's Meta-Model for the Modeling of Systems-of-Systems

Lucio Tirone (Aster) - lucio.tirone@aster-te.it
Emanuele Guidolotti (Aster) - emanuele.guidolotti@aster-te.it
Lorenzo Fornaro (Leonardo) - lorenzo.fornaro@leonardocompany.com

Keywords. MBSEArchitecture FrameworkSystems-of-SystemsSystem Modeling

Abstract. Being used by single companies and by coalitions of governments at the same time, Architecture Frameworks have spread widely as a key tool for the enablement of the Model Based Systems Engineering approach. The Unified Architecture Framework, promoted by the Object Management Group, is rapidly emerging as the reference framework to describe Enterprise Architecture, providing a standard representation for both defense and non-defense organizations' architecture descriptions. The work described in the present paper concerns the implementation of a simplified meta-model, derived as a tailoring of the Unified Architecture Framework's full meta-model, aimed at allowing the usage of the UAF for the description of System Architectures, rather than Enterprise Architectures. The main UAF View Domains concerned with Systems having the characteristics of Systems-of-Systems (Operational, Strategic and Resources), will be analyzed and a solution will be shown to allow a simple implementation of SysML models, as an architectural description of such Systems. A study case will also be presented, developed as a joint effort of Leonardo and Aster for the modeling of naval Combat Systems.

A UAV Case Study with Set-based Design

Colin Small (University of Arkansas) - cxs050@uark.edu
Gregory Parnell (University of Arkansas) - gparnell@uark.edu
Randy Buchanan (US Army Engineering Research and Development Center) - Randy.K.Buchanan@erdc.dren.mil
Matthew Cilli (US Army U.S. Army Armament Research, Development, and Engineering Center) - gmattcilli@gmail.com
Ed Pohl (University of Arkansas) - epohl@uark.edu
Simon Goerger (A UAV Case Study with Set-based Design) - Simon.R.Goerger@erdc.dren.mil
Zephan Wade (University of Arkansas) - zwwade@uark.edu

Keywords. Model-Based System EngineeringSet-Based DesignAnalysis of Alternatives

Abstract. The DoD and Engineered Resilient Systems (ERS) community seek to leverage the capabilities of model-based engineering (MBE) early in the design process to improve decision making in AoAs. Traditional tradespace exploration with point-based design often converges quickly on a solution and engineering changes are required after this selection. Set-based design considers sets of all possible solutions and enables down-selecting possibilities to converge at a final solution. Using an Army case study and an open source excel add-in called SIPMath, this research develops an integrated MBE model and example that simultaneously generates numerous designs through physics models into the value and cost tradespace allowing exploration for setbased design analysis and producing a better efficient frontier than traditional point-based design AoAs. Grouping design decisions into sets based on their characteristic decision, and simultaneously evaluating the value and cost tradespace, allows for a set-based design approach that provides insight into the design decisions.

Key Reserve Papers#130

An Agile Model-Based Approach for Managing Engineering Processes

Erich Meier (Method Park) - Erich.Meier@methodpark.com

Keywords. Systems Engineering ProcessEngineering Process ManagementProcess ModelingProcess Execution; #Automotive

Abstract. This paper describes a new approach for managing engineering process. Based on proven system engineering and agile concepts, we created a model-based process component concept for organizations to quickly define new existing engineering processes and adjust existing ones in an agile way. With our approach, engineering processes can be tailored in a program- or projectspecific way and executed in existing PLM or ALM engineering tools. Business-critical compliance to standards like ISO 26262, DO-178C, IEC 62304, or ISO 15288 can be assured through a mapping mechanism. We also describe how large engineering companies like General Motors, Honeywell Aerospace, or Siemens Diagnostics successfully applied our approach, became leaner and more agile, and could therefore efficiently react to disruptive engineering challenges.

An "EPIIC" Vision to Evolve Project Integration, Innovation, and Collaboration with Broad Impact for How NASA Executes Complex Projects

Robert Moreland (NASA, Headquarters, Office of the Chief Engineer) - robert.moreland@nasa.gov
John Evans (NASA, Headquarters, Office of Safety and Mission Assurance) - john.w.evans@nasa.gov
Jessica Knizhnik (NASA) - jessica.knizhnik@nasa.gov
Anna-Maria McGowan (NASA) - anna-maria.r.mcgowan@nasa.gov
Nipa Phojanamongkolkij (NASA) - nipa.Phojanamongkolkij@nasa.gov

Keywords. digital transformationModel BasedEnterpriseProject Management

Abstract. Evolving Project Integration, Innovation, and Collaboration (EPIIC) is a vision defined to transform the way projects manage information to support real-time decisions, capture best practices and lessons learned, perform assessments, and manage risk across a portfolio of projects. The foundational project management needs for data and information will be revolutionized through innovations on how we manage and access that data, implement configuration control, and certify compliance. The embedded intelligence of new interactive data interfaces integrate technical and programmatic data such that near real time analytics can be accomplished to more efficiently and accurately complete systems engineering and project management tasks. The system-wide data analytics that are integrated into customized data interfaces allows the growing team of engineers and managers required to develop and implement major NASA missions the ability to access authoritative source(s) of system information while greatly reducing the labor required to complete system assessments. This would allow, for example, much of what is accomplished in a scheduled design review to take place as needed, between any team members, at any time. An intelligent data interface that rigorously integrates systems engineering and project management information in near real time can provide substantially greater insight for systems engineers, project managers, and the large diverse teams required to complete a complex project. System engineers, programmatic personnel (those who focus on cost, schedule, and risk), the technical engineering disciplines, and project management can realize immediate benefit from the shared vision described herein. Implementation of the vision also enables significant improvements in the performance of the engineered system being developed.

An MBSE modeling approach to efficiently address complex systems and scalability

Jean Duprez (Airbus Operations SAS) - jean.duprez@airbus.com

Keywords. MBSEComplexityScalabilityDesignOccurrence ModelingVariability

Abstract. For decades Airbus has largely used modeling and simulation techniques all along the development cycle. Nowadays, the use of systemic approaches, associated with proper modeling tools and technics, provides efficient solutions to leverage associated benefits while addressing the increasing systems complexity. This paper highlights some of these modeling principles, providing ways to improve, ease and make design activities more efficient, and providing solutions to better master the overall design complexity. The paper illustrates how to combine them, thanks to a given model structure, based on a deployment case performed within Airbus. Such an implementation requires significant customization efforts, raising risks to well support its deployment in extended enterprise, with other partners. Out of specificities linked to features of used modeling tools, the goal of this paper is to share with the MBSE community some root principles and needs, in order to have them better involved into future tools and standards.

An MBSE Tool to Support Architecture Design for Spacecraft Electrical Power System

Liu Zhigang (Beijing Institute of Spacecraft System Engineering) - bitlzg@163.com
Yang Mengfei (Beijing Institute of Spacecraft System Engineering) - yangmengfei@cast.casc
Chen Qi (Beijing Institute of Spacecraft System Engineering) - chenqi@cast.casc
Du Qing (Beijing Institute of Spacecraft System Engineering) - duqing@cast.casc
Xia Ning (Beijing Institute of Spacecraft System Engineering) - xianing@cast.casc
Lu Jinzhi (KTH Royal Institute of Technology) - jinzhl@kth.se

Keywords. MBSEArchitecture designDomain-specific modelingModelicaAutomated Verification&Validation

Abstract. Since difficulty and complexity of spaceflight missions are increasing, current electric systems in the spacecraft become growingly complicated challenging the spacecraft electrical power system (EPS) architecture development. By using traditional approaches, system architectures are managed by document collections including various reports, documents and data chats. Due to lack of a unified visualization of system architectures, consistency and traceability among data, documents and information are difficult to manage, particular in supporting architecture design and system verification and validation. This paper presents a model-based systems engineering (MBSE) tool with emphasis on domain specific modeling (DSM), architecture visualization, model transformation and automated verification and validation by using Modelica. The MBSE tool aims to develop the architecture models of EPS, to support MBSE-driven visualizations of architectural hierarchies inspired by related techniques of Google Earth and to realize architecture-driven verification & validation by using Modelica language. Finally, through a case study of EPS, we evaluate the feasibility of our tool.

Analysis of Results for the Systems Engineering Worldviews Survey (July 2017)

Eileen Arnold (ConsideredThoughtfully, Inc.) - eparnold5@aol.com
Scott Jackson (Burnham Systems) - jackson@burnhamsystems.net
Hiliary Sillitto (Sillitto Enterprises) - hillary.sillitto@blueyonder.co.uk

Keywords. systemsystems engineeringworldviewsurveyanalysisINCOSE

Abstract. In 2016, INCOSE leadership asked the INCOSE Fellows to initiate a study to compare the current INCOSE definition of Systems Engineering (SE) with the aspirations set out in the SE Vision 2025. The SE Fellows Definition Committee created a SE Worldviews survey to investigate current perceptions of INCOSE members. Analysis of Results for the Systems Engineering Worldviews Survey (July 2017) contains an analysis of the results summarized and aggregated into five broad questions as follows: 1. What is Systems Engineering (SE)? 2. What are the defining characteristics of SE? 3. What is the scope of SE? 4. Who should have knowledge of SE, and 5. What does the future of SE look like? The analysis contains comparisons of paired question responses and results with agreement percentages at 80% and above.

Automated Component-Selection of Design Synthesis for Physical Architecture with Model-Based Systems Engineering using Evolutionary Trade-off

Habibi Husain Arifin (No Magic Asia) - habibihusainarifin@gmail.com
Ho Kit Robert Ong (No Magic Asia) - robert_ong@nomagic.com
Nasis Chimplee (No Magic Asia) - nasis.c@nomagic.com
Jirapun Daengdej (Assumption University of TH) - jirapun@au.edu
Thotsapon Sortrakul (Assumption University of TH) - thotsapon@scitech.au.edu

Keywords. Model-Based System EngineeringComponent-SelectionGenetic AlgorithmsEvolutionary AlgorithmsTrade-offSystems Modeling LanguageDesign Synthesis

Abstract. Component-Selection is an important task in design synthesis of MBSE. A trade study is commonly used to help systems engineers and stakeholders selecting the components of a systems design. A simple analysis may be sufficient when it involves only two parameters. However, when the components and their integration become more complex, the trade study also becomes harder, time- and cost-consuming, and error-prone. This paper aims to propose a method to automatically generate the solution by performing an evolutionary search. Sample components of a hybrid car which consists of an engine, an electric motor, and a battery are used in our initial prototype. The logical architecture is represented in the OMG SysML TM via CSM TM . Through the experimental result, this paper shows that the proposed technique allowed the system design to be efficiently selected.

Concept Maturity Levels

Lou Wheatcraft (Seilevel) - louw@reqexperts.com
Layne Lewis (Willow View Consulting) - llewis@willowviewconsulting.com

Keywords. Concept Maturity LevelsTechnology Readiness LevelsTechnology Readiness Assessmentsystem concept maturationscope definitionfeasible concept; #Automotive; #Heathcare; #PowerEnergy

Abstract. In this paper, the authors introduce and expand on a method first proposed in a paper: “Space Mission Concept Development Using Concept Maturity Levels (CMLs)” (Wessen, R. R. et al 2013). CMLs are a tool to help organizations access and mature a system concept in order to mitigate risks inherent in moving in to later development lifecycles when the feasibility of a concept has not been established. In the first part of the paper, we introduce the benefits and need for organizations to include the concept of CMLs in their systems engineering processes. We then go into more detail defining and explaining the activities and outcomes for each CML. A key application of CMLs is presented by the authors that maps CMLs to the Systems Engineering (SE) development lifecycles as well as to the concept of Technology Readiness Levels (TRLs). Next, we show how CMLs are an implementation of an older concept referred to as “The Doctrine of Successive Refinement.” Tools to help implement, manage, and mature the project through the various CMLs are presented. Lastly, several organizational approaches are described to help organizations initially mature system concepts faster than more traditional approaches.

Design and prototype development of Dynamic Supply Chain Supporting (DSCS) system in Connected Smart Factory environment: focusing on architecture and data model

Jonghee Park (Graduate school of Engineering Mastership, POSTECH) - jh5park@postech.ac.kr
Byeongwoo Jeon (Graduate school of Engineering Mastership, POSTECH) - jhs1728@postech.ac.kr
Dae-Geun Hong (Graduate school of Engineering Mastership, POSTECH) - dghong@postech.ac.kr
Suk-Hwan Suh (Graduate school of Engineering Mastership, POSTECH) - shs@postech.ac.kr

Keywords. Dynamic Supply ChainConnected Smart FactoryManufacturing for Personalized Production

Abstract. SCM (Supply Chain Management) is responsible for the construction and operation of supply chain based on supply chain information. SCM implemented in modern enterprise information system needs to increase speed, accuracy, efficiency in accordance with customized production paradigm. We design SCM support system technology that can dynamically and efficiently operate existing static and fixed supply chain under Connected Smart Factory environment that supports real-time information exchange between supply chain members according to Industry 4.0 concept. We also validate the technology using our demonstration test bed and prototype.

Key Reserve Papers#49

Digital Engineering Models of Complex Systems using Model-Based Systems Engineering (MBSE) from Enterprise Architecture (EA) to Systems of Systems (SoS) Architectures & Systems Development Life Cycle (SDLC)

Roy Tsui (Engility Corporation) - roytsui@ieee.org
Devin Davis (Engility Corporation)
John Sahlin (Engility Corporation)

Keywords. EASoSMBSESDLCUPDMSysMLOOSEM

Abstract. This paper presents the sharing of our experiences and lessons learned to modernize a warship with C6ISR utilizing the digital engineering MBSE models of complex systems. We captured Enterprise Architecture (EA) DoDAF views, KPP and KSA in Capability Views (CV). At the EA, information passes into domain specific SoS Block Definition Diagrams (BDD) and Internal Block Diagrams (IBD) to interface and exchange information via SysML models and generate the Interface Control Document (ICD) automatically. The paper illustrates the mapping of EA with SoS digital models and tracing from EA to SoS MOE, MOP, MOS and TPM. The paper applies a Use Case to exemplify OOSEM life cycle activities for requirements traceability. The paper has demonstrated that both EA and SoS are derived from Systems Engineering (SE) process and can be validated and verified via the “V-Model” and endorse the noticeable reduction in the total development cost per complex systems project.

Key Reserve Papers#177

Implementation of A3 architectural overviews in Lean Product Development Teams; A case study in the Subsea Industry

Sindre Løndal (University College of Southeast NO) - Sindre_l@hotmail.com
Kristin Falk (University College of Southeast NO) - Kristin.Falk@usn.no

Keywords. A3 architectural overviewsoil and gascase studylean product development teams

Abstract. This paper presents a case study investigating the use of A3 Architectural Overviews (A3AOs) in lean product development teams. A3AOs is a tool used in product development and lean manufacturing to increase communication and knowledge sharing across the organization. We studied the implementation in an engineering department of a global oil and gas supplier, by performing a case study and extensive depth interviews. We also studied earlier implementation initiatives of A3s in a thorough literature review. A finding was that, although current and former research have shown clear benefits of utilizing this tool, the company rarely uses it today. We wanted to investigate challenges with creating and implementing A3AO in the organization. Our results show that A3AOs may be a wellsuited tool to improve the requirements handover process within the company. We also make an outline of challenges and benefits with using and implementing A3AOs in the researched engineering department, with the goal to successfully implement A3AOs in the future.

Key Reserve Papers#70

Making Future-Proofing Design Decision under Uncertainty

Obaid Ur Rehman (UNSW Canberra) - o.rehman@adfa.edu.au
Michael Ryan (UNSW Canberra) - m.ryan@adfa.edu.au

Keywords. Decision making.Future-proofing.Analytic hierarchy process.

Abstract. The future-proofing methodology is based on the fact that system design must focus on more than the acquisition of the system and must consider the whole-of-lifecycle issues early in system design to develop an efficient and long-lasting sustainable design. For a sustainable design, the process such as design for sustainable future-proofing (DfSFP) requires that the design must consider the impact of the design on system's sustainability element. Therefore impact on the system must be assessed by the designer which may require feedback from the stakeholders and system users. However, detailed design data and useful feedback from the stakeholders not always available during the conceptual stage. Thus decision for future-proofing a system on the basis of early design and user data must consider the associated uncertainties. In this paper, we present a novel future-proof design selection methodology which incorporates the data uncertainties and fuzziness in a systematic and an effective way. The methodology is based on the analytic hierarchy process which is modified to include a stochastic process to address data uncertainties and fuzziness in the future-proofing decision-making process. The proposed methodology provides a useful tool for the future-proof system designer to visualize the impact of uncertainty and fuzziness in the data to make an effective future-proofing decision. In order to demonstrate the application and effectiveness of the proposed approach, an example of the construction of the future-proof house is presented. In the example, future-proofing solutions are analyzed and the most sustainable solution is chosen.

Minimum SysML Representations to Enable Rapid Evaluation using Agent-Based Simulation

Apoorv Maheshwari (Purdue University) - apoorv@purdue.edu
Ali Raz (Purdue University) - akraz@purdue.edu
Aleksandra Dervisevic (Purdue University) - adervise@purdue.edu
Robert Campbell (Purdue University) - rcampbel@purdue.edu
William Colligan (Architecture Technology Corporation) - bcolligan@atcorp.com
Andrew Murphy (Architecture Technology Corporation) - amurphy@atcorp.com
Oluwatomi Kolawole (Architecture Technology Corporation) - okolawole@atcorp.com
Daniel Delaurentis (Purdue University) - ddelaure@purdue.edu

Keywords. Model-Based Systems EngineeringAgile Systems EngineeringSystem Architecting Process ModelSysML SimulationAgent-based modelingNextGen Air transportation System

Abstract. The changing operational requirements and demands for new capabilities, often makes it necessary for systems architects to make substantial changes in a system's architecture. However, the traditional systems engineering processes advocate finalization of architecture at early stages of the design process with little or no change at the later stages of the design. The simulation development is often done towards the end of the design phase and thus, the traditional systems engineering approaches do not support a rapid architecture evolution. In this paper, we propose a Model-Based Systems Engineering (MBSE) process to facilitate rapid evaluation of changes in a system architecture and/or design artifact for complex systems. This process specifies the minimum set of information that needs to be included in system architecture using SysML diagrams with traceability between the diagrams and agent-based simulation (ABS) models of a complex system. We demonstrate this SysML-driven analysis approach to perform a rapid evaluation of evolving system architectures using a NASA-sponsored project to analyze ab initio architectures for the National Airspace System. We also demonstrate how the proposed approach enables early-on investigation during the architecture development whether an architecture will yield the desired operational benefit.

Model-Based Simulation for Design of nn Airport Autonomous Approach and Landing System

Oleksandra Snisarevska (George Mason University) - osnisare@gmu.edu
Lance Sherry (George Mason University) - lsherry@gmu.edu
John Shortle (George Mason University) - jshortle@gmu.edu

Keywords. Autonomous systemsModel-based engineeringSimulation analysisStochastic processes

Abstract. Spacing on the final approach segment while landing at an airport is critical to safe and efficient operations. Spacing on this segment is subject to a large number of stochastic factors that affect the ability of pairs of landing flights to achieve and maintain a desired separation. Due to the combinatorics of these stochastic factors, rule-based automation cannot meet the performance requirements or adapt as the system characteristics migrate over time. Previous research described the design of a closed-loop stochastic control system for an autonomous approach and landing system (A 2 LS) to manage spacing requirements to achieve safety and efficiency goals.
This paper describes the design of a model-based simulation used to test the A 2 LS concept-of-operations. The simulation includes a model of the sequence of flights on the approach, the flow spacing closed-loop control law for the A 2 LS, and a user-interface to adjust plant and control law parameters and visualize the results. The limitations and implications of the simulation on the Model-based System Engineering process are discussed.
This paper describes the design of a model-based simulation used to test the A2LS design. The simulation includes a “plant” model of the sequence of flights on the approach, the flow spacing closed-loop control law for the A2LS, and a user-interface to adjust plant and control law parameters and visualize the results. The limitations and implications of the simulation on the design process are discussed.

Model-based System Engineering for the Assessment of Tactical Performance in the Complex, High Tempo Game of Soccer

Lance Sherry (George Mason University) - lsherry@gmu.edu
Aiden Sherry (Methodist University) - aiden98sherry@gmail.com

Keywords. Probabilistic modelsmodel-based system analysiscomplexitysystems dynamics

Abstract. Soccer is an example of an enterprise in which adversarial groups of autonomous agents interact to create competitive advantage in time and space. The interaction is characterized by complex collaborations between the autonomous agents in space and time, coupled with the high tempo occurrence of random events. In this way the events in a game can exceed the cognitive ability of humans to process and analyze team tactical performance to make actionable training and game time adjustments that affect the outcome of the game.
This paper describes the application of model-based system engineering to assess tactical performance in the game of soccer. The game is modeled as a probabilistic sequence of random events that occur. The model is the basis for a probabilistic simulation of the game of soccer that can be used to assess the impact of a given team tactic on goals scored in a game. The model, the simulation, and an application of the model are described. The implications of the simulation on coaching and player development and limitations of the model are discussed.

Modeling Inference Enterprises Using Multiple Interoperating Models

Kathryn Laskey (George Mason University) - klaskey@gmu.edu
Edward Huang (George Mason University) - edwardhuan@gmail.com
Abbas Zaidi (George Mason University) - szaidi2@gmu.edu
David Brown (Innovative Decisions, Inc.) - dpbrown@innovativedecisions.com
Dennis Buede (Innovative Decisions, Inc.) - dbuede@innovativedecisions.com
Bahram Yousefi (George Mason University) - byousefi@gmu.edu
Shou Matsumoto (George Mason University) - cardialfly@gmail.com
Muhammad Imran (George Mason University) - mimran4@gmu.edu

Keywords. Inference enterpriseMulti-modelingEnterprise engineeringInsider threat detection

Abstract. A methodology is described for modeling enterprises that use data, tools, people and processes to make mission-focused inferences. Examples include cyber-operations centers detecting cyber intrusions, airport security systems detecting attempts to carry prohibited items onto airplanes, or mortgage underwriting offices predicting loan defaults. An inference enterprise gathers and analyzes data, generates alerts when a concerning event or behavior is identified, and follows up with more thorough investigation of alert cases. The purpose of modeling is to understand and evaluate enterprise performance to help identify ways to improve performance. This typically involves constructing a modeling workflow comprising components that may not have been designed to interoperate. It may involve combining multiple models based on different modeling formalisms. This paper presents a multi-modeling approach to inference enterprise modeling (MIEM). MIEM combines multiple models to generate multiple predictions of inference enterprise performance. These predictions are combined into an overall estimate of performance with error bounds. The MIEM methodology is illustrated on a problem of detecting insider threats in information systems.

SE Technical Leadership - A Model Based Framework

Emmanuelle Garcia (AIRBUS) - emmanuelle.garcia@airbus.com
Subash Kafle (Independant) - Subashke@gmail.com
Udit Sahoo (Rolls Royce) - udit.sahoo@rolls-royce.com
Lucio Tirone (Aster SpA) - lucio.tirone@aster-te.it
Lilian Boichon (AIRBUS Defense and Space) - lilian.boichon@airbus.com

Keywords. Technical LeadershipSE competencyModel Based Framework

Abstract. Systems engineering technical experience in conjunction with leadership skills have been considered as recipe for successful systems' developments (Williams & Reyes, 2012). A technical leader shall be able to easily link up technical engineering professionals and management teams. Competencies such as strategic thinker, systems thinker, effective communicator, team members' success enabler, project vision holder are necessary for someone to play a technical leader role. This paper attempts to introduce a model based systems engineering framework to define and articulate technical leader competencies. As a work product from the second cohort of the INCOSE Technical Leadership Institute (TLI), this paper leverages the technical leadership mind-map developed by the first cohort of the TLI.

Systems Engineering Pathology: Comprehensive Characterization of Systems Engineering Dysfunction

Heidi Davidz (Aerojet Rocketdyne) - heidi.davidz@rocket.com
Scott Jackson (Burnham Systems Consulting) - jackson@burnhamsystems.net
Dale Thomas (University of Alabama in Huntsville) - ldt0001@uah.edu

Keywords. Systems Engineering PathologySystems Engineering ExecutionSystems Engineering Quality

Abstract. In order to characterize dysfunction in the execution of the Systems Engineering (SE) process in a more methodical and systematic way, the Systems Science concept of Systems Pathology is extended to Systems Engineering Pathology. Poor SE execution can be due to inadequate execution, insufficient budgets, deficient interfacing, and other factors. These can be addressed by program/project audits and lessons learned. However, applying the science of Systems Pathology can provide a more integrated and methodical approach to address poor SE execution. SE Pathology can provide the holistic approach needed to better characterize dysfunction, for a better chance at intervention, prevention, and ultimately program success. Through a literature review, the logic behind Systems Engineering Pathology is explained and existing Systems Engineering Pathology work is discussed. These sources are aggregated to provide an expanded list of typical SE dysfunctions. Next steps for empirical study are proposed. Transfer of SE Pathology research findings to SE practice is discussed. As medicine has been gradually accumulating an understanding of causes, detection and treatment of diseased states, perhaps SE can begin to accumulate an understanding of causes, detection and treatment of dysfunctional execution. The objective would be to better achieve affordable, healthy SE functions enabled to positively influence program outcomes.

The Whole Nine Yards of Systems Engineering - Stakeholders and enabling / realization systems

Richard Beasley (Rolls-Royce plc) - Richard.Beasley@rolls-royce.com
Iain Cardow (Rolls-Royce plc) - Iain.Cardow@rolls-royce.com
Andrew Pickard (Rolls-Royce Corporation) - Andrew.C.Pickard@rolls-royce.com
Jon Symons (Rolls-Ropyce plc) - Jon.Symons@rolls-royce.com

Keywords. Realization SystemsEnterpriseMulti Project

Abstract. This paper explores how a Systems Engineer, during the development of a system, needs to convert their focus from considering the stakeholders of the system to becoming a stakeholder themselves. In particular, the paper explores the outflow of derived needs, not only to other elements of the system, but out to the realization or enabling systems. An extension to James Martin's classic 7 Samurai systems is made, adding consideration of a Business Execution system to create and deliver the solution (including engagement with the realization systems), and the layers of Enterprise system management to control multiple projects (and possibly sectors). This leads to identification of 9 systems involved in a system delivery – "the whole nine yards of Systems Engineering".
The implications of the interaction with the realization systems to both Program Management and the modelling are reviewed. In most companies, where there is more than one solution produced the realization systems are shared, and therefore must be considered as a complex, rather than complicated, capability system supporting the solution delivery.

Version 1.0 of the New INCOSE Competency Framework

Don Gelosh (Worcester Polytechnic Institute) - dsgelosh@wpi.edu
Mimi Heisey (Lockheed Martin Corporation) - mimi.heisey@lmco.com
John Snoderly (Defense Acquisition University) - John.Snoderly@dau.mil
Kenneth Nidiffer (Software Engineering Institute) - nidiffer@sei.cmu.edu
Richard Beasley (Rolls-Royce plc) - Richard.Beasley@rolls-royce.com

Keywords. competencyproficiencyframework

Abstract. The next major evolution of the INCOSE Competency Framework (ICF) is Version 1.0. This paper describes the major sections of the ICF Version 1.0 document. The main section of the document is the competency framework structure which has evolved into five competence groups and 36 core competence areas across five levels of proficiency. Because this is a role-based competency framework, another major section is a guide to role definition that describes the typical roles systems engineers may assume. This paper also describes how the Competency Framework relates to the Systems Engineering processes as described in the INCOSE SE Handbook, 4 th Ed. A subsequent section of the ICF Version 1.0 document provides use cases for the framework with a detailed look at recruitment, candidate assessment, education program improvement, resources for professional development, curriculum alignment, and career path development. The document also includes a section that explains how to tailor the competency framework to suit using organizations. The paper concludes by exploring the next steps to successfully publish and review Version 1.0 of the new INCOSE Competency Framework.

Panels

Panels#8

Accelerating Innovation Effectiveness: Model-Facilitated Collaboration by Regulators, Technical Societies, Customers, and Suppliers

William Schindel (ICTT System Sciences) - schindel@ictt.com
Troy Peterson (System Strategies, Inc.) - tpeterson@systemxi.com
Marian Heller (ASME) - HellerME@asme.org
Logen Johnson (SAE) - logen.johnson@sae.org
Tina Morrison (US FDA) - tina.morrison@fda.hhs.gov
Steven A. Donaldson (US DoD NAVAIR) - steven.donaldson@navy.mil
Joseph A. Pelletitere (FAA) - Joseph.pellettiere@faa.gov

Presented on: Tuesday, 10:00-12:10

Keywords. Collaboration; Model Based Methods; Innovation; MBSE Patterns; Regulation; Professional Societies

Abstract. Society benefits from innovation across the dimensions of life, including advancements in aviation and ground transportation, medicine and health care, production of food, energy, communication, and information systems, distribution of products and services, defense, and other evolving systems. In many of these areas, society also depends upon effective regulation (or its authoritative equivalent) to protect us from undue risks involving safety, credibility, and other aspects. Sometimes we hear questions of whether the systems of regulation are effective in their balance of reward and risk to society. Not so well known are the collaborative efforts by regulators and technical professional societies (ASME, INCOSE, others) to advance new model-enhanced frameworks in which the expectations of regulators and innovators are recognized on behalf of the society both serve. This panel will discuss some contemporary efforts, beyond traditional standards-making of earlier generations, including the perspectives of engineering societies, regulators, and customers. The discussion will focus on how computational models are changing (and potentially streamlining) this environment, and ask questions about the implications for future innovation, and the practicality of sharing regulatory, authority, and industry models and model-based patterns and frameworks. This panel is the second of a continuing public panel conversation intended to engage more of our communities in these efforts. Anyone involved in innovation for markets and domains requiring effective collaboration across supply chains, partner enterprises, or regulatory / certification authorities will find this session of interest.

Biography

William Schindel (ICTT System Sciences) - schindel@ictt.com
Bill Schindel is a member of the ASME standards team writing guidelines for model verification, validation, and uncertainty quantification (VVUQ) essential to regulatory submissions across aviation, medical devices, and other domains. Also a member of INCOSE, Bill chairs the MBSE Patterns Working Group of the INCOSE/OMG MBSE Initiative. He is president of ICTT System Sciences, and has practiced systems engineering for over thirty years, across multiple industry domains. Bill serves as president of the INCOSE Crossroads of America Chapter, is an INCOSE Fellow and Certified Systems Engineering Professional, and a member of AIAA and ASEE.

Position Paper

Arguably the most dramatically impactful example of extended group-wide learning process, during the last three centuries, is the edifice of the physical sciences. The language of its “lessons learned” repository is that of explicit quantitative

models—specifically, recurring patterns expressed as general models. The credibility of these models (whether wrong, close, or right) is expressed via Model Validation, Verification, and Uncertainty Quantification (Model VVUQ). Described in this way, the System 2 and System 3 portions of the INCOSE Agile Systems Engineering Life Cycle Management Pattern are models of Group Learning as well its effective ("muscle memory") application.
Vision for a Future (already underway) Collaboration:
• The Setting: Innovation, particularly in regulated domains
• The Need: Streamline the innovation cycle while still achieving regulatory goals
• The Domains: Aerospace, medicine, electrical grids, automotive, others
• The Opportunity: Enhanced trust shared models that society and regulatory authorities can trust during interaction with enterprises and researchers, streamlining joint processes
• Achieved Example: Automotive virtual crash testing
• Engineering Professional Societies: These System 3 entities occupy a special place in this ecosystem, by virtue of their ethical commitment, combined with technical expertise:
• Not the same position as the enterprises, or trade groups;
• Not the same position as the regulators;
• Not the same position as the academic research community;
• But a potentially catalytic collaborator with them all, to accelerate the advancement of this vision to reality.
• ASME's Model VVUQ Leadership Position: Attracted participation by INCOSE beginning in 2016 connected with:
• ASME's goals and leading position in V&V of Computational Models
• INCOSE's transformation of SE to a Model-Based Discipline
• Special role played by MBSE Patterns (re-usable, configurable models) in this transformation, and in the tradition of the physical sciences (shared, validated general models, configurable)
• Other engineering professional societies discussing this interest (e.g., SAE, IEEE)
• Other technical societies and trade groups discussing this interest (e.g., AIAA)
• Public forum discussion and panel interests for:
• INCOSE Agile Health Care Systems Conference May, 2017 (IL)
• INCOSE Great Lakes Regional Conference Oct, 2017 (MN)
• INCOSE International Symposium July, 2018 (Washington, DC)
• INCOSE Great Lakes Regional Conference Oct, 2018 (IN)
• Indiana private sector aero/medical team standing up a virtual verification V4 Institute, with ASME collaboration from outset

Troy Peterson (System Strategies, Inc.) - tpeterson@systemxi.com
Troy Peterson is a Vice President and Fellow with System Strategy, Inc. (SSI) where he is providing consulting services to help clients conceptualize and design for the deep interdependencies inherent in today's cyber-physical systems. Before joining SSI, Troy was Booz Allen's Chief Systems Engineer and a Booz Allen Fellow. Prior to this Troy worked at Ford Motor Company and as an entrepreneur operating a design and management consulting business. Troy is INCOSE's Assistant Director for Transformational within INCOSE and is the champion for accelerating the transformation of systems engineering to a model based discipline. Troy is also co-chair of the MBSE Patterns WG and Past President of the INCOSE Michigan Chapter. Troy has led several large projects in the delivery of complex systems and has instituted several methodologies to speed innovation. His experience spans commercial, government and academic environments across all product lifecycle phases. He has been appointed to several boards to improve engineering education and application. Troy is also a frequent speaker at leading engineering conferences. Troy received his BS ME from MSU, his MS in TechMgmt from RPI and an advanced graduate certificate in Systems Design and Management from MIT. He also holds INCOSE CSEP, PMI PMP and ASQ SSBB certifications
Position Paper
Over 50 years ago Christopher Alexander observed that "Today more and more design problems are reaching insoluble levels of complexity." and "At the same time that problems increase in quantity, complexity and difficulty, they also change faster than before." This was true then (1964), it is more true today and will be even more so 5, 10 and 50 years from now. In fact, today the complexity and rate of change is exploding. Megatrends such as the Internet of Things, Artificial Intelligence, Autonomy, 3D printing, High-Performance Computing, Storage and Computing everywhere are truly reshaping the innovation environment and society at large. These megatrends are digital in nature with endless data and feedback mechanisms. They increase the awareness of stakeholder needs and are driving the need for organizational and system agility as well as compressing development timelines.
As systems become more interconnected traditional system boundaries and methods are fading which is increasing both opportunity and risk. Likewise, the skill sets and lifecycle management processes needed to plan, develop and manage these systems are becoming more complex and multidisciplinary in nature. To add value and manage the growing complexity systems modelling is essential. INCOSE's Transformation strategic objective and Transformational Working Groups which include the Model Based Systems Engineering (MBSE) Initiative, MBSE Patterns, Ontology, Product Line Engineering, System Science and others are contemporary efforts directed toward helping the broader community in meeting today's innovation system challenges.
Alexander also pointed out that "Trial-and-error design is an admirable method. However, it is just real-world trial and error which we are trying to replace by a symbolic method. Because trial and error is too expensive and too slow." Systems modelling, as a symbolic method, provide us a robust way to virtually (digitally) streamline development in this new environment. To maximize the impact a model based approach industries, enterprises, programs, and projects need credible models which are reconfigurable, and reusable leveraging established configuration item to domain level patterns. The

tectonic contextual changes demand model based approaches to provide development speed, reconfigurability, and commonality across today's very complex supply chains and regulatory constraints across domains. In this shift, businesses will likely experience a significant shift in value toward how to build trust in rapidly deployable digital assets such as digital twins, digital threads, and an overall digital engineering capability. This is the context for System Engineering today – we have a window of opportunity to play a big role helping organizations digitally structure their innovation and lifecycle management systems. It will require guidelines, standards, model VVUQ, and a new paradigm for control, collaboration, and trust.

Marian Heller (ASME) - HellerME@asme.org
Marian Heller is a mechanical engineer and staff secretary for two of ASME's V&V (verification and validation) standards development committees: V&V 20 Verification and Validation in Computational Fluid Dynamics and Heat Transfer; and V&V 50 Verification and Validation of Computational Modelling for Advanced Manufacturing. Marian serves as Business Development Manager of Healthcare at ASME, exploring ways for ASME to provide greater support to the bioengineering and healthcare industries and increase the positive impact of mechanical engineers. She is also a facilitator, supporting ASME's road mapping and gap analysis workshops.

Position Paper

ASME has a long history of collaboration with other engineering societies and with regulatory authorities around the development of standards, as well as providing neutral information on technology to policy makers, and participating in activities such as E-Week, National Nanotechnology Day, technical conferences, joint memberships, joint position statements on technology policy, and major initiatives such as Engineering for Change.

Current challenges are enormously complex and rapidly evolving, and modelling and simulation are being used increasingly to enhance innovation, decrease time to market, and improve outcomes. Through its V&V efforts, ASME helps address the need to assess the credibility of models, and we have begun exploring the role of model-based patterns and frameworks. Increased engagement of other engineering societies and regulatory agencies helps focus early standards development efforts and ensures that sharing of guidance documents and best practices throughout the development process fosters acceleration of innovation.

The presentation will address the V&V Interactions with the Model Life Cycle Working Group, and the engagement of INCOSE in that WG; provide an overview of the Model Based Enterprise standards initiative; and present highlights of how ASME engages actively with regulators (e.g., NRC, DOT, FDA) and other entities, e.g. in standards development, government relations, and participation in the manufacturing institutes.

Logen Johnson (SAE) - logen.johnson@sae.org
Logen Johnson has been with SAE International for 3 years and is based in Washington, DC. In this role, Logen is responsible for supporting standards development operations for SAE's aerospace standards program. This includes working with the US and global aerospace community on new standards development as well as global strategy and outreach for SAE. Prior to joining SAE, Logen worked with other standard organizations in DC and he holds a BS degree from Wentworth Institute of Technology in Electromechanical Engineering.

Position Paper

Digital technology is here and playing an ever more important role in Industry. Many organizations are focusing on technologies that enable a broad range of opportunities, including digital twin, the Internet of Things and big data analytics to drive productivity, quality and cost improvements throughout the product lifecycle. As industries continue to adopt innovate and build business models around Digital Technology, industry and regulatory collaboration will be critical in shaping a successful approach to digitally integrated design, manufacturing, operations and maintenance through consensus standards and other materials.

In July 2017, SAE stood up a group that will help alleviate disparate digital activities by coordinating industry consensus standard development within SAE, supporting industry cohesion and certification.

SAE has engaged with NIST, INCOSE, FAA, EASA, ASME and leading companies to collaborate in areas such as predictive analytics, modelling and simulation, validation, system health management, data security, and data sharing, and others. Continuing to further industry cohesion and understanding the role of regulators in this new digital age is critical in adopting, implementing and realizing the benefits on new technologies at a demanded by the world today.

Tina Morrison (US FDA) - tina.morrison@fda.hhs.gov
Dr. Tina Morrison is the chair of the new FDA-wide working group on Modelling and Simulation (M&S), in the Office of the Chief Scientist. She has been serving as the Regulatory Advisor of M&S for the Center for Devices and Radiological Health (CDRH) since 2012. In that capacity, she leads the Regulatory Review of Computational Modelling working group, which has developed guidance documents on the use of M&S in the regulatory evaluation of medical devices [1]. She dedicates much of her energy towards advancing regulatory science with M&S because she believes the future of medical device design and evaluation, and thus enhanced patient care, lies with computation and enhanced visualization [2]. She serves as Chair of the ASME V&V Standards Committee on Verification and Validation of Computational Modelling, the Subcommittee V&V40 for Medical Devices, where she is leading the development of a strategy to assess the credibility of computational models [3]. She is also working with a team at CDRH to implement this strategy into the review of submissions that leverage M&S [4]. For seven years, she was a scientific reviewer on a variety of medical device submissions in Cardiovascular Devices. She is the Deputy Director of the Division of Applied Mechanics in FDA's Office of Science and Engineering Laboratories. She is a

mechanical engineer who received her PhD in Theoretical and Applied Mechanics from Cornell University in 2006.
Position Paper
Modelling and simulation approaches can enhance certainty, reduce both animal and human in vivo studies, and speed the development of medical products in the U.S. FDA has been very proactive engaging in important partnerships that are enhancing certainty and credibility of computational modelling, and developing novel approaches to minimize the burden of in vivo studies, both animal studies and clinical trials. Our main points will cover an overview of the outcomes thus far of those partnerships, and a look to where we are headed with simulation for medical products.

Steven A. Donaldson (US DoD NAVAIR) - steven.donaldson@navy.mil
Steven A. Donaldson, Division Head, NAVAIR Aeromechanics Engineering Division . Steven Donaldson currently serves as the Head of the Aeromechanics Engineering Division at the Naval Air Systems Command. This national engineering division is comprised of approximately 160 personnel responsible for delivering aeromechanical engineering products and services for all acquisition and sustainment engineering activities for Naval Aviation. He is responsible for the planning, direction, and execution of the Research and Engineering efforts related to the development and sustainment of Naval Aviation assets across the technical disciplines within the division including Applied Aerodynamics, Stability & Control, Aircraft Performance, Flight Controls, Store Separation, and Flight Vehicle Modelling and Simulation. Mr. Donaldson currently serves on the Board of Directors for the Department of Defense (DoD) High Performance Computing Modernization Program Computer Research and Engineering Acquisition Tools and Environments (CREATE) Air Vehicles Project whose charter is to develop and deploy computational engineering tools that address the needs of the air vehicle acquisition programs across the DoD.
Position Paper
Application of computationally-based engineering tools within the DoD has been successful in improving the engineering methods NAVAIR uses in the systems development and sustainment support of Naval Aviation. In addition, the advancement of the tools has allowed NAVAIR engineers to consider broader application of the tools to address a variety of aerodynamic conditions that have to be explored and accounted for as we develop and support aircraft and weapons systems, and for developing and defining operating envelopes for weapon system usage. Modelling and Simulation (M&S) through high-end computation has gained prevalence in DoD acquisition programs, but the extent of the application has been limited due to processing power and robust, proven M&S methods. The DoD has provided significant computational and financial resources to attack aircraft program issues and provide a means for validation of new toolsets that can be used within the DoD and Industry for future programs. In a time of heightened desire for increasing “speed to the fleet” and providing a source of data for sustainment of fleet-released products, NAVAIR has many successful examples of utilizing high-end computational tools.
Reducing costs and improving the timelines to develop, field, and sustain Naval weapon systems are paramount to the engineering activities within NAVAIR and Industry. While the DoD created programs to initiate classical “Science and Technology” initiatives, the suite of CREAT-AV tools have matured significantly to reduce costs, improve designs, improve test efficiency, explore innovative concepts, and improve safety.
NAVAIR programs that have succeeded in reducing costs and improving timelines of product development as well as introducing future applications of the many tools developed across the DoD, specifically the CREATE-AV tools such as CAPSTONE, Kestrel, and Helios.

Joseph A. Pelletitere (FAA) - Joseph.pellettiere@faa.gov
Joseph A. Pellettiere, Chief Scientific and Technical Advisor for Crash Dynamics, Federal Aviation Administration. Dr. Joseph Pellettiere supports the development of occupant injury criteria as they apply to Aerospace systems and the application of these criteria to the certification of aircraft structure, seats, and cabin interiors. He has been heavily involved in the development of processes and procedures of analysis methods within the certification process with the ultimate goal of seat certification by analysis. Dr. Pellettiere has also supported transport, rotorcraft and small airplane certification programs. Current focal projects include the investigation of full scale test methods and analytical techniques to support system level crash worthiness for both metallic and composite aircraft.
Position Paper
The FAA has been actively engaged in analytical methods that can support certification decisions. This includes support of various industry working groups and standards development. Parallel to these efforts the FAA has been updating its guidance for the use of analysis for seat certification and is looking to expand this guidance to a more general application. The FAA’s main concern is how to appropriately replace physical test data with analytical results and how the decision maker can use this information. A lot of questions have surround validation methods and uncertainty in the results.

Panels#18

Complex - Agile - Open : The Shape of Future System Realization

Larri Rosser (Raytheon) - Larri_Rosser@raytheon.com
Matthew Montoya (The Johns Hopkins University Applied Physics Laboratory (JHU/APL)) - matt.montoya@jhuapl.edu
Beth Wilson (Retired (WPI Adjunct Professor)) - wilsondrbeth@aol.com
Tod Newman (Raytheon Missile Systems) - wtnewman@raytheon.com

Presented on: Wednesday, 13:30-14:55

Keywords. Complex; Agile; Open; MOSA; OSA; Emergent; Interactions; Network; Defense; Security; Aerospace

Abstract. Engineering projects and systems are becoming increasingly dynamic, intricate and collaborative in response to forces such as globalization, interconnectivity, the pace of technical change and integration of human and natural systems. Approaches emerging in response to these changes include complex systems science, agile frameworks and techniques, and open architecture methods and standards.
Systems Engineering practitioners are beginning to employ these approaches in combination to address the challenges of current and future needs. Domains such as Agile Space employ open architectures as enablers for agility. Teams employ agile methods to solve complex problems in security, networking and healthcare domains. Systems engineers consider interfaces or level of openness in attempts to manage system complexity. As such pairwise applications become common, the interaction between these three sets of practices become more frequent and intricate.
This panel will explore the intersection of these three approaches, how they impact each other and how they interact--for example, what vicious or virtuous cycles exist between agility, openness and complexity?
In particular, this panel will focus on how systems engineers can leverage these interactions to our advantage.

Biography

Larri Rosser (Raytheon) - Larri_Rosser@raytheon.com
Larri Rosser is an Engineering Fellow, Certified Architect and SAFe Process Consult who works for Raytheon Intelligence, Information and Services. She has 30 years industry experience in aerospace, defense and computing technology, multiple patents in the area of human-computer interface and a BS in Information Systems and Computer Science from Charter Oak State College. Currently, she is a co-chair of the INCOSE Agile Systems and Systems Engineering Working Group and a member of the NDIA Agile and Systems Engineering Working Group. At Raytheon, she focuses on applying modern engineering methods to large engineered systems.

Position Paper

The fundamental charter of systems engineering is to create engineered solutions that are fit for purpose at a cost and in a timeframe that produces a favorable return on investment for the customer. Over the last decades, the challenges associated with meeting this charter have grown exponentially due to the increasing interconnectivity of systems and the pace of change in technology and mission needs. Systems are becoming larger and more connected, with more multifarious interactions with the humans and systems to which they connect. In my personal experience, the concepts of agility, openness and complexity have all been helpful in meeting the systems engineering charter for large scale systems, but I've found that they don't always play together well. For example, openness in an interface can reduce that interface's ability to address that edge conditions and emergent behaviors found in complex systems. Agility in a process or technical system makes it very responsive to change, but if changes are constant and unpredictable, what prevents that responsiveness from spiraling out of control? In this panel, we will discuss both vicious and virtuous interactions among complexity, agility and openness and how we can leverage them to enhance systems engineering success in a complicated and dynamic world.

Matthew Montoya (The Johns Hopkins University Applied Physics Laboratory (JHU/APL)) - matt.montoya@jhuapl.edu
Matthew Montoya is a Principal Chief Engineer at The Johns Hopkins University Applied Physics Laboratory and is responsible for strategic and technical direction for several cross-program systems engineering initiatives. Matthew is also an advisor, instructor, professor and researcher at The Johns Hopkins University in the Systems Engineering Program where he received the 2015 Outstanding Instructor Award. Matthew received his Bachelor's degree in Applied Physics from Colorado

State University, Master's degrees in Applied Mathematics and Systems Engineering from The Johns Hopkins University, a MBA from Loyola University of Maryland, and a Dr.Eng. in Systems Engineering from The George Washington University.

Position Paper

The goal of systems engineering is to work with the required stakeholders in order to gather the necessary information that helps articulate, build, and transition needed capabilities to the targeted end-user stakeholders - all this is easier said than done. There are many roadblocks in this process that can hinder or even derail this acquisition approach: 1) lack of consistent engagement of correctly targeted stakeholders and end-users; 2) lack of consistent resources; 3) inexperienced program and engineering teams: 4) ill-defined operational and technical requirements; 5) lack of clear transitions paths from operator to designers to testers and to deployment and fielding professionals. Missteps in any one of these areas will derail or disrupt the idealized capability delivery. With this in mind, how can agile and openness help in the identification to fielding of complex systems? The right tool in the wrong hand won't help and the wrong tool in the right hands won't help. So, how do you balance process vs experience and is there a priority and how might that fit and succeed or fail in a company's culture? The answer to all of these complex system questions is: it really depends. What matters is finding the right variable and levers that can be used to address the challenge, introduced at the right time - it is not a step function, but a learned and demonstrated methodology that must fit in the evolution of a company's culture.

Beth Wilson (Retired (WPI Adjunct Professor)) - wilsondrbeth@aol.com

Dr. Beth Wilson earned her PhD in Electrical Engineering from the University of Rhode Island. She is retired from Raytheon where she worked for 33 years as a design engineer, program manager, research scientist, functional manager, and test director on sonar, satellite, and radar programs. She is currently an Adjunct Professor at Worcester Polytechnic Institute in their Masters of Systems Engineering programs. Dr. Wilson is an INCOSE Expert Systems Engineering Professional (ESEP) and is a co-chair for the INCOSE Systems Security Engineering working group. She championed agile techniques while at Raytheon and now includes them in her classes at WPI.

Position Paper

Agile techniques are very relevant to systems engineers, but need to be implemented as part of the systems engineering techniques for architecture development, requirements analysis, systems integration, and systems verification. While in industry, I saw effective implementation of agile techniques on large programs and championed the use of agile for the systems engineering products aligned with hardware and software development. I also saw how quickly the implementation could drift to sub-optimal process methods driven by cultural resistance and inadequate training. Now in academia, I include agile techniques as part of the systems engineering training. I see resistance among the students based on misunderstandings that agile is for software only.

Tod Newman (Raytheon Missile Systems) - wtnewman@raytheon.com

Tod Newman is currently a member of Technical Staff for the Systems Design and Performance Directorate at Raytheon Missile Systems. He also leads research into advanced processing architectures and is the Chair of Raytheon's Information Systems and Computing Technology Network. He has a strong interest in complex systems and focuses on agile, DevOps, MBSE, and Predictive Analytics as approaches to isolate and mitigate complexity. He is a Raytheon Certified Architect. Prior to this position, Tod served as the Raytheon Corporate Technology Area Director for Information Systems and Computing (ISaC). He also led the RMS Test Systems Department for four years. He has worked in multiple technical roles on numerous programs and proposals in his 20 years with Texas Instruments and Raytheon and has converted numerous small efforts to Agile Product Development approaches. He is a 1992 graduate from the U.S. Coast Guard Academy.

Position Paper

For over ten years, publications have been urging the Systems Engineering discipline to take steps to address the increasing complexity of systems. Despite the bold assertions made that with our present understanding of complex behavior we can no longer design systems with an appropriate degree of confidence (Calvano, 2004), we are left with the feeling that whatever measures have been taken in the discipline, the growth of complexity continues to outpace. Mitigations appear to be present that allow us to address this issue in some fashion, but experience indicates that they are insufficient in isolation. The growth of Model Based Systems Engineering and its associated tools and mindsets show great promise in allowing better understanding of extremely complex systems and in providing infrastructure that can better manage the critical design information flow within the systems team and between the systems team and designers. Open Architectures are proving to be extremely valuable because by restricting variability in the building blocks of the system, we can potentially increase the ability to deliver product to the marketplace. However, investment in Open Architecture is very expensive and delivering the value proposition to the business teams is time consuming and difficult. There are new development techniques like Agile and ~~Kanban that have been effective when deployed with a mindset of better understanding the effort required to deliver a~~ system, reducing the size of work elements, and improving teamwork. Together with DevOps techniques of managing the development pipeline, businesses can focus on delivering these small chunks of value directly into the hands of a customer and thus reducing costly feedback loops and future rework. Without some method of integrating these concepts however, it feels like intense focus on any one of the techniques could be costly sub-optimization. It is believed, however, if a combination of these approaches are viewed as a system of complexity mitigation then businesses will finally begin to regain ground on the fast pace of complexity in our systems.

Panels#19

Exploding the Boundaries of Systems Engineering

Dorothy McKinney (ConsideredThoughtfully, Inc.) - dorothy.mckinney@incose.org
Dov Dori (Technicon and MIT) - dori@technion.ac.il
Azad Madni (University of Southern California / Intelligent Systems Technology) - azad.madni@usc.edu
James Martin (The Aerospace CorporationAero) - MartinQZX@gmail.com
Alan Harding (BAE Systems) - alan.d.harding@baesystems.com
Patrick Godfrey (Emeritus Professor University of Bristol) - patrick.godfrey@systems-thinking.co.uk
Michael deLamare (Bechtel) - madelama@bechtel.com

Presented on: Thursday, 10:00-12:10

Keywords. System; Systems Engineering; Definition; Transdisciplinary

Abstract. In this panel, we examine the current INCOSE definition of SE in the context of the aspirations set out in INCOSE's SE Vision 2025. We put on the table and discuss three fundamental observations: first, while '20th century systems' were, for the most part, 'deterministic' or nearly so, 21st century systems are increasingly non-deterministic, adaptive or 'evolutionary'. Second, while '20th century Systems Engineering Management' was implicitly based on a 'command and control' paradigm, 21st century Systems Engineering, to be successful, will usually need to use a collaborative leadership paradigm. Third, while 20th century systems were largely 'single systems', designed to 'solve' specific problems, 21st century systems are almost invariably networked, and they are parts of complex extended enterprises with multiple stakeholder objectives, often related to complex societal challenges. We offer a new straw man INCOSE definition of Systems Engineering to be criticized, showing the changes that would be required to take these and related factors into account.

Biography

Dorothy McKinney (ConsideredThoughtfully, Inc.) - dorothy.mckinney@incose.org
Dorothy McKinney is an INCOSE Fellow, and has just completed a term as Chair of the INCOSE Fellows. She is facilitating the work of the INCOSE Definition team, which is led by Hillary Sillitto. Dorothy is currently leading a dot com start-up, ConsideredThoughtfully.com which aims to provide just-in-time information for professionals interested in career development and professional growth. Dorothy retired in 2014 from Lockheed Martin after more than 34 years. She spent her last years there as a Fellow Emeritus. She has also served as an Adjunct Professor in the Graduate Engineering program at San Jose State University, teaching such subjects as Engineering Management and Software Project Management. From 2002 to 2013, Dorothy developed and taught a course on Requirements Engineering over the internet for Portland State University. Other industry experience included three years at ARGOSystems (a Boeing subsidiary), and nine years at SRI International (formerly called Stanford Research Institute). Professional society membership includes INCOSE, IEEE and AIAA. Dorothy has been active in INCOSE, since 1992. She is a past president of the San Francisco Bay Area chapter, serves on the chapter Board of Directors and also has served on the INCOSE Board of Directors. She was the Technical Chair of the INCOSE 2002 and 2007 Symposia (and co-chair in 1994). She served on the IEEE Software Industrial Advisory Board from 2000 to 2006 and again from 2009 to 2012.

Position Paper

We need to “explode” the definition of systems engineering! In the past, we within INCOSE have tried to define systems engineering in ways which fostered consensus on what we do. However, it is time for this inward-looking focus to shift to a focus on what systems engineering can do for the larger world. We need a new definition of systems engineering, one which more robustly supports INCOSE’s Vision 2025.

Defining systems engineering in such a way as to address the needs and concerns of all of the stakeholder groups that systems engineering desires to serve requires change. The evolving nature of the challenges that systems engineering needs to address, as well as the increasing complexity of the world in which systems engineering is done, mean that we need to “raise our game” to accomplish our aim of using systems engineering to serve the world’s needs. The purpose of this panel is to share a broad range of viewpoints on how all of these factors affect the definition that INCOSE should use for systems engineering, and how systems engineers can leverage an improved definition to reach out more effectively to stakeholders in all of the areas which systems engineering could benefit.

Dov Dori (Technicon and MIT) - dori@technion.ac.il
Professor Dov Dori, who received his PhD in Computer Science in 1988 from Weizmann Institute of Science, is Lebensfeld Chair in Industrial Engineering and Head of Enterprise System Modeling Laboratory at Technion, Israel. He is Fellow of IEEE, INCOSE, and IAPR, member of Omega Alpha Association, the International Honor Society for Systems Engineering, and Senior Member of ACM. Since 2000, he has been intermittently Visiting Professor at MIT, where he holds an adjunct position. Since 1993, when Dr. Dori invented Object-Process Methodology (OPM), he has been central to the field of Model-Based Systems Engineering. OPM is the first conceptual modeling language and methodology recognized as ISO 19450. Prof. Dori has authored over 300 highly cited publications. He has supervised over 50 graduate students in Israel and USA, of whom 12 are faculty members in three countries. Prof. Dori has chaired nine international conferences. He was Associate Editor of IEEE T-PAMI and is Associate Editor of Systems Engineering. He is cofounder and Co-Chair of the IEEE Society on SMC, TC on Model-based Systems Engineering. His 2002 book on OPM has been cited over 550 times, and he authored another book on Model-Based Systems Engineering with OPM and SysML (2016). Dr. Dori is among the most-renowned authors in Document Analysis and Recognition. In 1995, he won First Place in the “Dashed Line Detection Contest”. He has received various research and innovation awards, and public and industrial sponsors, including the EU, have funded his research.

Position Paper

For Systems Engineering (SE) to remain relevant and thrive in a changing world, we need a paradigm shift of moving from a collection of ad-hoc methods and tools to an underlying theory of systems and a universal, formal yet intuitive and simple modeling language to serve as a basis for a systems lifecyle support methodology. Furthermore, SE must move away from the historic, yet unjustifiable, separation between the development of systems’ hardware and the software that controls it to a unified modeling, execution and roundtrip engineering software environment.

In this new realm, equipped with a tool that does not require mastering the idiosyncrasies of a programming language, systems engineers will develop the software of complex systems alongside the overall system design as an integral part of the early system lifecycle stages. Modeled hardware components shall be gradually replaced by actual prototype components, and the software will be tested and refined iteratively with each such replacement, enabling agile systems development that integrated the development of hardware and software of the system.

To achieve this, there is a need for a universal platform for a systems generating system that shall enable systems engineers to develop complete and detailed system models. These models can be simulated and tested as part of a comprehensive support framework for product lifecycle management. This is a broad extension of the co-design paradigm of cyber-physical systems consisting of physical parts, hardware and software, where hardware is not just computer hardware, printed boards or logic circuits, but any physical component of a technical or socio-technical system, such as engines of any kind, energy, communication and transportation systems, etc. To this end, SE must incorporate and combine conceptual modeling, executable models, and roundtrip engineering as the foundations of this framework. Object-Process Methodology (OPM), ISO 19450, is a prime candidate for serving as the underlying conceptual modeling language and modeling methodology due to its minimal universal ontology, bi-modal graphics-text representation, and intuitive, understandable, simple semantics. Thus, we extend the traditional definition of SE from being responsible just for the overall architecture of the system and delegating the software components development to dedicated software engineers, to be in charge of the detailed design and testing of both the hardware and the software of the system.

“So what?” you ask? And I reply that the systems engineer of the near future, while still seeing the “big picture”, will be equipped with tools that enable her or him to tackle detailed design problems that involve hardware-software integration, making the SE profession much more involved and relevant throughout the system lifecycle.

Azad Madni (University of Southern California / Intelligent Systems Technology) - azad.madni@usc.edu
Dr. Azad Madni is the Executive Director of University of Southern California’s flagship program in Systems Architecting and Engineering, and a Professor of Astronautics in USC’s Viterbi School of Engineering. He is also a professor (by courtesy) in the schools of medicine and education. He is the founder and CEO of Intelligent Systems Technology Inc., a high-tech R&D company specializing in cross-disciplinary approaches to complex systems engineering. He received his BS, MS, and PhD degrees in Engineering from UCLA. His research sponsors in the government include DOD-SERC, DARPA, OSD, AFOSR, AFRL, ONR, ARL, RDECOM, DTRA, DOE, DOT, NIST and NASA. His commercial research sponsors include Boeing, General Motors, Raytheon, SAIC and several others. He has received several prestigious awards and honors including the 2011 INCOSE Pioneer Award. He is an elected Fellow of INCOSE, AAAS, AIAA, and Life Fellow of IEEE, IETE, and SDPS. In 2016, Boeing honored him during its centennial anniversary with a Lifetime Achievement Award and a Visionary Systems Engineering Leadership Award for his impact on Boeing, the aerospace industry and the nation. He is the author of Transdisciplinary Systems Engineering: Exploiting Convergence in a Hyper-Connected World (foreword by Norm Augustine), Springer 2017. He is the co-author (with T. Bahill) of Tradeoff Decisions in System Design, Springer 2016. He is the co-founder and current Chair of IEEE SMC Technical Committee on Model Based Systems Engineering. He has served as organizer and General Chair of the Conference on Systems Engineering Research (CSER) since 2008. His research interests are transdisciplinary systems engineering, formal methods in complex and resilient systems engineering, interactive storytelling in model-based systems engineering and STEM education.

Position Paper

Systems Engineering is undergoing a transformation fueled by increasing system complexity, hyper-connectivity, technological advances, and disciplinary convergence. This transformation today cuts across model-based systems engineering, formal methods in systems engineering, and transdisciplinary systems engineering. I define transdisciplinary systems engineering as an integrative discipline that reaches beyond engineering to make connections with other disciplines with a view to developing solutions to problems that appear intractable when viewed solely through an engineering lens. Examples of other disciplines are biology, cognitive science, computer science, entertainment arts, and cinematic storytelling. At the heart of transdisciplinary systems engineering is the ability to "think different" on multiple fronts. Ultimately, thinking different is at the heart of our ability to exploit disciplinary convergence. Specifically, the growing convergence of systems engineering with other disciplines can be expected to produce new concepts, solutions to intractable problems, or entirely new disciplines. The following two examples illustrate the "so what" impact of Transdisciplinary Systems Engineering based on disciplinary convergence.

Example #1: Achieving superior collaboration among all stakeholders by exploiting convergence of engineering and entertainment/cinematic arts

Collaboration among stakeholders especially in the early stages of system design and concept of operation development is crucial to acquiring stakeholder requirements and constraints. Unfortunately, current system modeling languages (e.g., UML, SysML) which tend to be engineer-oriented, are inappropriate for stakeholders who are not technically inclined. As a result, non-technical stakeholders tend to get left out in upfront engineering when requirements are discussed. The result is incomplete requirements and constraints specification that inevitably lead down the line to extraneous design iterations and rework. Transdisciplinary SE Solution: Convergence of engineering and entertainment/cinematic arts. Map system models and use cases to system stories that can be interactively executed in simulation and virtual worlds. Stakeholders can interact with the system model during story execution and explore system behavior from their respective perspectives to get a good feel for the system. As important, they can vary assumptions and system parameters, uncover latent interactions, and explore alternate futures and outcomes. Based on this acquired understanding about the system, they can provide and better justify their requirements during collaborative tradeoff analysis. Impact: Elimination of extraneous design iterations and rework resulting from incomplete requirements collection in upfront engineering.

Example #2: Increase generation of novel ideas and options in upfront engineering

Most novel ideas are generated and explored during early design. Unfortunately, small groups, especially startups, are limited in collaborative brainstorming by the size of their group. This limits their knowledge and ability to generate creative options. Transdisciplinary SE Solution: Convergence of collaborative engineering and social networks/media. With advances in social media and crowdsourcing, this small collaborative group can extend its reach virtually during ideation and novel option generation. With the benefit of traditional collaboration and crowdsourcing, the virtual team of original collaborators and crowdsourced individuals can bring greater knowledge to bear on the ideation and collaborative option generation process. Impact: A richer set of ideas and options in upfront engineering leading to a potentially superior system or product.

In sum, disciplinary convergence is an enabler of transdisciplinary systems engineering. And transdisciplinary systems engineering is a potential enabler of solutions to the U.S. National Academy of Engineering's Grand Challenge problems.

James Martin (The Aerospace CorporationAero) - MartinQZX@gmail.com

James Martin, PhD, is founder and chair of the Systems Science Working Group. He is an enterprise architect and systems engineer with The Aerospace Corporation developing solutions for information systems and space systems. He was a key author on the BKCASE project in development of the SE Body of Knowledge (SEBOK). 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 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 was leader of the Standards Technical Committee. He received from INCOSE the Founders Award for his long and distinguished achievements in the field.

Position Paper

Systems Engineering has traditionally been about developing and supporting man-made systems primarily composed of hardware and software. We have developed our tools and methods over the decades to deal with eliciting requirements and constraints from stakeholders, and designing the various aspects of hardware and software, such as data processing, size and weight, energy consumption and efficiency, handling waste byproducts, and all of the other logistical challenges. However, many of the systems challenges in this day and age must deal with more of the "soft systems" aspects, such as policies and processes, roles and responsibilities, needs and expectations, look and feel, intolerance of change and disruption, and so on.

We often need to address the "enterprise" level challenges of the systems — and explicitly deal with all of the different enterprises which are involved. These include the enterprise that develops and maintains the system, the enterprise that utilizes and benefits from the system, the enterprise that stands to lose from our deployed solution seeing they will lose of the advantages they currently have, the enterprise that must deal with our system's pollution and waste byproducts, along with the enterprise that must supply energy and materials to keep our system going. These enterprises present challenges more along the lines of PESTEL – the dimensions of the problem that deal with the Political, Economic, Social, Technological, Environmental and Legal forces facing the various enterprises associated with our delivered system. Is SE up to the PESTEL challenge?

Our SE process, methods and tools need to change to better accommodate the PESTEL challenges. We need more of those who do SE to have a background other than traditional engineering knowledge and skills. SE's may not be able to develop all of the needed skills — perhaps SE's need to learn to partner more effectively with others who have the needed skills and contact networks, and together we can succeed. We may not be able to rely as heavily on "requirements" since the soft elements of the system solution (such as people) don't always respond well to hard and fast mandates in the system specification.

I challenge the audience to learn some PESTEL-related skills themselves, so they can become a more effective part of the solution.

Alan Harding (BAE Systems) - alan.d.harding@baesystems.com
Alan Harding is the head of the information systems engineering discipline for the BAE Systems Military Air and Information business. He is a BAE Systems Global Engineering Fellow, a Fellow of the IET, and a Chartered Engineer. Alan is the 2016-2018 President of the International Council On Systems Engineering (INCOSE), the global professional society for systems engineering. He is a practicing systems engineer with over 30 years of experience in defence and security applications. Specialist interest areas include capability, systems-of-systems, architecture, and competency development.

Position Paper

INCOSE is the Global Authority on Systems Engineering. We have contributed to many definitions of systems engineering in various standards and present our own definition. These definitions are somewhat consistent, and reasonably useful. The INCOSE definition (given on www.incose.org/AboutSE) contains good words but does not say what we mean by systems engineering, or give a sense of today's requisite variety of applications.

INCOSE should have and promote the best possible definition, as befits our leadership role, and that we can all use with confidence. As President I chartered this Fellows' activity, led by Hillary Sillitto, to give leadership to INCOSE and the wider systems community by developing an improved definition that we can use as a key enabler when promoting and developing systems engineering.

I am passionate that we have a definition that unites us, that is inclusive, that is understandable, and is something we can promote with passion and pride as we promote systems approaches globally and across a wide range of application domains – from policy systems to technological systems to socio-technical systems, from systems of systems to quite specific technical systems, in fact any man-made systems where we are deliberately involved in creating or improving them.

The main thing this definition must do is to allow us to break out of the confines of our traditional boundaries – those domains where systems engineering is recognised and practised, more or less, and that has been the case for many years. Examples include defence and aerospace, along with some areas of transportation, power and energy etc.

INCOSE, as champions of systems engineering, must be ready and able to engage in conversations about the nature of systems engineering and its applicability to a diverse range of systems (technical, socio-technical, systems of systems, service systems) in a wide range of contexts without being shackled to a "traditional" view of SE which can be seen by some as clerical, slow, lacking innovation, and not agile.

The challenge:

- The new definition (the "what") must be written in plain language simply used, and must be accompanied with a clear value proposition (the "why") that speaks to a non-technical audience.
- It must relate to the body of systems engineering standards and knowhow (the "how") of which INCOSE and others are custodians, and have sufficient technically credibility to the INCOSE expert audience.
- If it uses different language to what is normal within INCOSE today we must understand the mapping and any etymological point of detail – but this must be hidden from the wider audience because in truth the audience for these types of rigour is very niche
- This definition must be as powerful and useful to us as the INCOSE Vision and Mission; together they will give us the narrative to engage with those who up until now either do not see the relevance of INCOSE or SE, or who have not heard of us.
- This definition must convey an open style of systems engineering, not locked into any specific technology area, business model or notation, and one that does not exclude an particular approach

I want to be able to speak with C-suite executives, leaders of technical societies, colleagues and members of wider society with a definition of SE that makes sense as the start of a conversation, and to which I can add richness as the conversation develops.

Seeking a single definition is not without challenge – our INCOSE community is diverse in background, culture, application domain, and mindset. Equally our target audience is much wider than "just INCOSE" – we seek to lead the global systems community.

But the prize is great – if we get the definition I am asking for it will be a point of coherence across this global community and a key enabler for us to promote and move closer to "a better world through a systems approach".

Patrick Godfrey (Emeritus Professor University of Bristol) - patrick.godfrey@systems-thinking.co.uk
Patrick Godfrey has been a civil engineering practitioner for 50 years of which he was a Director of Halcrow, an international civil engineering consultancy, for 30 years and 10 years the Professor of Engineering Systems at the University of Bristol. He is now an Emeritus Professor and his aim is to help people deliver the Sustainability Goals within 30 years. He believes systems thinking and learning skills are two sides of the same coin required for success. Patrick is a Fellow of: the Royal Academy of Engineers, INCOSE, the Institution of Civil Engineers, the Energy Institute and Honorary Fellow of the Institute of Actuaries. He is co-author of Doing it Differently - Systems for Rethinking Infrastructure, ICE Publications (2017)

Position Paper

INCOSE's Vision 2025 is consistent with the UN Sustainable Development Goals, they demonstrate we are in a period where the 21st Century systems and the context within which they must be successful are rapidly increasing in complexity, uncertainty, conflict and scale.

The drivers for this change may be summarised as follows:

• “20th century systems” were, for the most part, “deterministic” or nearly so, and their design paradigm sought to minimise or “conquer” complexity. 21st century systems are increasingly non-deterministic, adaptive or “evolutionary”, and their design paradigm must be one that accepts, understands and seeks to manage complexity.
• 20th Century systems were largely “single systems”, however complex, conceived as largely stand-alone systems and designed to “solve” specific problems. 21st Century systems are almost invariably networked, and parts of bigger systems. Many of these bigger systems are not single-purpose or single-agency but complex extended enterprises with multiple and diverse stakeholder objectives, often related to complex challenges such as achieving the Sustainable Development Goals (SDGs).
• Many of the systems we are now concerned with include societal and naturally-occurring elements. Our understanding of “what a system is” must expand to embrace these other system types – and these cannot be “controlled” in the way we expect to control purely technological systems, but can at best be understood and then influenced.
It follows that, for the 21st Century, Systems Engineering is done by people, for people, to improve the human condition. That means we need to:
• Respect diversity and different worldviews
• Admit to the uncertainties involved and ‘learn together’ to provide the resilience and adaptability to deliver the outcomes needed.
• Recognise that for complex systems, top - down control is not effective. We have to lead through influence.
• To deliver our purposes, shared meta frameworks are needed for systems integration and to observe and respond to the outcomes (intended or unintended) as they emerge.
Because, it is by ‘learning together’ that we can succeed together.

Michael deLamare (Bechtel) - madelama@bechtel.com

Mr. deLamare has over 35 years of experience in the application of Systems Engineering to various kinds of systems and projects. The domains include Space and Defense, Environmental Remediation, and Nuclear and Industrial facilities. This experience is on behalf of DOD and DOE clients. He currently serves as the corporate Systems Engineering Manager for Bechtel’s Nuclear, Security and Environmental business unit. His responsibilities include defining Bechtel's Systems Engineering program. This role develops systems engineering processes for the business line; developing the SE culture and training; and supporting systems engineering implementation on projects distributed throughout the U.S. Mr. deLamare holds a B.S. in Physics from the University of California at Irvine, an M.S. in Systems Engineering from Johns Hopkins University, and is certified as an INCOSE Expert Systems Engineering Professional. He also serves as Bechtel’s representative to the Corporate Advisory Board, and chairs the Critical Infrastructure Protection and Recovery working group.

Position Paper

For the past several decades, systems engineering practitioners have progressed this discipline’s state-of-the-art to develop technical systems meeting specific stakeholder needs and requirements. The Body of Knowledge (BoK) is substantial, and when applied with tact and competence, extremely successful. There is also cross-domain applicability with respect to the type of technical systems, including aircraft, spacecraft, civil infrastructure, medical equipment, oil & gas systems, transportation systems, and more. We should not lose what we fought so hard to build.
However, systems of the twenty first century are hyper-networked and extremely adaptive with purposes that evolve beyond what the system designers intended or even imagined to be possible. Further, there is a growing need to analyze and understand other classes of systems such as highly autonomous, socio-technical, natural, and societal systems. Our traditional methods of systems analysis, such as process modeling, functional modeling and the traditional allocation of functions and requirements to architecture expect that we can establish reliable controls to achieve objectives. These methods of the past century, while still needed and effective for centrally controlled technical systems, are not sufficient for delivering the networked and self-adaptive systems of the future. For example, design of a coherent traffic system based on multiple independent vehicles might not be achievable using traditional methods alone, and may be better understood using more agent-based approaches. Such approaches have been applied by social scientists over the past couple of decades, and could perhaps help improve our traditional practices. The Systems Engineering discipline needs to reach out to other disciplines and expanding the current BoK to address these other system types, and transforming itself to be more broadly relevant.

Panels#19

Exploding the Boundaries of Systems Engineering

Dorothy McKinney (ConsideredThoughtfully, Inc.) - dorothy.mckinney@incose.org
Dov Dori (Technicon and MIT) - dori@technion.ac.il
Azad Madni (University of Southern California / Intelligent Systems Technology) - azad.madni@usc.edu
James Martin (The Aerospace CorporationAero) - MartinQZX@gmail.com
Alan Harding (BAE Systems) - alan.d.harding@baesystems.com
Patrick Godfrey (Emeritus Professor University of Bristol) - patrick.godfrey@systems-thinking.co.uk
Michael deLamare (Bechtel) - madelama@bechtel.com

Presented on: Thursday, 00:00-00:00

Keywords. System; Systems Engineering; Definition; Transdisciplinary

Abstract. In this panel, we examine the current INCOSE definition of SE in the context of the aspirations set out in INCOSE's SE Vision 2025. We put on the table and discuss three fundamental observations: first, while '20th century systems' were, for the most part, 'deterministic' or nearly so, 21st century systems are increasingly non-deterministic, adaptive or 'evolutionary'. Second, while '20th century Systems Engineering Management' was implicitly based on a 'command and control' paradigm, 21st century Systems Engineering, to be successful, will usually need to use a collaborative leadership paradigm. Third, while 20th century systems were largely 'single systems', designed to 'solve' specific problems, 21st century systems are almost invariably networked, and they are parts of complex extended enterprises with multiple stakeholder objectives, often related to complex societal challenges. We offer a new straw man INCOSE definition of Systems Engineering to be criticized, showing the changes that would be required to take these and related factors into account.

Biography

Dorothy McKinney (ConsideredThoughtfully, Inc.) - dorothy.mckinney@incose.org
Dorothy McKinney is an INCOSE Fellow, and has just completed a term as Chair of the INCOSE Fellows. She is facilitating the work of the INCOSE Definition team, which is led by Hillary Sillitto. Dorothy is currently leading a dot com start-up, ConsideredThoughtfully.com which aims to provide just-in-time information for professionals interested in career development and professional growth. Dorothy retired in 2014 from Lockheed Martin after more than 34 years. She spent her last years there as a Fellow Emeritus. She has also served as an Adjunct Professor in the Graduate Engineering program at San Jose State University, teaching such subjects as Engineering Management and Software Project Management. From 2002 to 2013, Dorothy developed and taught a course on Requirements Engineering over the internet for Portland State University. Other industry experience included three years at ARGOSystems (a Boeing subsidiary), and nine years at SRI International (formerly called Stanford Research Institute). Professional society membership includes INCOSE, IEEE and AIAA. Dorothy has been active in INCOSE, since 1992. She is a past president of the San Francisco Bay Area chapter, serves on the chapter Board of Directors and also has served on the INCOSE Board of Directors. She was the Technical Chair of the INCOSE 2002 and 2007 Symposia (and co-chair in 1994). She served on the IEEE Software Industrial Advisory Board from 2000 to 2006 and again from 2009 to 2012.

Position Paper

We need to "explode" the definition of systems engineering! In the past, we within INCOSE have tried to define systems engineering in ways which fostered consensus on what we do. However, it is time for this inward-looking focus to shift to a focus on what systems engineering can do for the larger world. We need a new definition of systems engineering, one which more robustly supports INCOSE's Vision 2025.

Defining systems engineering in such a way as to address the needs and concerns of all of the stakeholder groups that systems engineering desires to serve requires change. The evolving nature of the challenges that systems engineering needs to address, as well as the increasing complexity of the world in which systems engineering is done, mean that we need to "raise our game" to accomplish our aim of using systems engineering to serve the world's needs. The purpose of this panel is to share a broad range of viewpoints on how all of these factors affect the definition that INCOSE should use for systems engineering, and how systems engineers can leverage an improved definition to reach out more effectively to stakeholders in all of the areas which systems engineering could benefit.

Dov Dori (Technicon and MIT) - dori@technion.ac.il
Professor Dov Dori, who received his PhD in Computer Science in 1988 from Weizmann Institute of Science, is Lebensfeld Chair in Industrial Engineering and Head of Enterprise System Modeling Laboratory at Technion, Israel. He is Fellow of IEEE, INCOSE, and IAPR, member of Omega Alpha Association, the International Honor Society for Systems Engineering, and Senior Member of ACM. Since 2000, he has been intermittently Visiting Professor at MIT, where he holds an adjunct position. Since 1993, when Dr. Dori invented Object-Process Methodology (OPM), he has been central to the field of Model-Based Systems Engineering. OPM is the first conceptual modeling language and methodology recognized as ISO 19450. Prof. Dori has authored over 300 highly cited publications. He has supervised over 50 graduate students in Israel and USA, of whom 12 are faculty members in three countries. Prof. Dori has chaired nine international conferences. He was Associate Editor of IEEE T-PAMI and is Associate Editor of Systems Engineering. He is cofounder and Co-Chair of the IEEE Society on SMC, TC on Model-based Systems Engineering. His 2002 book on OPM has been cited over 550 times, and he authored another book on Model-Based Systems Engineering with OPM and SysML (2016). Dr. Dori is among the most-renowned authors in Document Analysis and Recognition. In 1995, he won First Place in the “Dashed Line Detection Contest”. He has received various research and innovation awards, and public and industrial sponsors, including the EU, have funded his research.

Position Paper

For Systems Engineering (SE) to remain relevant and thrive in a changing world, we need a paradigm shift of moving from a collection of ad-hoc methods and tools to an underlying theory of systems and a universal, formal yet intuitive and simple modeling language to serve as a basis for a systems lifecyle support methodology. Furthermore, SE must move away from the historic, yet unjustifiable, separation between the development of systems’ hardware and the software that controls it to a unified modeling, execution and roundtrip engineering software environment.

In this new realm, equipped with a tool that does not require mastering the idiosyncrasies of a programming language, systems engineers will develop the software of complex systems alongside the overall system design as an integral part of the early system lifecycle stages. Modeled hardware components shall be gradually replaced by actual prototype components, and the software will be tested and refined iteratively with each such replacement, enabling agile systems development that integrated the development of hardware and software of the system.

To achieve this, there is a need for a universal platform for a systems generating system that shall enable systems engineers to develop complete and detailed system models. These models can be simulated and tested as part of a comprehensive support framework for product lifecycle management. This is a broad extension of the co-design paradigm of cyber-physical systems consisting of physical parts, hardware and software, where hardware is not just computer hardware, printed boards or logic circuits, but any physical component of a technical or socio-technical system, such as engines of any kind, energy, communication and transportation systems, etc. To this end, SE must incorporate and combine conceptual modeling, executable models, and roundtrip engineering as the foundations of this framework. Object-Process Methodology (OPM), ISO 19450, is a prime candidate for serving as the underlying conceptual modeling language and modeling methodology due to its minimal universal ontology, bi-modal graphics-text representation, and intuitive, understandable, simple semantics. Thus, we extend the traditional definition of SE from being responsible just for the overall architecture of the system and delegating the software components development to dedicated software engineers, to be in charge of the detailed design and testing of both the hardware and the software of the system.

“So what?” you ask? And I reply that the systems engineer of the near future, while still seeing the “big picture”, will be equipped with tools that enable her or him to tackle detailed design problems that involve hardware-software integration, making the SE profession much more involved and relevant throughout the system lifecycle.

Azad Madni (University of Southern California / Intelligent Systems Technology) - azad.madni@usc.edu
Dr. Azad Madni is the Executive Director of University of Southern California’s flagship program in Systems Architecting and Engineering, and a Professor of Astronautics in USC’s Viterbi School of Engineering. He is also a professor (by courtesy) in the schools of medicine and education. He is the founder and CEO of Intelligent Systems Technology Inc., a high-tech R&D company specializing in cross-disciplinary approaches to complex systems engineering. He received his BS, MS, and PhD degrees in Engineering from UCLA. His research sponsors in the government include DOD-SERC, DARPA, OSD, AFOSR, AFRL, ONR, ARL, RDECOM, DTRA, DOE, DOT, NIST and NASA. His commercial research sponsors include Boeing, General Motors, Raytheon, SAIC and several others. He has received several prestigious awards and honors including the 2011 INCOSE Pioneer Award. He is an elected Fellow of INCOSE, AAAS, AIAA, and Life Fellow of IEEE, IETE, and SDPS. In 2016, Boeing honored him during its centennial anniversary with a Lifetime Achievement Award and a Visionary Systems Engineering Leadership Award for his impact on Boeing, the aerospace industry and the nation. He is the author of Transdisciplinary Systems Engineering: Exploiting Convergence in a Hyper-Connected World (foreword by Norm Augustine), Springer 2017. He is the co-author (with T. Bahill) of Tradeoff Decisions in System Design, Springer 2016. He is the co-founder and current Chair of IEEE SMC Technical Committee on Model Based Systems Engineering. He has served as organizer and General Chair of the Conference on Systems Engineering Research (CSER) since 2008. His research interests are transdisciplinary systems engineering, formal methods in complex and resilient systems engineering, interactive storytelling in model-based systems engineering and STEM education.

Position Paper

Systems Engineering is undergoing a transformation fueled by increasing system complexity, hyper-connectivity, technological advances, and disciplinary convergence. This transformation today cuts across model-based systems engineering, formal methods in systems engineering, and transdisciplinary systems engineering. I define transdisciplinary systems engineering as an integrative discipline that reaches beyond engineering to make connections with other disciplines with a view to developing solutions to problems that appear intractable when viewed solely through an engineering lens. Examples of other disciplines are biology, cognitive science, computer science, entertainment arts, and cinematic storytelling. At the heart of transdisciplinary systems engineering is the ability to “think different” on multiple fronts. Ultimately, thinking different is at the heart of our ability to exploit disciplinary convergence. Specifically, the growing convergence of systems engineering with other disciplines can be expected to produce new concepts, solutions to intractable problems, or entirely new disciplines. The following two examples illustrate the “so what” impact of Transdisciplinary Systems Engineering based on disciplinary convergence.

Example #1: Achieving superior collaboration among all stakeholders by exploiting convergence of engineering and entertainment/cinematic arts

Collaboration among stakeholders especially in the early stages of system design and concept of operation development is crucial to acquiring stakeholder requirements and constraints. Unfortunately, current system modeling languages (e.g., UML, SysML) which tend to be engineer-oriented, are inappropriate for stakeholders who are not technically inclined. As a result, non-technical stakeholders tend to get left out in upfront engineering when requirements are discussed. The result is incomplete requirements and constraints specification that inevitably lead down the line to extraneous design iterations and rework. Transdisciplinary SE Solution: Convergence of engineering and entertainment/cinematic arts. Map system models and use cases to system stories that can be interactively executed in simulation and virtual worlds. Stakeholders can interact with the system model during story execution and explore system behavior from their respective perspectives to get a good feel for the system. As important, they can vary assumptions and system parameters, uncover latent interactions, and explore alternate futures and outcomes. Based on this acquired understanding about the system, they can provide and better justify their requirements during collaborative tradeoff analysis. Impact: Elimination of extraneous design iterations and rework resulting from incomplete requirements collection in upfront engineering.

Example #2: Increase generation of novel ideas and options in upfront engineering

Most novel ideas are generated and explored during early design. Unfortunately, small groups, especially startups, are limited in collaborative brainstorming by the size of their group. This limits their knowledge and ability to generate creative options. Transdisciplinary SE Solution: Convergence of collaborative engineering and social networks/media. With advances in social media and crowdsourcing, this small collaborative group can extend its reach virtually during ideation and novel option generation. With the benefit of traditional collaboration and crowdsourcing, the virtual team of original collaborators and crowdsourced individuals can bring greater knowledge to bear on the ideation and collaborative option generation process. Impact: A richer set of ideas and options in upfront engineering leading to a potentially superior system or product.

In sum, disciplinary convergence is an enabler of transdisciplinary systems engineering. And transdisciplinary systems engineering is a potential enabler of solutions to the U.S. National Academy of Engineering’s Grand Challenge problems.

James Martin (The Aerospace CorporationAero) - MartinQZX@gmail.com

James Martin, PhD, is founder and chair of the Systems Science Working Group. He is an enterprise architect and systems engineer with The Aerospace Corporation developing solutions for information systems and space systems. He was a key author on the BKCASE project in development of the SE Body of Knowledge (SEBOK). 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 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 was leader of the Standards Technical Committee. He received from INCOSE the Founders Award for his long and distinguished achievements in the field.

Position Paper

Systems Engineering has traditionally been about developing and supporting man-made systems primarily composed of hardware and software. We have developed our tools and methods over the decades to deal with eliciting requirements and constraints from stakeholders, and designing the various aspects of hardware and software, such as data processing, size and weight, energy consumption and efficiency, handling waste byproducts, and all of the other logistical challenges. However, many of the systems challenges in this day and age must deal with more of the “soft systems” aspects, such as policies and processes, roles and responsibilities, needs and expectations, look and feel, intolerance of change and disruption, and so on.

We often need to address the “enterprise” level challenges of the systems — and explicitly deal with all of the different enterprises which are involved. These include the enterprise that develops and maintains the system, the enterprise that utilizes and benefits from the system, the enterprise that stands to lose from our deployed solution seeing they will lose of the advantages they currently have, the enterprise that must deal with our system’s pollution and waste byproducts, along with the enterprise that must supply energy and materials to keep our system going. These enterprises present challenges more along the lines of PESTEL – the dimensions of the problem that deal with the Political, Economic, Social, Technological, Environmental and Legal forces facing the various enterprises associated with our delivered system. Is SE up to the PESTEL challenge?

Our SE process, methods and tools need to change to better accommodate the PESTEL challenges. We need more of those who do SE to have a background other than traditional engineering knowledge and skills. SE’s may not be able to develop all of the needed skills — perhaps SE’s need to learn to partner more effectively with others who have the needed skills and contact networks, and together we can succeed. We may not be able to rely as heavily on “requirements” since the soft elements of the system solution (such as people) don’t always respond well to hard and fast mandates in the system specification.

I challenge the audience to learn some PESTEL-related skills themselves, so they can become a more effective part of the solution.

Alan Harding (BAE Systems) - alan.d.harding@baesystems.com
Alan Harding is the head of the information systems engineering discipline for the BAE Systems Military Air and Information business. He is a BAE Systems Global Engineering Fellow, a Fellow of the IET, and a Chartered Engineer. Alan is the 2016-2018 President of the International Council On Systems Engineering (INCOSE), the global professional society for systems engineering. He is a practicing systems engineer with over 30 years of experience in defence and security applications. Specialist interest areas include capability, systems-of-systems, architecture, and competency development.
Position Paper
INCOSE is the Global Authority on Systems Engineering. We have contributed to many definitions of systems engineering in various standards and present our own definition. These definitions are somewhat consistent, and reasonably useful. The INCOSE definition (given on www.incose.org/AboutSE) contains good words but does not say what we mean by systems engineering, or give a sense of today's requisite variety of applications.
INCOSE should have and promote the best possible definition, as befits our leadership role, and that we can all use with confidence. As President I chartered this Fellows' activity, led by Hillary Sillitto, to give leadership to INCOSE and the wider systems community by developing an improved definition that we can use as a key enabler when promoting and developing systems engineering.
I am passionate that we have a definition that unites us, that is inclusive, that is understandable, and is something we can promote with passion and pride as we promote systems approaches globally and across a wide range of application domains – from policy systems to technological systems to socio-technical systems, from systems of systems to quite specific technical systems, in fact any man-made systems where we are deliberately involved in creating or improving them.
The main thing this definition must do is to allow us to break out of the confines of our traditional boundaries – those domains where systems engineering is recognised and practised, more or less, and that has been the case for many years. Examples include defence and aerospace, along with some areas of transportation, power and energy etc.
INCOSE, as champions of systems engineering, must be ready and able to engage in conversations about the nature of systems engineering and its applicability to a diverse range of systems (technical, socio-technical, systems of systems, service systems) in a wide range of contexts without being shackled to a "traditional" view of SE which can be seen by some as clerical, slow, lacking innovation, and not agile.
The challenge:
- The new definition (the "what") must be written in plain language simply used, and must be accompanied with a clear value proposition (the "why") that speaks to a non-technical audience.
- It must relate to the body of systems engineering standards and knowhow (the "how") of which INCOSE and others are custodians, and have sufficient technically credibility to the INCOSE expert audience.
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• Many of the systems we are now concerned with include societal and naturally-occurring elements. Our understanding of “what a system is” must expand to embrace these other system types – and these cannot be “controlled” in the way we expect to control purely technological systems, but can at best be understood and then influenced.
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Michael deLamare (Bechtel) - madelama@bechtel.com

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Position Paper

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However, systems of the twenty first century are hyper-networked and extremely adaptive with purposes that evolve beyond what the system designers intended or even imagined to be possible. Further, there is a growing need to analyze and understand other classes of systems such as highly autonomous, socio-technical, natural, and societal systems. Our traditional methods of systems analysis, such as process modeling, functional modeling and the traditional allocation of functions and requirements to architecture expect that we can establish reliable controls to achieve objectives. These methods of the past century, while still needed and effective for centrally controlled technical systems, are not sufficient for delivering the networked and self-adaptive systems of the future. For example, design of a coherent traffic system based on multiple independent vehicles might not be achievable using traditional methods alone, and may be better understood using more agent-based approaches. Such approaches have been applied by social scientists over the past couple of decades, and could perhaps help improve our traditional practices. The Systems Engineering discipline needs to reach out to other disciplines and expanding the current BoK to address these other system types, and transforming itself to be more broadly relevant.

Integrating Project Management, Systems Engineering, and Earned Value Management to Improve Project Progress

Gordon M. Kranz (Enlightened IPM) - gmkranz@eipm-llc.com
David Walden (Sysnovation, LLC) - Dave@sysnovation.com
Eric S. Rebentisch (MIT) - erebenti@mit.edu
Dale Gillam (SAIC) - gillamd@saic.com
Daniel L. Lynch (Raytheon Missile Systems) - Daniel_L_Lynch@raytheon.com

Presented on: Wednesday, 15:30-16:55

Keywords. systems engineering; project management; earned value; integrated performance

Abstract. Many projects use Earned Value Management (EVM) to plan and assess progress. Project Management (PM) relies on accurate EVM data to effectively and efficiently manage projects. However, many EVM professionals have said that cost and schedule performance are not well connected with program technical accomplishments typically led by Systems Engineering (SE), and this leads to inconsistent and misleading EVM reporting.
This panel will discuss ways to better integrate PM, SE, and EVM to ensure claimed Earned Value (EV) represents an accurate assessment of the program progress-to-plan consistent with technical accomplishments.

Biography

Gordon M. Kranz (Enlightened IPM) - gmkranz@eipm-llc.com
Gordon M. Kranz, PMP, currently serves as President of Enlightened IPM, a consulting firm providing Government agencies and contractors advice and guidance on integrated program management. With over 35 years of experience in the DoD and private sectors, Mr. Kranz served as Deputy Director PARCA for Earned Value Management. Mr. Kranz initiated the Government and industry collaboration on Agile – EVM implementation to form the basis for current emerging guidance and policy. Before his role at PARCA Mr. Kranz was the Executive Director, Engineering and Analysis, for the Defense Contract Management Agency and worked at General Dynamics in industry. Mr. Kranz received a bachelor’s degree from North Dakota State University and a master’s degree from the Air Force Institute of Technology. He is a certified Program Management Professional (PMP), a Professional Scrum Master I (PSM1) and is DAWIA Engineering level 3 certified.
Position Paper
It is critical that the PM, SE, and EVM communities sit down at the table together and break down their stovepipes. The only way to get accurate EVM plans, status, and forecasts is through these three communities working together to focus on the integrated program performance that reflects actual system progress on satisfying project objectives. This panel is intended to be a start to this dialog process.

David Walden (Sysnovation, LLC) - Dave@sysnovation.com
David D. Walden, ESEP, is co-owner and principal consultant for Sysnovation, LLC, a Systems Engineering consulting and training firm he formed in 2006. Previously, Mr. Walden was with General Dynamics Advanced Information Systems for 13 years and McDonnell Aircraft Company for 10 years. Mr. Walden was the lead editor of the INCOSE SE Handbook Fourth Edition. He is an INCOSE liaison to ISO/IEC JTC1/SC7 Working Groups 10 and 20. Mr. Walden was Program Manager of the INCOSE Certification Program from 2007-2013. He has an M.S. in Management of Technology (MOT) from the University of Minnesota, an M.S. in Electrical Engineering and in Computer Science from Washington University in St. Louis, and a B.S. in Electrical Engineering from Valparaiso University in Indiana. Mr. Walden was one of the first to earn the INCOSE Certified Systems Engineering Professional (CSEP) credential in 2004 and was awarded the INCOSE Expert Systems Engineering Professional (ESEP) credential in 2011.
Position Paper
In many organizations, current EV practices focus on the activities that the technical team does and the work products that they produce, rather than if the activities and work products actually lead to system technical success. Therefore, EV needs to move from what people do/produce to what the system does. The temporal nature of many SE products aligns nicely with

the temporal nature of EV planning, statusing, and forecasting.

Eric S. Rebentisch (MIT) - erebenti@mit.edu
Eric S. Rebentisch is a lecturer and research associate at the Massachusetts Institute of Technology (MIT) and Lead Researcher of MIT's Consortium for Engineering Program Excellence. His primary areas of research include High Performance Enterprise Product Development, Lean Product Development, Lean Project Management, Enterprise Change Management, and System Architecting and Development Strategies. He is editor of "Integrating Program Management and Systems Engineering" and author of numerous other publications. He has played key roles in analysis, policy recommendations, and transformation initiatives within the US and other governments. He holds a Ph.D. in the Management of Technological Innovation from the Massachusetts Institute of Technology, a Master's degree in Organizational Behavior from Brigham Young University, and a B.S. in Aerospace Engineering from California State Polytechnic University. He has taught graduate level and executive education courses on Systems Engineering, Six Sigma, Lean Product Development, Lean Enterprise, and Research Methods.

Position Paper

When implemented properly, EV provides a high-level indicator of program performance that reflects the state of the various elements of the overall system. In addition to the active integration of program management and systems engineering efforts, it is critical that EV be linked to the product, the processes, the organization, and other aspects of the entire sociotechnical system that constitutes the program. With all of these elements represented, the EV system not only indicates current status, but also enables tighter integration of the leadership team and overall program.

Dale Gillam (SAIC) - gillamd@saic.com
Dale Gillam is a Program Manager and the Earned Value Management (EVM) and Scheduling Focal Point for SAIC. Mr. Gillam's expertise is in program start-up, planning, scheduling, and EVM, with an emphasis on implementing Integrated Program Management (IPM) solutions. Mr. Gillam is responsible for policy and practice definition, oversight and compliance, customer interface, and program implementation. Mr. Gillam has overseen hundreds and led dozens of IPM solutions for many U.S. Department of Defense and Civilian Agency customers. The solutions have spanned the spectrum from million dollar task orders, to several hundred million dollar services and staff augmentation contracts, to multi-billion dollar developmental contracts across all contract types. Mr. Gillam serves as the Vice-Chairman and on the Governing Board of the National Defense Industrial Association's Integrated Program Management Division (NDIA IPMD). Mr. Gillam recently concluded service on the Governing Board of the College of Performance Management (CPM) and of the National Contract Management Association (NCMA) Tyson's Chapter. Mr. Gillam's formal education includes a B.B.A. and an M.B.A and several executive programs from the University of Virginia, Stanford University, George Washington University, San Diego State University, and Radford University. Mr. Gillam also has twelve current industry certifications in different functional areas related to integrated program management (CFM, SCPM, CMC, CCE/A, PMP, CMQ/OE, CMA, EVP, CSM, CSSGB, CPCM, PMI-SP).

Position Paper

The National Defense Industrial Association's Integrated Program Management Division (NDIA IPMD), the College of Performance Management (CPM), and the National Contract Management Association (NCMA) are all concerned with project performance. Opportunities exist to work across these organizations to improve the depth in each discipline while also improving the integration across the disciplines to support better program outcomes.

Daniel L. Lynch (Raytheon Missile Systems) - Daniel_L_Lynch@raytheon.com
Daniel L. Lynch has over 39 years of Integrated Program Management experience in the defense industry ranging within the design, development, and production environments with Raytheon, BAE Systems, and RCA Corporation. Within that span, he's also spent 10 years working as a self-employed consultant with clients in both the private and public sectors. He is currently the Senior Manager and EVMS Focal Point for Raytheon Missile Systems (RMS), a multi-billion dollar annual sales operation with an EVM System that was validated with a perfect score in 2008. His primary focus is on the Implementation, Compliance, and Surveillance of RMS' EVM System in addition to Learning, Integrated Baseline Reviews, Integrated Program Management Analysis and program oversight. External to Raytheon Missile Systems, he has been an active participant for over a decade and has served both government and industry as the Chairman of the NDIA-Integrated Program Management Division. He has additionally been a member of the Project Management Institute (PMI) along with being a sought after speaker and instructor for the College of performance Management (CPM).

Position Paper

Preparing and conducting a high-quality Integrated Baseline Review (IBR) is critical for successful Integrated Program Management Analysis and producing meaningful EV data for program oversight throughout the life of a project. There is significant opportunity to integrate PM, SE, and EV to prepare and hold a successful IBR.

Panels#11

Inter-agency Government Panel on Systems Engineering of the Future

Anna-Maria McGowan (NASA) - Anna-Maria.R.McGowan@NASA.gov
Scott Lucero (DoD) - don.s.lucero.civ@mail.mil
Timothy Sprock (NIST) - timothy.sprock@nist.gov

Presented on: Monday, 10:00-12:10

Keywords. Complex Systems; #Government; Socio-technical Systems; Interdisciplinary

Abstract. The complexity of engineered systems has swelled in the last several decades, and this trend is likely to continue for the foreseeable future. While projects are becoming more complex, current engineering practice has largely evolved from a top-down approach that is the legacy of past successes. A fundamental rethinking of engineering methodologies is urgently needed if our nation is to ensure that the large, complex systems critical to our national security, economy, and quality of life are resilient in the face of natural disasters, creative adversaries, and an uncertain future.
The Interagency Working Group on Engineering Complex Systems explores these issues from the perspectives of several U.S. government agencies executing diverse missions. This panel session of the chief engineers from several federal agencies will address major challenges in engineering systems of the future, and will discuss ongoing initiatives to address these challenges.

Panels#17

Is Systems Engineering Succumbing to Buzzwords?

Steven Dam (SPEC Innovations) - steven.dam@specinnovations.com
Dennis Buede (Innovative Decisions, Inc.) - dbuede@innovativedecisions.com
Michael Delamare (Bechtel) - madelama@bechtel.com
Mitchell Kerman (Idaho National Laboratory) - mitchell.kerman@inl.gov
Jerry Sellers (TSTI) - jerry.sellers@mac.com
Warren Vaneman (Virginia Tech) - wvaneman@verizon.net

Presented on: Tuesday, 13:30-14:55

Keywords. SysML; Agile Systems Engineering; Mission Engineering; MBSE

Abstract. Like many disciplines, systems engineering is at mercy of impulse and fads. IDEF, Architecture, SysML, Lean, Agile, MBSE, Mission Engineering and many other languages, frameworks, and methodologies have been proposed to solve all system engineering problems. Truly, can any one (or more) of these approaches really meet the wide variety of domain-specific problems that we face on a daily basis as systems engineers? This panel of experts will discuss this question and others from the audience. We anticipate a freewheeling discussion with significant audience participation. Come defend your favorite buzzword!
Dr. Steven Dam will moderate an all-star panel to discuss this topic. The panel includes: Dr. Dennis Buede, who is President of Innovative Decisions, Inc. and is currently performing research in systems engineering for IARPA, and other major government organizations - Mr. Michael deLamare, Director of Systems Engineering on Government Programs at Bechtel and Chair of the INCOSE CIPR Working Group - Dr. Mitchell Kerman, Director of Systems Engineering at Idaho National Laboratory - Dr. Jerry Seller, who teaches systems engineering through TSTI and Stevens Institute for NASA, ESA, and many other organizations worldwide - and retired CAPT Warren Vaneman, P.h.D, who is currently a professor of systems engineering at Virginia Tech and Naval Postgraduate School.

Biography

Steven Dam (SPEC Innovations) - steven.dam@specinnovations.com
Dr. Dam is the President and Founder of the Systems and Proposal Engineering Company (SPEC Innovations), based in Manassas, VA. He has been involved with structured analysis, software development, and system engineering for over 35 years. He participated in the development of C4ISR Architecture Framework (now DoDAF), the Business Enterprise Architecture (BEA), and Net-Centric Enterprise Services (NCES) architecture. He currently is applying system-engineering techniques to various DoD and DOE projects. Dr. Dam is the author of two systems engineering-based books: “DoD Architecture Framework: A Guide to Applying System Engineering to Develop Integrated, Executable Architectures;” and “Proposal Engineering: A Guide to Developing Winning, Cost-Effective Proposals.” Dr. Dam has a BS degree in Physics from George Mason University and a PhD. in Physics from the University of South Carolina. Dr. Dam is also an INCOSE certified Expert Systems Engineering Professional (ESEP).
Position Paper
Every ten years or so we get a “new” approach to management. In my lifetime, there has been: “Management by Objective,” “Total Quality Management,” “Business Process Reengineering,” and “Lean Six-Sigma.” Since program management tends to follow these trends, they impact systems engineering in the same way. At the same time, disciplines, such as software, have also had their own trends, often driven by programming languages: Basic, Fortran, C, Pascal, C++, SmallTalk, Ada, Java, Ruby, etc. (check out the Wikipedia page – there are several hundred of them). These software trends often link to the languages: structured analysis (e.g., Basic, Fortran), object analysis (e.g., C++, Java), Agile (e.g., JavaScript, Ruby). As systems engineers we often find ourselves having to respond to these trends. For example, SysML was an answer to UML. But when we strip down all of these trends they actually have common underpinnings (e.g., for management changes you need top down support; in software hybrid structured and object appear to overlap significantly). Systems engineering principles, as espoused by INCOSE, endure through all these trends. We just need to hold on to our principles.

Dennis Buede (Innovative Decisions, Inc.) - dbuede@innovativedecisions.com

Dr. Buede has over forty years of experience in both the theoretical development and engineering application of decision support technologies. He received his Ph.D. and M.S. from the Engineering-Economic Systems Department of Stanford University and his B.S. in Aerospace Engineering from the University of Cincinnati. He is currently Chief Innovation Officer of Innovative Decisions, Inc., which conducts decision and risk analyses. He has been a Professor of Systems Engineering and Engineering Management at Stevens Institute of Technology and Professor at George Mason University. Prior to that he ran his own consulting and research company for eight years. He has done extensive research in the fields of decision analysis, data fusion and systems engineering. In particular, he has pioneered in the development of new decision methodologies in the areas of system design and evaluation, and resource allocation. He has authored The Engineering Design of Systems: Methods and Models, coauthored a book titled Decision Synthesis, and authored or coauthored numerous professional and technical papers in the above fields. He belongs to the Institute for Operations Research and Management Science, the Institute of Electronic and Electrical Engineers, and the International Council on Systems Engineering. He is a Fellow of INCOSE.

Position Paper

Systems Engineering is responsible for integrating the design work of other engineering disciplines and therefore must keep abreast of and be able speak about the latest and greatest design and analysis concepts (buzz words) from these other engineering disciplines. It is the systems engineer's role (working with engineers from the other disciplines) to separate the wheat from the chaff, to use an analogy. As a result, the systems engineering discipline is subjected to many more buzz words, and new concepts, than engineers from other disciplines are. There are going to times when a useful concept in one discipline adds no value to other disciplines, including systems engineering. But there are many examples of a concept (e.g., control and stability) spreading from one discipline to many or all disciplines. Often other disciplines modify and improve concepts originated in a different discipline. It is this interplay across design disciplines that is most likely to raise the performance of all the disciplines. But there is a cost because many such concepts need to end up the junk bin, and it often takes awhile for the "junk bin" consensus to build against the wishes of a few zealots.

Michael Delamare (Bechtel) - madelama@bechtel.com

Mr. deLamare has over 35 years of experience in the application of Systems Engineering to various kinds of systems and projects. The domains include Space and Defense, Environmental Remediation, and Nuclear and Industrial facilities. This experience is on behalf of DOD and DOE clients. He currently serves as the corporate Systems Engineering Manager for Bechtel's Nuclear, Security and Environmental business unit. His responsibilities include defining Bechtel's Systems Engineering program. This role develops systems engineering processes for the business line; developing the SE culture and training; and supporting systems engineering implementation on projects distributed throughout the U.S. Mr. deLamare holds a B.S. in Physics from the University of California at Irvine, an M.S. in Systems Engineering from Johns Hopkins University, and is certified as an INCOSE Expert Systems Engineering Professional. He also serves as Bechtel's representative to the Corporate Advisory Board, and chairs the Critical Infrastructure Protection and Recovery working group.

Position Paper

A critical skill in systems engineering is the ability to communicate. As a discipline, we have many ideas and concepts bundled together that we are eager to share with whoever will listen. After all, what we know brings order to an otherwise chaotic process of system development. However, it is difficult to gain ready acceptance due to a language barrier that has been developing over decades. Communications from systems engineers to managers, stakeholders, users and other engineering is difficult enough without the highly specialized "systems-speak" and complicated diagrams that are hard for non-systems specialists to decipher. Take a step across domains such as aerospace, medical equipment, civil infrastructure, transportation, oil and gas, consumer electronics, software and others and this problem significantly compounds. The communications gap is wide enough that it is hard for domains where systems engineering is not a common discipline to recognize its value. This problem is exacerbated by the language we use and our inability to separate our methods from the basic systems and system development principles. In the last statement is an important key since all of the domains mentioned share the common goal to deliver systems that meet client, user and stakeholder needs in efficient and effective manners. There are core concepts and principles that transcend each domain and provide common footing for meaningful exchanges of ideas. We need to return to these fundamentals in the way we communicate our discipline.

Mitchell Kerman (Idaho National Laboratory) - mitchell.kerman@inl.gov

Dr. Kerman has a diverse background with extensive experience in computer modeling and simulation, operations analysis, systems engineering, engineering management, and business development. Prior to joining INL, he was the Director of Program Development and Transition for the Systems Engineering Research Center (SERC), a Department of Defense University Affiliated Research Center (UARC) led by Stevens Institute of Technology in Hoboken, New Jersey. Dr. Kerman has taught graduate classes in both operations analysis and systems engineering. He is the author of two textbooks on the topics of computation and introductory computer programming and has published numerous articles in technical journals and trade publications. Dr. Kerman is also a retired Navy officer with 27 years of combined active duty and reserve experience in submarine warfare, naval coastal warfare, coordination and guidance of merchant shipping, and NATO operations. Dr. Kerman has a BS in computer systems engineering from Arizona State University, a MS in operations analysis from Naval Postgraduate School, and a PhD in systems engineering from Stevens Institute of Technology.

Position Paper

The systems in our world are becoming more complex, and this is occurring at an ever-increasing rate. To adequately characterize and manage this complexity, we need better systems engineering processes, methods, and tools. This rapid pace of change also results in new ideas for possible solution methods, some more mature and better tested than others.

The unfortunate side-effect is an engineering environment predominated by buzzwords and “flavor of the day” solution techniques. We, as systems engineers, are charged with cutting to the chase – that is, quickly narrowing our solution space to those essential elements truly needed to address the problem. Buzzwords and “flavored” solution techniques only add value if they stand the test of time and offer true utility to the practitioner.

Jerry Sellers (TSTI) - jerry.sellers@mac.com

Dr. Jerry Jon Sellers, author of Understanding Space: An Introduction to Astronautics, and is a contributing author and editor of Applied Space Systems Engineering, and a contributing author of Human Spaceflight Analysis and Design. He has over 30 years of space systems experience including Guidance & On-board Navigation Officer in Space Shuttle Mission Control; Assistant Professor of Astronautics at the U.S. Air Force Academy; and Chief of Astronautics for the Air Force European Office of Aerospace Research & Development. He is an Associate Fellow at AIAA and the former Chairman of the Space Systems Technical Committee. He is also an adjunct professor at Stevens Institute of Technology, a certified Scaled-Agile Program Consultant and Corresponding Member of the International Academy of Astronautics.

Position Paper

As a young engineer, I had the good fortune to have a conversation with Joe Shea, NASA Apollo Program Manager. One thing he said that’s always stuck with me was “there’s no substitute for knowing what in the hell you’re talking about.” As a practice, SE is as old as human kind. Only about 70 years of that have we made it a discipline in its own right with terms and models and languages, etc. From my perspective, the fundamental framework of SE, how we take a need and turn it into a capability is essentially immutable. However, we then implement that framework into organizations that have their own unique culture and protocols. Add to that the tools SE’s are given (pencil and paper, PCs or MBSE) and you get the processes and practices that determine SE actually gets done. Words are important. Terms need to be consistent. But, at the end of the day, Joe Shea’s guidance rings true.

Warren Vaneman (Virginia Tech) - wvaneman@verizon.net

Warren Vaneman is a Professor of Practice in the Department of Systems Engineering at the Naval Postgraduate School. He has more than 20 years of systems engineering experience in various government agencies, including serving as a chief architect within the intelligence community. His research interests include System of Systems Engineering and Integration, and Model-based Systems Engineering. Warren received his Ph.D. in Industrial and System Engineering, and M.S. in Systems Engineering from Virginia Tech, and his B.S. in Meteorology and Oceanography from the State University of New York Maritime College. Dr. Vaneman duties included serving as the Chief Architect, National Reconnaissance Office Ground Enterprise Directorate, Architecture Analysis Division, National Reconnaissance Office, and Senior Systems Engineer, National Geospatial-Intelligence Agency. In a parallel career, Warren was a Captain in the U.S. Navy Reserve, where he was a surface warfare officer and a senior member of the Navy Space Cadre. He also had six command tours of duty. He has ~~participated in several campaigns and operations including, Desert Storm, Operation Enduring Freedom, and Operation Burnt~~ Frost. Dr. Vaneman has received many awards: Legion of Merit (twice), Defense Meritorious Service Medal (three times), Meritorious Service Medal, Navy Commendation Medal (5 times), Joint Service Achievement Medal, Navy Achievement Medal (3 times), National Reconnaissance Office Systems Engineering Senior Technical Civilian (twice).

Position Paper

Organizations often adopt the “buzzword of the day” for their systems engineering processes. Many of the underlying concepts for these buzzwords are sound systems engineering processes, and enjoy the popularity of the moment. However, many organizations are searching for a quick fix to their systemic problems, lack the discipline to implement the concepts correctly, and as envisioned by the systems engineering community. As a result, these “engineering by buzzword” concepts often fail, tainting not only the buzzword, but the sound corresponding systems engineering concept. Thus, organizations often make slow advances in their systems engineering processes, leading them to believe that systems engineering is an expensive endeavour that contributes little. While poor implementation within organizations is a problem, the systems engineering community allows their sound concepts to become bumper stickers, a phenomenon not seen in other engineering disciplines. For systems engineering to be successful in the long-term, the community must resist the adoption of these buzzwords, and promote the sound, disciplined processes that can be used as intended for organization success.

Is systems engineering well-equiped for the fourth industrial revolution?

Avigdor Zonnenshain (TECHNION) - avigdorz100@gmail.com
Ron Kenett (KPA Ltd. and Univ. of Torino, Italy) - ron@kpa-group.com
Kerry Lunney (THALES) - Kerry.lunny@thalesgroup.co.au
Robert Swarz (WPI) - rswarz@WPI.EDU
Hillary Sillitto (consultant) - Hillary.sillitto@blueyonder.co.uk
Cecilia Haskins (Norwegian University of Science and Technology) - Cecilia.Haskins@ntnu.no
Dean Bartles (University of New Hampshire) - dean.bartles@unh.edu
Alice Squires (Washington State University) - alice.squires@wsu.edu

Presented on: Thursday, 08:00-09:25

Keywords. Fourth Industrial Revolution; Internet of Things; Data Analytics; Advanced Manufacturing; INDUSTRY 4.0

Abstract. During the last decade, industries in advanced economies have experienced significant changes in engineering & manufacturing practices, processes, and technologies that have the potential create a resurgence in their engineering & manufacturing activities. This phenomenon is often referred to as the Fourth Industrial Revolution or Industry 4.0 , and is based on advanced manufacturing & engineering technologies, such as massive digitization, big data analytics, advanced robotics and adaptive automation, additive and precisions manufacturing (e.g., 3-D printing), modelling & simulation, artificial intelligence, and the nano-engineering of materials.
The proposed panel will discuss the above-mentioned dilemma with its different aspects, like:
• Do the traditional systems engineering processes fit the needs of systems in the new era?
• What are the challenges, opportunities & threats for the SE discipline in the Fourth Industrial Revolution?
• Does the INCOSE VISION 2025 address properly the challenges of the Fourth Industrial Revolution?
• One of the important features of the Fourth Industrial Revolution is the advanced use of Data Analytics. How can the systems engineering discipline exploit this trend to be more evidence based?
• What is the proposed leadership role for systems engineers in the Fourth Industrial Revolution ecosystem?

Biography

Avigdor Zonnenshain (TECHNION) - avigdorz100@gmail.com
Dr. A Zonnenshain is currently the Senior Research Fellow at The Gordon Center for Systems Engineering and at the Neaman Institute at the Technion, Haifa, Israel. He has a Ph.D. in Systems Engineering from the University of Arizona, Tuscon. Formerly, He held several major positions in the quality and systems engineering area in RAFAEL & in the Prime Minister's Office. He is an active member of the Israel Society for Quality (ISQ). He was also the Chairman of the Standardization Committee for Management & Quality. He is a Senior Adjunct Lecturer at the Technion?Israel Institute of Technology. He is a member of the Board of Directors of the University of Haifa. He is an active member of INCOSE & INCOSE_IL (past president). He is a Fellow of INCOSE.

Ron Kenett (KPA Ltd. and Univ. of Torino, Italy) - ron@kpa-group.com
Professor Ron Kenett is Chairman of the KPA Group, Israel and Senior Research Fellow at the Neaman Institute, Technion, Haifa. He is an applied statistician combining expertise in academic, consulting and business domains. Ron is Past President of the Israel Statistical Association (ISA) and of the European Network for Business and Industrial Statistics (ENBIS). He authored and co-authored over 250 papers and 12 books on topics such as biostatistics, healthcare, industrial statistics, data mining, customer surveys, multivariate quality control, risk management and integrated management models. The KPA Group, he founded in 1994, is a leading Israeli firm focused on generating insights through analytics with a wide range if customers including HP, Unilever, the Israel aeronautics Industry, Elbit, Stratasys and Applied Materials. He is editor in chief of Wiley's StatsRef, and was awarded the 2013 Greenfield Medal by the Royal Statistical Society in recognition for excellence in contributions to the applications of Statistics. His recent edited book to be published by Wiley in 2018 is titled: Analytic

Methods in Systems and Software Testing (ISBN- 9781119271505). He founded the point and click translator company, Babylon.com and is member of the board of several startup companies.

Position Paper

"From Documents to Data"

Systems engineering (SE) is a discipline dealing with complex issues in quantitative terms. The extended access to big data from sensors, together with concepts and technologies of the fourth industrial revolution, offers to SE an opportunity to grow and expand. The bottom line is that SE should move from being focused on documents to an approach being driven by data (From D to D). This transition involves new and old disciplines such as computer simulations, statistically derived design and operational spaces, multivariate process control and monitoring, prognostic health management, complexity management and performance evaluation methodologies. A transition from D to D is posing a range of analytic challenges including sophisticated predictive analytics, data integration accounting for information generated at various levels of form, resolution and speed. Questions that need to be considered regard the evaluation of high level and detailed designs, setting up of test suites in parallel with system development and advanced support to decision making providing an indication of impact of alternative scenarios. These questions relate to the design of alpha and beta tests and the proper analysis of feedback from field tracking studies. A paper dealing with analytic challenges in the context of Industry 4.0 can be found in https://ssrn.com/abstract=3003830. A comprehensive treatment of system and software process improvement methods that deal with some of these issues can be found in http://www.crcpress.com/product/isbn/9781420060508. Addressing these challenges requires a review of SE methodologies, enhancement of analytic methods supporting SE activities and improved tools and platforms. Specifically, SE should expand the applications of simulations and computer experiments using statistical methods for calibration of emulators. Other applications that need to be addressed by SE is multivariate process monitoring and optimized data resolution and integration. Yet another domain that needs enhanced attention is the practice of data driven risk management and robust design methods. Introducing these changes requires initiatives affecting practitioners, researchers and educators.

Kerry Lunney (THALES) - Kerry.lunny@thalesgroup.co.au

Ms Kerry Lunney has extensive experience developing and delivering large system solutions, including design, software development, infrastructure implementation, hardware deployments, integration, sell-off, training and on-going support. She has worked in various industries including ICT, Gaming, Financial, Transport, Aerospace and Defence, in Australia, Asia and USA. The systems delivered include combat systems, mission systems, communication systems, road and rail ITSs, flight simulators, security systems, vehicle electronic systems, gaming systems and ICT foundation systems. Kerry is Country Engineering Director and Chief Engineer in Thales Australia. In this role she provides technical leadership and governance on bids and projects, delivers technical training programs, and participates on a number of Technical Boards and Communities of Thales. Recent roles include Chief Systems Engineer, Solutions Architect and Design Authority. Kerry is a member of IEEE, a Fellow Member of Engineers Australia with the status of Engineering Executive and Chartered Professional Engineer, and holds INCOSE ESEP qualification. In addition to her "day job," Kerry is the INCOSE President-Elect. She has also been a past INCOSE Director of Asia Oceania, a past National President of SESA, the Australian Chapter of INCOSE, and has held various roles on conference and events committees including the Symposium Chair for INCOSE IS2001Melbourne, Australia.

Position Paper

"The Increasing Challenge of Interoperability"

Is the 4th Industrial Revolution a new renaissance period coming upon us? No matter what anyone may think, it is here and it will thrive, paced not by technology, but by the want to adapt and adopt, and at the price people can afford.

As part of the panel I will focus on interoperability challenges of the 4th Industrial Revolution. We are faced with integrating and blending physical, digital and biological elements. This is not something that a lot of Systems experts have faced. Likewise, the human is an integral part of the system but how can we adequately model a human to a level of detail that may be required. It is near impossible. To date, we have included the human representation in our models but at a very high procedural level typically. We are also faced with masses of digital data. As Systems specialists this is a minefield of possibilities. But where do we focus? What is our starting point? How do we build and modify legacy systems that may be part of a solution?

For addressing interoperability, I will look out methods that are common today for the design and implementation often for disparate systems, to operate as a larger single entity. I will then dissect these methods to put forward a position of what is useful, what could be modified, and what we need to throw away and start afresh. This could include processes, guidelines, tools and frameworks. A case study on the worldwide challenge of energy supply or similar problem of equal magnitude will be used to illustrate the interoperability arguments.

Based on presenting the interoperability challenges we traditionally view as Systems specialists and what this means in the 4th Industrial Revolution. This will open the floor to discuss how design is critical, particularly as we cannot ignore how machines will be augmenting humans. As Systems Thinker, Systems Engineers and indeed INCOSE, we will need to transform to continue in pivotal role; otherwise we will become dinosaurs, an artefact of a past era.

Robert Swarz (WPI) - rswarz@WPI.EDU

Bob Swarz is a Professor of Practice in the Systems Engineering program of Worcester Polytechnic Institute in Worcester, Massachusetts, USA. He holds a Ph.D. in Electrical Engineering from New York University, an M.B.A. from Boston University, an M.S. from Rensselaer Polytechnic Institute, and a B.S., also from NYU. In addition to his academic background, he has engineered systems at The MITRE Corporation, Pratt and Whitney Aircraft, and Digital Equipment Corporation. His current research interests are in system dependability and security, complex systems of systems, model-based systems engineering, and system architecture.

Position Paper

There is a need for fundamental change in Systems Engineering to meet the challenges & opportunities

What is a system? Virtually all of the textbooks and classes on Systems Engineering (SE) begin by trying to define a system. The description usually involves some combination or variations of the following themes: (1) it's an engineered response to a need, (2) it possesses synergy (the whole is greater than the sum of its parts), (3) it is bounded (you can draw a box around it), (4) it has known internal functions, relationships, and interfaces, and (5) it is based on stable and clearly stated requirements.

What is systems engineering? Rather than being based in scientific principles (as I always point out to my students, there is no "Ohm's Law of Systems Engineering"), Systems Engineering consists of a rich and useful set of principles, processes, and lessons-learned.

What has changed? Our notions of what a system is and the characteristics of systems engineering have served us well for the past 60 or 70 years; however, with the exponential increases in the amount of computational power, communications bandwidth, raw data, and addressable objects, things have changed! The Internet of Things and Big Data have changed our fundamental concepts of what systems are and how we do systems engineering.

Everything! System complexity has increased so much that it is not uncommon for systems to exhibit emergent behavior, occasionally with unintended consequences, i.e., the ability to perform functions that could not be imagined by examination of its component parts. Increases in communications bandwidth and the so-called Internet of Things obviates the boundedness of systems. The vast amount of data presents enormous challenges to manage, store, analyze (and use!) it.

My remarks will suggest how the discipline of systems engineering needs to fundamentally change to keep up with these technological changes.

Cecilia Haskins (Norwegian University of Science and Technology) - Cecilia.Haskins@ntnu.no

Cecilia Haskins entered academia after more than thirty years as a practicing systems engineer. Her career spans large and small firms, commercial and government projects, as employee and entrepreneur. During the mid-1990's she was actively part of the tool creation community working on early generations of model-based systems engineering products. Her educational background includes a BSc in Chemistry from Chestnut Hill College, and an MBA from Wharton, University of Pennsylvania. This combination has contributed to her ability to understand issues with an insider's view of both the business environments and the technical solution domains. She has been recognized as a Certified Systems Engineering Professional since 2004. After earning her PhD in systems engineering from NTNU she developed and teaches an overview course with a novel lab. Her research interests include engineering educations, and innovative applications of systems engineering to socio-technical problems such as those encountered in software intensive systems, sustainable development, and global production systems.

Position Paper

…Not yet!

Automation solutions are nearly ubiquitous in production facilities around the world. Progress in the sophistication found in robots and other forms of mechanistic manipulations and object recognition continues to be a mainstay of research. Automation brings with it the paradox of removing the probability of errors introduced by human operations at the same time it increases the vulnerability of systems produced by automation at the point of human intervention. Residual errors that the machines cannot detect are nearly impossible for human operators to diagnose.

With the pre-announcement of the 4th revolution of industrial engineering and manufacturing, both industry and academia are struggling to achieve a definition of the so-called Industry 4.0. The range of buzzwords includes 'internet-of-things,' zero-defect production, additive manufacturing, and digital twinning. Any one of these topics is worthy of a domain of its own, and unraveling the interactions is daunting, to say the least.

The field of manufacturing systems engineering has received paltry attention in literature and research agendas. But, it is undoubtedly time that industrial engineering courses consider the potential contributions that the systems engineering discipline can offer and identifies processes to address the new challenges that face organizations in terms of adoption, transition, investment, security, and training.

For example, the SE Vision 2025 illustrates application domains by showing various industries, such as Automotive or Energy. The following pages are highly product-focused, with relatively little offered about the production process. When my students go out to support our industrial manufacturing partners, more often than not they meet small and medium sized firms who are trying to expand or become more efficient. We are able to apply various SE analysis techniques to help them understand their current situation, but SE does not yet cover the next steps. Questions such as – where should they invest to achieve the best benefit, how should they plan their transition from current to future states, and as they increase their dependency on IT and the internet, how much risk are they absorbing in the process – remain unanswered. Many of these questions are interconnected not only to technical decisions but also to human issues as well. The vision suggests that spanning the entire lifecycle will include manufacturing, but this will need to become a focused area of research if that vision is to be realized. The complexities of Industry 4.0 will not make this an easier task.

Dean Bartles (University of New Hampshire) - dean.bartles@unh.edu

Dean L. Bartles, Ph. D., FSME, FASME, is the Director of the John Olson Advanced Manufacturing Center at the University of New Hampshire. Dean was formerly the founding Executive Director of the Advanced Robotics for Manufacturing Institute at Carnegie Melon, the Chief Manufacturing Officer for UI LABS, the Founding Executive Director of the Digital Manufacturing and Design Innovation Institute and the founding Chairman of the Smart Manufacturing Leadership Coalition. Dean is the current "Past President" of the Society of Manufacturing Engineers as well as the current "Past President" of the North American Manufacturing Research Institute. 2017 Program Chair – ASME Industry Advisory Board. Member - Board of Governors - Manufacturing Leadership Council. Adjunct Professor - Mechanical Engineering and Science – University of Illinois – Urbana Champaign

Position Paper

Bring in the Cloud!

Today's high precision CNC machines are the backbone of discreet manufacturing plants worldwide. Many machines in the Industrial Base today would be characterized as "legacy" machines and range in age from five years to thirty plus years and they lack today's sensor technology needed for the adoption of Industry 4.0 methodologies. Although the newer machines on the market have the requisite sensor technology to support the Industry 4.0 movement, they are still controlled by "local" controllers embedded directly on the machine tool. For Industry 4.0 to have a chance of reaching its full potential, all of the machines siting on all the shop floors in all the plants everywhere, both legacy machines as well as more modern ones, need to communicate with each other and be controlled in the cloud. A "system of systems" engineering approach needs to be undertaken to properly address this challenge.

A robust supply chain of the future OEM will have to have complete transparency. Every subcomponent being manufactured at every supplier in the supply chain and in every company plant everywhere will need to communicate to the overarching Enterprise Manufacturing System ("EMS") and inform every other machine regarding its status, it availability, its capability, the status of each component as it is produced, the exact digital twin information of each component as it is finished on one machine and transfers to the next so that the next machine knows exactly what it will be receiving. When new 3-D models are received for quotation, the EMS will automatically know the most efficient sequence of operations needed utilizing the most efficient mix of available and capable machines in the supply chain. As parts are released by the EMS for manufacture, real time data is transmitted back to the EMS and cloud-based adaptive control technology will facilitate real time, on the fly, changes as required to the sequence of operations, utilization of available and capable machines, and even the program a given machine is running. All of this will depend on cloud technology which today is insufficient to accomplish the above described tasks. New technology areas such as Time Sensitive Network technologies will help to facilitate this required evolution. All of these future domain ideas need to be carefully planned out in concert with the developments ongoing of the technologies themselves. Only a bottom up "system of systems" engineering approach will afford a reasonable path of success identifying all potential risks and their complementary mitigation strategies.

Alice Squires (Washington State University) - alice.squires@wsu.edu

Dr. Alice Squires has served in technical and leadership roles for about 35 years. After nearly 25 years in industry, Alice is serving engineering education as a Clinical Associate Professor in the Engineering and Technology Management department of Washington State University. She earned her BSEE from University of Maryland, College Park, Maryland; her MBA from George Mason University, Fairfax, Virginia; and her doctorate in Systems Engineering from Stevens Institute of Technology, Hoboken, New Jersey. She has been serving academia in part since 2001. In industry, Alice served IBM as an Advisory Engineer/Scientist, Lockheed Martin and General Dynamics as a Senior Engineering/Scientist Manager and Aurora Flight Sciences as Systems Engineering Manager. She has also served as a consultant Senior Systems Engineer to small and large commercial and defense organizations. Alice currently serves as American Society for Engineering Education (ASEE) ~~Director for both the Systems Engineering Division (SED) and Corporate Member Council (CMC). She is Founder and Chair~~ of the INCOSE Empowering Women as Leaders in Systems Engineering (EWLSE) committee and serves as INCOSE Academic Matters Assistant Director for Sector I, the Americas. She is a Senior IEEE Member, a PMI certified Project Management Professional (PMP), an ASEM certified Professional Engineering Manager (PEM), and an INCOSE Expert Systems Engineering Practitioner (ESEP) with Acquisition (-ACQ). Alice was a key contributing member of two recent team awards: the 2016 Women in Engineering Pro-Active Network Strategic Partner Award awarded to the ASEE Diversity Committee, and the 2012 Product of the Year Award by the International Council on Systems Engineering (INCOSE) for Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE) Publications.

Position Paper

Breaking Bounds through Systems Science

Industry 4.0 provides one example of the acceleration of change in systems that we've experience in just the last 50 years. To truly prepare for the Industry 4.0, the systems engineering community needs to fully embrace and proactively support the perspectives that 1) we need an agile definition of systems engineering that seamlessly evolves as new types of systems emerge, 2) that the understanding and use of systems engineering principles, concepts, and practices cannot be the sole purview of systems engineering experts for the systems of the future to thrive, 3) that, therefore, the ownership, terminology, process, methods, and tools of systems engineering need to be shared and collaboratively developed to expand well beyond its current bounds, and 4) that systems science provides the backbone that allows the first three perspectives to thrive. SE Vision 2025 provides a basic foundation upon which to build and suggests a step toward preparing the engineering community for a future that in part is already here. For my panel presentation I will expand on the four perspective areas and compare and contrast with SE Vision concepts, using examples from cyber-physical systems, Internet of things, and cognitive computing.

Panels#13

Overcoming MBSE adoption challenges

Aurelijus Morkevicius (No Magic Inc.) - aurelijus.morkevicius@nomagic.com
Michael J. Vinarcik (Booz Allen Hamilton) - vinarcik_michael@bah.com
Mohammad Chami (Bombardier Transportation GmbH) - mc@chamiconsulting.com
George E. Walley (Ford Motor Company) - gwalley2@ford.com

Presented on: Monday, 15:30-16:55

Keywords. Systems Engineering; MBSE; MBSE adoption challenges; MBSE benefits

Abstract. International Council on Systems Engineering (INCOSE) introduce Model-Based Systems Engineering (MBSE) as the modern approach to Systems Engineering (SE) as well as envision that MBSE becomes a common practice and a synonym of SE by 2020. However, a lot of organizations, though understanding potential benefits of MBSE, struggle in changing their engineering practices and establishing a strong modelling culture. For getting started they need a transparent vision, which would answer their questions like 'how long does it take to adopt MBSE?', 'what are the main phases of this process?', 'how long does each phase take?', 'what are the main deliverables and showstoppers of each phase?', 'what parties and how many people are involved in the process?', 'which party should take the leading role?', 'is MBSE adoption worth the investment at all?'. These and many more questions will be challenged in this panel discussion with managers, team leaders, systems engineers, and more experts in the audience on the campaign to find the silver bullet and fight common MBSE adoption challenges.

Biography

Aurelijus Morkevicius (No Magic Inc.) - aurelijus.morkevicius@nomagic.com
Aurelijus Morkevicius is OMG® Certified UML, Systems Modeling and BPM professional. Currently he is a Head of Solutions Department at No Magic Europe. He has the expertise of model-based systems and software engineering (mostly based on UML and SysML) and defence architectures (DoDAF, MODAF, NAF, UAF). Aurelijus is working with companies such as General Electric, Bombardier Transportation, Deutsche Bahn, ZF, Ford, SIEMENS, BMW, etc. He is also a chairman and one of the leading architects for the current OMG UAF (previously known as UPDM) standard development group. In addition, Aurelijus is actively involved in educational activities. He received a PhD in Informatics Engineering from the Kaunas University of Technology in 2013. Aurelijus is also a lecturer, author of multiple articles, and a speaker in multiple conferences.

Position Paper

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Michael J. Vinarcik (Booz Allen Hamilton) - vinarcik_michael@bah.com
Michael J. Vinarcik is a Senior Lead Systems Engineer at Booz Allen Hamilton and an adjunct professor at the University of Detroit Mercy. He has over twenty years of automotive and defense engineering experience. He received a BS (Metallurgical Engineering) from the Ohio State University, an MBA from the University of Michigan, and an MS (Product Development) from the University of Detroit Mercy. Michael has presented at NDIA Ground Vehicle Systems Engineering and Technology Symposia, INCOSE and ASEE regional conferences. He contributed chapters to Industrial Applications of X-ray Diffraction, Taguchi's Quality Engineering Handbook, and Case Studies in SoS, Enterprise Systems, and Complex Systems Engineering; he also contributed a case study to the SEBoK. Michael is a licensed Professional Engineer (Michigan) and holds INCOSE ESEP-Acq, OCSMP: Model Builder – Advanced, Booz Allen Hamilton Systems Engineering Expert Belt, ASQ Certified Quality Engineer, and ASQ Certified Reliability Engineer certifications. He is a Fellow of the Engineering Society of Detroit, chaired the 2010-2011 INCOSE Great Lakes Regional Conferences, and was the 2012 President of the INCOSE Michigan Chapter. He currently co-leads INCOSE's Model Based Conceptual Design Working Group and is the President and Founder of Sigma Theta Mu, the systems honor society.

Position Paper

The current shift in systems engineering towards a model-based discipline is accelerating (with demand for competent far outstripping supply); however, executing a successful transformation usually requires changes in process, technology, and culture. Many organizations focus on technology since it is the easiest to implement (at least on paper); culture is the hardest (and is often overlooked).

To successfully adopt MBSE, the following challenges must be addressed:

• Transformation fatigue/flavor-of-the-month syndrome: Many organizations have undergone so many transformations, with the pendulum swinging to-and-fro, that experienced staff may believe that they can just "wait out" changes and things will return to a comfortable status quo. Management champions must help with the adoption process by assisting with the needed cultural transformations.

• Expectations vs. reality: Just as ADM Rickover wrote in his "paper reactors" letter, theoreticians underestimate the issues with actual execution; it is important to foster a pragmatic, realistic approach and ensure stakeholders understand the short-term increased costs of the transformation will lead to gains in rigor and productivity later.

• Method development: MBSE successes come from trained staff properly applying good modeling techniques to each project's/organization's system of interest. An anti-process, pro-method mindset needs to be cultivated that is focused on outcomes, not just "checking the box."

• Talent shortages: At this point in the adoption of MBSE, every organization suffers from a lack of skilled modelers. A robust training program to identify, train, develop, and reward competent practitioners is necessary to ensure talent is available to support the expanded demand within each organization.

• Sharing with the modeling community: Many organizations are paranoid about sharing their modeling techniques in the belief that they are a competitive advantage. While some aspects undoubtedly are sensitive, active participation in the growing MBSE community is important to allow everyone to learn from fundamentals and best practices while preserving the internal practices specific to their system.

• Document-centric and diagram-centric mindsets: MBSE "zombies" exist who think they are practicing MBSE but are not; instead, they shamble about in the semblance of life but are either non-productive or destructive. Rooting out obsolete thinking (such as "let's just make the same documents faster by using a modeling tool") is one of the greatest challenges in any MBSE adoption effort.

• Tool limitations: There are still limitations to the modeling languages and tools available; modelers need to understand where those limits are so that the organization obtains all of the value currently available while understanding the limits of the approach (at least until the next tool or language update).

• Federation of tools: Federating tools, especially in high-security environments, leads to information technology challenges, in policy as well as software capability. Cultivating a supportive mindset in the IT community while engaging stakeholders and tool vendors is critical to success.

As the body of practitioners grows and successful approaches to resolving these challenges become public, the transformation to MBSE will accelerate.

Mohammad Chami (Bombardier Transportation GmbH) - mc@chamiconsulting.com
Mohammad Chami is a model based systems engineering expert with a solid academic and industrial experience in modeling languages, processes, developing and deploying methods for systems modeling and customizing its tools. Currently, Mohammad is employed as a Modeling Expert at Bombardier Transportation, with a primary focus on the development and deployment of MBSE on operational projects across all BT divisions, leading the MBSE key users' Network and frequently giving MBSE trainings. Mohammad holds two master's degrees in Electronics and Mechatronics, the OMG Certified Systems Modeling Professional Certificate (OCSMP), has the Bombardier Recognition of appointment as "Engineering Management, Processes, Methods and Tools" Expert, is a member of INCOSE and actively participating in its chapters GfSE, SWISSED and other activities (e.g. OMG, NOSE, AFIS, MODELS), author or co-author of numerous publications and gave various presentations and talks at international conferences.

Position Paper

Overcoming MBSE adoption challenges is every organization's dream to achieve effective MBSE implementation. Sadly, MBSE investment cost is still very high and there is a need to reduce its cost and accelerate its adoption. Although MBSE remains to be the focal point of any systems engineering activities, its adoption still faces signi?cant hurdles to demonstrate its return on investment. Unfortunately, we keep on hearing about "pimped-up" MBSE success stories and it is much less common to hear about failure stories.

According to my observations and nearly ten years ago, the most common question asked during MBSE community events

was “why should I model?”. Though, this question remains to be asked by those who have not adopted MBSE yet. During the last ?ve years, with the growing MBSE industrial adoption, more intention moved towards the question “how should I model?” to establish great models. Those who have been developing models are now asking “how should I use and manage models ef?ciently?” to achieve reusable models with longer life cycle. The answers of these questions are mainly provided from tool vendors or consulting companies based on technical MBSE solutions. The non-technical parts are often forgotten and if not they are kept in experienced MBSE experts’ minds.
On a wider scope, one can clearly notice that MBSE adoption challenges are based on common factors: human, ?nancial, organizational and technological. Hereby, it is often the case that it is not MBSE itself but the way it is adopted. Therefore, there is a need first to establish a clear pattern of MBSE adoption challenges among the MBSE community as a precondition in order to explore the solution space for dealing with them.

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Position Paper

If low scale/local adoption is the goal, lead user enthusiasm and some small success stories may be sufficient. However for sustainable, successful, enterprise-level, model-based transformation a full-court press is needed, starting with decision authority. At the working level: consistent navigational views, task-oriented UIs to aid ingress users and/or easy the modelling workload for complex or error-prone tasks, and clear modelling guidelines that are directly reinforced by tested and representative exemplar model(s) that reflect the guidelines is critical. These exemplar models - a single one if feasible or several domain-specific models depending on the size of the company – should exhibit clear navigation to then also serve as a basis for tool/script/report/profile/process change testing. This will mechanize and make more robust proposed changes to the modelling ecosystem, which helps companies rollout change faster and breeds confidence in the user and middle-management ranks. To play the long-game, it takes support from higher levels within the company to dedicate a team – an initially bigger team for a couple year effort, followed by a potentially reduced core crew – to establish the above & support the growing user base through the initial steps of adoption & learning into consistent value creation.

Panels#13

Overcoming MBSE adoption challenges

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Presented on: Thursday, 00:00-00:00

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George Walley is a Systems Engineering Technical Expect within the Autonomous Vehicle Systems & Controls Engineering research arm at Ford Motor Company, where he has worked for 14 years. His and his team’s current product work is in the area of SAE Level 2-4 Autonomous Vehicle System development, previously working on control systems for next-generation electrified vehicle powertrain systems, including delivery of Ford’s first Start-Stop equipped cars in the US. A software & embedded systems developer at-heart, his other work experience includes work in developing and testing quality history/quarantine tracking systems and building authentication/authorization layers for applications. In parallel to product work, George also helps to define, extend, and champion deployment of MBSE processes, methods, and tools at-large within Ford as part of Ford’s digital transformation paradigm shift within product development. He has given invited industry lectures to professional groups and SE programs at MIT and other schools and holds a BS in Computer Engineering from Northwestern University and MS in Product Development & Engineering Management from University of Detroit Mercy. He serves in various volunteer & leadership capacities within the Michigan INCOSE chapter and INCOSE working groups.

Position Paper

If low scale/local adoption is the goal, lead user enthusiasm and some small success stories may be sufficient. However for sustainable, successful, enterprise-level, model-based transformation a full-court press is needed, starting with decision authority. At the working level: consistent navigational views, task-oriented UIs to aid ingress users and/or easy the modelling workload for complex or error-prone tasks, and clear modelling guidelines that are directly reinforced by tested and representative exemplar model(s) that reflect the guidelines is critical. These exemplar models - a single one if feasible or several domain-specific models depending on the size of the company – should exhibit clear navigation to then also serve as a basis for tool/script/report/profile/process change testing. This will mechanize and make more robust proposed changes to the modelling ecosystem, which helps companies rollout change faster and breeds confidence in the user and middle-management ranks. To play the long-game, it takes support from higher levels within the company to dedicate a team – an initially bigger team for a couple year effort, followed by a potentially reduced core crew – to establish the above & support the growing user base through the initial steps of adoption & learning into consistent value creation.

Overcoming MBSE adoption challenges

Aurelijus Morkevicius (No Magic Inc.) - aurelijus.morkevicius@nomagic.com
Michael J. Vinarcik (Booz Allen Hamilton) - vinarcik_michael@bah.com
Mohammad Chami (Bombardier Transportation GmbH) - mc@chamiconsulting.com
George E. Walley (Ford Motor Company) - gwalley2@ford.com

Presented on: Thursday, 00:00-00:00

Keywords. Systems Engineering; MBSE; MBSE adoption challenges; MBSE benefits

Abstract. International Council on Systems Engineering (INCOSE) introduce Model-Based Systems Engineering (MBSE) as the modern approach to Systems Engineering (SE) as well as envision that MBSE becomes a common practice and a synonym of SE by 2020. However, a lot of organizations, though understanding potential benefits of MBSE, struggle in changing their engineering practices and establishing a strong modelling culture. For getting started they need a transparent vision, which would answer their questions like 'how long does it take to adopt MBSE?', 'what are the main phases of this process?', 'how long does each phase take?', 'what are the main deliverables and showstoppers of each phase?', 'what parties and how many people are involved in the process?', 'which party should take the leading role?', 'is MBSE adoption worth the investment at all?'. These and many more questions will be challenged in this panel discussion with managers, team leaders, systems engineers, and more experts in the audience on the campaign to find the silver bullet and fight common MBSE adoption challenges.

Biography

Aurelijus Morkevicius (No Magic Inc.) - aurelijus.morkevicius@nomagic.com
Aurelijus Morkevicius is OMG® Certified UML, Systems Modeling and BPM professional. Currently he is a Head of Solutions Department at No Magic Europe. He has the expertise of model-based systems and software engineering (mostly based on UML and SysML) and defence architectures (DoDAF, MODAF, NAF, UAF). Aurelijus is working with companies such as General Electric, Bombardier Transportation, Deutsche Bahn, ZF, Ford, SIEMENS, BMW, etc. He is also a chairman and one of the leading architects for the current OMG UAF (previously known as UPDM) standard development group. In addition, Aurelijus is actively involved in educational activities. He received a PhD in Informatics Engineering from the Kaunas University of Technology in 2013. Aurelijus is also a lecturer, author of multiple articles, and a speaker in multiple conferences.

Position Paper

International Council on Systems Engineering (INCOSE) introduce Model-Based Systems Engineering (MBSE) as the modern approach to Systems Engineering (SE) as well as envision that MBSE becomes a common practice and a synonym of SE by 2020. However, a lot of organizations, though understanding potential benefits of MBSE, struggle in changing their engineering practices and establishing a strong modelling culture. For getting started they need a transparent vision, which would answer their questions like “how long does it take to adopt MBSE?”, “what are the main phases of this process?”, “how long does each phase take?”, “what are the main deliverables and showstoppers of each phase?”, “what parties and how many people are involved in the process?”, “which party should take the leading role?”, “is MBSE adoption worth the investment at all?”. These and many more questions needs to be answered after an organization makes the decision to adopt model-based systems engineering (MBSE). It is a long way before this decision proves right. There are many obstacles in this way, like stories about unsuccessful MBSE applications, insufficient information on how to proceed, and employee resistance to the cultural change to name a few. Neither of them is a true issue, if suitable enablers for MBSE adoption are chosen. For example, nowadays, MBSE is enabled by Systems Modeling Language (SysML). However, SysML is neither a framework nor a method: it provides no information about the modeling process and thus must be combined with some methodology to become truly applicable. MBSE method and language are two of four important factors in MBSE adoption process. Other two are tools and personnel. All four needs to be integrated plus they have to be integrated with SE process and other engineering disciplines, like mechanical engineering, electrical engineering, electronics, software engineering, etc. to make MBSE adoption process a success.

Michael J. Vinarcik (Booz Allen Hamilton) - vinarcik_michael@bah.com
Michael J. Vinarcik is a Senior Lead Systems Engineer at Booz Allen Hamilton and an adjunct professor at the University of Detroit Mercy. He has over twenty years of automotive and defense engineering experience. He received a BS (Metallurgical Engineering) from the Ohio State University, an MBA from the University of Michigan, and an MS (Product Development) from the University of Detroit Mercy. Michael has presented at NDIA Ground Vehicle Systems Engineering and Technology Symposia, INCOSE and ASEE regional conferences. He contributed chapters to Industrial Applications of X-ray Diffraction, Taguchi's Quality Engineering Handbook, and Case Studies in SoS, Enterprise Systems, and Complex Systems Engineering; he also contributed a case study to the SEBoK. Michael is a licensed Professional Engineer (Michigan) and holds INCOSE ESEP-Acq, OCSMP: Model Builder – Advanced, Booz Allen Hamilton Systems Engineering Expert Belt, ASQ Certified Quality Engineer, and ASQ Certified Reliability Engineer certifications. He is a Fellow of the Engineering Society of Detroit, chaired the 2010-2011 INCOSE Great Lakes Regional Conferences, and was the 2012 President of the INCOSE Michigan Chapter. He currently co-leads INCOSE's Model Based Conceptual Design Working Group and is the President and Founder of Sigma Theta Mu, the systems honor society.

Position Paper

The current shift in systems engineering towards a model-based discipline is accelerating (with demand for competent far outstripping supply); however, executing a successful transformation usually requires changes in process, technology, and culture. Many organizations focus on technology since it is the easiest to implement (at least on paper); culture is the hardest (and is often overlooked).

To successfully adopt MBSE, the following challenges must be addressed:

• Transformation fatigue/flavor-of-the-month syndrome: Many organizations have undergone so many transformations, with the pendulum swinging to-and-fro, that experienced staff may believe that they can just "wait out" changes and things will return to a comfortable status quo. Management champions must help with the adoption process by assisting with the needed cultural transformations.

• Expectations vs. reality: Just as ADM Rickover wrote in his "paper reactors" letter, theoreticians underestimate the issues with actual execution; it is important to foster a pragmatic, realistic approach and ensure stakeholders understand the short-term increased costs of the transformation will lead to gains in rigor and productivity later.

• Method development: MBSE successes come from trained staff properly applying good modeling techniques to each project's/organization's system of interest. An anti-process, pro-method mindset needs to be cultivated that is focused on outcomes, not just "checking the box."

• Talent shortages: At this point in the adoption of MBSE, every organization suffers from a lack of skilled modelers. A robust training program to identify, train, develop, and reward competent practitioners is necessary to ensure talent is available to support the expanded demand within each organization.

• Sharing with the modeling community: Many organizations are paranoid about sharing their modeling techniques in the belief that they are a competitive advantage. While some aspects undoubtedly are sensitive, active participation in the growing MBSE community is important to allow everyone to learn from fundamentals and best practices while preserving the internal practices specific to their system.

• Document-centric and diagram-centric mindsets: MBSE "zombies" exist who think they are practicing MBSE but are not; instead, they shamble about in the semblance of life but are either non-productive or destructive. Rooting out obsolete thinking (such as "let's just make the same documents faster by using a modeling tool") is one of the greatest challenges in any MBSE adoption effort.

• Tool limitations: There are still limitations to the modeling languages and tools available; modelers need to understand where those limits are so that the organization obtains all of the value currently available while understanding the limits of the approach (at least until the next tool or language update).

• Federation of tools: Federating tools, especially in high-security environments, leads to information technology challenges, in policy as well as software capability. Cultivating a supportive mindset in the IT community while engaging stakeholders and tool vendors is critical to success.

As the body of practitioners grows and successful approaches to resolving these challenges become public, the transformation to MBSE will accelerate.

Mohammad Chami (Bombardier Transportation GmbH) - mc@chamiconsulting.com
Mohammad Chami is a model based systems engineering expert with a solid academic and industrial experience in modeling languages, processes, developing and deploying methods for systems modeling and customizing its tools. Currently, Mohammad is employed as a Modeling Expert at Bombardier Transportation, with a primary focus on the development and deployment of MBSE on operational projects across all BT divisions, leading the MBSE key users' Network and frequently giving MBSE trainings. Mohammad holds two master's degrees in Electronics and Mechatronics, the OMG Certified Systems Modeling Professional Certificate (OCSMP), has the Bombardier Recognition of appointment as "Engineering Management, Processes, Methods and Tools" Expert, is a member of INCOSE and actively participating in its chapters GfSE, SWISSED and other activities (e.g. OMG, NOSE, AFIS, MODELS), author or co-author of numerous publications and gave various presentations and talks at international conferences.

Position Paper

Overcoming MBSE adoption challenges is every organization's dream to achieve effective MBSE implementation. Sadly, MBSE investment cost is still very high and there is a need to reduce its cost and accelerate its adoption. Although MBSE remains to be the focal point of any systems engineering activities, its adoption still faces signi?cant hurdles to demonstrate its return on investment. Unfortunately, we keep on hearing about "pimped-up" MBSE success stories and it is much less common to hear about failure stories.

According to my observations and nearly ten years ago, the most common question asked during MBSE community events

was “why should I model?”. Though, this question remains to be asked by those who have not adopted MBSE yet. During the last ?ve years, with the growing MBSE industrial adoption, more intention moved towards the question “how should I model?” to establish great models. Those who have been developing models are now asking “how should I use and manage models ef?ciently?” to achieve reusable models with longer life cycle. The answers of these questions are mainly provided from tool vendors or consulting companies based on technical MBSE solutions. The non-technical parts are often forgotten and if not they are kept in experienced MBSE experts’ minds.
On a wider scope, one can clearly notice that MBSE adoption challenges are based on common factors: human, ?nancial, organizational and technological. Hereby, it is often the case that it is not MBSE itself but the way it is adopted. Therefore, there is a need first to establish a clear pattern of MBSE adoption challenges among the MBSE community as a precondition in order to explore the solution space for dealing with them.

George E. Walley (Ford Motor Company) - gwalley2@ford.com
George Walley is a Systems Engineering Technical Expect within the Autonomous Vehicle Systems & Controls Engineering research arm at Ford Motor Company, where he has worked for 14 years. His and his team’s current product work is in the area of SAE Level 2-4 Autonomous Vehicle System development, previously working on control systems for next-generation electrified vehicle powertrain systems, including delivery of Ford’s first Start-Stop equipped cars in the US. A software & embedded systems developer at-heart, his other work experience includes work in developing and testing quality history/quarantine tracking systems and building authentication/authorization layers for applications. In parallel to product work, George also helps to define, extend, and champion deployment of MBSE processes, methods, and tools at-large within Ford as part of Ford’s digital transformation paradigm shift within product development. He has given invited industry lectures to professional groups and SE programs at MIT and other schools and holds a BS in Computer Engineering from Northwestern University and MS in Product Development & Engineering Management from University of Detroit Mercy. He serves in various volunteer & leadership capacities within the Michigan INCOSE chapter and INCOSE working groups.

Position Paper

If low scale/local adoption is the goal, lead user enthusiasm and some small success stories may be sufficient. However for sustainable, successful, enterprise-level, model-based transformation a full-court press is needed, starting with decision authority. At the working level: consistent navigational views, task-oriented UIs to aid ingress users and/or easy the modelling workload for complex or error-prone tasks, and clear modelling guidelines that are directly reinforced by tested and representative exemplar model(s) that reflect the guidelines is critical. These exemplar models - a single one if feasible or several domain-specific models depending on the size of the company – should exhibit clear navigation to then also serve as a basis for tool/script/report/profile/process change testing. This will mechanize and make more robust proposed changes to the modelling ecosystem, which helps companies rollout change faster and breeds confidence in the user and middle-management ranks. To play the long-game, it takes support from higher levels within the company to dedicate a team – an initially bigger team for a couple year effort, followed by a potentially reduced core crew – to establish the above & support the growing user base through the initial steps of adoption & learning into consistent value creation.

Panels#14

Revolutionizing the Ways that Architecture Can Impact System Success

Jean-Luc Garnier (Thales) - jean-luc.garnier@thalesgroup.com
James Martin (Aerospace Corporation) - martinqzx@gmail.com
Anand Kumar (TCS Research) - anand.ar@tcs.com
Gerrit Muller (University College of South East Norway) - gerrit.muller@gmail.com
Michael Wilkinson (Atkins) - mike.wilkinson@atkinsglobal.com
Richard Martin (Tinwisle Corp) - richardm@tinwisle.com

Presented on: Monday, 13:30-14:55

Keywords. Architecture; Architecting; Architecture life cycle

Abstract. The ISO/IEC/IEEE 15288 standard on system life cycle processes says that 'The results of the Architecture Definition process are widely used across the life cycle processes (of a 'system').'
This statement means that Architecture should begin prior to, or at least concurrently with, the early stages of the system life cycle, and should be maintained throughout subsequent stages. But we need to ask: Is our current architecture practice ready for this challenge?
The panel will address the notion of Architecture Life Cycle and the scheduling of the Architecting Activities with regards to the system Life Cycle and related activities.
In particular, this panel will discuss regarding questions such as:
1. Is it possible to involve external (customer, user, external authorities) and internal (provider team, internal authorities) in a collaborative architecting activities?
2. How to consider contracting with regards to architecting, and related data?
3. How to consider architecting with regards to requirements definition and Design Definition?

Biography

Jean-Luc Garnier (Thales) - jean-luc.garnier@thalesgroup.com
Jean-Luc Garnier is Systems Engineering and Architecting Director within the Thales Technical Directorate. His is Project Manager of the NATO Architecture Framework Methodology, Convener of the Architecture Expert Group of the European Defence Agency, Chairman of the AFNOR Architecture Working Group and Project Editor of the ISO/IEC-42020 standard on Architecture processes.

Position Paper

“Architecture” is currently a term used to cover different artifacts during several phases/stages of a System/Product life cycle. It could be thought during the early phases as information for orientation of the activities and as vision on the “solution”, as output of the design activities, as expression for reverse abstraction of existing solution, etc. A huge variation of data/models also exists in the architecture description, depending on the covered concerns and perspectives. In any case, the added value of Architectures and models is to ability to analyze the problem spaces, identify potential solutions and select the best ones with involvement of the stakeholders.

James Martin (Aerospace Corporation) - martinqzx@gmail.com
James Martin has led several INCOSE panels and been a panellist for a number of other panels. He has been an INCOSE member for 25 years. Chair of Systems Science Working Group. INCOSE representative to ISO standards activity for architecture. PhD in Enterprise Architecture from George Mason University with Prof Andy Sage as thesis advisor. INCOSE Fellow and INCOSE Founders Award winner.

Position Paper

Architecture can be thought of as the “game plan”, but also as the strategic way ahead. It is a powerful tool that can be used by decision makers, at both the strategic and tactical levels, to help them understand future possibilities and potential impacts of their decisions on many diverse stakeholders. However, this is what architecture can do only if we improve the tools and methods, and the ways and means, by which we develop and utilize architecture.

Anand Kumar (TCS Research) - anand.ar@tcs.com
Dr Anand Kumar is a Principal Scientist with TCS Research developing solutions for business systems, automation systems, instrumentation systems and architecture environments. Dr Anand Kumar researches in the areas of Business Systems, Service Systems, Architecture and Digital Product-Service Systems. He is the India representative to ISO architecture standards working groups and co-editor of ISO/IEC/IEEE 42020 - architecture processes standard and ISO/IEC/IEEE - architecture evaluation standard. He is the co-chair for INCOSE Architecture working group and ISSS digital product-service systems working group.

Position Paper

The role of an architect goes beyond the architecture processes of synthesis, analysis and detailing of the architecture. Architects are responsible for the evolution of the architecture and the architected entity over time.

It is often the case that the life of an architecture goes beyond the life of the architected entity. In such cases, it is prudent that the architecture serves as the basis based on which the activities related to the architected entity is performed. If this is not the case then issues such as feature creep, value destruction, indifferent users and ineffective solutions are faced leading to the failure of the architecture and the architected entity as a whole.

Gerrit Muller (University College of South East Norway) - gerrit.muller@gmail.com
Gerrit Muller, originally from the Netherlands, received his Master's degree in physics from the University of Amsterdam in 1979. He worked from 1980 until 1997 at Philips Medical Systems as system architect, followed by two years at ASML as manager systems engineering, returning to Philips (Research) in 1999. Since 2003, he has worked as senior research fellow at the Embedded Systems Institute in Eindhoven, focusing on developing system architecture methods and the education of new system architects, receiving his doctorate in 2004. In January 2008, he became full professor of systems engineering at University College of South East Norway in Kongsberg, Norway. He continues to work as senior research fellow at the Embedded Systems Innovations by TNO in Eindhoven in a part-time position. All information (System Architecture articles, course material, curriculum vitae) can be found at: Gaudí systems architecting http://www.gaudisite.nl/

Position Paper

Architects are responsible for the architecture and the architecting. However, effective architecting requires an inclusive approach, where the participation of internal and external stakeholders in architecting is stimulated as much as possible. This may sound obvious, but the general management and process approaches with clear governance and responsibilities, easily seduces stakeholders to stay away from architecting. Protective or defensive architects may reinforce such unwanted behavior.

A major challenge is to educate all these stakeholders into the breadth of architecture. A common misunderstanding is that the structure of the system (the parts and their interconnections) is the architecture, lacking its relation to the system context (e.g. customers and life cycle), and lacking interactions (dynamic behavior) and the related quality attributes (e.g. key performance parameters).

An architecture provides a rationale and guidelines for specification and design choices (a.o. requirements).

Major challenge for architects is to help these stakeholders by providing overview and focus, in the complex and dynamic context of systems development and the life cycles of systems and their architecture.

Michael Wilkinson (Atkins) - mike.wilkinson@atkinsglobal.com
Mike Wilkinson is the Technical Director of Niteworks, an innovation/collaboration construct with over 170 organisational members, where he is on secondment from Atkins. He has a first degree in physics and a PhD in theoretical physics from King's College London. He is past president of the UK branch of INCOSE and has also served as its Academic Director. He is a co-chair of INCOSE UK's AWG and chair of the International AWG. He is a visiting professor at the University of Loughborough, where he is associated with the Engineering System of Systems (ESoS) group. Mike moderated a very successful panel session at IS16 and also at the UK Chapter's Annual Conference in 2011 (ASEC11).

Position Paper

System architecting is a relatively new discipline that is difficult to define and explain in simple terms, resulting in poor understanding of how do it and what benefits to expect. This observation applies not just to users, customers and engineers from other disciplines but also to some would-be practitioners! It is therefore critical to have clarity and a common understanding among stakeholders.

A productive way of thinking about architecting is that its primary purpose is to enable informed decision making by understanding a system's 'problem space', its 'solution space' and how they relate. The useful scope of architecture is therefore much broader than TSE and there is much to gain by drawing on architecting practice from outside of TSE. If formulated correctly, architecting can be applied to all kinds of systems in all domains, including enterprises, natural systems and human activity systems.

Going further, architecture can be made the central pillar of systems engineering, delivering a wide range of benefits. These include: better design choices; improved stakeholder engagement; more effective communications; better requirements; re-use through modularity and standardisation; technology refresh; and greater system/environment coherence.

Navigating the complexity of architecting is supported by describing different 'styles' of architecting, suited to different situations. The different styles provide an excellent 'shorthand' for architects and others to agree on the nature of the architecting required.

It is also useful to explore what architecting is not, and thereby avoid common pitfalls. Architecting is: not just concerned with static functional and physical structure but addresses 'structure' of all kinds; not the same as modelling although it makes use of models and directs modelling; not additional or optional but an essential and integrated part of SE.

Richard Martin (Tinwisle Corp) - richardm@tinwisle.com

Richard Martin is convener of the ISO TC184 SC5 WG1, developing standards for enterprise-reference architectures and methodologies in the domain of industrial automation systems and member of ISO-IEC JWG21 Smart Manufacturing reference model. He is also strongly involved in the Federation of Enterprise Architecture Professional Organizations (FEAPO) and in urban planning for his community, now serving on its Redevelopment Commission.

Position Paper

As an aspect of design, architecture enables better design decisions resulting from a comprehensive examination of needs, wants, and consequences occurring before commitment to implementation specifics. The distinction between architecture and other design aspects is the elegance, efficiency, and effectiveness of its conceptualization beyond simple attention to form and function. A well-conceived and maintained architecture supports continuous improvement by supplying accurate information about the current structure and expected behaviour of essential architectural elements. Architecting the enterprise performing the system architecture effort is essential for achieving elegance, efficiency, and effectiveness for the system.

Systems of Systems Engineering - An Approach to Agile Systems Engineering?

Judith S. Dahmann (The MITRE Corporation) - jdahmann@mitre.org
Rick Dove (Paradigm Shift International) - rkdove@earthlink.net
Stephen C. Cook (Shoal Engineering) - Stephen.cook@shoalgroup.com
Alan Harding (BAE Systems) - Alan.d.harding@baesystems.com
Matthew Wylie (Shoal Engineering) - Matthew.wylie@shoalgroup.com
William C. Schindel (ICTT System Sciences) - schindel@ictt.com
Duncan Kemp (UK Ministry of Defence) - duncan@17media.co.uk

Presented on: Wednesday, 10:00-12:10

Keywords. System of systems; systems of system; agile; agile systems engineering

Abstract. Traditionally we have focused on agility in the way we develop systems - both in the way we design systems to allow for adaptation and change as well as in the systems engineering processes we employ to both develop and adapt systems. Increasingly, however, we are recognizing that many user capabilities are supported by systems of systems and the idea is growing that another perspective on agility may be through flexible and adaptable composition of systems to more flexibly and responsively provide user capabilities in a dynamic environment.
This panel explores this idea by addressing a set of questions from various perspectives:
• What does it mean to be agile?
• Why SoS engineering as an agile approach?
• What are the opportunities provided by SoS composition for agility in meeting user system needs?
• What are the challenges?

Biography

Judith S. Dahmann (The MITRE Corporation) - jdahmann@mitre.org
Dr. Judith Dahmann is a principal senior scientist in the MITRE Corporation Systems Engineering Technical Center where she is the SoSE Capability Action Team Lead. Center for Advanced Systems Analysis and Acquisition. Dr. Dahmann is the technical lead for SoSE for Office of the Director of Systems Engineering in the US DOD Office of the Under Secretary of Defense for Acquisition, Technology and Logistics where she led the development of the US DoD guide for systems engineering of systems of systems (SoS). She also leads MITRE support to a set of ongoing DARPA SoS technical research programs. and ongoing SoS engineering guidance, oversight and research. Dr. Dahmann is an INCOSE fellow and co-chair of the INCOSE SoS Working Group.
Position Paper
Systems of systems engineering (SoSE) is the process of planning, analyzing, organizing, and integrating the capabilities of a mix of existing and new independent systems into capability that is greater than the sum of the capabilities of the constituent parts. One of the challenges of SoSE is the dynamics of the SoS environment and the need to evolve the SoS to meet changing needs. The SoSE implementers view or 'wave' model, reflects a common approach to SoSE processes. By design this model is inherently agile, where each wave begins with an assessment of change which affect the SoS and tailors actions to address the new situation facing the SoS. The wave model was envisioned as a 'design' time approach, but new research is seeking to adapt this to address a closer to 'runtime' capability, with a focus on architecting SoS and interoperability technologies to support rapid composition of SoS 'on demand'.

Rick Dove (Paradigm Shift International) - rkdove@earthlink.net
Rick Dove was co-PI on the original work which identified Agility as the next competitive differentiator, in a 3-month industry-collaborative workshop funded by the US Office of the Secretary of Defense in 1991 at Lehigh University. He went on to organize and lead the US DARPA-funded industry collaborative research at Lehigh University's Agility Forum,

developing fundamental understandings of what enables and characterizes system's agility. He authored Response Ability – The Language, Structure, and Culture of the Agile Enterprise. He has employed these agile concepts in both system architecture and program management for large enterprise IT systems, for rapid manufacturing systems and services, and for self-organizing security strategies. At Stevens Institute of Technology he teaches graduate courses in basic and advanced agile-systems and agile systems-engineering, at client sites. He is CEO/CTO of Paradigm Shift, an applied research firm specializing in agile systems concepts and education. He is an INCOSE Fellow, and chairs the INCOSE working groups on Agile Systems and Systems engineering, and on System Security Engineering.

Position Paper

My view of agile systems and agile systems engineering has always required an architecture that is inherently a system of systems (SoS) architecture, with SoS constituent relationships. For agile systems engineering processes this isn't clearly evident on small single-team software projects, until you consider how that team interacts with the enterprise/organizational and other development-external systems that surround it. But for agile systems, small or large, software-only or mixed discipline, an SoS architecture is required. In the software-only development project this emerges from object oriented languages and platform tools like eclipse. In the mixed-discipline development project this emerges from Live-Virtual-Constructive infrastructures and open systems architecture approaches, and is now emerging in model/simulation-centric object-oriented development-platform work still in early stages. Agile systems engineering processes, viewed as systems of systems, consist of relatively independent operational resources (e.g., multiple development teams, external stakeholders) which interact with each other to achieve a common collective mission. This SoS perspective reveals a body of knowledge for consideration in guiding the design and operation of systems engineering processes and the systems they develop. The objective in both process and system is flexible and adaptable composition and resilience of capabilities that provide sustainable operation in a dynamic environment.

Stephen C. Cook (Shoal Engineering) - Stephen.cook@shoalgroup.com

Prof Stephen Cook, PhD, has had a varied career that commenced with ten years in the telecommunications and aerospace industries in the UK and Australia, working as a design engineer, systems engineer, and technical manager. He subsequently joined the Defence Science and Technology Organisation rising to Research Leader Military Information Networks in 1994 responsible for the management and scientific leadership of a substantial branch of research staff. In 1997 he was seconded to the University of South Australia as Professor of Systems Engineering and became the founding director of the Defence and Systems Institute where he developed an interest in the theoretical underpinnings of SE. In 2014, Cook left UniSA and established the consulting firm Creative Systems Engineering that provides consulting in SE, enterprise improvement, and SoSE to clients through Shoal Engineering Pty Ltd and other organizations. He also holds the part-time position of Professor of Defence Systems at the University of Adelaide where he teaches postgraduate courses in complex systems and supervises research students. He is an INCOSE Fellow, a Fellow of Engineers Australia, Past President of the Systems Engineering Society of Australia, a Member of the Omega Alpha Association SE honor society, and an active member of several INCOSE working groups.

Position Paper

Shoal Engineering has been working with the Australian Department of Defence on a range of projects to define, design, trial and assure SoSE practices within the department. The underpinning scholarship has examined leading international SoSE practices and uncovered that SoSE is inherently evolutionary and middle-out and shares many of the traits seen as indicative of the need for an agile development approach.

Australian Defence SoSE research has produced a set of principles for designing and executing SoSE activities. These principles will be compared to the Agile precepts to address the degree of converge between contemporary SoSE and agile thinking and practice.

SoSE practices can be divided into several categories, the more directive ones plan and evolve multiple projects in a coherent manner. The more reactive ones such as those that produce ad hoc SoS for say disaster relief are composed in unique ways to meet exigencies with modest pre-planning. This spectrum will be examined to address how the various classes of SoSE can be applied meet user needs in an agile fashion.

Alan Harding (BAE Systems) - Alan.d.harding@baesystems.com

Alan Harding is the head of the information systems engineering discipline for the BAE Systems Military Air and Information business. He is a BAE Systems Global Engineering Fellow, a Fellow of the IET, and a Chartered Engineer. Alan is the 2016-2018 President of the International Council On Systems Engineering (INCOSE), the global professional society for systems engineering. He is a practicing systems engineer with over 30 years of experience in defence and security applications. Specialist interest areas include capability, systems-of-systems, architecture, and competency development.

Position Paper

The global environment is now highly connected, has increasing prevalence of autonomous actors, and its complexity and scale both seem to escalate seemingly without limit.

As systems engineers our customers (the users of capability to achieve their business purposes) need sufficiently agile capabilities that allow them to respond to, and where possible anticipate changes in this changing environment.

These desired capabilities, and the systems of systems that comprise them, often need to be dependable - exhibiting characteristics of availability, security and safety.

Given the changing demands and changing context, clearly there is an emergent need to engineer systems of systems responses that themselves can be intrinsically agile or can be reconfigured into another configuration that meets the changed capability need.

I will discuss examples where we engineer systems of systems with the emergent property of exhibiting the desired capability, in order to explore the proposition of composable systems of systems to meet the changing customer needs.

Matthew Wylie (Shoal Engineering) - Matthew.wylie@shoalgroup.com

Matthew Wylie is a professional engineer with a wide range of systems engineering and project management experience. Matthew has led systems engineering projects and teams in the defence, automotive, and electronics industries; and has experience managing systems engineering projects in all phases of the systems lifecycle. Matthew is the Shoal Capability Design, Defence Team Lead within the Shoal Engineering where he oversees and participates in the SoS and Project capability design tasks. In recent years he has been heavily involved in the design and demonstration of defence model-based SoSE approaches. His background includes work on merging model-based conceptual design practices with agile software engineering approaches.

Position Paper

Utilising agile software development methods for the development of complex, software-reliant systems provides significant advantages in providing a flexible development environment that embraces change and allows for evolving stakeholder needs to be addressed. However, where systems are required to meet defined levels of assurance and performance, a strong underlying architecture is also required. In this case, an agile development approach must be supported by an architecture that provides flexibility, while maintaining the required integrity for an assured system. Matthew address the panel questions from his experience in designing, applying, and merging architecture-based SoSE and agile software development

William C. Schindel (ICTT System Sciences) - schindel@ictt.com

Bill Schindel is president of ICTT System Sciences, where he practices Pattern-Based Systems Engineering for commercial and other organizations. His engineering career began in mil/aero systems with IBM Federal Systems, included faculty service at Rose-Hulman Institute of Technology, and founding of several systems enterprises. He is an INCOSE Fellow, co-leads the INCOSE MBSE Patterns Working Group, and is a member of the lead team of the INCOSE Agile Systems Engineering Life Cycle Discovery Project and the INCOSE MBE Transformation. Bill also serves on the ASME VV50 standards committee concerned with verification, validation, and uncertainty quantification of models for advanced manufacturing systems.

Position Paper

Our work and perspective on agility is concerned with the entire life cycle of systems, in the context of the dynamical environments in which they are planned, designed, constructed or manufactured, marketed and distributed, selected or deselected, operated (including competing or adversarial systems), maintained, updated or evolved, and retired. That context is itself a SoS, including some elements that cooperate and some that compete, and which themselves increasingly display aspects of agility. The related MBSE pattern which we are using to represent this context is concerned in particular with system learning, including how past experience impacts agility and contributes to ability to adapt architecture and behaviour to differing situations. This pattern, descriptive not proscriptive, can be used to analyse degrees of agility (including its lack), and how degree of sharing experience/IP within and across SoS members is related to understanding which composabilities are valued and selected

Duncan Kemp (UK Ministry of Defence) - duncan@17media.co.uk

Duncan Kemp is a chief systems engineer and the DE&S Fellow for Systems Engineering, where he is responsible for developing DE&S Systems Engineering practice and people. Duncan's is currently the team leader of DE&S' internal technical support team, providing a range of systems engineering support to a mixture of conventional and agile projects. Previous roles have included • Engineering skills development TL responsible for development of over 500 professional engineers in MOD. Duncan was key to developing the UK MODs engineering professionalisation strategy and introduced a range of new training for junior engineers. • Chief systems engineer for rail in the UK Department for Transport. He was responsible for initiating a strategic review of UK rail, which identified over £850M p.a. of savings due to the adoption of better systems approaches. • Chief architect for C4 systems in MOD, responsible for the integration of all UK Command, control and computing systems. Duncan is a chartered engineer and Fellow of the Institution of Engineering and Technology. He was one of the authoring team on the SE Vision 2025, lead author on the INCOSE UK Capability SE guide and has presented at a range of national and international engineering conferences.

Position Paper

Duncan will discuss the approaches he has used to design and deliver operational capabilities. He will describe how he has used a range of agile and capability systems engineering approaches using a range of personal examples.

Duncan will discuss the need for:

• A clear compelling purpose, to align key stakeholders, focus on what matters most and drive towards delivery.
• A simple and clear architecture, understood by all, that covers physical, functional, performance and commercial aspects of the System of Systems.
• Effective project and programme management to drive delivery.
• Risk and opportunities management at all levels, including the initiation of apparently duplicate projects to mitigate portfolio risk.
• A culture of high risk tolerance and radical tailoring balanced with the need to 'take as long as it takes' for critical elements of SoS effectiveness such as safety
• Disciplined practitioners, with experience of delivering similar solutions in similar situations

Invited Panels

Future Directions of SE Research

Alan Harding (BAE Systems) - alan.d.harding@baesystems.com
Larry Strawser (Johns Hopkins Univ.) - lstraws1@jhu.edu
Tom Herald (Lockheed Martin) - tom.herald@lmco.com
Tom McDermott (Georgia Tech) - tmcdermo@stevens.edu
Jon Wade (Stevens Institute) - dr.jon.wade@gmail.com

Presented on: Thursday, 10:00-12:10

Keywords.

Abstract. During 2017, INCOSE conducted a series of workshops aimed at identifying and describing Systems Engineering Research needed to help apply SE to address four of the grand challenges per the SE Vision 2025. The project selected Safety and Security, Healthcare, Education, and Clean Water as the top four challenges to address. This panel will explore the path forward for INCOSE, industry, academia, government, and other partners to enable and facilitate the research. This includes how to develop a viable strategy for increasing the "reach" of INCOSE (and SE, in general) across all domains: demonstrating the value of SE in tackling the Global Challenges that humanity faces.

Systems Approaches to Governance and Policy

Mo Monsouri (Stevens Institute of Technology) - mo.mansouri@stevens.edu
Alan Harding (BAE Systems) - alan.d.harding@baesystems.com
Willie Donaldson (Strategic Venture Planning) - svpwilly@gmail.com
Zhang Xinguo (Aviation Industry Corporation of China, Ltd. (AVIC)) - zhangxg@avic.com

Presented on: Monday, 10:00-12:10

Keywords. #Government

Abstract. The ever-changing interactions among a variety of systems, often connected through complex networks, requires for new governing approaches in order to optimize collective gains for all acting systems. Systems approaches and practices are most applicable in such circumstances through designing governance structures and policy development to regulate interactions among systems and assure effectiveness and optimize collective gain for the system. This panel will aim at discussing the phenomenon as well as systemic challenges of transforming existing systems approaches and practices to address such complexity at hand. The purpose of the panel is to examine current research and practices, also explore future directions on methods and tools related to governance for System of Systems and other complex environments through implementation of incentive structures, regulations and policy design and analysis.

Systems Engineering: Taming the Inevitable Controller of Capabilities

Sarah Sheard (Software Engineering Institute (SEI)) - sheard@sei.cmu.edu
Paul Nielsen (Software Engineering Institute (SEI)) - Nielsen@sei.cmu.edu
William LaPlante (MITRE) - billlaplante@mitre.org
Heinz Stoewer (Space Associates) - heinzstoewer@spaceassociates.net
Claire Leon (Loyola Marymount, formerly AF SMC) - claire.leon@lmu.edu

Presented on: Wednesday, 10:00-12:10

Keywords.

Abstract. this panel discussion, leaders of government and industry share insights and strategies in dealing today with the technologies of tomorrow: the vast field of software-enabled and software-controlled capabilities. What is the role of software in shaping and creating these solutions, and what should be the role of systems engineering in constraining, guiding, and limiting the software, all the while using software to perform most systems engineering tasks? How does software enable quantum leaps in capabilities, without risking the entire effort with out-of-control costs and/or cybervulnerabilities? What interactions between software and systems engineers are critical in balancing the risks and rewards?

Question after all panelists have spoken: What is one thing systems engineers need to do now to ensure success in the software-intensive future?

The Impact on Systems Engineering from Future Technology Advances

Bill Miller (Stevens Institute of Technology) - wdmiller220@gmail.com
Paul Nielsen (Software Engineering Institute) - Nielsen@sei.cmu.edu
David Rousseau - david.rousseau@systemsphilosophy.org
Paul Schreinemakers - schreinemakers@me.com
Quoc Do (Nash Consulting)

Presented on: Tuesday, 10:00-12:10

Keywords.

Abstract. This panel will look at the the impact on systems engineering from future technology advances as we continue to see accelerated adoption of new technologies. Many of the recent technology advances are driving systems into a more dynamic, non-deterministic, stochastic and evolutionary environment. This panel will look at the challenges and impacts and the changes needed for systems engineering to be effective.

Roundtables

Roundtables#23

Roundtable: Are We Ready? Reimagining SE for a global, connected and agile world

Virginia Lentz (Retired (IBM & UTC) - vlentz1@nc.rr.com
David Long (Vitech) - dlong@vitechcorp.com
John Thomas (John-a-thomas) - john.thomas@john-a-thomas.com
Ken Ptack (J&K Consulting) - Swoop42@verizon.net
Duncan Kemp (UK MOD) - Duncan.kemp735@mod.gov.uk
Dr. Stephen Cook (Shoal Engineering) - Stephen.cook@shoalgroup.com

Presented on: Tuesday, 15:30-16:55

Keywords. SE management; agile; basic principles; SE development; flexible SE

Abstract. Even before the introduction of the iPhone in 2007, the product development world changed. We were made aware of the fast pace and changing needs with the arrival of the iPhone and the explosion of function via apps etc. INCOSE processes and tools represent the last 50 - 60 plus years of product development. What do we need to do to be relevant in this new environment? We must draw on what we have while returning to basic principles, so we can effectively and efficiently deliver value to our customers and stakeholders. We need to draw on all the INCOSE assets, such as the Body of Knowledge, the Competency Framework, the work of groups such as the Systems of Systems, Very Small Entities (VSE) and Model Based Conceptual Design Working Groups.

SEs need to reestablish their position as the technical connective tissue of the organization. We need to tell the younger SEs that it is ok to tailor and take informed shortcuts, as long as the focus is to build, to evolve, to reach out to new specialties, to better understand humans.

The SERC HELIX report lists important characteristics of effective SEs: Paradoxical Mindset, Effective Communicator, Flexible comfort zone, Smart leadership and self-starter.

This panel will discuss what we have and how to use it, and what we need to develop to support effective SEs as a vital cog in product development of the future. The round table discussions will add to all of our collective knowledge.

System Safety Roundtable: Understanding the State of the Art and State of the Practice in System Safety Engineering

Duncan Kemp (Ministry of Defence) - Duncan.Kemp735@mod.gov.uk
Meaghan O'Neil (INCOSE) - meaghan.oneil@gmail.com

Presented on: Monday, 10:00-12:10

Keywords. #TechOps; #Safety

Abstract. This highly interactive roundtable is an opportunity to collaborate with system safety colleagues in academia, government and industry to better understand the state of the art and state of the practice in system safety management in different sectors and geographies. The session with be a chance to understand, contribute to and shape the emerging thinking of the INCOSE System Safety Working Group.

Tutorials

Tutorials#11

A practical introduction to Capability Systems Engineering: Designing Hyperloop, a new 800 mph ground transportation capability

Duncan Kemp (Ministry of Defence) - duncan@17media.co.uk
Samantha Williams (mod) - Samantha.williams952@mod.uk

Presented on: Saturday, 08:00-17:00

Keywords. Capability; Systems Engineering; Hyperloop; Case study; Operational Concept; Design; Perfromance

Abstract. Operational capabilities are different from the typical products that systems engineers develop. Capabilities are often complex systems of systems comprising people, processes, information and equipment. Capability systems engineering techniques have been used in Rail and Defence to ensure that major programmes deliver the required levels of operational effectiveness.
This tutorial will give you practical experience of designing an effective operational capability. Based upon the 2014 INCOSE UK Capability Systems Engineering Guide, attendees will have the opportunity to apply Capability SE processes to manage a real-world case study.
The case study is based around the Hyperloop concept, a new 800 mph ground transportation mode. Following on from a short introduction to Capability SE and transport capabilities you will gain practical experience of Developing:
o The purpose and measures of effectiveness for hyperloop.
o The operational concept, including passenger flow, vehicle flow, maintenance, resilience and recovery.
o The whole system architecture, including functional, performance, commercial and physical
o The requirements for critical sub-systems
You will finally pull together the development plan to manage the risks and uncertainties exposed in the design iterations.
The tutorial is based upon highly successful training events run by the UK Ministry of Defence (for Defence Capability SEs) and the Birmingham Centre for Rail Research and Engineering (for Rail Capability SEs)

Biography

Duncan Kemp (Ministry of Defence) - duncan@17media.co.uk
Duncan Kemp is Chief Systems Engineer and the Defence Equipment and Support (DE&S) Fellow for Systems Engineering(SE). Duncan is the Technical Discipline lead for SE in DE&S, responsible for SE processes, tools and development of SE competence. Over the last two years Duncan has also developed and led the DE&S' internal systems engineering consultancy team. Duncan was part of the team that developed the UK SE Masters Apprenticeship Programme. Previously Duncan was chief systems engineer for rail in the UK Department for Transport. He was responsible for initiating a strategic review of UK rail, which identified over £850M p.a. Savings due to the adoption of better systems approaches. Within rail Duncan supported major programmes such as Thameslink and High Speed 2 in the development if their whole system approaches. He was also the chair of the cross-industry system reliability improvement group. Duncan is a chartered professional engineer and Fellow of the Institution of Engineering and Technology. He was one of the authoring team on the SE Vision 2025 and the INCOSE UK Agile SE Guide. He was lead author of the INCOSE UK Capability SE guide. He has presented over 15 papers at INCOSE international symposia and INCOSE UK conferences.

Samantha Williams (mod) - Samantha.williams952@mod.uk
Sam Williams is a Systems Engineer with over 20 years of engineering experience within defence acquisition. Sam is currently head of policy and the lead architect for the MOD Systems of Systems Approach team, helping the MoD adopt a systems approach to improve coherency across defence. She is currently leading a significant project to update MODs requirements and acceptance process. Sam delivers the MOD's in-house training in Systems Thinking and System of Systems Approach. Sam worked with Duncan to develop and deliver the Capability Systems Engineering master class that this tutorial is based upon. Sam is a Chartered Professional Engineer, CSEP and Member of the Institution of Engineering and Technology. She is the events Director for SCIO, a STEM ambassador and founder of 'Think! Do!' an organisation that gets kids thinking about philosophy, systems thinking, science, engineering & maths in a fun and participatory way.

Tutorials#InvTut#1

Back to Basics: Fundamentals for Systems Engineering Success (Novice)

David Long (Vitech Corp.) - dlong@vitechcorp.com

Presented on: Sunday, 08:00-12:00

Keywords. #SEFundementals

Abstract. “I know the processes”, “we’re managing requirements”, “I have a tool”, “it’s all checklists and documents”. Systems engineering is a rich practice leveraging an evolving set of processes, methods, and tools to address problems complicated and complex. With this richness, it is easy to become lost in nuance, details, and disconnected processes. In reality, the path to systems engineering success lies in perspective, the big picture, and integration.
This half-day tutorial provides a primer to the foundational concepts of systems engineering within a framework for overall project success. We will focus on the classic systems engineering domains of requirements, behavior, architecture, and V&V. Rather than treating these in isolation, the fundamentals are positioned within a flexible systems engineering process suitable for system development tasks across the complexity spectrum. While there is a place for process and documentation standards, our focus will be on eliciting the proper requirements, understanding the problem and solution domain, enhancing communication amongst the design team and the stakeholders, and satisfying the system need. Through discussions of the fundamental concepts integrated with sample exercises, we will maintain our focus upon the true deliverables – the system itself and overall project success.
By the end of the tutorial, participants will
• Understand the case for systems engineering, its applicability, and its value
• Learn essential concepts of requirements, behavior, architecture, and V&V
• Appreciate related topics of systems architecture, architecture frameworks, systems of systems, and model-based systems engineering (MBSE)

Biography

David Long (Vitech Corp.) - dlong@vitechcorp.com
For over twenty-five years, David Long has focused on helping organizations increase their systems engineering proficiency while simultaneously working to advance the state of the art. David is the founder and president of Vitech Corporation where he developed CORE™, a leading systems engineering software environment. He continues to lead the Vitech team as they deliver innovative solutions to help organizations develop and deploy next-generation systems. David is a frequent presenter at industry events worldwide delivering keynotes and tutorials spanning introductory systems engineering, the value of systems engineering and systems engineers, the advanced application of MBSE, digital engineering, and the future of engineering systems. His experiences led him to co-author the book A Primer for Model-Based Systems Engineering to help spread the fundamental concepts of this key approach to modern challenges.

Complex System Failure: Identification, Assessment, Response, and Evaluation (Novice)

Charles Keating (Old Dominion University) - ckeating@odu.edu
Joseph Bradley (Leading Change, LLC) - josephbradley@leading-change.org
Richard Hodge (DrRichardHodge.com) - richard@drrichardhodge.com

Presented on: Saturday, 08:00-17:00

Keywords. Complex Systems; System Failure; Failure Modes Effects and Criticality Analysis

Abstract. This tutorial better prepares Systems Engineering practitioners to understand and preclude failure modes for increasingly complex systems. Complex systems are subject to multiple failure modes that span the holistic spectrum of technical, human, social, managerial, organizational, policy, and political dimensions. These failure modes can stem from underlying systemic deficiencies in the design, execution, or development of the system. This tutorial is focused on four primary objectives: (1) examine of the nature of complex system failure and the systemic error sources for failure, (2) introduce an analysis framework to identify potential failure modes in design, execution, and development of complex systems, (3) provide an assessment approach to classify the existence and potential impacts for failure modes, and (4) suggests corresponding strategies that might preclude the failure modes all together or mitigate their impacts. The tutorial is organized to introduce concepts through guided discussion and hands-on practical application exercises. This approach prepares participants to immediately apply what has been learned to their specific complex systems of interest. Participants are given the opportunity to apply concepts, tools, and techniques to practical issues and challenges in dealing with complex systems. As a result of the tutorial, participants will be better prepared and equipped to identify potential failure modes prior to experiencing their effects, mitigate negative consequences of failure modes with responsive system based strategies, and conduct post failure analysis to identify system modifications to preclude future occurrences of the failure modes.

Biography

Charles Keating (Old Dominion University) - ckeating@odu.edu
Charles B. Keating serves as Professor of Engineering Management and Systems Engineering and Director for the National Centers for System of Systems Engineering (NCSOSE) at Old Dominion University. His research focuses on Systems Engineering, System of System of Systems Engineering, Management Cybernetics, and Complex System Governance. He is a Fellow, Past President, and 2015 Sarchet Award recipient from American Society for Engineering Management for his pioneering efforts in the field. He has published over 100 peer reviewed papers and graduated 22 Ph.D.s. His research has spanned defense, security, aerospace, healthcare, R&D, and automotive industries. He holds a B.S. in Engineering from the United States Military Academy (West Point), a M.A. in Management from Central Michigan University, and a Ph.D. in Engineering Management from Old Dominion University. His memberships include the American Society for Engineering Management, the International Council on Systems Engineering, the Institute for Industrial Engineers, and the International Society for System Sciences.

Joseph Bradley (Leading Change, LLC) - josephbradley@leading-change.org
Dr. Bradley, received the Ph.D. degree in Engineering Management from Old Dominion University, received the Degree of Mechanical Engineer and a Master of Science in Mechanical Engineering from Naval Postgraduate School, and a BE from The Cooper Union. Prior to joining Old Dominion University, he was Deputy Director for Force Maintenance at Commander, Submarine Force, Atlantic Fleet. Prior to that, he served in various consulting roles, including Program Manager’s Representative for the conversion of the USS OHIO and USS MICHIGAN to SSGNs. He is a retired Engineering Duty Officer and submariner, having served over 26 years in the United States Navy. He is a member of the American Society of Naval Engineers, Association for Computing Machinery and ASQ. His research interests include complex system governance, action research, project management, system dynamics, and decision making using modeling and simulation.

Richard Hodge (DrRichardHodge.com) - richard@drrichardhodge.com

Dr. Hodge brings over 40 years experience, with strong foundations in defence science where he fulfilled representative and advisory posts including Defence Science counsellor in Washington DC and Scientific Adviser, Strategic Policy and Planning in Canberra. He was a ‘founding father’ of Booz Allen Hamilton’s defence office in Canberra. Then General Manager for CAE Professional Services in Australia, before returning to consulting to help people address their toughest problems. A consultant, educator and expert in "living enterprises" at individual, group and organisation levels, creating capabilities in people to solve problems in ways that don't create further problems. He is engaged in building new knowledge from the science of life and living, using that to help people layer complexity, find simple patterns of thinking and examine the relationships among them. These patterns help explain, manage and govern the complexity we find in our world. While he learnt the ropes from working extensively in national security enterprises, the absolute beauty is finding those patterns influencing individual and group behaviours as well as complex enterprises - and then transporting the thinking easily across other equally complex enterprises like health, transport, education and energy.

Effective Communication and Analysis in the Age of MBSE (Novice)

Ronald Kratzke (Vitech Corporation) - rkratzke@vitechcorp.com

Presented on: Sunday, 13:30-17:00

Keywords. MBSE; SysML; Activity Diagram; EFFBD; BDD

Abstract. Models and representations have always been cornerstones of engineering, systems engineering included. Regrettably, rather than bringing clarity, the rise of model-based systems engineering has brought increased confusion and conflict regarding models and representations. Given the inherent breadth of operational architectures and systems engineering as we connect stakeholders and technical experts, we require the richest representation set possible. However, the number of views we have in our toolkit can lead to confusion rather than understanding. Therefore, we must seek to integrate these seemingly diverse representations as perspectives of an underlying systems model rather than as distinct products and endpoints themselves. This tutorial describes model based system engineering principals and provides a thorough review of the many views that a model may produce.

Surveying the multitude of system representations available – SysML and traditional analysis views, logical and physical, contextual and technical, systems and beyond – we will connect a diverse set of representations to each other and, most importantly, to the common underlying model and how the views can be used to communication to various groups. We will highlight various representations, each with their specific content and strengths. These strengths lead to preferred usage contexts and scenarios as part of a continuum of perspectives on the systems model. Understanding the contexts and scenarios, we will review content, notation, usage, analytical and communication value, and target audiences. Leveraging the strengths of each view, we will learn the constructive role these representations can play to address the system design challenges of today.

Biography

Ronald Kratzke (Vitech Corporation) - rkratzke@vitechcorp.com
Ron Kratzke has over five years' experience as a Principal Systems Engineer with Vitech Corporation. He spent the first 20 years of his professional career as a U.S. Navy Surface Warfare officer specializing in nuclear power surface ship engineering. During his naval career he achieved specialty recognition in nuclear power plant operation, surface missile systems, and electronic warfare. Ron was introduced to the practice of system engineering in the later half of his navy career while completing a master's degree in Engineering Management and working on the Navy Staff in the Pentagon participating in integrated mission area analysis and developing capability requirements for the Navy in coordination with the Department of Defense Joint Staff. Following his navy career, Ron spent 12 years supporting advanced system design for a number of U.S. government organizations and has had responsibility as a Chief System Engineer, Chief System Architect, and Project Manager. Ron has a BA in Statistics from the University of Rochester, a MA in International Relations and Strategic Planning from the Naval War College, and a MS in Applied Science from Southern Methodist University. Ron is also a Certified Six Sigma Green Belt by the American Society for Quality.

How Acquirers and Suppliers can use Systems Engineering to Achieve Better Acquisition Results (Expert)

Clement Smartt (Georgia Institute of Technology) - clement.smartt@gtri.gatech.edu
Carlee Bishop (Georgia Institute of Technology) - carlee.bishop@gtri.gatech.edu

Presented on: Saturday, 08:00-17:00

Keywords. proposal; acquisition; supplier; acquirer; decision analysis; systems engineering strategy

Abstract. This tutorial will equip leaders with an understanding of how to use systems engineering to master the proposal process for complex systems for both acquirers and suppliers, thereby establishing the foundation for success over the system or program lifecycle. Topics include how acquirers can use systems engineering to obtain products or services that satisfy their needs, and how suppliers can prioritize what business opportunities to pursue, manage proposal efforts, define technical scope and solution of what will be proposed, and prepare proposal documents. Systematic, repeatable processes and analytical techniques are introduced to guide proposal-related decision-making.

Biography

Clement Smartt (Georgia Institute of Technology) - clement.smartt@gtri.gatech.edu
Dr. Clement Smartt's recent doctoral research focuses on the use of systems engineering on proposals. Dr. Smartt earned the 2012 INCOSE Foundation Award for this research. He has multiple journal and conference papers on the topic and is lead instructor for a related short course in the area at Georgia Tech. Dr. Smartt has extensive experience with using systems engineering on proposals from both the acquirer and supplier perspectives. Dr. Smartt has 20 years of experience in industry and applied research, including working as a Principal Systems Engineer for L-3 Mission Integration and GTRI. Dr. Smartt's technical expertise is in modelling and simulation and systems engineering of ISR, radar, and electronic warfare (EW) systems.

Carlee Bishop (Georgia Institute of Technology) - carlee.bishop@gtri.gatech.edu
Dr. Carlee Bishop has over 34 years of professional military and defense-related leadership and management experience that includes directing studies and analysis efforts for HQ European Command, managing formal C-141 flight training programs for 800+ students, directing college-level programs in engineering, and managing major Department of Defense Projects. She has over 20 years of teaching experience in Systems Engineering and Space Systems Design at Georgia Tech, in Astronautical Engineering at the U.S. Air Force Academy, and in C-141 Formal Flight Training Programs. Dr Bishop is a Principal Research Engineer at the Georgia Tech Research Institute. She led the development of the Professional Master's Degree in Applied Systems Engineering (PMASE) and the Systems Engineering Certificate Programs and directed the PMASE program from 2009 to 2017. The U.S. Air Force Academy selected her to be a visiting professor in the Astronautical Engineering Department and she is currently serving as a visiting professor in the Systems Engineering Department at the US Military Academy, West Point. She is a Command Pilot with approximately 3000 hours in C-141, T-41, TG-7, T-38, and T-37 aircraft. She is an INCOSE Certified Systems Engineering Professional.

Integrating Systems Engineering, Project Management, and Quality Management (Novice)

Ann Hodges (Sandia National Laboratories) - alhodge@sandia.gov
Heidi Hahn (Los Alamos National Laboratory) - hahn@lanl.gov

Presented on: Sunday, 08:00-17:00

Keywords. mission assurance framework; systems engineering; project management; quality management; graded approach; systems engineering;project management;quality management integration

Abstract. Recently there has been increasing interest in applying systems engineering (SE) and program or project management (PM) in an integrated way. INCOSE has formed an alliance with the Project Management Institute (PMI) and formed a PM-SE Working Group for this purpose, for example. Both Sandia National Laboratories and Los Alamos National Laboratory have taken up this quest, and each has developed what they call their Mission Assurance Framework, which describes the set of tools they use to facilitate the integrated application of SE, PM, and engineering quality and rigor (which is one area of overlap in the specializations claimed by each discipline, along with topics such as stakeholder analysis and configuration management), to achieve mission success. The presenters will describe their organizations' implementation of their Mission Assurance Framework, conduct an exercise to identify similarities and differences, and discuss what factors contributed to the decisions that were made. Participants will work through a series of exercises around questions to consider in making integration decisions for their own organizations.

Biography

Ann Hodges (Sandia National Laboratories) - alhodge@sandia.gov
Dr. Heidi Hahn - Heidi Ann Hahn is Senior Executive Advisor to the Associate Director for Engineering Sciences at Los Alamos National Laboratory (LANL), responsible for development of processes and tools to promote engineering capability; professional development of R&D engineers; and engineering capability assessment. She is the author of the enterprise-wide Conduct of Engineering for R&D program and the developer of and instructor for the R&D Engineering Primer, a course for entry-level R&D engineers about the LANL Mission Assurance Framework (the integrated application of systems engineering, project management, and engineering quality and rigor). She was the Deputy Project Director for a business process reengineering and software implementation project and was also Group Leader for the Human Factors Engineering Group. Heidi obtained a PhD in Industrial Engineering and OR from Virginia Tech, and holds ESEP-Acq and PMP certifications.

Heidi Hahn (Los Alamos National Laboratory) - hahn@lanl.gov
Ann L. Hodges - Ann Hodges is the National Security Programs (NSP) Program Management Unit’s (PMU) Mission Assurance systems engineering lead at Sandia National Laboratories as well as lead for the systems engineering-related part of the NSP PMU Mission Assurance framework, and is currently a deputy program manager and systems engineer for a complex exploratory-phase project. She is a primary author of the Mission Assurance framework, which is a risk-informed graded approach to the application of project management, systems engineering and quality management. She has worked over 40 years at Sandia National Laboratories and is a Distinguished Member of Technical Staff. Ann obtained a BBA and an MS in Computer Science from the University of New Mexico, and holds CSEP, SAFe SPC4, CMII certifications.

Introduction to Systems Security Engineering (Expert)

Mark Winstead (MITRE) - mwinstead@mitre.org
Michael McEvilley (The MITRE Corporation) - mcevilley@mitre.org
Daryl Hild (MITRE) - d.hild@ieee.org

Presented on: Sunday, 08:00-17:00

Keywords. Systems Security Engineering; Security; SSE; Threat; Risk; Assurance; Level of Rigor; Resilience; Fault Management

Abstract. Systems security engineering (SSE), as an integral part of systems engineering, applies scientific, mathematical, engineering, and measurement principles, concepts, and methods to coordinate, orchestrate, and direct the activities of security and other contributing engineering specialties (e.g. reliability, safety and human factors) to deliver dependably secure systems. This tutorial provides an overview of SSE, its concepts, and the increasingly critical role that SSE has as part of Systems Engineering (SE). The tutorial is aligned with the INCOSE SSE Working Group-reviewed NIST SP 800-160 (Systems Security Engineering).

SE is about meeting stakeholder needs; Integrating system security into SE is about meeting the security protection needs derived from those stakeholder needs. SSE activities address system-of-interest loss concerns associated with the system throughout its life cycle, in consideration of adverse conditions resulting from threats, disruptions and hazards. The tutorial addresses SSE as a discipline, as a role, as a set of life cycle activities, and as a body of knowledge. The tutorial will offer a system-oriented framing of the security perspective with connections to the technical engineering and technical engineering management methods and activities employed as part of a systems engineering project to address stakeholder security concerns.
This tutorial targets the experienced systems engineer who is a novice in SSE as a specialty discipline of SE

Biography

Mark Winstead (MITRE) - mwinstead@mitre.org
Mark, the MITRE Corporation's Systems Security Engineering Department chief engineer, had over twenty-five years' STEM experience before joining MITRE in 2014, including stints as a crypto-mathematician, software engineer, systems engineer, systems architect and systems engineer as well as systems security engineer. He has worked for several defense contractors, an Environmental Protection Agency contractor, a Facebook-like startup, a fabless semi-conductor manufacturer of commercial security protocol acceleration solutions, and a network performance management solutions company. In addition to serving as a chief engineer, Mark works with various MITRE sponsors, helping programs with security engineering as well as teaming with others on integrating SSE into the acquisition systems engineering process. He has also worked with the MITRE Institute on developing materials for training in SSE. Mark is a graduate of the University of Virginia (PhD, Mathematics) and Florida State University (BS & MS, Mathematics). He resides in Colorado Springs, CO.

Michael McEvilley (The MITRE Corporation) - mcevilley@mitre.org
Michael has over 35 years' experience in high confidence software-intensive systems and requirements engineering. He served in the USAF as officer-in-charge of computer operations for a tactical intelligence squadron, worked in industry developing software for the Aegis Weapons System and for Command and Control (C2) of worldwide military airlift operations. With the MITRE Corporation, he has supported several DoD programs with focus on requirements analysis, and system design assurance for safety- and security critical ground, surface, subsurface, and air weapons platforms. Michael is currently a System Assurance Lead in the MITRE Systems Engineering Technical Center and supports DoD systems engineering efforts for program protection planning and for achieving confidence in weapon systems engineered to operate in contested cyberspace environments. Michael is co-author of NIST SP 800-160 Volume 1 Systems Security Engineering: Considerations for a Multidisciplinary Approach in the Engineering of Trustworthy Secure Systems.

Daryl Hild (MITRE) - d.hild@ieee.org

Daryl's career spans 3 decades consulting on systems engineering solutions that span US Army tactical communications networks, Army information technology network and systems management solutions, NORAD/NORTHCOM air warning and missile warning systems, the US Air Force global positioning system, space systems, and cyberspace security. He currently serves as the Department Head for the Systems Security Engineering department within the MITRE Systems Engineering Technical Center. Daryl has collaborated with the MITRE Institute on developing a Systems Security Engineering (SSE) ~~competency model and a Systems Security Engineering Learning Path. As well, Daryl is developing operational concepts and~~ constructs for engineering defensive and offensive cybersecurity capabilities. Prior to MITRE, Daryl was an Army Signal Officer from 1984 to 1990. He received his bachelor degree in Electrical Engineering from Washington University, St. Louis, MO; and his master and doctoral degrees in Electrical and Computer Engineering from the University of Arizona, Tucson, AZ. In the community, Daryl serves as a BSA Venturing advisor enabling youth to develop leadership skills through community service projects and high adventure experiences.

Project Design and Management with the Project Value, Risk, and Opportunity (PVRO) Framework (Expert)

Tyson Browning (Neeley School of Business, TCU) - t.browning@tcu.edu

Presented on: Saturday, 08:00-12:00

Keywords. project management; risk/opportunity management; technical performance management; SE/PM integration

Abstract. Projects and programs should create value. That is the desire and plan, but uncertainties cloud the paths to this destination. Conventional techniques such as earned value management (EVM) focus on time and cost but do not address technical performance, uncertainty, risk, and opportunity. This tutorial introduces a project/program value, risk, and opportunity (PVRO) framework that integrates systems engineering with project management and marketing. PVRO incorporates the concepts of key performance indicators (KPIs), technical performance measures (TPMs), risk reduction profiles, value/utility functions, probability distributions, and activity networks. It accounts for progress and added value in product development as a function of the useful information produced. PVRO supports planning, monitoring, control, and tradeoff decision support. An example project, developing a drone aircraft, demonstrates the framework's application to project design and tracking, including setting project goals that balance risk and opportunity. New indices for risk, opportunity, and learning are introduced that focus all project participants on common objectives and measures of progress.
This tutorial introduces the PVRO framework and example applications useful to product developers, systems engineers, and project and program managers. Examples are presented from several industries. Participants will engage in hands-on exercises and come away with a clearer understanding of the drivers of project/program value in the presence of uncertainty. Participants will receive a copy of the presentation materials and access to free tools that can be applied immediately for quick results and insights.

Biography

Tyson Browning (Neeley School of Business, TCU) - t.browning@tcu.edu
Dr. Tyson R. Browning (www.TysonBrowning.com) is an internationally recognized speaker and expert in methods for managing complex projects. He is Professor of Operations Management at the Neeley School of Business at Texas Christian University (TCU) in Fort Worth, Texas, where he teaches MBA courses on Operations Management, Project Management, Risk Management, and Process Improvement and conducts research on managing complex projects and processes. He has previous work experience with Lockheed Martin, Lean Aerospace Initiative, Honeywell Space Systems, and Los Alamos National Laboratory, and he has consulted for organizations such as BNSF Railways, General Motors, Lockheed Martin, Northrop Grumman, Seagate, Siemens, Southern California Edison, U.S. Navy, and two European consortia on complex systems. Dr. Browning has two Master's degrees and a Ph.D. from MIT. He has authored numerous papers for conferences and journals, including IEEE Transactions on Engineering Management, Journal of Mechanical Design, Project Management Journal, as well as ten papers in Systems Engineering. He has been an INCOSE member since 1995. He has served as an Associate Editor for Systems Engineering, as a Department Editor for IEEE-TEM, and is currently the co-Editor-in-Chief of the Journal of Operations Management. He co-authored the book Design Structure Matrix Methods and Applications (MIT Press, 2012).

Requirements Engineering for Contract-Based Systems (Novice)

Brian Berenbach (Georgia Institute of Technology) - bberenbach@alumni.emory.edu

Presented on: Sunday, 08:00-12:00

Keywords. Requirements engineering; Contracts; SE Management

Abstract. Requirements elicitation and management for contract-based projects is significantly more complex than for product or product line development. For example, many practitioners are unaware of the fact that the traditional "V" model for requirements tracing may not work where there is a legal contract describing project deliverables; nearly every aspect of systems engineering is more challenging, from elicitation to risk analysis and compliance management.
This half-day tutorial will describe in some detail contract issues that are typically not discussed in requirements texts and courses, and will focus on topics such as proposal and contract creation, and RE processes and tooling where the objective is to deliver on-time and in-budget while demonstrating compliance with a contract. The tutorial will touch on some rarely taught but important topics such as due diligence, options, penalty clauses, regulatory requirements, managing subcontractors and the change management process.
This tutorial will be of interest to any systems engineer or who currently is or may be involved in a project as a prime or subcontractor or contract administrator.
Moreover, the instructor has created this tutorial to include most, if not all the things about contract-based projects he wished he had known when starting his career as a systems engineer.

Biography

Brian Berenbach (Georgia Institute of Technology) - bberenbach@alumni.emory.edu
Brian Berenbach retired from Siemens in 2013 after working for over 40 years as a systems engineer. After retiring, he joined the staff of Georgia Tech, mentoring graduate systems engineering students. Mr. Berenbach is an INCOSE ESEP and an ACM Distinguished Engineer. He has published widely on systems and requirements engineering, including a text book "Software and Systems Requirements Engineering: In Practice" published by McGraw-Hill. During his long career he participated in the creation of proposals, contract negotiation and execution of contracts for large complex systems in the medical, transportation, IT and power domains. As an SE researcher, Mr. Berenbach holds 4 patents in requirements engineering.

Tutorials#13

The “Secret Weapon” for Systems Engineering – Using Creativity to Improve Your SE Process and Product (Expert)

Jennifer Narkevicius (Creative Purpose LLC) - jnarkevicius@jeniussolutions.com
Donna Bennett (Creative Purpose LLC) - donna@creativepurposellc.com

Presented on: Saturday, 13:30-17:00

Keywords. SE process; Differentiator; Creativity; Actionable Tools

Abstract. You are an expert Systems Engineer and your team does good work. But what if you and your team could bring a “secret weapon” to your Systems Engineering (SE) process that could help you better meet all stakeholders’ requirements, reduce rework, maintain or improve program metrics, and brought the team together in a positive way? Adding focused creativity tools has been demonstrated to have strong positive return on investment. Actively applying creativity to your SE toolkit can improve your overall engineering work by eliciting more original ideas at each stage of the project while improving your personal work processes and products. In addition, creativity can be used as part of team management and be a differentiator throughout the process. These tools can also improve both formal and informal team leadership by encouraging even reticent team members to participate. In this tutorial, you will learn about multiple creativity tools to help generate better ideas; expand the problem space without increasing the project size, and assure that team members contribute. You will get hands-on experience to help you address accelerating technology including autonomous and complex systems design. Creativity tools will support your need for workable solutions that meet the performance requirements becomes greater. Creativity tools are inexpensive and do not add extensive time to project schedules. They can and should be embedded with the standard SE tools. You will learn what creativity is and how it can be applied in SE; how to use tools and techniques to personally be more creative; to unleash the creativity in your team members; and how to integrate these tools with the rest of your SE toolkit. By the end of this tutorial you will have the skills, tools, and techniques to bring the creativity “secret weapon” to your work.

Biography

Jennifer Narkevicius (Creative Purpose LLC) - jnarkevicius@jeniussolutions.com
Jennifer McGovern Narkevicius, PhD has worked with Defense, Transport, Infrastructure, distributed networked social and work interactions, supported decision making, and design of web-based enterprise applications through research, development, test and evaluation. She facilitates clients’ efforts to define and develop the interactions of the users with the other elements of systems. Throughout her career, Jen has worked in Systems Engineering focusing on Human Systems Integration, identifying and defining the systems requirements that include human capabilities and limitations. In parallel, she has taught enrichment course focusing on using creativity to improve student’s math performance, problem solving, organizational strategic planning, and teamwork. Jen is a professional musician teaching, performing and arranging traditional music. Dr. Narkevicius is member of INCOSE, Human Factors and Ergonomics Society, and the American Harp Society. She holds a PhD in Cognitive Psychology, with master’s degrees in Systems Engineering, Adult Development Psychology and Special Education: Gifted and Talented and is Certified Music Practitioner.

Donna Bennett (Creative Purpose LLC) - donna@creativepurposellc.com
Donna Bennett, LCSW-C is a Clinical Social Worker with 25 years of experience in program development and implementation across Southern Maryland. Donna has successfully written innovative programming grants to bring services to youth and families. She is the owner of Coaching for the Voyage, which offers therapy, life coaching and ADHD coaching to clients in an innovative practice incorporating a strengths based model as well as creative strategies utilizing the Expressive Arts to facilitate clients meeting their personal goals. This practice proudly serves military members and military contractors in the Southern Maryland area. Donna has extensive training in the use of the Expressive Arts for self- growth, healing and promoting creativity and incorporates these strategies into individual and group work. Donna is a Certified Music Practitioner and plays prescriptive harp music for individuals who are ill and dying. Donna also writes original music to facilitate her work and to perform. Donna is a Licensed Certified Social Worker- Clinical with a Master of Social Work from Delaware State

University and a BS in Recreation and Parks from the School of Forestry at West Virginia University. Donna is completing a Certificate of Advanced Graduate Studies in the Expressive Arts from Salve Regina University.

Trade-off Analytics: Developing and Evaluating the Tradespace (Novice)

Gregory Parnell (University of Arkansas) - gparnell@uark.edu
Ed Pohl (University of Arkansas) - epohl@uark.edu

Presented on: Sunday, 08:00-17:00

Keywords. Trade-off Analysis; Tradespace; Analysis of Alternatives; Decision Management

Abstract. The tutorial presents the best practices and common mistakes for Trade-off Analyses. The tutorial uses the Decision Management Process developed by the INCOSE Decision Analysis Working group for the SE Handbook and the SeBok. The tutorial uses the concepts of multiobjective decision analysis to structure the decision requiring the trade-off analysis. The tutorial topics include decision management, framing a decision, developing objectives and value measures, Set-Based Design, defining the tradespace, evaluating alternatives, and communicating results.

Biography

Gregory Parnell (University of Arkansas) - gparnell@uark.edu
Dr. Gregory S. Parnell is a Research Professor of Industrial Engineering and Director, M.S. in Operations Management at the University of Arkansas. He teaches systems engineering, decision analysis, operations management, project management, and IE design courses. His research focuses on systems engineering, decision analysis, risk analysis, and resource allocation. He edited Trade-off Analytics: Creating and Exploring the Tradespace, Wiley & Sons, 2017, co-edited Decision Making for Systems Engineering and Management, Wiley Series in Systems Engineering, 2nd Ed, Wiley & Sons Inc., 2011 and co-wrote the Wiley & Sons Handbook of Decision Analysis, 2013. He is a fellow of INCOSE, INFORMS, MORS, the Society for Decision Professionals, and the Lean Systems Society. He has published over 100 papers and book chapters. He is a retired Colonel in the U.S. Air Force. Dr. Parnell received his Ph.D. from Stanford University.

Ed Pohl (University of Arkansas) - epohl@uark.edu
Dr. Edward A. Pohl is Head of the Industrial Engineering Department, Professor and holder of the 21st Century Professorship of Engineering at the University of Arkansas. Dr. Pohl also serves as the Director of the Center for Innovation in Healthcare Logistics and former Co-Director of the emerging Insti¬tute for Advanced Data Analytics. Before coming to Arkansas, Dr. Pohl spent 21 years in the United States Air Force where he served in a variety of engineering, operations, analysis, and academic positions dur¬ing his career. Dr. Pohl is a Fellow of the Institute of Industrial and Systems Engineers, a Fellow of the Society of Reliability Engineers, a Diplomate in the Society for Health Systems and a Senior Member of the Institute of Electrical and Electronics Engineers. Dr. Pohl's research interests are in risk, reliability, engineering optimization, supply chain risk analysis, healthcare logistics, decision making and quality. He has published more than 100 refereed articles and given more than 100 pre¬sentations at national and international conferences. Dr. Pohl is an Associate Editor for the Institute of Electrical and Electronics Engineers (IEEE) Transaction on Reliability, the Journal of Risk and Reliability, and the Journal of Military Operations Research. Dr. Pohl recently received the 2016 American Society for Engineering Education John L. Imhoff Global Excellence Award for Industrial Engineering Education.

Tutorials#4

Understanding and Applying the INCOSE SE Handbook Fourth Edition (Novice)

David Walden (Sysnovation, LLC) - Dave@sysnovation.com

Presented on: Saturday, 08:00-17:00

Keywords. systems engineering; handbook; SE processes

Abstract. The Fourth Edition of the INCOSE Systems Engineering Handbook (SEH) was released in 2015. The objective of this one-day tutorial is to provide a top-level overview of the handbook and how it can be used to plan, manage, and realize complex systems within the context of demanding business constraints. Participants are introduced to key Systems Engineering terminology, concepts, and principles in the handbook, answering questions such as:

• What is Systems Engineering and why is it important?
• Why is the INCOSE SEH relevant to you and your organization?
• What are the key Systems Engineering processes in the SE Handbook?
• How can you use the material in the SE Handbook to make a difference on your projects?

Practical information and tools are provided that will help the participants deal with issues that inevitably occur in the real world. The participants will complete several team-based exercises to solidify the concepts being presented. Each student will receive a complete set of lecture notes and an annotated bibliography.

Note: this tutorial is an overview of the handbook and does not include the level of detail typically presented in an INCOSE Systems Engineering Professional (SEP) preparation course.

Biography

David Walden (Sysnovation, LLC) - Dave@sysnovation.com

David D. Walden, ESEP, is co-owner and principal consultant for Sysnovation, LLC, a Systems Engineering consulting and training firm he formed in 2006. Previously, Mr. Walden was with General Dynamics Advanced Information Systems for 13 years and McDonnell Aircraft Company for 10 years. Mr. Walden was the lead editor of the INCOSE SE Handbook Fourth Edition. He is an INCOSE liaison to ISO/IEC JTC1/SC7 Working Groups 10 and 20. Mr. Walden was Program Manager of the INCOSE Certification Program from 2007-2013. He has an M.S. in Management of Technology (MOT) from the University of Minnesota, an M.S. in Electrical Engineering and in Computer Science from Washington University in St. Louis, and a B.S. in Electrical Engineering from Valparaiso University in Indiana. Mr. Walden was one of the first to earn the INCOSE Certified Systems Engineering Professional (CSEP) credential in 2004 and was awarded the INCOSE Expert Systems Engineering Professional (ESEP) credential in 2011.

Presentations

Presentations#6

A study of the full potential of the application of Systems Engineering in healthcare

Bohdan Oppenheim (Loyola Marymount University) - boppenheim@lmu.edu

Presented on: Wednesday, 15:30-16:10

Keywords. healthcare systems engineering; healthcare; tailoring; #Industry

Abstract. The presentation will summarize a sabbatical-long systematic study of the full potential of the application of Systems Engineering in healthcare. Both healthcare professionals and systems engineers still struggle with the understanding of the new overlapping domain of Healthcare Systems Engineering (HSE), which applies Systems Engineering (SE) to Healthcare. Confusion exists on both sides of the professional fence. Healthcare professionals (medical and administrative) do not appreciate the potential of SE in healthcare, and confuse SE with regular engineering, causing frustration that 'regular engineers' are not solving their systems-wide challenges. Many SEs who attempt to transition into healthcare from traditional aerospace/defense programs have only a superficial understanding of the highly unique needs of medicine and healthcare, particularly in the extremely fragmented and suboptimal U.S. healthcare. Many SEs who try to apply the tools and processes which work fine in aerospace, e.g. MBSE, meet with a lack of interest from healthcare professionals. Knowing that the healthcare share of the U.S. economy is 20%, or $3 trillion, and being used to the defense environment where project schedules are measured in years and budgets in billions of dollars, they tend to be disappointed by the small scale of typical healthcare projects in hospitals and clinics, which are measured in weeks or months, with budgets below $200 thousands. These disjunctions cause major gaps between the healthcare needs and the solutions proposed by most systems engineers.

The study undertaken in 2017/18 by the author involves intensive interviews and surveys with tens of healthcare executives in Kaiser Permanente, Children's Hospital of LA, UCLA Health and VA. The presentation will summarize the opportunities for healthcare improvement, both urgent and long-term, both local (hospitals and clinics) and regional/national, that SE can and should address. A mapping of healthcare subdomains onto SE offerings will be presented, with weighted scale of importance and potential for impact. The results should be useful to healthcare professionals enabling them to ask for actionable and meaningful help from SEs, and to SE professionals seeking work opportunities in healthcare. The results will also inform academic programs in HSE.

A systems approach for achieving operational control of the southwest border

Ryan Riccucci (U.S. Border Patrol) - riccucci@hotmail.com
Chris Pietrzak (U.S. Border Patrol) - chris.d.pietrzak@cbp.dhs.gov

Presented on: Monday, 13:30-14:10

Keywords. System-of-systems; Operational Control; Border Security; #RisksComplex

Abstract. BACKGROUND
On January 25, 2017, the President issued Executive Order (EO) 13767 mandating 'Operational Control' (OPCON) of the southwest border (SWB), defined as the prevention of all unlawful entries into the United States, including entries by terrorists, other unlawful aliens, instruments of terrorism, narcotics, and other contraband. The EO required the U.S. Border Patrol (USBP) to quickly develop a repeatable, traceable, and defensible methodology to produce a resource plan that, if executed, would result in OPCON of the SWB. The USBP tailored and applied systems engineering principles to design a methodology to quickly synthesize data from the field into a comprehensive, hierarchically prioritized resource plan called the SWB Capability Roadmap.
The Roadmap employed a system-of-systems approach to achieving OPCON, identifying user-defined, prioritized solution configurations in each unique border area at all 47 stations along the SWB in a two-week timeframe. Each solution set was a customized configuration of five capability categories, calibrated to balance those capabilities, and define a deployment plan that could be tailored through the combinatorial application of prioritization filters. The five solution categories are (a)surveillance, (b) personnel, (c) mobility assets (vehicles), (d) access roads, and (e) tactical infrastructure (barrier).
METHODOLOGY
The USBP applied a system-of-systems approach to create a phased, iterative methodology to analyze the complex border environment from multiple perspectives. USBP Headquarters coordinated with the leadership at the 9 sectors that encompass the 47 stations along the SWB to apply this methodology to gather stakeholder-defined needs, priorities, and requirements from the strategic, operational, and tactical views. Because the SWB is a complex system of systems, with an operational environment characterized by multivariate geophysical conditions and an adaptive threat, the USBP employs the Capability Gap Analysis Process to conduct the mission analysis to gather gaps and mission needs to inform operational requirements from the end-user perspective to understand stakeholder needs and system requirements
Planning Coordination
Stakeholders were provided a planning guide, a suite of customized analytical tools, and responsive support from USBP Headquarters subject matter experts (SMEs) for technical assistance. Planning teleconferences with all stakeholders ensured a shared understanding and coordinated execution of the methodology based on the following guidance: (a) Each sector and station will determine the necessary solutions to prevent all unlawful entries into the United States, (b) Solutions will be informed by and linked to sector and station Capability Gap Analysis Process (CGAP) data, (c) Sectors and stations shall assume that as OPCON is achieved in adjacent areas, levels of illicit traffic in their area will reach historic highs, (d) Sectors shall consider their unmitigated capability gaps and how gaps would likely be exploited by increased levels of illicit activity.

Threat Analysis

Current intelligence products provided a baseline of threat capabilities, characteristics, and intent. A Threat Survey was administered to Intelligence Agents along the SWB to identify how each sector and station views the threat today, and how they see it evolving in the future.
Utilizing Geospatial Information System (GIS) software, USBP SMEs developed a groundbreaking algorithm to cross-reference topography, elevation, ground clutter, and proximity to roads/cities to determine a 'vanishing line' where threats were likely to abscond. The vanishing line provided a visualization for stations to reference when determining capability configurations. The vanishing line was validated using a historical trend analysis of border enforcement data of illicit entries that absconded (i.e. got aways).
Solution Configuration
Each sector utilized their existing CGAP inventory and current intelligence on the threat to provide the baseline for a Concept of Operations (CONOP) to achieve the OPCON in their respective area. Sector leadership was surveyed to determine and exhaust potential Non-Materiel Solutions for gaps. Then, sector leadership completed an AHP prioritization process to

compare the USBP's 12 Master Capabilities to determine a customized, enterprise-level hierarchy of capabilities. Concurrently, station leadership completed a 2-step Analytical Hierarchy Process (AHP) comparing the 5 tactical capability categories, and again applying AHP to compare specific assets within each capability category to determine the user-defined, capability-based weights for tailored solution configurations (capability laydowns) for each station.

To expedite the production of a real-world, georeferenced capability laydowns, each sector received a customized set of standardized GIS files already containing some information (e.g. existing roads, fencing segments) respective to each sector. Each sector's GIS SMEs used their sector CONOP, station leadership guidance, and CGAP data to plot notional laydowns for persistent surveillance sites and new or improved roads.

RESULTS

The resulting Roadmap is a decision support tool for USBP leadership, providing a traceable compendium of information linking stakeholder needs and system requirements on the southwest border. The Roadmap provides a conceptual model to analyze trade-offs on cost and performance to prioritize solutions based on risk. The Roadmap provides value as an evidence-based, comprehensive plan to achieve OPCON, defining the system performance parameters to inform the analysis and planning of business requirements for various funding scenarios.

A Systems Thinking Approach to Philanthropy: How a Systemic Approach to Philanthropy Could Strengthen Our Social Impact

Kayla Marshall (Lockheed Martin) - kmashall202@gmail.com

Presented on: Wednesday, 15:30-16:10

Keywords. Systems Thinking; Philanthropy; Social Systems and Systems Thinking; Social Systems; Global Philanthropy; #Academia

Abstract. Philanthropy is evolving from simply throwing money at a social issue to using our skills and knowledge to address the root causes of the issues. Systems Thinking can be used to increase the value and effectivity of social initiatives resulting in measurable impacts while minimizing unintended consequences. Social systems are complex and their complexity creates difficulty when navigating them in attempts to create economic growth and stability for lower income communities, for example. If social systems can be better understood, then root cause to social inequities can be identified. Once the driving forces and the interconnections between social systems are understood then we can begin to manipulate those social structures and create a more desirable system outcome (i.e. equitable social systems). Understanding and addressing the root cause will allow us to create sustainable solutions. The more we understand systemic behavior the more we can anticipate the system behavior and work with the systems, and in this case shape the quality of our lives. If we want to move our social structures to equitable sustainment, then we must allow ourselves, as philanthropist, to think systemically when addressing root causes to social systems. The presentation includes a Systems Thinking approach to addressing social systems. The components of social systems are explored as well as how philanthropy can influence our social systems. Through establishing the common components of social systems we can identify how philanthropy could be best used and began to development tools for approaching social systems that incorporate the skill sets of system thinkers. We will be able to determine if and how a Systems thinking skill set can be employed to strengthen philanthropy to a measurable social impact tool.

Presentations#10

Agile Systems Engineering to Maximize Research Innovation

Rosa Heckle (MITRE) - rheckle@mitre.org

Presented on: Tuesday, 16:15-16:55

Keywords. Agile Development; Emerging Technologies ; Research and Development; Systems Engineering

Abstract. The research literature has shown that introducing systems engineering (SE) practices in a computer/technologies research environment can be difficult. The issue lies in the fact that the underlying goals and motives of research differ from traditional end-user focused systems development. In research, software is developed for exploration purposes, a proof-of-concept, or to generate novel outcomes. SE methodologies are often neglected for the sake of a domain's unique needs for exploration and vision. Value generation is placed on advancing science and development of novel capabilities. So when applying SE methods in this environment, it is important that the processes fit the environment and the strategic intent for maximum impact. Trying to infuse/impose the traditional SE practices with rigorous processes, documentation, and requirements into this environment has been met with much angst and contention from scientists and developers. Research has shown that too much formality in a scientific computing environment can do more harm than good. As a result, practices must be developed specifically for this environment and introduced carefully so that generation of science and engineering results is not negatively impacted. To address these concerns, we took an evolutionary and agile approach. We introduced agile SE methodologies with a focus on architecture, processes, and customer perspectives, tailored to fit the team dynamics and environment. The methodologies were introduced in an evolutionary manner so that cultural changes needed to make the new process effective would be more readily accepted. This paper presents a case study of the implementation of agile systems engineering methods within two technology research teams, one team in the computer vision domain, the second team in the human language technologies domain. We will present the SE processes used and how they were tailored specifically for the environment. We will describe what worked, what didn't work, as well as the issues that emerged, and lessons learned.

Presentations#43

AirSPEED: Continuous Process Improvement Initiatives in the United States Navy

Jeffrey Brown (US Navy) - jeffrey.a.brown4@navy.mil

Presented on: Wednesday, 15:30-16:10

Keywords. Theory of Constraints; Lean; Six Sigma; #Government

Abstract. The United States Navy utilizes a blend of three Continuous Process Improvement methodologies in its afloat and ashore aircraft maintenance repair organizations. I propose a presentation that will briefly define the Navy's interpretation of Lean, Six Sigma, and Theory of Constraints, and then provide examples and discussion of CPI projects that synthesize tools from all three. The United States Navy has reaped the benefits of CPI in service environments as well as conventional manufacturing environments. My presentation will provide examples of and discussion of each. I will model it after the format of the TED talks.

Applying a Systems Thinking Approach to Understanding Military Aviation Maintenance Complexity

Michael Do (US Army) - michael.do@comcast.net

Presented on: Thursday, 08:00-08:40

Keywords. Complex Systems; Aviation Maintenance Systems; Complexity; System Accidents; Systems Thinking; #Government

Abstract. Army aviation system accidents, especially when they result in the life of Soldiers are unrecoverable and a tragedy. How do we prevent these accidents? One way to prevent aviation accidents is to ensure aircrafts are properly maintained. This can be done by implementing a scheduled maintenance program (SMP) that optimizes aviation maintenance. In order to optimize Army aircraft maintenance, we must understand the behavior of these systems and how their individual parts and components are linked and interdependent with each other within the larger context of a more complex aviation maintenance system. Complex systems are becoming more important in both the natural and social sciences due to the complexity of systems being developed to solve real world problems. The nature of complex systems exhibits such complexity that it makes their behavior difficult to understand, predict, and control. This presentation applies the systems thinking approach to a complex problem set, in particular, aircraft maintenance to help facilitate an understanding of the complexity involved with Army aviation maintenance systems.

Presentations#31

Assessing the Potential of IoT in Systems Engineering Discipline

Thirunavukkarasu Ramalingam (UTC Aerospace Systems) - thirunavukkarasu.ramalingam@utas.utc.com
Daniel Tweten (UTC Aerospace Systems) - Daniel.Tweten@utas.utc.com

Keywords. Internet of Things (IoT); IoT Characteristics; System Engineering; System Engineering Elements; Aerospace systems; Connected devices

Abstract. Internet of Things (IoT) is becoming more and more important in many industry sectors and domains. Digital Technology evolution is happening rapid fast, within no time this will impact every business. Digital transformation is at the heart of business strategies nowadays and it begins with the executive mandate. There is a strong sense of urgency among executives as the threat of digitally enabled competitors remains high on the list of concerns. When we see the birth of IoT, it all started in the year 1999. However, number of devices is started increasing from year 2003, 500 million connected devices. As per Cisco forecast in the year 2020 there will be 50 billion connected devices for the world populations of 7.6 billion! Metcalfe's Law reminds us that three interconnected components result in a maximum of three interconnections, but with four the maximum number of interconnections rises to six, and with ten components, designers must deal with 45! Estimated more than 50 billion connected devices by 2020 will change/challenge the way system engineering is carried out now. IoT is NOT a distant future, it's happening now, as a system engineering professional we have to be quick in making the right decisions which can mean a lot in system engineering discipline. More connected device will create more complexity for the systems. The IoT is a hyper-System of Systems problem with multiple requirements, multiple governance and millions of stakeholders. System Engineering (SE) will have a big impact due to IoT, What other than SE can handle all of that?
This exploratory research is targeted towards identifying the various IoT characteristics and its impact on System Engineering discipline. A methodology was developed to establish the relationship between the IoT characteristics and System Engineering elements (Design requirements). Matrix methodology also helped in identifying the positive and negative correlation between the IoT characteristics and its linkage with various systems engineering element. This investigative research could be used by System Engineering professional to understand the impact of IoT in System Engineering.
The objective of the presentations are listed below
1. Identify various IoT characteristics
2. Definition of IoT characteristics
3. Survey results high impact IoT characteristics in system engineering discipline
4. Map the IoT characteristics with System Engineering elements
5. Recommendations
6. Conclusions

Presentations#51

Autonomous Sensor Tasking for Space Situational Awareness Using Deep Reinforcement Learning Techniques

Quintina Jones (Raytheon) - quintina.r.jones@gmail.com

Presented on: Wednesday, 11:30-12:10

Keywords. Reinforcement Learning; Space Situational Awareness; Machine Learning; #Industry

Abstract. The Joint Space Operations Center of the United States Strategic Command's Joint Functional Component Command for Space is responsible for detecting, tracking, and identifying all artificial objects in the Earth's orbit. Over 39,000 man-made objects are cataloged and over 16,000 objects are being tracked. It also tasks the Space Surveillance Network, a network of 30 space surveillance telescopes observing these space objects, which results in approximately 400,000 observations daily. There must be an autonomous system to manage resources generating the catalog of space objects and update information on these space objects for catalog maintenance. Generating the catalog will require the ability to discern objects through pattern recognition for proper classification. Maintaining the growing space object catalog will become more complex due to sensors ever increasing capability to detect a larger number of objects. This work will focus on the development and analysis of physically based machine learning algorithms for real-time inference of Space Objects energy parameters and states to predict the space objects orbits for the purpose of sensor tasking system to meet the high-level goals of Space Situational Awareness. By using a predictive algorithm, the system only needs to track periodically instead of continuously, which minimizes system utilization. Summarily, the system will need to be able to track existing objects already in the catalog. The sensors tasking problem will be devised as a Markov Decision Process and solved using Reinforcement Learning to design a deep neural network to generate the optimal actions for the sensors for tracking space objects.

Presentations#41

Challenges to Implementing MOSA for Major DoD Acquisition Programs

Edward Moshinsky (Lockheed Martin Corporation) - edward.a.moshinsky@lmco.com

Presented on: Thursday, 08:45-09:25

Keywords. MOSA; Modular Open Systems Approach; OSA; Open Systems; Architecture; DoD; acquisition; #Government

Abstract. Driven by acquisition reform imperatives, Modular Open Systems Approach (MOSA) is a pending requirement for major DoD system acquisitions. This presentation was developed in close coordination with the NDIA Architecture Committee, and incorporates DoD, industry, and academia perspectives. The presentation reviews the expected benefits and approaches of implementing MOSA, and explores the key implementation challenges that the new MOSA requirements impose on both the acquisition program offices and contractors.
Specific areas of discussion include definitions and measures for System Modularity, Openness, and Data Rights/IP. Impacts to open standards efforts and contractors' IP investment are discussed.
Recommendations for further study in MOSA implementations are also presented.

Collaborative Systems Engineering in the Ascent Abort-2 Crew Module/Separation Ring Project

Antony Williams (Jacobs) - antony.williams@jacobs.com
Jenny Devolites (NASA) - jennifer.devolites@nasa.gov

Presented on: Thursday, 08:00-08:40

Keywords. Data Centric Systems Engineering; Collaborative Engineering; Systems Engineering Tools

Abstract. "Generally speaking, systems engineering (SE) tool-sets face a dilemma balancing power and accessibility. High-powered SE tools (MagicDraw, Cradle, Core, etc.) tend to be specialized and are available only to highly trained Systems Engineers, and/or through the use of a 'back room' developer team making the output products available to the broader team. On the other hand, highly accessible tools (MS Word, Excel, etc.) do not have the power to implement SE in a rigorous manner.

NASA has to test all aspects of the new human-rated Orion Multi-Purpose Crew Vehicle spacecraft prior to its first crewed mission. The test program includes uncrewed launch abort flight tests to demonstrate the capability to save the crew in the event that a launch failure occurs. Orion's second abort flight test will be a low-altitude flight test known as "Ascent Abort 2 (AA-2)." This test is currently scheduled to be carried out at Cape Canaveral Air Force Station's Space Launch Complex 46 (SLC-46) in Florida in 2019. NASA's in-house AA-2 Crew Module and Separation Ring (CSR) Team is producing the crew module and separation ring.

Operating jointly as both an Advanced Exploration Systems (AES) Project and an Orion Project, the CSR project charter includes development of innovative, streamlined and generally more efficient practices for creation of flight hardware and software. One result of this tasking has been development of a collaborative and data-centric systems engineering environment within the team's shared web environment (Microsoft SharePoint).

Through the use of built-in, 'out of the box capabilities' present in MS SharePoint, the CSR Systems Engineering team has created (with some limited developer support) a data-centric architecture for the project's SE implementation, including functional and interface analysis, requirements development and management, risk management, verification planning and management, test results, and end item management. Data elements are linked between data structures so as to define and control relationships between item types, link requirements to parents and children, and link tests to the requirements that they verify.

The overall project team integration is increased by also linking SE content to project management content over the project life cycle, including team communication, action items, configuration management, decisional and meeting materials, and life cycle reviews. This presentation will provide an overview of the collaborative SE environment, showing how it provides the power for a number of SE tasks while still providing the accessibility and transparency to allow the full project team to collaborate and succeed. Given the project phase, we'll be able to present a nearly full lifecycle discussion, from concept through verification and approaching delivery."

Presentations#50

Enabling Agility in Bureaucratic Environments: Lessons from Complexity Leadership Theory and Agile Software Development

Rita Creel (Carnegie Mellon University Software Engineering Institute) - rc@sei.cmu.edu

Presented on: Tuesday, 13:30-14:10

Keywords. agility; bureaucracy; case study; complexity; cybersecurity; leadership; software engineering; systems engineering; #Industry

Abstract. Leadership models conceived in the industrial era have long been applied to large-scale engineering projects (Uhl-Bien, Marion, & McKelvey, 2007). Bridges, skyscrapers, transportation systems, and power distribution systems all originated in an age in which organizations relied on centralized leadership, detailed specifications, top-down plans, and bureaucratic communication and management structures. Although industrial-age leadership may have been adequate to build physical systems with relatively stable requirements, it is unsuitable for today's systems, which increasingly depend on the dynamic capabilities supplied by software (Boehm, 2006). To be competitive, teams that build and operate such systems must be able to rapidly deploy innovative technologies and new capabilities while assuring a level of dependability commensurate with system criticality. Accordingly, software and systems engineering researchers and practitioners have advocated a balance of top-down planning and software development agility, with some identifying a number of leadership characteristics essential for cultivating this balance (Adkins, 2010 - Batra, Xia, VanderMeer, & Dutta, 2010 - Boehm & Turner, 2004 - Highsmith, 2014). However, considerable work remains to mine the leadership body of knowledge and apply it to agility and innovation in the context of engineering of complex, software-reliant systems.
The leadership literature offers numerous concepts that could be explored to advance the understanding of leadership in teams adopting agile development methods or, more generally, transitioning to innovative approaches. Of particular interest, complexity leadership theory encourages local autonomy, emergent leadership, and divergent solutions when appropriate, even, and perhaps especially, within bureaucratic frameworks (Goldstein, Hazy, & Lichtenstein, 2010 - Uhl-Bien et al., 2007). This presentation introduces proposed case study research to investigate the applicability of complexity leadership theory to agile software development teams positioned within larger, bureaucratic organizations. An organization is bureaucratic if it is hierarchically structured, its operations are bound by formal rules, clear division of labor is evident, and decision authority is determined by hierarchical position rather than expertise (Bass, 2008, pp. 303-304 - Uhl- Bien & Marion, 2009, p. 632). A software team is agile if its structure and operations facilitate continuous deployment of software that meets or exceeds customer expectations and if it autonomously adapts team practices and software deliveries to meet evolving needs (Highsmith, 2014). Given the urgent concerns surrounding cybersecurity in software development, the case study will incorporate questions on the integration of security controls and policies in the development environment and their influence on the balance between agility and bureaucratic control (Lanford, 2017).
The presentation will highlight key terms and concepts from complexity leadership theory and agile software development in bureaucratic environments. Next, it will describe functions of complexity leadership to be studied in the context of agile software development in a bureaucratic system and organizational context. The influence of selected cybersecurity risk factors on the balance between agility and bureaucracy will be introduced. The presentation will conclude with questions for case study research and the corresponding methods and analysis techniques to be applied.
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Presentations#44

Enabling Government Ownership of the Technical Baseline Through Model-Based Systems Engineering

Jonathan Kruse (Lockheed Martin Space) - jonathan.kruse@lmco.com
Ed Moshinsky (Lockheed Martin Space) - edward.a.moshinky@lmco.com
Paul Kohl (Lockheed Martin Space) - paul.v.kohl@lmco.com

Presented on: Wednesday, 16:15-16:55

Keywords. MBSE; Ownership of the Technical Baseline; Open System Architecture; Air Force; DOD; #Government

Abstract. After decades of experiencing cost overruns, delays, and sustainability concerns throughout multiple programs, the Government (led by the Air Force) has a new focus on gaining technical knowledge of their systems through an initiative called Ownership of The Technical Baseline (OTTB). The Government wishes to have the ability to perform their own trade studies, conduct their own analyses, and recreate the work of contractors so that they can have full independence for fair and open competition for the operation and sustainment of their systems. To provide the Government with the solutions they desire and save taxpayers' dollars, we desired to develop a digital, data-rich approach for providing the Government with all the technical data required to fully Own the Technical Baseline. Our approach to delivering the customer's requirements and desires was to develop a fully model-based system architecture integrated with the aspects of the conceptualization, analysis and simulation, mechanical design, manufacturing, and sustainment. Our approach captures the system attributes, including architecture definition, physical characteristics, performance, trade studies, and analysis. We developed approaches using SysML and DODAF for developing, capturing, and documenting system trade studies, analyses, and their results so that the customer, and future contractor and customer engineers, will have full visibility and insight to the trade study process in one unified data repository--the System Architecture Model (SAM). Additionally, by integrating analytical models using automated approaches, we have created a vast data archive, linked directly to the SAM, from which the customer can better understand how and why we made the design decisions that we did. Also, we developed methods for utilizing our SAM for analyzing the system for cybersecurity and Open Systems Architecture (OSA). The SAM is also used to fully document the analytical architecture of the system lifecycle and how those analyses tie to requirements and the system design. Our approach resulted in a detailed system architecture model, digitally integrated with external analyses, that captures the design of the system. By fully capturing the architecture, design, and performance of the system in digital models, we are able to deliver the technical baseline to the customer in a method that is easily consumable.?

Presentations#40

Engineering Complex Mission Capabilities through Lead Systems Integration

Warren Vaneman (Naval Postgraduate School) - wvaneman@nps.edu
Ronald Carlson (Naval Postgraduate School) - rrcarlso@nps.edu

Presented on: Tuesday, 14:15-14:55

Keywords. Lead Systems Integrator; Lead Systems Integration; System of Systems; System of Systems Engineering and Integration; #Government

Abstract. Modern complex mission capabilities are fundamentally achieved with multi-mission, highly interoperable system of systems (SoS). The engineering, acquisition, and management of these mission capabilities, across the SoS lifecycle, requires the complex integration of interdependent new and legacy systems from the lowest component level to the highest enterprise level.
Recognizing the challenges of multi-billion-dollar SoS acquisitions, in the mid-1990s, the U.S. government embraced the practice of partnering with industry to effectively develop and integrate these SoS. The term 'Lead System Integrator' became commonplace in large-scale SoS developments within the Department of Defense (DoD). However, after several high-profile SoS acquisition failures, it was evident that a full-scale rebalancing of risks and rewards was needed. In 2008 Congress directed the Secretary of Defense to ensure that the acquisition workforce is of the appropriate size and skills necessary to accomplish inherently governmental functions related to acquisition of major defense systems, and to minimize, and eventually eliminate the use of contractors to perform LSI functions.
Lead Systems Integration is an acquisition strategy that employs a series of methods, practices, and principles to increase the span of both management and engineering acquisition authority and control to acquire a SoS or highly complex systems. LSI is effectively a 'marriage' of program management and multiple functional disciplines which must work together cooperatively to assert and execute trade space in the SoS given multiple constituent system acquisitions. The LSI function is to assert and execute SoS and stakeholder trade space to affordably optimize integrated mission capabilities across the SoS lifecycle. The roles of the LSI are similar to the roles of any systems engineer or system integrator within a program office. The primary difference is the span of LSI design and integration authority that persists throughout the SoS lifecycle.
To successfully plan, develop, and manage a SoS, a comprehensive development, acquisition, and implementation strategy is required. The LSI Enterprise Framework defines a means to engineer and manage the capabilities and interdependencies of a SoS, that can be executed by the government LSI, across multiple systems, programs, and stakeholder levels. The LSI Enterprise Framework captures the complex, interdependent, and mission capability areas through four levels to characterize the systems from the enterprise to the component level.
This presentation defines Lead Systems Integration, introduces the LSI Enterprise Framework, illustrates how it could be used for the engineering management of SoS, and begins to shape the problem to satisfy a set of mission capabilities.

Engineering System Security for a System of Systems Context

Carol Woody (Software Engineering Institute) - cwoody@cert.org

Presented on: Monday, 15:30-16:10

Keywords. System security; System of system security; Engineered in security; Designed in security; #RisksComplex

Abstract. When systems were stand-alone with well-defined boundaries, security involved making sure unauthorized access was not allowed. Now with systems composed of widely distributed software and hardware components connected using various communication mechanisms, security involves a combination of how well the components limit access to authorized resources and how well the components manage connectivity and information sharing among themselves to ensure trust relationships are properly established and supported. Security can no longer be relegated to gateway devices such as firewalls and routers. The security of a system becomes an emergent property of how well the various components are selected and engineered to work together to maintain the confidentiality, integrity, and availability of shared data and services. The operational context in which technology is fielded is an emerging risk environment. Growing inter-connectivity and accessibility among systems, cyber-physical devices, organizations, and technology services is creating a vast data-rich environment. Organizations and individuals are assembling vast repositories of information and positioning them for broad access. The investment in technology is far outpacing our current knowledge levels and impacting our ability to management its use. New devices are appearing in the market place that capitalize on connectivity and access to data that improve utility and address an increasing array of individual and organizational needs. Everything we do these days increasingly involves system and software technology: cars, planes, banks, restaurants, stores, telephones, appliances, and entertainment. Many new devices are coming from the consumer market, but these devices are seeping into broad organizational use. There is also growth in devices that operate with autonomy. At the same time malicious elements are moving into these same environments to capitalize on access to data and opportunities to leverage these emerging capabilities for malicious intent. The same tools used for protection are also available to those with malicious intent. The new kinds of technology that were built to be quickly marketed, low in cost, easy to install, limited in functionality, and, in many cases, devoid of even basic authentication and authorization capabilities. To function effectively in this emerging environment we must be able to comprehend and model the complex inter-relationships and influences of technologies, processes, and organizations in use.

Presentations#53

Framework for addressing Human-Machine Teaming in Agile Design

Patricia Mcdermott (MITRE) - pmcdermott@mitre.org
Cindy Dominguez (MITRE) - cdominguez@mitre.org

Presented on: Tuesday, 16:15-16:55

Keywords. Human-machine teaming; agile design; autonomy; automation; observability; trust ; #Industry

Abstract. Complex systems, from so-called “self-driving cars” to swarms of unmanned aerial systems, are being developed with more automation and autonomy. Advances in technology and in particular, machine learning, have enabled systems to take over an increasing array of functions from command and control to navigation. The problem is that humans can find these systems to be cumbersome and untrustworthy, causing them to be ignored or the automation to be disabled. To address this problem, researchers mined guidance from the human-machine teaming literature to bridge the gap between research and practice. The result is a framework that describes ten design themes for successfully implementing human-machine teaming in complex systems.

The presentation will focus on explaining the ten design themes and how they are interrelated. In addition, the authors will describe a methodology for applying the framework in an agile design process to create tailored user stories.

The ten themes are organized into four pillars. The first pillar of Transparency contains themes that stress the importance of the human being able to understand the autonomy. The autonomy should be observable (allowing the human to see “under the hood” to perceive assumptions behind recommendations and ascertain what the autonomous partner is doing relative to task progress) and predicable (so its future intentions and activities clear and do not surprise the human). The second pillar of Amplify Abilities highlights themes in which the combination of human and automation capabilities is greater than the sum of its parts, resulting in better situation understanding and problem solving. To this end, autonomy should direct attention (to critical problem features and cues), help humans explore solutions (by leveraging multiple views, knowledge, and solutions to jointly understand options and implications), and be adaptable (by recognizing and adjusting fluidly to unexpected situations). The third pillar of Coordination addresses how humans and automation interact. The automation must be directable (so the human can direct and redirect the automated partner’s resources, activities, and priorities), it should help the humans develop calibrated trust in the autonomy (so the human understands when and how much to trust the automated partner), and it should foster common ground (so that pertinent beliefs, assumptions and intentions are shared. These first three pillars address Design Content, or how human-automation interaction is operationalized in a specific system.

The fourth pillar addresses the General Design and has invariant themes that do not alter for different systems. Information Presentation describes how data should be formatted to support understandability and simplicity in autonomous systems. Design Process has guidance on the systems engineering processes applicable to human-machine teaming.

Each theme will be described in more detail including critical aspects of the concept and examples of how the theme has been successfully or unsuccessfully implemented in a system. These case studies bring the theme to life and allow the audience to better recognize the theme in other systems and projects on which they are working. For example, for the theme of Observability, the presentation will describe what needs to be observable (e.g., goals, progress, past performance, algorithms, explanation for degraded performance), why observability is important, and advice on how to make information observable (e.g., information on actions and intentions must be salient enough to draw attention and informative enough to enable effective intervention). The case study will describe the Auto-GCAS, a ground collision avoidance system for the F-16 platform that was developed by the Air Force. Auto-GCAS was designed to prevent controlled flight into terrain, the number one killer of pilots. Pilots’ trust of the system is critical because the pilots have the option to turn the automation off. The system exemplifies good observability - chevrons on the screen move toward each other as the system is about to activate. When the chevrons touch, the system maneuvers to prevent a crash. The Auto-GCAS system has saved four lives so far.

Understanding this human-machine teaming framework can help engineers design more effective systems. Successful human-machine teaming allows complex systems to go beyond decision aiding to achieve true partnership in which the joint performance of human and machine is greater than either alone.

Presentations#45

Mash-up Rubric - Strategies for Integrating Emerging Technologies to Address Dynamic Requirements

Scott Lucero (ODASD(SE)) - don.s.lucero.civ@mail.mil

Presented on: Wednesday, 10:45-11:25

Keywords. research; integration methods; requirements changes; emerging technologies; #Industry

Abstract. The nature of systems is changing, and these systems are having an impact on everyday life. From increasingly autonomous vehicles, algorithmic trading, and real-time assimilation of big data, innovative technologies such as artificial intelligence, metamaterials and advanced photonics and are working their way into defense systems, and are challenging the traditional practice of systems engineering. This talk introduces a rubric for selecting different acquisition approaches based on our confidence in today's requirements and how they will evolve, and our ability to respond to those requirements. As systems move from merely satisfying requirements to constant experimentation, from static to dynamic and continuous certification, from automated to learning systems, from hierarchical to layered architectures, this rubric can help systems engineers keep pace with the dynamic nature of today's systems.

Measuring Belonging in A System of Systems to Influence Architectural Decisions

Clifton Baldwin (US Federal Aviation Administration) - cliftonbaldwin@gmail.com
Wilson Felder (Stevens Institute of Technology) - wilson.felder@stevens.edu

Presented on: Thursday, 08:45-09:25

Keywords. System-of-Systems; System-of-Systems Engineering; System Architecture

Abstract. While an organization may have some proprietary data obtained from their own system of systems (SoS), quantitative metrics for these types of systems are not readily available to study. However, not all SoS are human-designed and owned. If we look outside of the traditional scope of engineered systems, we can find much data related to SoS. To obtain unadulterated metrics, we explored a target SoS consisting of migrating waterfowl flock.
Other studies have researched the characteristics unique to SoS. While there is no convergence for what these attributes are called, there appears to be a common set. SoS are systems as a whole as well as each of their constituent systems. These constituent systems have some connectivity that allows the sharing of information dynamically. Furthermore, each system brings a diversity of features in that each system may have its own goals and the constituent systems collaborate in such a way to contribute to the SoS goal as well as their own. In previous studies we used the term Belonging to refer to this collaboration on goals and proposed a mathematical framework derived from first principles to describe the characteristics. Applying the SoS characteristics mathematically, an agent based model simulates the formation and evolution of the SoS over time, including the aerodynamic benefit transferred among flock members. Unlike the often sensitive data associated with engineered SoS, we validated the model against the ornithological literature. Using our model, we measure the beneficial interaction of systems within the simulated SoS, in other words the Belonging of the systems.
Our approach demonstrates the overall SoS goal emerges organically from the transfer of drag reduction benefits among flock members, which is computed applying the Breguet range equation to the mathematical framework of SoS characteristics. In accordance with a SoS, the benefits accrue to each individual member system as well as to the collective. The area of most interest to the systems engineer may be the degree to which Belonging benefits the whole varies depending on initial choices made regarding the architecture of the system-of-systems.
This presentation will discuss our current results from applying the mathematical framework to our chosen exemplar SoS via the agent based model and simulation. These results include a Belonging matrix, which records how the systems as well as the collective benefited from the architecture. A secondary result is a graphical depiction of the flock formed. While we were able to validate the flock formations, we are currently working on finding a machine learning procedure to assign some numeric value to the formation and add another quantitative metric. After running hundreds of simulations, we can show different flock formation, i.e. SoS architectures. Each run has its own quantitative belonging results. We argue these results can inform the design of engineered systems using identical analytical techniques.

Presentations#36

Model-Based Systems Engineering for Electronic Voting System Security

Dirk Zwemer (Intercax LLC) - dirk.zwemer@intercax.com

Presented on: Monday, 16:15-16:55

Keywords. MBSE; elections; cybersecurity; electronic voting systems; #RisksComplex

Abstract. Electronic voting system (EVS) security has been a major source of anxiety at both the national and local level, intensified by efforts of foreign actors to compromise those systems. Beyond the usual concern for vote manipulation, vote invalidation and denial of service can have equally grave effects. EVS comprises a System-of-Systems, ranging from state-level voter databases to individual voting machines, so the best technology and practices of Model-Based Systems Engineering (MBSE) are required.

In this small case study, we will apply MBSE to identifying EVS vulnerabilities by demonstrating integration of system architecture, FMEA (failure mode effect analysis) and project management models. This provides a systematic approach for tracing system features to failure modes to progress in implementing mitigation measures, even for systems of large scope and high complexity.

This requires a federated set of tools and models, which will include

1. A system architecture model of requirements, structure and behavior captured in SysML
2. Support of a classic FMEA process via a specialized SysML profile
3. An issue tracking system managing status, schedule, assigned personnel and resolution of failure mode elimination or reduction
4. A model integration platform that manages the SysML-issue tracking connections

In our case study, we will focus on the vulnerabilities in information exchange rather than voting machine hardware or software. These exchanges can be modeled efficiently in SysML sequence diagrams. As an example, the figure below covers voters casting their ballots, one part of the voting process that also includes set-up, testing, vote aggregation and breakdown. Modeling the EVS behavior as a whole insures that all possible avenues of intervention are considered.

Each message in the sequence diagram is subject to one or more potential failure modes. Each failure mode is connected to a mitigation task in the project management domain. By connecting messages and failure modes directly to the relevant tasks, progress to a complete solution can be efficiently monitored by developers and project managers.

This case study will feature implementation in practice with commercially available software tools. Further potential integrations with requirements management, CAD, software configuration repositories and simulation will also be considered.

Presentations#7

Preparing for the era of Autonomous Systems that Do No Harm

Jack Ring (Educe LLC) - jring7@gmail.com
William Miller (Stevens Institute of Technology) - wdmiller220@gmail.com

Presented on: Wednesday, 10:00-10:40

Keywords. Autonomous systems; Do No Harm; General Semantics; Non-deterministic situations; #Industry

Abstract. This presentation will highlight the challenge of SE'ing autonomous systems that help stakeholders cope with non-deterministic situations. The challenge is to initialize the right degree of autonomy for success in situations that rank high in Extent, Variety, and Ambiguity while also ensuring the system will Do No Harm. Success in the non-deterministic game ensures stakeholders will Win or Draw but Not Lose.
The purpose of this session is to initiate a dialog that clarifies the challenge and discovers the impediments that the next generation of systems practitioners must become capable of overcoming. The session will not sell preconceived designs. It will provoke new concepts and perspectives thereby broadening participation and learning by all INCOSE members.
Current INCOSE standards, handbooks, curricula and practices are not currently resulting in fault-free operational systems and are already indicating an inability to cope with the emerging wave of autonomous systems. Although the current focus on transforming to MBSE will cope with complexity it will not pursue the kind of SE that can initialize an autonomous system that will Do No Harm.
We will acknowledge many kinds of systems such as C5ISR, Critical Infrastructures, Manufacturing Automation, Intelligent Enterprises and a system of Laws and Legislation. We will present a Fit For Purpose metric for both deployed systems and the sociotechnical systems that initializes deployed systems. We will highlight why current and intended SE practices are inadequate and suggest general objectives for a kind of 'SE That Learns' to guarantee stakeholders will Win or Draw but Not Lose. We will suggest ways of foreseeing the kinds of harm and ensuring autonomous systems will Do No Harm.
A presentation at the San Diego Chapter Mini Conference, 12/2/17, addressed four current inadequacies, notably, 1. Requirements Management, 2. Risk Management, 3. TEVV, and 4. The concept of Cyberspace, and outlined respective possible therapies. The presentation was very positively received by a small but senior audience.
This proposed presentation will address those four inadequacies along with four more, notably, 5. Ways of specifying and assessing 'harm' (for example but not limited to 'Ethically Aligned Design, Version 2' http://standards.ieee.org/develop/indconn/ec/autonomous_systems.html).
6. Sustaining a Digital Twin as a System Management workbench for ensuring that deployed, incomprehensible SoS's are perpetually Fit For Purpose.
7. A System Modeling language composed of ontologically precise, executable objects thereby emulating rather than simulating anticipated behaviors, capabilities and effects on context, and
8. Ensuring viable sociotechnical system autonomy by heeding the Starkermann limits. www.starkermann.com.
The presentation will conclude by advising the audience how to participate in the on-going, on-line medium that facilitates a poll of the presentation audience and fosters an on-going dialog. Further, an INCOSE webinar will invite all INCOSE Chapters to dialog. The envisioned dialog will lead to an INCOSE-wide poll to a) gauge the expected efficacy of the ideas presented and b) solicit other concepts for next era SE practices and proficiencies.
We anticipate the initial dialog will span one year with findings available at IW19 and recommendations at IS19. Follow-on dialog prompts may evolve to be exercised beyond INCOSE.

Presentations#21

STIEM: Towards Faster Design, Integration, and Execution of Inference Models

Shou Matsumoto (George Mason University) - smatsum2@masonlive.gmu.edu
Edward Huang (George Mason University) - chuang10@gmu.edu
Kathryn Laskey (George Mason University) - klaskey@gmu.edu

Presented on: Monday, 14:15-14:55

Keywords. Multi-Modeling; Inference Enterprise; Model-Based Systems Engineering; Insider Threat Detection; #RisksComplex

Abstract. Often, complex problems cannot be solved by employing a single analytical model or method. Rather, they require a combination of several such methods supplementing or complementing each other. Process and technical tools are needed to streamline and support what has traditionally been a cumbersome and error-prone manual integration process.
The term ‘Inference Enterprise’ is used to refer to the collection of data, tools, and algorithms that an organization employs to address some inference task. We view Inference Enterprises as involving both manual and automated processes, but we are specifically concerned with the automated portion of it. Nevertheless, models will necessarily include interfaces to human systems, and its performance can be characterized by assumptions and parameters inherent or resulting from activities performed by humans. This vision of an Inference Enterprise requires the ability to integrate multiple data representations and multiple formalisms (models) for inference, all linked together in an underlying Business Process Model or workflow.
To address the multi-modeling challenge of Inference Enterprise, we have developed ‘Semantic Testbed for Inference Enterprise Modeling (STIEM)’, a model-based systems engineering framework and tool—built on top of Phoenix Integration ModelCenter®—for design, integration and orchestration of software-based inference models. STIEM provides a central controller to coordinate exchange of information and control of software components. STIEM offers standardized interfaces for semantic and syntactic interoperation among multiple models executing as parts of a workflow. It also offers several built-in tools, provided as part of the ModelCenter® platform, for quick prototyping and sensitivity analyses. The STIEM approach is useful to a broad set of areas that involve multiple analysis models—examples include defense/national security, homeland security, intelligence analysis, and information security. Capabilities we present are applicable for designing, integrating and executing/orchestrating any set of software components with distinct and visible input and output interfaces (e.g. input/output files).
Our focused application is to insider threats, specifically to estimating the connections between the number of insiders of concern and the number or alerts issued by insider threat detection systems flagging potentially problematic insider behaviors. We use STIEM to represent information, tools, algorithms, and methods to create an analysis workflow, and to evaluate the enterprise’s performance for insider threat detection. Our contributions to systems engineering area can be summarized as follows:
(I) We developed a case study and application of inference enterprise multi-modeling to the insider threat domain, specifically to estimating how well system alerts based on insider behaviors perform at identifying insiders of true concern. Workflows and software assets are managed in STIEM to represent and simulate an inference enterprise and to perform analyses under different assumptions and scenarios.
(II) We developed a repository of reusable software assets/components for statistical simulation to reconstruct population data from summary statistics. These can be brought together as needed as components in a model workflow. This provides a systematic way of reverse engineering data from statistical information about such data. We also developed a wide range of machine-learning and inference components, including models based on Neural Networks, Decision Trees, Naive Bayes Models, Random Forests, Hidden Markov Models, and Support Vector Machines. We show that STIEM is suitable for quickly producing solutions by modeling a workflow of components available in such a pre-populated repository.
(III) We developed a method for quickly adding new components into STIEM’s repository, by automatically generating wrappers (aka adapters) that translate software interfaces to a format compatible with STIEM, and consequently compatible with ModelCenter®.
(IV) We offer a simple method which enables platform-independent parallel execution and asynchronous calls of components in a workflow. Parallel execution enables flexible and efficient usage of computational resources, and asynchronous execution/call address large overheads associated with data synchronization and monitoring of long-running components.
Our presentation will address Inference Enterprises, STIEM, and related technical achievements in the perspective of systems design, integration, execution, and analysis. The focus is on system level engineering and integration. Therefore,

technical details of the machine learning and simulation components are omitted.
As a future work, our research team is developing an advanced insider threat domain ontology and a model workflow language to support partial automation and rapid development of new model workflows when new inference problems are encountered.

Presentations#14

System Design Impact on Uncertainty within Automotive Driver Assistance Systems

Dariusz Cieslar (Aptiv) - dariusz.cieslar@aptiv.com
Pawel Skruch (Aptiv) - pawel.skruch@aptiv.com

Keywords. Driver Assistance; Automated Driving; System Design; Uncertainty; Automotive

Abstract. Appropriate warning and automatic intervention by Advanced Driver Assistance Systems (ADAS) in critical conditions can lead to avoidance or a significant reduction of accident severity. Unnecessary interventions can have negative impact on driver's comfort and trust in technology. A binary decision whether to intervene or not has to be taken by a system that relies on uncertain data. Automotive perception systems determine the state of the host vehicle, traffic situation and driver attention by filtering raw measurement that can be characterized by processes with random components. The chain of processing involves several interconnected stages. Design of system architecture and behavior plays an important role in controlled propagation of uncertainty through the system. It is claimed that statistical consistency of interfaces shall be maintained as a principle. Apart from multiple possible definitions of consistency, any heuristics in processing nodes poses a major challenge to ensuring such characteristics. In addition, each time delay and coordinate transformation inflates the uncertainties, while each processing node should be exploited to reduce them.
The consideration of generic features of such systems is conducted using real-world examples from various system development stages. Samples of measurements by automotive radars intended for series production are displayed to illustrate the scope of uncertainty in raw measurements. Results of object estimation are also shown to better support the main claim of the presentation: within uncertain system both nominal values and uncertainty estimates are of primary importance and should be considered during system design.

Presentations#47

Systems Engineering and Society: SE Needs Recognition from the General Public to Become Universally Appreciated

Stephen Sutton (Retired) - sjsutton.243@comcast.net

Presented on: Monday, 13:30-14:10

Keywords. public policy; societal issues; SE Vision 2020; #Government

Abstract. INCOSE celebrates its 28th anniversary in 2018. Systems Engineering, a relatively young profession, grows in importance with more undergraduate and graduate degree programs and undergraduate degree programs incorporating systems engineering topics. The world grows more 'complex' and 'smaller' thanks to technology and addresses very serious issues that affect the affluent and indigent, the democracy and the dictatorship, the religious and the non-observant, the isolationist and the internationalist - all aspects of and people in our global society. Issues such as clean water and air, changing climate, proliferation of weapons of mass destruction and cyber weapons, threats from space weather, healthcare, spread of deadly disease, available and renewable energy, affordable transportation, migrating displaced populations, and a safe and plentiful food supply.

Isn't it time for systems engineering get its due as a discipline that can help society with these difficult issues? The INCOSE Systems Engineering Vision 2025 offers us insights on the benefits of systems engineering to society. But society needs to appreciate and understand these benefits. INCOSE can provide that by influencing systems engineering education and demonstrating to the public how it benefits from systems engineering. Getting recognition and appreciation from the general public can lead to recognition and appreciation from government policy makers at all levels of government.

This presentation describes a role for systems engineers and the systems engineering discipline to aid public policy and decision makers, and proposes how INCOSE can become more known and appreciated as the ambassador for systems engineering to support objective public policy decision making. The author will provide examples based on federal, state, and local policy issues discussed in the general media.

Systems of Systems: An Application for Systems Engineering or the Systems Engineering of the Future?

Judith Dahmann (The MITRE Corporation) - jdahmann@mitre.org

Presented on: Thursday, 08:00-08:40

Keywords. system of systems; systems of systems; modularity; MOSA

Abstract. Ever since the subject of systems of systems (SoS) was first addressed in the 1980s, there has been a continuing dialog over the differences between systems and SoS and their implications for systems engineering of SoS. Mark Maier's characterization of SoS has been a cornerstone of these discussions; notably his operational and managerial independence of systems comprising an SoS as the defining features of SoS and drivers for systems engineering them. There is growing interest and work surrounding the characterization of SoS, how it affects the application of systems engineering principles and practices to SoS and how it differs from 'traditional' systems engineering.

At the same time, the emerging consensus within the community on the characterization, principles, and practices of SoS engineering (SoSE) are contributing to other changes. The community has recognized that rarely, if ever, is a system built and deployed that does not interact with other systems. Increasingly, systems are getting more intelligent – with the result that they are networked into a larger control system or applied in conjunction with other systems to provide an operational capability. As a consequence, more attention is being given to SoS considerations when engineering new systems, including the development of draft ISO/IEEE standard 21839 codifying these considerations to enable systems engineers to more readily develop systems in an SoS context. This standard sets the context for viewing new systems as 'components' of larger systems or, in SoS terms, as constituents of a system of systems.

Additionally, there is increased emphasis on the use of open standards and modularity to facilitate integration of 'off the shelf components' or interfaces into available services as a core approach to system design. Few, if any, software systems today are built as a greenfield, standalone new-development capabilities. Instead, they often integrate commercial or open source products, developed for different purposes or for use in other systems, into the system to achieve new capabilities. As this trend continues, these 'systems,' based in part on components built and evolved independently from the new system, begin to take on the characteristics of an SoS.

The result is that these systems pose a number of the same challenges facing systems engineering of SoS, as the owners of the constituent components make changes to meet the needs of a broader or different user base but which may not take into consideration the needs of the system in question. As these trends continue and SoS concepts become part of the broader approach to engineering systems, what does this mean for the distinguishing features of systems of systems engineering?

Presentations#23

The Changing Role of Systems Engineers in the United States Department of Defense (DoD)

Karl Geist (INCOSE) - kcgeist@gmail.com

Presented on: Tuesday, 13:30-14:10

Keywords. SE Changing Role; DoD Employment; Required Skills; #Government

Abstract. This presentation is intended to provide an overview and insight on how the role of Systems Engineers has and is changing in DoD. It compares what Systems Engineers' responsibilities were over the past forty years in DoD as Government Engineer to what Systems Engineers' responsibilities are now as requested by the Government in its Request for Proposals (RFPs). This will be accomplished by comparing tasking and required skills one needed to perform as a Government Systems Engineer to the tasking and required skills one needs to perform as a Government Contracted Systems Engineer in RFPs today. This will show the evolution of my career developing as a Systems Engineer as a background and then outline my Contractor career to compare similarities and differences. Also, the presentation will analyze expected required skills in a changing environment for Government Contracted Systems Engineers, make observations of various requirements, and attempt to determine conclusion from the data.

The Evolving Role of Stakeholders: From Users To Co-Designers

Robert McMahon (INCOSE) - robert.r.mcmahon@gmail.com

Presented on: Monday, 14:15-14:55

Keywords. participatory engineering; stakeholder engagement; co-design; sustainability; #Government

Abstract. As engineers become increasingly involved in designing solutions to complex societal needs, stakeholder engagement is a crucial ingredient for ensuring sustainable outcomes. Engineered systems that have a direct impact on people's daily lives, such as transportation infrastructure, communication networks, health informatics, or smart cities, run the risk of public rejection if they fail to take into account the perspectives of all affected parties. As INCOSE's Systems Engineering Vision 2025 points out, decisions in public policy are frequently made without applying a systems approach to elicit the full range of stakeholder needs and understand the consequences of potential policy options on those stakeholders. Moreover, the public is even more likely to reject a solution if they perceive that it is being imposed on them in a top-down fashion, without their active participation in the decision-making process. Broad-based protest movements have often been sparked by a perceived lack of control over government actions, whether on the right side of the political spectrum (such as the Tea Party movement) or on the left side (such as the Occupy movement). The discipline of systems engineering, with its emphasis on stakeholder engagement, is uniquely positioned to address this situation. Just as the concept of 'participatory democracy' was developed to advocate for the active participation of citizens in planning the political policies that affect them, there is growing interest in a 'participatory engineering' process by which citizens actively participate in identifying the human and societal needs of their local environment, and then collaborate with engineers as co-designers to develop appropriate, sustainable, and socially acceptable solutions.

Public officials began to address these issues several decades ago, recognizing that top-down government programs devised without sufficient community involvement were failing to work out as designed. In his 1967 book 'To Seek a Newer World', US Senator Robert Kennedy surveyed the history of urban renewal projects and pointed out that homeowners had rarely been asked what they thought about plans that included the demolition of their houses. To correct this, he and other government leaders created the nation's first community development corporation, in the Bedford Stuyvesant neighborhood of Brooklyn, NY, for which residents of the affected neighborhood were included on the board of directors. As Kennedy wrote about this innovative new initiative, the planning process not only involved the community, the ideas themselves grew out of the community. From a systems engineering perspective, we would recognize this as an example of engaging the relevant stakeholders in characterizing the problems and helping to develop the set of potential solutions.

The engineering community has also been addressing these issues across a variety of domains. For example, the Oresund Bridge/Tunnel connecting Copenhagen, Denmark and Malmo, Sweden is an award-winning example of diverse stakeholder involvement early in the concept stage, and is included as a case study in the INCOSE Systems Engineering Handbook. The National Science Foundation funded research in Haiti following the 2010 earthquake, in which a team from Drexel University in Philadelphia, PA investigated recovery efforts and compared the outcomes of stakeholder-based participatory processes against those of traditional top-down planning processes. The Built Environment & Sustainable Technologies (BEST) Research Institute in Liverpool, UK has published studies on the importance of stakeholder engagement in achieving sustainability in the construction sector. These case studies provide valuable lessons learned from real-world applications and illustrate the value of participatory engineering.

Key to the success of this type of participatory engineering is direct contact with the stakeholders. Systems engineers frequently rely on proxies, such as regulatory agencies or government representatives, to stand in for the actual stakeholders, but such an approach may inadvertently omit nuances of the local experience base while reducing the affected individuals' feeling of commitment to the project. Furthermore, every effort must be made to engage members of the affected community at times and places that accommodate their personal schedules, rather than merely holding a pro forma public hearing in the middle of a workday. This can be accomplished through scheduling multiple meetings during evenings and weekends at easily accessible and well-known community meeting halls, or even by conducting door-to-door canvassing on weekends, to supplement e-participation and maximize the active participation rate.

The Importance of Psychology in Systems Engineering

Sathya Venkatasubramanian (StarsHR) - vsvagheeswar@gmail.com

Presented on: Tuesday, 15:30-16:10

Keywords. Psychology; Breakthrough; Orbit; Shifting; Innovation

Abstract. A system is typically defined as a construct or a collection of different elements that together produce results not obtainable by the elements alone. In other words, combined effect of the sum is greater than the individual effect of the parts. Systems Engineering (SE) is a vehicle that enables the creation and execution of an interdisciplinary process to ensure that the customer and stakeholder's needs are satisfied in a high quality, trustworthy, cost efficient and schedule compliant manner throughout a system's entire life cycle.
According to a classical definition, systems engineering is 'an interdisciplinary and iterative approach to transforming users' needs into a system architecture and design that results in an effective operational system. That is more 'engineering' talk than 'systems' talk!
With the experience of driving breakthrough innovation across multiple industry segments, I am 'seeing' a few flaws in this approach.
This presentation brings forth considerations that successful systems engineering outcomes are a result of powerful psychological considerations and practices that pave the way for engineering success and therefore commercial value.
Below are some topics from the SE framework as it exists today and my proposals to alter how we can look at the framework with the mindset of breakthrough thinking.
>> SE outcome is entirely dependent on what is gathered as the users' needs.
- Who identifies what these needs are?
- Is it possible for the customer to mis-identify a need?
- Are we merely listening to what the customer is saying, or are we sensing what the customer is experiencing?
>> Choice of problem and the ability to state is succinctly is important
- Successful outcomes are guaranteed not by the choice of answers, but by the choice of the question.
- Choosing the problem is a matter of choice and successful problem solvers are motivated to go after a compelling purpose first, and picking the best problem that when solved will help them achieve that purpose.
- In fact, why does it always have to remain a problem? Why can't there be an opportunity - where one does not see a problem, at least not yet?
>> SE outcome is not guaranteed without re-evaluation.
- The recommendation to constantly re-evaluate and make course corrections is an effort at continuous improvement, meant to reduce the chances of making a mistake, leading to an intolerance towards risk-taking and consequently the incorporation of an organization that is tuned for continuous improvement as opposed to continuous transformation.
>> Successful organizations that are geared towards making history needs to find the right balance for how much effort is spent on continuous transformation (CT) as well as continuous improvement (CI). In fact, CI is an essential part of CT. However, a lot of today's businesses appear to consider that CI is almost the sole reason for their existence!
The presentation will aim to cover the aspects of how a change in thinking can help Systems Engineers get better at what they solve, how they solve and with what they solve it with, highlighting the importance of psychological considerations and thinking ability.

Presentations#32

Using Systems Engineering Workshops and MBSE to drive agile development

Harry Koehnemann (321 Gang) - harry@321gang.com
Mark Coats (General Dynamics) - mark.coats@gd-ms.com

Presented on: Tuesday, 15:30-16:10

Keywords. MBSE; Agile; Lean; Lean-Startup; #Industry

Abstract. In agile development, backlogs drive the work teams perform. In order to make System Engineering relevant in agile contexts, their efforts must continually influence and guide the work in those backlogs. In this presentation, we discuss a collaborative method that puts traditional MBSE practices into an agile context. The method is built around the Systems Engineering Workshop which creates engineering specifications in a face-to-face, collaborative environment. Workshops support all system activities including requirements, analysis, design, and eventually driving the implementation work in backlogs. Workshops are held continually throughout the development process. With this approach, the system specifications evolve along with the system, creating a runway of decisions that drive a solution's roadmap and backlog. As teams implement those decisions, they provide fast feedback for discussions in future workshops.

This approach adopts many lean and agile practices into systems engineering activities. Frequent workshops reduce the batch size of systems engineering efforts and focus them on near-term decisions. Continuous workshops allow SEs defer longer-term decisions and reduce the work-in-process (WIP). Smaller batches and lower WIP allow faster feedback on decisions and more opportunities to learn and adapt. And finally, workshops are a face-to-face collaborate effort supporting agile's 'best form of communication' principle.

Since workshops continually evolve specifications, we advocate representing specifications with models, SysML for system level and then domain-specific for disciplines (ecad, mcad, software, database, etc.). Models are much easier to change than documents. And we leverage the standard MBSE system engineering process - Use Cases define context, Activity Diagrams detail the behavior, Sequence Diagrams realize the behavior as a series of interactions, and block diagrams and interfaces define the system's components.

While straightforward, the community provides little guidance transitioning from Use Case/Activity models of a system's behavior to Sequences which detail the collaborations of a smaller thread through the system. We advocate applying Lean Startup guidance to validation assumptions early and prioritize the work to validate those assumptions using Don Reinertsen's Cost of Delay models. Systems are filled with hypotheses to be validated. We use sequences to define the minimum viable product (MVP) to validate an assumption early. Sequences are derived from the Activities, but focus on a MVP to validate some assumption. And these sequences become the Features or Epics that drive the backlogs.

We have seen many benefits to applying agile workshops to a systems engineering context. They promote constant focus on system usage, expose issues early, and enable engineering decisions through collaboration among domain experts. This creates a shared understanding of system structure, behavior, and information that is accessible via the model. All agile planning and backlogs are informed by the system model. Workshops and model also provide an excellent vehicle to manage change requests and engage with customers.

Invited Presentations

… is everything a system of systems and does it matter?

Judith Dahmann (The MITRE Corporation) - jdahmann@mitre.org
Alan Harding (BAE Systems) - alan.d.harding@baesystems.com

Presented on: Monday, 14:15-14:55

Keywords. #TechOps; #SoS

Abstract. Our world is increasingly joined-up – our phones are smart connected devices, retailers understand and can predict our shopping patterns, and governments use a wide range of information to keep us safe and secure. Systems of systems engineering is a maturing aspect of systems engineering that is becoming increasingly prevalent. This session will explore some topical examples, whether they qualify as systems of systems and “so what?” and will highlight what INCOSE is doing in this important area.

Embedded Control of Medical Devices: Trust, But Verify

Chris Unger (GE Healthcare) - Christopher.Unger@med.ge.com
Bill Schindel (ICTT System Sciences) - schindel@ictt.com
Marc Horner (ANSYS, Inc.)

Presented on: Monday, 13:30-14:10

Keywords. #Industry; #TechOps; #Healthcare

Abstract. The Healthcare Working Group has analyzed the industry stakeholders and has identified three primary stakeholder groups: Medical Technology (OEMs for devices and services), Healthcare Delivery, and Healthcare Systems Education. There are focused workstreams for each, and a quick summary of our approach will be given. In the area of Healthcare MedTech, we have formed a User Advisory Board (UAB) and have held four annual conferences on the state of Agile SE and general SE best practices. The UAB has identified MBSE as one of the areas where INCOSE can help.

Empowering Women Leadership Forum: "Embracing Systems Engineering Leadership Diversity"

Alice Squires - alice.squires@wsu.edu

Presented on: Saturday, 08:00-16:45

Keywords. EWLSE

Abstract. Please plan to attend the Empower Women Leadership Forum: Embracing Systems Engineering Leadership Diversity to hear from leaders in the systems engineering field including Kristen Baldwin, Victoria Cox, David Long, and Bill Parkins. The Forum will kick off at 8:00 am in the morning with introduction and keynotes, with a networking break from 9:30 – 10:00am, and then a “Leadership Journey” panel from 10:00 am to noon where the panelists will talk about their leadership style, what works, what has been challenging, and provide some anecdotal examples that have been turning points in their leadership journey, and more. After lunch, the forum will pick back up at 1:30pm with a professionally led hands-on interactive workshop for the attendees for the afternoon with a short networking break from 3:00 – 3:30pm. The forum ends about 4:45pm to allow time for setting up for the 5:00 – 6:00pm Empowering Women Reception - forum attendees are invited and can expect attendance from many INCOSE leaders at this informal networking reception. We hope to see you there!
Please send an email to ewlse@incose.org to let us know you will be attending the Leadership Forum and / or the Reception, “last minute” attendees are also welcome.

MBSE Lightning Round

Presented on: Saturday, 13:30-17:00

Keywords. Inspire MBSE; #MBSE

Abstract. 13:30 Introduction

13:45 Evolving MBSE to enable the digital future | David Long
14:05 Changing the world with models | Troy Peterson
14:25 Seven Reasons to trust/distrust models | Donna Rhodes
14:45 ROI Stories from the edge of MBSE | Mark Sampson

15:05 Break

15:20 Autonomous Vehicle development using MBSE | Chris Davey
15:40 MBSE'ing Diapers | Bob Sherman
16:00 Using models to develop students | Ricardo Valerdi
16:20 Manufacturing Software with models | Stephen Mellor

16:50 Panel/Forum
17:10 Closing

Writing Excellent Requirements using the INCOSE Guide to Writing Requirements

Lou Wheatcraft (Requirements Experts/Seilevel) - louw@reqexperts.com
Mike Ryan (UNSW Canberra) - M.Ryan@adfa.edu.au

Presented on: Monday, 16:15-16:55

Keywords. #SEFundementals; #TechOps; #Requirements

Abstract. Would you classify your requirements as “Excellent” or just mediocre? Fundamentally, requirements are the language we use to communicate stakeholder needs to the development team. Many projects have serious problems due to poor communication of the requirements resulting in major cost and schedule impacts as well as systems that often don’t meet the stakeholder needs. To address these communication issues and associated risks, it is imperative requirements and sets of requirements are well-formed – or you could say the requirements developed are “Excellent”! This presentation provides an overview of the INCOSE Guide to Writing Requirements, one of INCOSE’s premier products. The Guide focuses on the characteristics that must be possessed by well-formed requirement statements and sets of requirements and a set of rules for writing requirement statements that, if followed, will result in the requirements having these characteristics. The guide also includes a set of attributes that can be included with the requirement statements to form a complete requirement expression. Finally, the guide addresses the concept of boilerplate, template, or patterns for a requirement statements. Using the information in the Guide will help you to write an excellent set of requirements.