PPI SyEN

SYSTEMS ENGINEERING NEWSJOURNAL EDITION 115 | AUG 2022

Continuous Learning Opportunities Abound

MORE MUSINGS ON EMERGENCE
Follow-up questions from the INCOSE IS

SYSTEMS ENGINEERING RESOURCES
Improve your SE effectiveness

SYSTEMS ENGINEERING IN SOCIETY
Expanding applications of SE globally

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PPI SyEN

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WELCOME

Dear readers,

Welcome to another edition of PPI SyEN. As 2022 rolls on and we approach the last quarter of this year, it's a great time to reflect on our personal and professional goals and correct our sails to align our efforts with our objectives. In line with this, this edition is dedicated to the continuous, life-long learner as this edition of PPI SyEN contains abundant opportunities to learn throughout.

In the spirit of reflection and course direction, INCOSE has released its mid-year impact statement. Find out more about INCOSE's mid-year review in Systems Engineering News. Additionally, in this month's SE news section, you will learn about exciting awards issued by the system dynamics society, updates to popular SE software tools, updates about PPI and CTI courses, new documents added to PPI's esteemed Systems Engineering Goldmine and much more!

If you have burning ideas you'd like to share related to resilience, modeling, or effective decision making in engineering – there are abundant opportunities to do so in upcoming conferences on Resilience Engineering, NAFEMS, and more. If you'd like to hear thoughts from other engineers in the field, perhaps one of the past or upcoming webinars and software tool training opportunities is up your alley! Read more about these in Conferences, Meetings, and Webinars. Whether you'd prefer networking in person with like-minded systems engineering practitioners or you'd prefer to dial in from your home or office space, there are several exciting conferences all around the world, a few of which PPI and CTI are sponsoring. We hope to see you at one of these learning and networking events sometime soon!

This month's Feature Article is written by John Fitch as he shares further Musings on Emergence, building upon July 2022's Spotlight article: IS2022 Thoughts on Emergence. In this article, John integrates concepts into the previously established framework and extrapolates, in true emergent fashion, to device new questions and contemplations.

Syenna has some thoughts to share on how a learning framework may be applied to learning a new language and we have a wide variety of resources in the arsenal including aerospace-related forums, opportunities to partake in smart city modeling activities, riveting books, journals and so much more.

Whether you are an engineer, a nail technician, a barber, a doctor, an athlete, a musician, or any other kind of professional, you have had to learn a range of concepts and skills to equip you for the job. As the world advances more technologically, the new literacy is not so much about what you can or can't do but how skilfully and how quickly you're able to learn along your chosen path or career. With information so freely and abundantly available through the power of the internet, it's increasingly important to be conscious of what information you consume and how you turn that information into knowledge in this lifetime on earth. Thank you for reading this month's newsjournal, I hope you enjoy it!

René

Managing Editor, PPI SyEN

PPI Systems Engineering Newsjournal (PPI SyEN) seeks:

- To advance the practice and perceived value of systems engineering across a broad range of activities, responsibilities, and job-descriptions
- To influence the field of systems engineering from an independent perspective
- To provide information, tools, techniques, and other value to a wide spectrum of practitioners, from the experienced, to the newcomer, to the curious
- To emphasize that systems engineering exists within the context of (and should be contributory toward) larger social/enterprise systems, not just an end within itself
- To give back to the Systems Engineering community

PPI defines systems engineering as:
an approach to the engineering of systems, based on systems thinking, that aims to transform a need for a solution into an actual solution that meets imperatives and maximizes effectiveness on a whole-of-life basis, in accordance with the values of the stakeholders whom the solution is to serve. Systems engineering embraces both technical and management dimensions of problem definition and problem solving.

SYSTEMS ENGINEERING NEWS

Recent events and updates in the field of systems engineering

SESA Systems Engineering Test and Evaluation (SETE) Conference 2022 is Now In-Person

The Systems Engineering Society of Australia (SESA) has updated their plans and program for the Systems Engineering Test and Evaluation (SETE) Conference. SETE will now be held on 12-14 September 2022 in Canberra as an in-person (not hybrid) event. The Southern Cross Chapter of the International Test and Evaluation Association (ITEA) co-sponsors SETE.

The conference theme is "*enabling resilience through disruption*". Topics include:

- Resilient systems
- Methodology advances
- Digital innovation
- Human and social factors

These topics cut across multiple system domains, including transport, infrastructure, defense, and socio-technical.

Optional half-day tutorials to be delivered on 12 September include:

- Systems 101 - An Introductory Tutorial on Systems Thinking and Systems Engineering
- Engaging Non-Engineering Executives in Systems Engineering Using a Learning Framework
- The Beginner's Guide to Model-Based Systems Engineering (MBSE)
- Cyberworthiness Evaluation and Management Toolkit (CEMT)
- Tutorial on Machine Learning and Systems Thinking
- Design of Public Transport Systems Using Thread-based MBSE Techniques
- Lethal Autonomy and a humancentric view of complex military and safety critical systems - FLAWS vs Human CLAWS
- Designing a digitally enabled T&E program for a collaborative system of systems

See conference details. View the latest program. Register here.

Awards at the 2022 International System Dynamics Conference

At the 2022 International System Dynamics Conference (ISDC 2022) that was held on 18-22 July, the System Dynamics Society (SDS) announced a range of awards to individuals who have contributed to the theory and application of system dynamics and to the advancement of the Society.

Yaman Barlas received the Lifetime Achievement Award, a recognition for those who have made significant contributions to a field or practice over an extended period of time. Barlas was lauded for his lasting contributions in research, in teaching, in nurturing and mentoring students who themselves have gone on to become leaders in the System Dynamics field. He has also made important contributions in service to the SDS as an organizer of conferences, a leader in the Society governance, and as the editor of the System Dynamics Review.

The Outstanding Service Award recognizes individuals that have, on a volunteer basis, made exceptional contributions to the Society over an extended period. *Birgit Kopainsky* and *Sara Metcalf* received this award at ISDC 2022. Kopainsky was the first female President of the SDS. She serves on numerous committees having created the learning committee and has agreed to be a program chair twice already. Her implementation force has been immensely helpful to thrust the Society forwards. Metcalf, the Vice-President of Meetings of the SDS, was praised for her "herculean work in making the virtual and then hybrid conferences being a success" and for "attention to detail" in support of various SDS committees.

The Dana Meadows Award, recognizing the very best student work in the field, was given to *Nefel Tellioglu* for presenting an important development to the field by building a System Dynamics model also at the individual level of agents with clear explanations of the model behavior. The paper, co-authored with Nic Geard and Rebecca Chisholm was titled, "*Modelling the effect of within-host dynamics on the diversity of a multi-strain pathogen*".

Pei Shan Loo received the Lupina Young Researchers Award which highlights outstanding papers dealing with health-related topics, authored by students or recent graduates. Loo's paper, "*Cholera response model: Yemen Al-Hudaydah*" was recognized for an insightful model on managing complex contagious disease processes that informs humanitarian partnerships.

Additional awards included:

- Barry Richmond Scholarship Award, given to *Mariana Torres Arroyo* for the paper, "*How Can Food Donation Policies Improve Fresh Produce Rescue and Reduce Waste?*"
- Honorable Mention for both the Dana Meadows and Lupina Young Researchers Award to *Ismay Bax* for the paper, "*Exploring the Impact of Vaccine Confidence on the Transmission of Infectious Disease*".
- Honorable Mention for the Lupina Young Researchers Award to *Sanser Guz* for the paper, "*Dynamic Analysis of Public Health Insurance Programmes*".

Read the SDS full awards announcement here.

PPI SyEN congratulates these award recipients for their contributions to the field of System Dynamics.

INCOSE Releases 2022 Mid-Year Impact Statement

The International Council on Systems Engineering (INCOSE) has released its 2022 Mid-Year Impact Statement.

The document seeks to demonstrate with significant evidence that INCOSE is the premier choice of systems engineers for professional development based on its size (> 20K individual members, 126 corporate members, 52 working groups, 65 chapters worldwide and 75 countries represented), programs, products, publications, community, events, engagement, and proactive influence of the future of systems engineering as a discipline and on society in general.

Download the Impact Statement.
Learn more about INCOSE membership.

Cradle 7.7 Released

3SL has announced that version 7.7 of its Cradle multi-user, enterprise, lifecycle, systems engineering software has been released.

Cradle users can:

- Define their systems engineering database (data types, users, team, workflows).
- Load information from documents, spreadsheets and other tools.
- Create new items, queries and views.
- Generate data, cross-references and hierarchies.
- Analyze data using tables, matrices and graphical diagrams.
- Publish user defined documents and reports (integrated with Microsoft Office).

Cradle 7.7 contains new capabilities including:

- Snapshots
- Metrics added to graphs
- New header option in views
- New reports
- Annular dial type added to Dashboards
- Precision option added to Dashboards
- Ability to test email setup from User Preferences

Read the 3SL August newsletter for details on these new features.
View Cradle 7.7 release notes.
Learn more about Cradle. Start a free trial of Cradle 7.7.

New Documents in PPI's Systems Engineering Goldmine

PPI continues to add new content to the Systems Engineering Goldmine (SEG), which already comprises over 4 GB of resources. The SEG menu, shown to the left, illustrates the rich range of information available.

In addition to new definitions (as highlighted in SyEN June 2022), SEG contains a variety of documents that provide example or guidance of systems engineering work products or practices.

Here are some documents that have been updated or added to the SEG in the last quarter and that illustrate the range of topics addressed in this unique resource.

Architecture Definition vs. Design Definition
The boundaries between Architecture Definition and Design definition remain unsharp. What are the criteria for distinguishing the two processes? This was the topic of the Bern round table in Systems Engineering on October 24th, 2018, and the outcome is presented in this paper. (Source: SSSE Round Table)

Avionics Software Engineering, Requirements Management Guidebook
The Requirements Management Guidebook was developed at the request of Naval Air Systems Command through the Computer Resources Group's (CRG) Requirements Management Working Group (RMWG). (Source: Software Requirements Management Working Group - Department of the Navy)

Business Case Systems Engineering
Systems Engineering (SE) has grown but its popularity has still not spread as widely as some of the authors would wish. Therefore, in an earlier brainstorming session, topics for a roundtable were collected. The Business Case for SE was one such topic. (Source: SSSE Round Table)

Concept of Operations, Urban Air Traffic Management (Version 1)
This Document presents a model Concept of Operations (CONOPS) for traffic management of Urban Air mobility (UAM). The introduction of these new aircraft will enable Urban Air Mobility operations to grow to an unprecedented scale. As a result, UAM operations may unlock new mobility and economic opportunities for Urban and regional communities. It is an excellent example of a CONOPS, and how a CONOPS differs from an OCD." (Source: Department of Infrastructure, Transport, Regional Development and Communications)

Engineering Elegant Systems: The Practice of Systems Engineering
These processes developed from a list of pragmatic practices that were viewed as successful in 1993.They have been refined over the subsequent years, but the application of the processes varies greatly among different organizations. The formula for success seems more dependent on the individual systems engineer characteristics than a systematic following of any set of processes. (Source: National Aeronautics and Space Administration)

Engineering Elegant Systems: Theory of Systems Engineering
Systems engineers typically conduct a series of architecture trade studies that culminate in the selection of a specific system configuration. System design proceeds from this configuration definition executed by various engineering disciplines. Systems engineers often assume, sometimes implicitly, that the decomposition of the system functions to these various engineering disciplines is linear. (Source: National Aeronautics and Space Administration)

ISO & Innovation
ISO has developed a large portfolio of International Standards and guidance documents that enable an organization to align all its systems and processes to undertake innovation activities and initiatives. They address all factors that contribute to an organization being innovative, right down to the implementation of an effective innovation management system. (Source: ISO www.oec.org/site/innovationstrategy/defininginnovation.htm)

Mission Assurance Guide
The primary purpose of the Mission Assurance Guide (MAG) is to provide practical guidance to personnel of The Aerospace Corporation (Aerospace) and, in general, National Security Space (NSS) program office personnel, who are responsible for executing mission assurance (MA) functions that are key to achieving program and mission success (Source: The Aerospace Corporation)

NASA Procedural Requirements
Software engineering is a core capability and a key enabling technology for NASA's missions and supporting infrastructure. This NASA Procedural Requirements (NPR) supports the implementation of the NASA Policy Directive (NPD) 2820.1, NASA Software Policies. This NPR provides the minimal set of requirements established by the Agency for software acquisition, development, maintenance, operations, and management. (Source: National Aeronautics and Space Administration)

NASA Software Safety Guidebook
This document has been issued to make available to software safety practitioners a guidebook for assessing software systems for software's contribution to safety and techniques for analyzing and applying appropriate safety techniques and methods to software. (Source: National Aeronautics and Space Administration)

NASA Systems Engineering Handbook
This handbook is intended to provide general guidance and information on systems engineering that will be useful to the NASA community. It provides a generic description of Systems Engineering (SE) as it should be applied throughout NASA. (Source: National Aeronautics and Space Administration)

OMG Systems Modeling Language (Version 1.5)
The purpose of this International Standard is to specify the Systems Modeling Language (SysML), a general-purpose modeling language for systems engineering. Its intent is to specify the language so that systems engineering modelers may learn to apply and use SysML; modeling tool vendors may implement and support SysML; and both can provide feedback to improve future versions. SysML is designed to provide simple but powerful constructs for modeling a wide range of systems engineering problems. It is particularly effective in specifying requirements, structure, behavior, allocations, and constraints on system properties to support engineering analysis. (Source: Object Management Group, Inc)

Reference Architecture Description
This document provides guidance for the development and use of Reference Architecture in the form of a DoD definition for Reference Architecture and a description for DoD-wide Reference Architecture. (Source: Department Of Defense)

Requirements Development, Verification, and Validation Exhibited in Famous Failures
Requirements Development, Requirements Verification, Requirements Validation, System Verification, and System Validation are important systems engineering tasks. This paper describes these tasks and then discusses famous systems where these tasks were done correctly and incorrectly. (Source: Wiley Periodicals, Inc)

Software Development Effort Estimation: Formal Models or Expert Judgment?
Which is better for estimating software project resources: formal models, as instantiated in estimation tools, or expert judgment? Two luminaries, Magne Jørgensen and Barry Boehm, debate this question within this article, they're colleagues with a strong inclination to combine methods. But for this debate, they're taking opposite sides and trying to help software project managers figure out when, and under what conditions, each method would be best. (Source: IEEE Computer Society)

State of Reliability - Memorandum for Principal Deputy Under Secretary of Defense
Importance of system reliability as a major problem for Department of Defense (DoD) acquisitions. (Source: U.S. Department of Defense)

SYSTEMS ENGINEERING NEWS

Systems Engineering Philosophy: No Easy Answers?
This paper is an attempt to fill the gap in the literature on the philosophical drivers of systems engineering. It discusses the philosophy of science, philosophy of technology, and their relationship to systems engineering. Exploring some topical issues relevant to this discussion such as, what is systems engineering, and how can it be better bounded. (Source: University of Southern California Los Angeles, CA)

Systems Engineering Technical Review Process
To establish policy, outline the process, and assign responsibilities for the planning and conduct of Systems Engineering Technical Reviews (SETRs) of Naval Air Systems Command (NAVAIR) programs (Source: Naval Air Systems Command)

System Interoperability Influence on System of Systems Engineering Effort
This paper discusses System interoperability which has been defined in a multitude of ways to understand various aspects and levels of interoperability. (Ford et al. 2007a) identified 34 definitions of system interoperability. However, the most common definition of system interoperability by far according to (Ford et al. 2007a) is the Department of Defense (DoD) 1977 definition: The ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together. (Source: University of Southern California Los Angeles, CA)

System Requirements Specification
The EIRENE System Requirements Specification defines a radio system satisfying the mobile communications requirements of the European railways [EIRENE FRS]. It encompasses ground-train voice and data communications, together with the ground- based mobile communications needs of trackside workers, station and depot staff and railway administrative and managerial personnel. (Source: GSM-R Operators Group)

Systems Security Engineering- Considerations for a Multidisciplinary Approach in the Engineering of Trustworthy Secure Systems (Volume 1)
The objective is to address security issues from a stakeholder protection needs, concerns, and requirements perspective and to use established engineering processes to ensure that such needs, concerns, and requirements are addressed with appropriate fidelity and rigor, early and in a sustainable manner throughout the life cycle of the system. (Source: U.S. Department of Commerce)

The Petri Net Method
First introduced by Carl Adam Petri in 1962. A diagrammatic tool to model concurrency and synchronization in distributed systems. Very similar to State Transition Diagrams. Used as a visual communication aid to model the system behavior, Based on strong mathematical foundation. (Source: School of Computer Science & Software Engineering, Monash University)

The SEG is a free resource, intended for use by clients, alumni and friends of Project Performance International (PPI) as well as clients, alumni and friends of subsidiary company Certification Training International (CTI). If you do not already have access to the Systems Engineering Goldmine, you may apply for free access here.

PPI and CTI Slowly Resume In-Person Courses

Since the onset of the pandemic PPI's main concern has been preserving the safety and health of our clients and team members. Thankfully this has been possible through the shift from in-person to online training and consulting. Over the past 3 years, our PPI Live-Online™ and CTI Live-Online™ courses have consistently received excellent feedback and we are delighted to have been able to deliver the same high quality training of which our clients are accustomed through using digital technologies.

With the restrictions and severity of COVID-19 easing off around the world in recent months, PPI has observed an increase in interest of our clients to resume in-person courses. PPI is delighted to announce a resumption of in-person training to corporate clients and select public courses where the risk of hosting an in-person course is sufficiently low for that region. Virtual delivery of our training and consulting services will remain the most sizable delivery format for both PPI and CTI as both companies are deeply concerned with the environment and minimising our carbon footprint thereby limiting travel and use of hard copy materials in courses where possible.

The next in-person Systems Engineering Five Day public course is scheduled to take place at the Holiday Inn Eindhoven, Netherlands from 31 October to 4 November 2022. Register for this course via the following link.

PPI and CTI 2023 Public Course Schedules Now Live!

PPI and CTI are delighted to announce that PPI's 2023 schedule for systems engineering related and SE certification courses are open for registration. If you would like to attend one of PPI and CTI courses or have someone in your team who you think would take advantage of our sophisticated training solutions, we invite you to check out the dates. We look forward to seeing you in an upcoming course soon! Be a part of the nearly 20,0000 engineers who have improved their lives with our courses. View our upcoming courses on our website by clicking on the course you are interested in and then selecting 'Full Schedule'

PPI list of courses
CTI list of courses

CONFERENCES, MEETINGS & WEBINARS

Registration Opens for PDMA Inspire Innovation Conference

The Product Development Management Association (PDMA) announces the opening of registration for its Inspire Innovation Conference to be held on 12-15 November, in Orlando, Florida, USA. Held in conjunction with the Journal of Product Innovation Management (JPIM) Research Forum, this four-day in-person event has the theme "Explore a New World of New Product Development".

Conference speakers and their topics include:

- Marianne Lewis, Dean and Professor of Management, University of Cincinnati: *Innovation Tensions and Both/And Thinking*
- Jack Schafer, Former FBI and Author: 1) *Leveraging FBI Elicitation Techniques in Voice of the Customer Research*; 2) *Applying What You've Learned about FBI Elicitation Techniques in Voice of the Customer Research*
- Brad Shuck, Associate Professor at the University of Louisville: *Reimagining Engagement in Product Development and Management: A Masterclass on the Employee Experience in the Future of Work*
- Mark Adkins, CEO, LeanMed LLC: *Mission Driven Innovation: Product Development that Produces Social Impact*
- Susan Burek, Senior Consultant, Foresight Science & Technology: *The Corporate Environmental Sustainability Journey*
- David Matheson, President and CEO, SmartOrg, Inc.: 1) *Get into the Discovery Zone*; 2) *Turbocharge your innovation incubation decisions*
- Peter Monkhouse, Co-Founder, NewGenP: 1) *Projects Deliver Products, Products Deliver Strategy*; 2) *Know your Customer*

See conference details. Register here.

Registration Opens for INCOSE UK Annual SE Conference (ASEC 2022)

Registration is open for the INCOSE UK Annual Systems Engineering Conference (ASEC 2022) to be held on 22-23 November at the Crowne Plaza, Newcastle, United Kingdom. The two-day in-person event will feature 2 keynotes, 11 plenary sessions, an interactive panel session and 4 tutorials and multiple additional networking and collaboration opportunities. The theme of ASEC 2022 is '*Building Towards a Brighter Future*', further focusing on:

- Exploiting change and transformation
- Moving the Systems Engineering profession forward

- Developing professionals for the future
- Embedding a systems approach in the UK

Plenary session topics include:

- Zero Emissions Flight Infrastructure - How Systems Engineering is shaping the future of sustainable aviation
- Systems Modelling for Sustainable Development
- A Systems Approach To Process Maturity Improvement
- Managing The Longest System Lifecycle - Implementing a systems approach to geological disposal of radioactive waste
- ESI Assurance (Engage, Synchronize, Integrate) - Future proofing Engineering Assurance for High Integrity System Development
- Agile and Systems Engineering: The Good, The Bad and The Ugly
- A Digitally-Enabled Approach To Engineering Systems
- Opportunities For Applying Systems Engineering To Infrastructure Development
- Getting the 'Digital First' Future You Want
- The Use Of Social Network Metrics In Model-Based Systems Engineering
- Rethinking Engineering - How visiting professors are supporting Scottish universities to develop a systems-led curriculum to meet the needs of industry

Tutorial topics include:

- Analysing Services and Service Systems: Dr. Simon Wright, (SYMTECH)
- Stakeholder Needs Driven Systems Development: Dr. Kim Stansfield, John Fraser, Stephen Dimelow, (INCOSE UK)
- Model-Based Security Engineering: TBA (Cardiff University)
- Systems Thinking Awareness: Rob Black (Sellafield Ltd)

See conference details. Register here.

Registration Opens for Complex Systems Design & Management (CSD&M) Conference

Registration is open for the 13th Complex Systems Design & Management (CSD&M) Conference to be held on 15-16 December in Paris, France. This in-person event was created by the French Center of Excellence on Systems Architecture, Management, Economy & Strategy (CESAMES). CESAMES believes that mastering complexity can only be achieved with a strong and true cooperation between all key stakeholders (academic, industrial, and governmental actors).

The theme of the conference is '*Building a sustainable & resilient world thanks to a collaborative eco-system with virtual playground*'.

Conference tracks will be arranged around subthemes:

- *How to engage and perform a digital transformation within your eco-system*: Paths and experience feedbacks on digital transformation initiatives withing an organization or with the eco-system.
- *Modeling and Simulation Systems Engineering practices*: Best practices for model-based techniques in a modeling and simulation (MODSIM) approach, to specify, analyze, design, and verify systems.

- *Building sustainable, secured, evolutive and resilient systems*: System architecting methods to address new expected system perspectives such as security, sustainability, resiliency, and scalability.
- *Means and methods to integrate humans in virtual playgrounds*: Integration of the human as a virtual twin into the system to better anticipate increasing system complexity and autonomy.

Learn more about the CSD&M Conference. See program details. Register here.

Call for Papers: 10th Resilience Engineering Symposium

A Call for Papers has been announced for the 10th Resilience Engineering Symposium, co-organized by MINES Paris Centre of Risks and Crises and the Resilience Engineering Association (REA). The Symposium will be held in Sophia Antipolis, France on 26-30 June 2023. The theme is "Resilience at frontiers, frontiers of resilience".

Resilience Engineering is a trans-disciplinary perspective that focuses on developing on theories and practices that enable the continuity of operations and societal activities to deliver essential services in the face of ever-growing dynamics and uncertainty. It addresses complexity, non-linearity, inter-dependencies, emergence, formal and informal social structures, threats, and opportunities.

The 10th Resilience Engineering Symposium's theme focuses on understanding how systems adjust their behavior when approaching boundaries. The theme will explore the limits and scope of the Resilience Engineering perspective to support systems coping with the actual and future complexities. Questions to be addressed include:

- What is the nature of boundaries to be considered by Resilience Engineering studies?
- How do their nature and dynamic affect adaptive capacities?
- How do other boundaries (organizational, national, or geographical) affect systems adaptive capacities?
- How does the Resilience Engineering perspective adapt to support organizations coping with this new complexity?
- What is the actual and future nature of complex threats and opportunities?
- What are the limits of the Resilience Engineering perspective towards their complexity?
- Are there principles, concepts and practices that can be scaled-up (or not) from resilient systems to resilient organizations towards resilient societies?

Proposals are requested for other contributions including participation in an industrial panel, methods for visualizing resilience in creative works and the Young Talents Program for Masters and PhD students pursuing research in Resilience Engineering.

The paper submission deadline is 30 October 2022.
The deadline for submission of industrial testimonies and visual representation studies is 15 January 2023.

Learn more about MINES Paris here.
Join the Resilience Engineering Association here.

CONFERENCES, MEETINGS & WEBINARS

Call for Papers - NAFEMS World Congress 2023

NAFEMS, the International Association for the Engineering Modelling, Analysis and Simulation Community, has issued a Call for Papers for the NAFEMS World Congress 2023 (NWC23). NWC23 is scheduled for 15-18 May 2023 in Tampa, Florida, USA. The conference theme is *A World of Engineering Simulation*. Topics of interest represent all aspects of engineering modelling, analysis & simulation, including:

- Engineering Data Science
- Autonomous Vehicles
- Electrification
- Reduced Order Modelling
- Particle Methods
- Digital Twins
- Additive Manufacturing
- Simulation Supporting Certification
- Designer Oriented Simulation
- Artificial Intelligence and Machine Learning
- Integrated Computational Materials Engineering (ICME)
- Simulation Data Management

The deadline for submission of a 300-word abstract is 25 November 2022.
Read the Call for Papers.

Learn more about NAFEMS.

Business Architecture Primer

The Object Management Group (OMG) and Business Architecture Associates (BAA) are hosting a half-day Business Architecture Primer on 19 September 2022. This hybrid event will take place physically in Burlingame, California, USA (in the Hyatt Regency San Francisco Airport hotel adjacent to OMG's third quarter Technical Meeting) as well as virtually. Whynde Kuehn and William Ulrich of BAA, both experts and thought leaders in the field, will deliver "A Fast-Paced Journey Through the Discipline" of business architecture.

Topics include:

- Understanding Business Architecture Basics: Power in Simplicity
- Framing the Value Proposition: Its Role in End-to-End Strategy Execution
- Cutting through the Noise: Dispelling 12 Common Myths
- Establishing the Foundational Business Architecture
- Applying Business Architecture in Practice
- Driving IT Architecture Transformation
- Establishing a Center of Excellence and Governance Structure
- Deploying Practice Infrastructure: Knowledge, Tooling & More

Learn more and register here.

CONFERENCES, MEETINGS & WEBINARS

International Symposium on the Analytic Hierarchy Process

The Creative Decisions Foundation has announced that the International Symposium on the Analytic Hierarchy Process (ISAHP) will take place on 15-18 December 2022 as a virtual conference. The ISAHP is a biennial conference on multi-criteria decision analysis, with a particular focus the analytic hierarchy process (AHP) and its extension, the analytic network process (ANP), both developed by Thomas L. Saaty, and the combination/comparison of these with other methods.

The theme for this symposium is "*Decision-Making in Business Practice*" and the focus will be to showcase the latest research (completed, in-process and proposals) and practical applications in the use of the AHP and ANP. Conference tracks include:

- Multi-Criteria Decision Analysis (MCDA) Theory
- Education, Government and Public Policy
- Industrial and Manufacturing Engineering
- Innovation and Entrepreneurship
- Healthcare
- Ethics, Social Responsibility and Sustainability
- Risk Analysis and Disaster Management
- Supply Chain Management
- Extensions of Fuzzy Sets and Fuzzy Decision Making
- Machine Learning, Artificial Intelligence and Digitalization
- Business Applications

View the Call for Papers. The submission deadline is 14 November.
Register for ISAHP 2022.

Learn more about AHP.
View papers and presentation videos from sixteen past conferences.

Outstanding INCOSE Los Angeles Webinars – July through September

This summer the INCOSE Los Angeles (USA) chapter has been the host for some outstanding webinars on topics that are central to effective systems engineering.

On 12 July, David Long, INCOSE Past President and Fellow, shared a presentation titled "*Digital Data Packages: Making the Digital Thread Work*". This talk addressed the practical challenges of turning the highly-popularized concept of a Digital Thread into reality and went beyond to cover key concepts behind effective Digital Engineering.

Topics addressed and key points included:

Introduction to the Digital Thread

- The Digital Thread is one part of the broader Digital Transformation topic along with the Digital Twin, Digital Engineering and MBSE.

- Product Lifecycle Management (PLM) originally had little emphasis on requirements or product design, focusing on post-design through-life support.
- The driver behind the need for the Digital Thread is the unprecedented increase in system scale and increasing complexity in a variety of dimensions (mission, technical, technical, product line, project team and dynamic).
- Industry's initial steps toward the Digital Thread resulted in the creation of multiple digital siloes, e.g., requirements, MBSE, ECAD, MCAD, ALM, PLM. To effectively manage change, this disjoint lifecycle must be replaced with an unbroken thread of traceability.

Complementing the Digital Thread and ASoT with Digital Data Packages

- Digital Engineering goes beyond just traceability to connect engineering knowledge on the fly within an Authoritative Source of Truth (ASOT).
- Digital Engineering is done by people, most of who suffer from the problem of having too much information. Therefore, there is a need for simplification, i.e., filtering out potentially millions of pieces of extraneous information when making a critical decision.
- By limiting information overload, the Digital Thread is a partial solution to the problem of miscommunication in a designing organization. The full solution requires complementing the Digital Thread with an ASOT and Digital Data Packages.
- Systems Engineering is a transform that takes in requirements and outputs the specification of a design envelope, interfaces, and the role (aka essential context) of each system element in the whole.
- Recommended reading for a non-technical understanding of systems: Team of Teams by Stanley McChrystal.
- Detailed designers need the essential context, but not the traceability, abstractions, alternatives, analysis, mitigated risks, design journey, etc. that led to their subsystem's specification.
- A Digital Data Package is the encapsulation of the necessary data for each player in the design lifecycle. It leverages a black box approach, i.e., "opaqueness" to limit the complexity experienced by each contributor.

Defining a Digital Data Package Connecting Systems Architecture and Detailed Design

- Begin the definition of the Digital Data Package with the Design Envelope, which is based on the parts tree, i.e., the physical implementation architecture (components and their design parameters and interconnections).
- Communicate the role that each component plays, i.e., the minimum context for each component, using visualizations that are fit for the audience (component developers).
- Communicate the requirements (why) and verification requirements (proof/evidence that requirements have been satisfied).
- Verification Requirements are the coordination point between engineering and test representing a critical acceptance criteria for detailed design.
- Address all the remaining aspects of architecture including states, behavior (functional requirements) and exchanges (transferred items).

Completing the Digital Picture

- The prerequisite for effective Digital Engineering is a common language, i.e., a semantically meaningful common information metamodel.

- Maintain and connect all data, but limit the data provided to designers at any level or in any lifecycle role to the right data, at the right place, at the right time and in the right presentation format. Viewpoints on steroids.

Some memorable quotes were shared:

- *If you do Digital Thread right, it promises unbroken traceability from first expression of needs through design, through operations, through upgrades and ultimately through retirement. If you do it wrong, that Digital Thread can become a tangled knot.*
- *The Digital Thread is a network, a mesh – and often times a knot.*
- *Einstein applied to the Digital Knot: Provide only the information required to make a decision, but no more.*
- *Conway's Law (1967): Any organization that designs a system (defined broadly) will produce a design whose structure is a copy of the organization's communication structure.*
- *Long's Corollary to Conway (2020): Flaws in the communication structure of an enterprise will manifest as defects in the system under development.*
- *In MBSE, architecture is requirements for the next person downstream.*
- *Dave Walden: In systems engineering, lines matter as much as boxes.*

Download David Long's presentation here.
INCOSE members may access the video through INCOSE Connect here.

On 9 August, Tami Katz, Chair of the INCOSE Requirements Working Group (RWG) shared a presentation, titled "*Achieving Designs that Satisfy Stakeholders Through Better Requirements*". This talk showcased recent products and resources created by the RWG to help with the requirements development process, leading to a system development effort that satisfies stakeholder expectations.

Topics addressed included:

- Traditional requirements processes and associated challenges
- Highlights from INCOSE Needs and Requirements Manual (NRM)
- Examples for a sample project

Takeaways included:

- The RWG has been at work developing and refining a set of products that are aligned with other INCOSE publications.
- These RWG products are available in the INCOSE Store.
- Three technical processes of the ISO 15288 standard (Business or mission analysis, Stakeholder needs and requirements definition and System requirements definition) are responsible for establishing the overall requirements for a system of interest.
- Missing the stakeholder needs and requirements technical process can result in a system that conforms to requirements (is fully verified) yet does not address the needs of the stakeholders.
- Stakeholder needs and requirements "level" nomenclature is misleading, leading many systems engineers to start their efforts at the system level, which bypasses the focus on stakeholder needs. The NRM recommends increased focus on needs.
- A variety of Systems Thinking techniques may be used to establish an integrated set of stakeholder needs. This integrated set of needs is the source of system requirements.
- Because they apply recursively and at all levels of system context, the terms *verification* and *validation*, should always be accompanied by a contextual qualifier, e.g., *needs* verification, *design* verification or *system* validation.

- Verification and validation occur across the system lifecycle and may be applied to any development work product by comparison against an appropriate reference or standard for that work product. EDITOR'S NOTE: PPI's Wedge Model highlights this recursive and lifecycle nature of verification and validation.
- A data-centric approach (vs document-centric) enables a single source of truth and improves lifecycle traceability.
- Much of the RWG's new content is being included in the new INCOSE SE Handbook version 5, which is scheduled for release in 2023.

Some memorable quotes were shared:

- *Developing needs is the foundation of establishing requirements that satisfy our stakeholders.*
- *Needs represent the stakeholder and customer/acquirer view of the system of interest (SOI).*
- *Validation is more important than verification.*

Download Tami Katz's presentation here.
View the video on INCOSE RWG YouTube channel.
Learn more about the INCOSE RWG here.

For September, the INCOSE Los Angeles chapter will focus on Model-Based Systems Engineering (MBSE).

The 13 September chapter speaker meeting will hear from Casey Medina, CSEP and owner of Studio SE, on the topic "*Are You Ready to Model? Considerations for Building Effective Models*".

Abstract: As MBSE and SysML gain traction and popularity in a variety of industries, it begs the question: "Are we really ready to embrace modeling and simulation?" In this LA Chapter event, we will explore the factors that will encourage and inhibit success in adopting model-based methods. Come prepared for an enlightening and interactive discussion as Casey Medina describes his experiences and revelations from deploying MBSE across a range of organizations.

Register here.

On 17 September, Casey Medina will offer a tutorial on *Advanced Concepts in SysML*. The tutorial will explore some intermediate and advanced uses of the Systems Modeling Language (SysML) using Cameo Systems Modeler. In this virtual, hands-on tutorial, participants will learn to:

- Deploy opaque expressions
- Trigger events using Sequence Diagrams
- Use the Simulation Toolkit to evaluate system behavior

This is an advanced tutorial, so previous Cameo/SysML experience is needed.

Register here.
View other INCOSE Los Angeles chapter events and resources.

CONFERENCES, MEETINGS & WEBINARS

Webcast: The Benefits of a Requirements Verification Architecture Model

On 21 September, the INCOSE San Diego chapter is hosting a hybrid (in-person and webcast) presentation titled *The Benefits of a Requirements Verification Architecture Model*. Charley Patton, CSEP, will discuss the concept of a Requirements Verification Architecture Model (RVAM) and present examples of a RVAM practiced on his current program with Northrop Grumman.

A complete RVAM brings together requirements, architecture entities, and verification cases in a suite of diagrams that provide an important development team coordination tool.

Learn more and RSVP here.

INCOSE/GfSE Webinar on Decision Patterns

On 28 September, PPI's John Fitch will present a webinar titled "*Leveraging decision patterns to tame complexity and accelerate solution delivery*" as part of the INCOSE/GfSE webinar series. GfSE is INCOSE's German chapter.

Takeaways from this presentation:

- Decision patterns are a useful technique for managing the complexity and reducing the time-to-capability of engineered systems.
- Decisions are the integrative mechanism of systems engineering and as such decision-to-everything traceability and associated viewpoints should be at the heart of any organization's digital thread.
- Proven decision patterns exist that may be used to quickly frame the scope of any project, validate system requirements, and provide a structure for organizing project work around the most critical choices.
- Although there is limited "native" software tool support for a decision-centric approach to engineering, existing MBSE tools or desktop tools may be extended to deliver this capability.

Prepare for this presentation by reading these SyEN articles on decision patterns:

- Introduction to Decision Patterns - SyEN December 2021 Edition
- Decision Patterns – So What? - SyEN April 2022 Edition
- Reverse Engineering Stakeholder Decisions from Their Requirements – SyEN June 2022 Edition

Learn more. Register here.

Upcoming Arcadia-Capella Online Training Opportunities

Obeo is offering three sessions of Arcadia and Capella training in the coming months. Targeting Capella beginner users, each course will be delivered by a Thales MBSE expert, in English, through 6 sessions of 3.5 hours each.

Available dates:

- 26 September – 4 October
- 7 November – 15 November
- 5 December – 12 December

To take advantage of this opportunity to learn how to use effectively the open-source tool Capella and the Arcadia MBSE method, please contact sales@obeosoft.ca for pricing and registration.

Upcoming conference in which PPI is participating

PPI is proud to be sponsoring the following conferences during the remainder of 2022. If you'll be attending any of the following conferences, please connect with us! It's always a pleasure to catch up with old friends and new at SE conferences around the world.

SESA Systems Engineering Test and Evaluation (SETE) Conference

12 – 14 Sept, 2022, Canberra, Australia

Please see the opening item in this month's Systems Engineering News section for more details about this conference.

PPI is proud to be sponsoring SETE this year! Although we will not have physical representation from our company at this conference due to a very busy training period for us in the coming weeks, we are delighted to support a fantastic SE community on our home turf!

SIGE Symposium on Operational Applications in Defense Areas

27 – 29 Sept, 2022, Brazil

SIGE is an conference that takes place annually in Brazil, hosted by the Instituto Tecnológico de Aeronáutica with the objective of creating an environment for the exchange of experiences between the academic, industrial and operational sectors of the Armed Forces, in topics of teaching, research and development in the areas of Defense. This year the SIGE will be conducted in hybrid format - inviting both in person and online participation.

This year's event is integrated with 3rd IVR Workshop and 11th Defense Applications Remote Sensing Symposium – SERFA/IVR and Defense Electronic Warfare Encounter – EGED. Another highlight is the following five mini courses on offer:

1. Model-Based Systems Engineering by Prof. Dr. Christopher ShneiderCerqueira
2. Introduction to Missions and Space Systems Projects by Prof. Dr. Marcio Martins da Silva Costa
3. Fundamentals of Astrodynamics by Prof. Dr. Willer Gomes dos Santos
4. Infrared imagers and illuminators by Prof. Dr. Alvaro Jose Damião
5. Strategic Decision Analysis by Dr. Gregory S. Parnell, Colonel USAF

Western States Regional Conference (WSRC) 2022

30 Sept – 2 Oct, 2022, Golden, CO, USA

The WSRC 2022 is a 3-day event of presentations and keynotes on systems engineering topics hosted by the Colorado Front Range Chapter of INCOSE. The WSRC is open to the public (not just INCOSE members) and is targeted to systems engineers; program managers, educators, technology professionals, and many others who benefit from the systems approach to solving challenging

problems and optimizing processes. This year the theme is 'Clime above the buzzwords' where presenters will "Climb Above the Buzzwords" to highlight the utility of their cutting-edge work. The conference aims to go beyond strategic visions and pitches for change—and popular buzzwords—and share how we are actually driving change in the systems engineering community.
https://www.incose.org/wsrc/

INCOSE South Africa 16th Annual Conference 2022
14 – 16 Nov, 2022, South Africa
The INCOSE SA conference allows industry, organizations, educators, researchers, and government to showcase cutting edge practice and research. This year's theme, "New Normal", focuses on applying systems thinking and systems engineering principles and processes within a disrupted and constraint environment. The conference provides the opportunity to network with professionals, share ideas, knowledge and practices, and learn more about the most recent innovations, trends, experiences and issues in Systems Engineering from many South African domains.

Structure of the conference
The conference will be a virtual event over three full days (14 – 16 November). Each day starts with a plenary after which it will split into two tracks of paper and paperless presentations.
https://www.incose.org.za/annual-conference-2022

"

Systems engineering is not a process, it is a set of principles and a set of process tools with which to implement the principles. Apply the principles all the time. Use the tools selectively, based on the specifics of the task at hand.

Robert Halligan

FEATURE ARTICLE

More Musings on Emergence

by John Fitch (PPI Presenter and Principal Consultant)

Email: jfitch@ppi-int.com

Introduction

Our Spotlight article in last month's SyEN Edition 114 began with four questions posed by Jakob Axelsson of Mälardalen University, Sweden, in his IS2022 paper titled "*What Systems Engineers Should Know About Emergence*":

- What Phenomena Should Be Called Emergent?
- Are Emergent Phenomena Predictable?
- Can System-Level Phenomena Affect Element-Level Phenomena?
- Must There Be an Observer for an Emergent Phenomenon to Exist?

As is the case for almost any line of serious inquiry, the PPI team's process of answering these questions uncovered another layer of questions yet to be answered.

A bit of research

Before diving into those follow-on questions, it may be helpful to review some authoritative voices on the topic of emergence. Both the Fourth Edition of the INCOSE Systems Engineering Handbook[1] and version 2.6 of the Systems Engineering Body of Knowledge (SEBoK)[2] have done the heavy lifting of a typical literature search and condensed their findings into compact overviews of this topic. In the SE Handbook, "emergent properties" are defined in the three-paragraph section, 4.4.2.3 on page 68. In the SEBoK, a brief chapter on Emergence is found within the Systems Science knowledge area on pages 140-144. Both documents associate emergence with the topic of system complexity.

However, readers could say (tongue in cheek) that we can find emergence almost everywhere we look in these sources. Both documents are filled with numerous references to emergence, emergent behaviors, and emergent properties.

A search of the 305-page Handbook yields 9 references to the concept of emergence, used as a noun. The Handbook also uses emergent as an adjective 26 times, mostly modifying either property/properties or behavior/behaviors. Three references exist for emergent requirement(s).

The 1065-page SEBoK includes 127 references to emergence and 82 to emergent (58 "propert___"; 20 "behav____"; and 4 "requirement_").

Given the understanding that emergence is a characteristic of the physical universe, the idea of an emergent requirement should raise questions. Careful reading of these uses in the Handbook and SEBoK seem to imply that emergent requirements are simply emergent behaviors that trigger new requirements that are deemed necessary to control emergent system phenomena. Understood through this lens, there is no such thing as an emergent requirement, but there are requirements that

are derived from the need to and decision to control or exploit the emergent behaviors that result from a particular system design.

The SE Handbook, section 4.4.2.3 defines emergence as "the principle that whole entities exhibit properties, which are meaningful only when attributed to the whole, not to its parts." It asserts that "every model of a human activity system exhibits properties as a whole entity that derive from its component activities and their structure but cannot be reduced to them."

The Handbook states that the source of emergent properties is the interactions between system elements "that create desirable or undesirable phenomena."

Multiple schemes have been proposed for distinguishing emergence by type. Noting that there is no industry-wide concurrence, the SEBoK summarizes multiple types and associates them with complicated vs complex systems.

- Simple: Predictable emergent properties of complicated, but not complex systems. Predicting these is the bread and butter of most design efforts.
- Weak: Expected emergence which is desired (or at least allowed for) in a complex system structure, but difficult to predict as to its level or scale.
- Strong: Unexpected emergence in complex systems, not predicted or observed until system simulation, test or operations.
- Chaotic/unpredictable: Likely to be seen in systems of systems where independently developed and managed systems are combined and interact in novel ways.

The SEBoK notes that some practitioners use the term emergence only when speaking of strong (unexpected) emergence.

The challenge with these definitions and classification schemes is the blending of multiple dimensions of scale (strength of the phenomena and their resulting positive or negative impact on stakeholder value), predictability (based on scientific understanding), predictability (based on effectiveness and time/investment in modeling) and predictability (of behaviors that have never been observed in any other system).

This paper is too brief to resolve the differences of opinions among the scientific and engineering community and to propose "the" definitive classification scheme for emergence. Based on career interests, the author is 85% engineer, 10% scientist and just 5% philosopher. With those biases, the more interesting subject is how the reality of emergence in the physical world can and should influence the conduct of systems engineering.

Initial Musings

Before attempting to model emergence in the context systems engineering, please consider some initial hypotheses:

- The existence of emergence in a system says nothing about the observability of the emergent phenomena, nor their predictability, nor their relevance/importance to system stakeholders.
- A phenomenon may be emergent, but not within our current powers to observe it.
- A phenomenon may be emergent and observable, but beyond our current powers to predict it with any confidence.
- A phenomenon that is emergent, observable, and predictable may not be of sufficient scale to be relevant to system stakeholders.
- The value of an emergent phenomenon is a function of its observability, predictability, the scale of its impact on stakeholder measures of performance/effectiveness or other constraints, exploitability (if positive) and controllability (if negative).

What factors determine the relevance of emergent phenomena to a system design?

It's obvious that not all emergent phenomena have the same relevance to a system's stakeholders and therefore to the system design. Figure 1 provides a simple lifecycle model of an emergent phenomenon that highlights the factors that may distinguish an emergent behavior as vital to system success or merely as a nuisance to be managed or ignored.

The relevance of an emergent behavior or property of a system begins with an estimate of its potency, i.e., powerful phenomena are more likely to be significant. Lightning, explosions, nuclear fission, nuclear fusion, or matter/anti-matter annihilation come to mind. Mathematically, look for phenomena with large coefficients or exponents, e.g., $E = MC^2$.

Potency generally correlates positively with the number of applications (use cases) in which the phenomenon might provide differentiation for the system by the magnitude of its contributions to the system's value proposition. At this level of concept innovation, we are likely dealing with high-level stakeholder need statements, not formal requirements. Potency may also highlight phenomena which are value-destroying and therefore must be greatly reduced if a solution concept is to be considered viable.

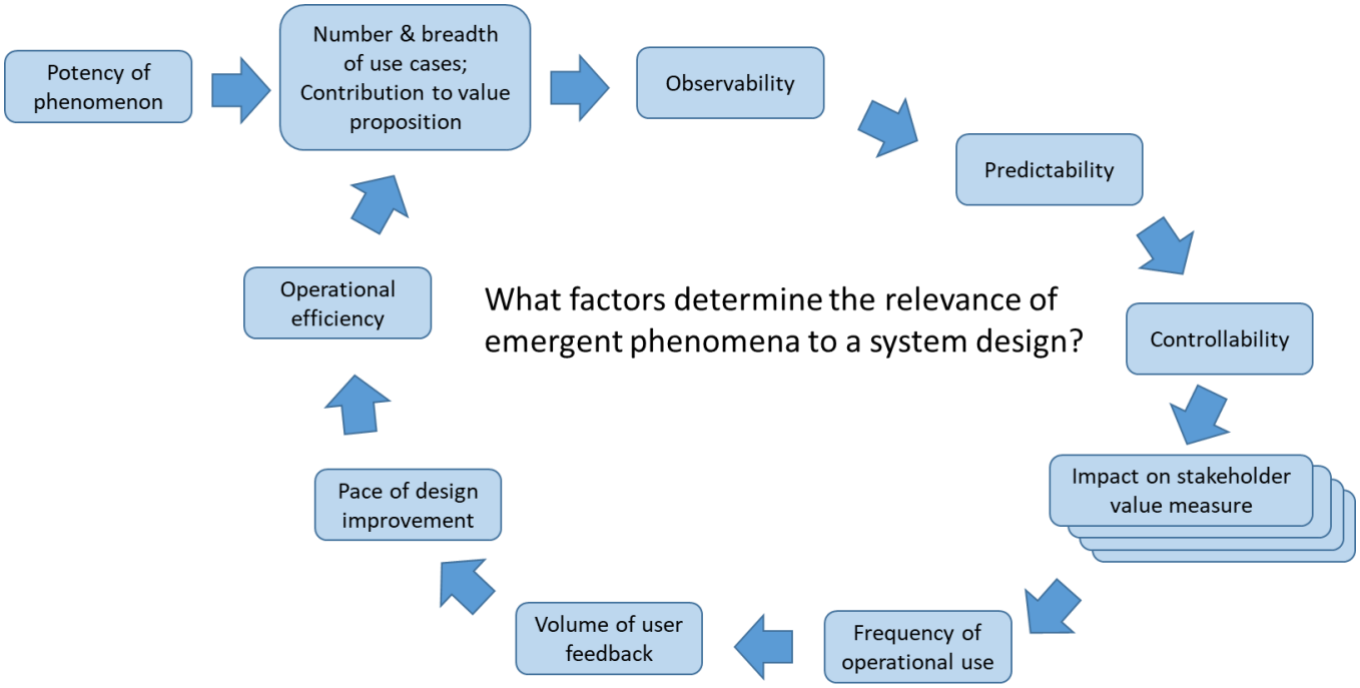

Figure 1: Lifecycle of an emergent phenomenon in the context of a System of Interest (SOI)

The System/Product Design decision pattern introduced in SyEN Edition 107 (December 2021) has a branch that addresses the choices to be made concerning the phenomenology that will power a system. The oval in Figure 2 highlights those decisions and their contribution to the overall solution concept. The entire decision branch could aptly be labeled "Choosing the science and technology foundations" for the system.

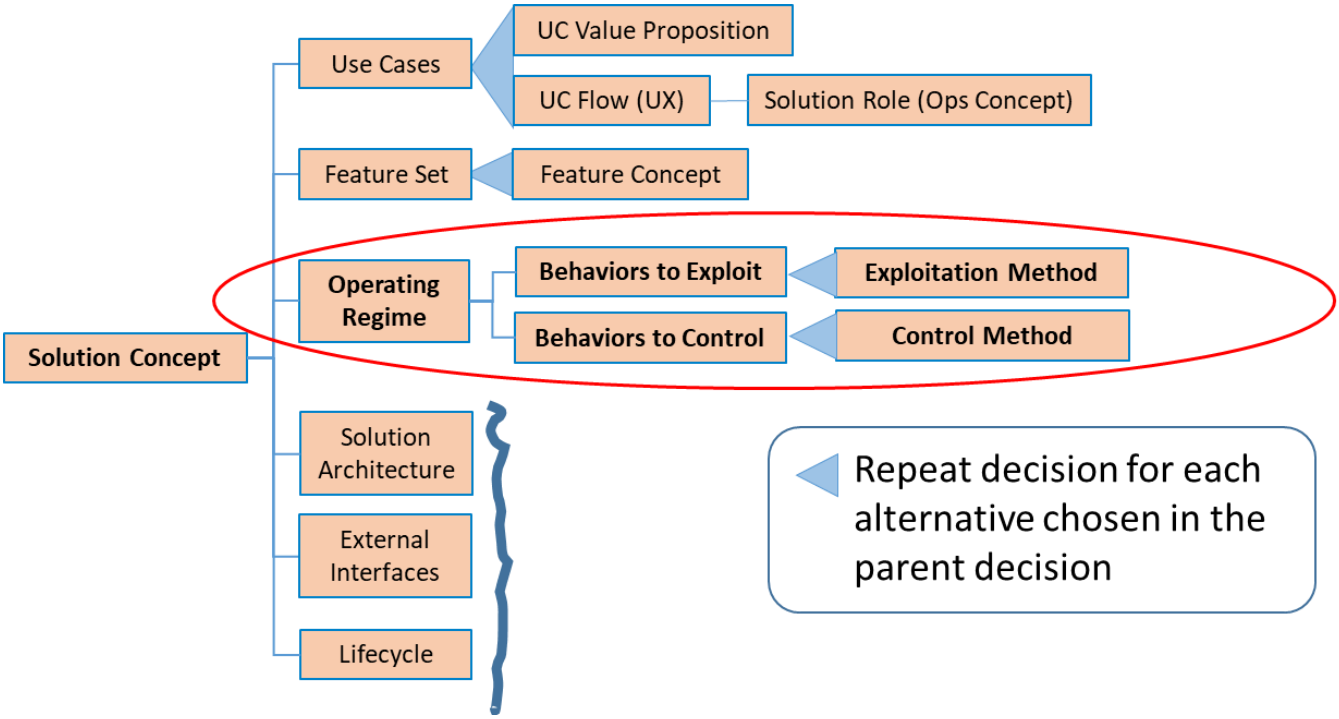

Figure 2: System Design Decisions that address Emergence

These decisions, expressed as questions that demand an answer, are shown in the table below.

Decision Name	Decision Description
1 Solution Concept	What is the top-level concept for this system or solution? What makes it unique?
1.3 Operating Regime	In what range of conditions, environments and performance levels will the solution operate?
1.3.1 Behaviors to Exploit	What behaviors/properties (science) within the operating regime will be exploited to create value?
1.3.1.1 Exploitation Method	How will the solution exploit this behavior/property to deliver value?
1.3.2 Behaviors to Control	What behaviors/properties (science) within the operating regime will be controlled (regulated, suppressed or avoided) to realize value?
1.3.2.1 Control Method	How will the solution control or suppress this unwanted behavior/property?

Although much of the operating regime may be derived directly from the range of use cases that have been chosen to be within the system's mission scope, in some cases this decision becomes a top-level choice of the science to be used to accomplish the system's missions. For example, a military system with a primary mission to "destroy airborne target" could accomplish this in the domain of kinetic

energy (physical interceptor or chemical explosives), electromagnetic energy (directed energy weapon) or cyberspace (injection of self-destruct virus).

Within an operating regime or domain, the initial steps toward managing emergence may be thought of as making decisions to separate emergent phenomena into two sets; Behaviors to Exploit and Behaviors to Control and then deciding for each phenomenon the best Exploitation Method or Control Method. These high-level decisions conceive technology/solution building blocks from which solution architecture alternatives may be synthesized and from which system functions will be derived.

Let's assume a phenomenon that is potent and aligned with stakeholder needs as relevant to the system's use cases and value proposition. Such a phenomenon remains outside of the reach of engineering unless the instrumentation exists to make it observable in sufficient detail to either correlate its behavior with other well-understood factors or to discern its causality (the underlying mechanisms of action) that explain the behavior. Potent, relevant phenomena will typically attract research investment to achieve the needed level of observability, but it behooves the engineer to consider the maturity of observation technologies before committing to a solution concept based on a particular phenomenon. ASK: *How confident are we that the mechanisms of action behind this emergent behavior are understood, based on the observability provided by current instrumentation?*

Observability does not guarantee the predictability of emergent behaviors. Predictability requires:

- Cycles of learning based on real world observations that quantify correlation or research that results in validated models of causality.
- Investment in the development, refinement, and validation of predictive models and the tools required to apply them to an engineering problem.
- The ability to extrapolate existing models to new situations (problem environments and conditions or solution combinations) to anticipate the existence of a significant number of "new" emergent behaviors. This extrapolation capability may have very limited ability to estimate the scale of an emergent behavior, but at least builds the detection and measurement of the phenomenon into the project plan.

Emergence, even when predictable, is of very limited use without the ability to control the phenomenon as part of the system design. Controllability may be stated positively, i.e., the ability to exploit an emergent property to create additional stakeholder value. In the case of value-destroying phenomena, controllability implies the ability to prevent or reduce the loss in stakeholder value attributable to the phenomena. This may be accomplished by prevention of the phenomenon and/or the inclusion of impact-reducing contingent actions into the system design.

Emergence is a property of a system, therefore requiring at least two interacting elements. But to observe and predict emergence, we may need to model the interactions of subsystems/components N levels below the system context. The value of N varies depending on the type of system and the causality behind the emergent properties.

To adequately explain how the elements that comprise a metallic wire produce electrical conductivity or the elements that comprise air transmit and attenuate acoustic waves, we may need to model interacting molecules, atoms, or even sub-atomic particles. The level of system model required to predict, exploit, or control emergent phenomena doesn't alter in any way the fact of emergence, but it does drive the practical utility or disutility of emergent behaviors/properties in the System of Interest (SOI).

For many emergent phenomena, we have only correlation data to inform our exploitation and control strategies. In such cases, mankind has not yet been able to adequately describe the mechanism(s) of action, i.e., model causality.

Pharmaceuticals and other medical interventions are examples where solutions are often based on correlation between solution designs and measures of safety and efficacy gathered from large scale field trials.

Taken together, the observability, predictability and controllability of emergence are inputs to the assessment of the maturity of any technology derived from an emergent phenomenon.

In an ideal (aka mythical) world, all value-creating emergent phenomena would contribute positively to every stakeholder value measure. Knowing from experience that this is not the case, engineers must be ready to address the tradeoffs that are implied when a powerful, observable, predictable and exploitable phenomenon creates one type of stakeholder value while destroying value in several other areas. Innovation and design techniques such as TRIZ [3] or Axiomatic Design [4] may point the way to limit these conflicts, i.e., contradictions in TRIZ or functional requirement coupling in Axiomatic Design. Where these conflicts can't be sidestepped, decision analysis based on multi-attribute utility theory (MAUT) may be used to maximize stakeholder value when evaluating between solution alternatives.

The remainder of Figure 1 shows a continuous improvement loop powered by feedback. Systems that maximize stakeholder value receive high levels of operational use. This increases the availability of user feedback, both positive and negative. Feedback, if appropriately harvested, should increase the pace of innovation and design improvements. In general, these design improvements yield a higher level of operational efficiency through reduced resource consumption, increased operational tempo or improved user experience and satisfaction.

Operational efficiencies create opportunities and momentum (stakeholder support and resources) to extend the solution to new use cases or to fund higher levels of value creation for existing use cases. This virtuous feedback loop could continue until stakeholders "raise the bar" and demand performance that is out of reach for the original phenomenon.

How does emergence relate to our definition of the System of Interest?

We speak of emergence as having a context, i.e., behavior or properties exhibited at the boundary of the SOI. But the SOI is an abstract creation of the human mind; everything in the natural world interacts with everything else in accordance with the laws of nature. When looking at a phenomenon measured at the system boundary, that behavior/property may be the result of interactions between our original SOI and an external system/actor combined with the environment in which the two systems exist. In other words, our SOI is part of other broader SOI's each of which can provide the context for describing a phenomenon as emergent.

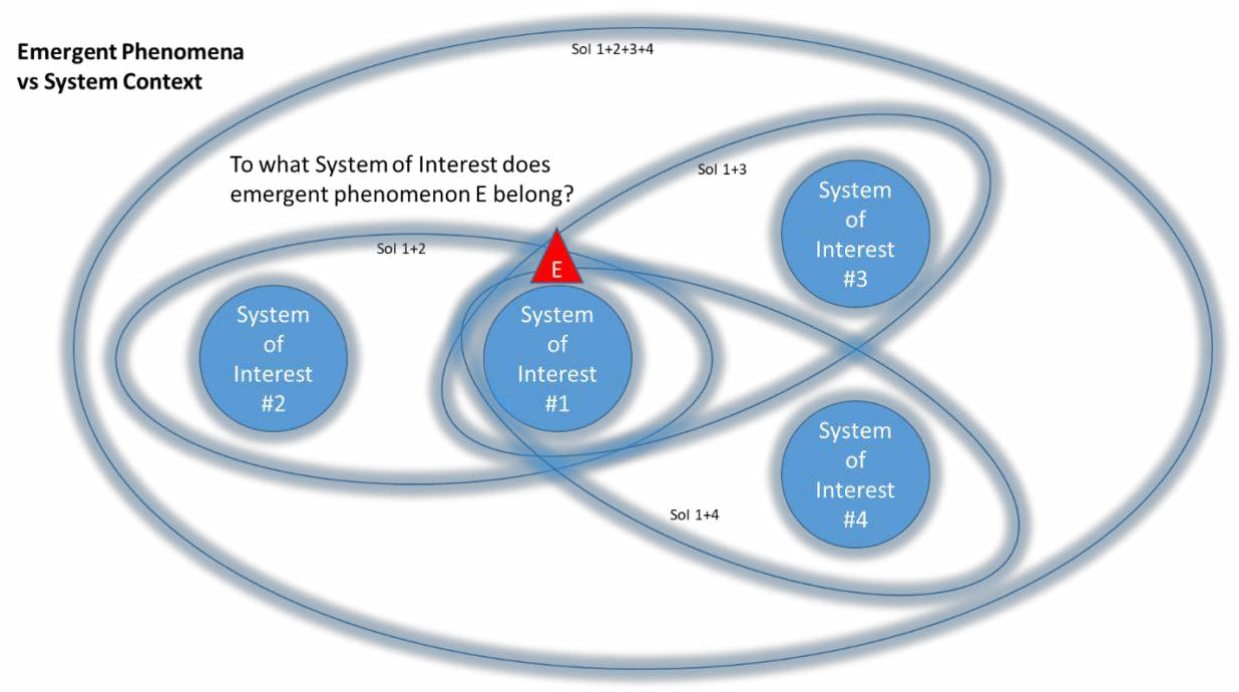

Figure 3: Emergent Phenomena vs System Context

In Figure 3, emergent phenomenon E is observed as occurring at the boundary of SOI #1. However, it cannot safely be assumed that phenomenon E is the consequence of the interactions between the components within SOI #1. Just as likely, phenomenon E may be produced by SOI #1's interaction with SOI #2 or #3 or #4 and perhaps the environmental conditions shared by the interacting systems. Nor should we limit our search for the causality behind emergent phenomena to pairwise interactions. Phenomenon E could result from the combined interactions between SOI's 1, 2, 3 and 4 and their enveloping environments. Where new technologies or components are combined in new environments, multiple rounds of analysis, e.g., modeling, simulation, and physical experimentation, may be required to isolate the causality that produces an emergent behavior.

How does emergence differ if the system includes multiple human actors, each with memories, states, and choice?

Predicting and managing emergence in systems with multiple human actors presents even greater challenge. Imagine a musical performance being experienced by a large audience of individuals and groups (couples, families, and friends). Emergence may be experienced at many levels. The tone (frequency and harmonics) that emerges from a stringed instrument is an emergent property of string composition, tension and the string-to-instrument and string-to-musician interfaces. The emotional state of the musician and their skill in playing the score may impact the timing and quality of the sounds emitted from the instrument. If the band or orchestra (another SOI) hasn't completed sufficient pre-performance tuning, then discordant notes may be produced from the various instruments that interfere with the enjoyment of the concert. The audience is part of the larger system also; they come to the performance with different states of mind, body, and soul. Some audience members may be preoccupied with business worries, experiencing strife with a someone sitting next to them or frustration at attending a musical event in which they have limited interest. Others may be primed for full immersion in the performance, the content of which may evoke either joyous or sad memories. Add in the showmanship of the conductor or band leader and the facility layout, environmental conditions and acoustics as variables and the ability to predict or control whether the performance will be a smashing success or falls flat is certainly in doubt.

One can safely imagine that the effort, tools, and skills required to effectively manage emergence in complex systems will continue to grow as the number of human actors and artificial intelligence (AI) agents and their human-human, human-AI and AI-AI interactions increase.

How does emergence influence System Requirements Analysis practices?

Though the term "emergent requirements" appears in both the SE Handbook and SEBoK, in this author's understanding this term is a contraction of a broader concept, i.e., emergent behaviors/properties that demand a response in the solution design and therefore create derived requirements on the system and its elements.

The primary impact of emergence on System Requirements Analysis process is the need to gather information concerning the system context that may be used to understand the potential interactions between the SOI and external systems, across the full lifecycle of the SOI. To that end, Context Analysis (CA) plays an important role in identifying each external system, characterizing its interface with the SOI, and capturing the environmental conditions under which the interaction occurs.

Design Requirements Analysis (DRA) may be a particularly valuable technique that uncovers where stakeholders have prescribed a solution by specifying the "internals" of the SOI rather than the functionality and performance expected at the SOI boundary. Stakeholder-specified technologies, directed-use components, internal interfaces, or physical layouts impose on the design the emergent properties associated with these elements. A solution development team may lack the expertise and models needed to anticipate emergence that emanates from the imposed portion of the solution design. Extra effort is called for to propose to the stakeholders how the imposed design may be replaced with solution-independent requirements. If these proposed changes are not accepted, stakeholders should be encouraged to share their experience with the imposed design elements and participate in the process of anticipating emergent system behaviors.

Functional Analysis during System Requirements Analysis identifies the role that the SOI plays in accomplishing broader mission scenarios or use cases. Each system-level, system-assigned function will have one or more Measures of Performance (MOPs) that express how well the system function must be performed. System-level performance is an emergent property of the performance of interacting system components as they deliver the solution-level functions allocated to them through the system design. Technology and architecture design decisions will determine how solution-level performance rolls up (typically expressed mathematically) to produce the system-level emergent behavior.

Rest of Scenario Analysis complements Functional Analysis by capturing more thoroughly the conditions (environmental, threat, etc.) under which use cases and system-assigned functions will be performed. This information may uncover emergent properties of the system that arise from interactions between system elements when delivering functionality under extreme conditions.

How does emergence influence System Design/Decision-making practices?

Design evaluation and decision-making is an exercise that depends on predicting emergence, i.e., estimating the performance/properties of the SOI by looking at the parts and their interactions for each solution alternative. System-level Measures of Effectiveness (MOEs) are typically the salient value-creating emergent properties that serve as the evaluation criteria in such design tradeoffs.

Incremental development is a strategy by which multiple design iterations and virtual or physical prototypes are used to uncover hard-to-predict emergence. However, the ability to effectively predict emergent behaviors often requires multiple system designs and deployments within a particular domain to enable the maturation of behavioral patterns and associated system modeling capabilities.

If domain-specific decision patterns have been developed for a family of systems/solutions, the criteria pattern for each decision is a place to capture lessons learned concerning emergence. For example, the "Choose Technology" decision for a Detect Target function might include a criteria pattern that addresses the need to mitigate the impact of previously observed countermeasures or extreme weather conditions on detection probability.

How does emergence influence System Integration practices?

Systems Integration (SI) is ultimately where emergence emerges. When system elements are combined into increasing levels of scale and completeness, we can expect emergent behaviors/properties that were estimated or predicted (and some which weren't) to begin to be seen. Multiple system development and system integration strategies exist that can help uncover unexpected emergence early in the project and provide insights into the causality behind emergent behaviors. In a system with a high likelihood of numerous "new" emergent behaviors, the combination of Waterfall development and "Big Bang" integration should be avoided.

How does emergence influence Verification and Validation practices?

Test cases should be defined that address the full range of environmental conditions under which the system must perform, such that emergent behaviors don't fall through the cracks. For example, the verification of the structural design of a suspension bridge should include a range of dynamic wind-loading scenarios to increase the likelihood of uncovering a case where an emergent property, resonance, could lead to structural failure, e.g., the 1940 collapse of the Tacoma Narrows bridge.[5]

How does emergence influence Systems Engineering Management practices?

The Technical Performance Measurement (TPM) process should define Technical Parameters (TPs) and associated Planned Value Profiles (PVPs) to monitor the most significant value-creating and value-destroying emergent system properties. TPM provides an early warning system to detect if value-creating emergent properties are on track toward achieving required levels of performance and if value-destroying emergent behaviors have been effectively controlled as the system design evolves.

Conclusions and Takeaways

Through a two-month excursion into the topic of emergence, the author has formed several tentative conclusions and takeaways, all subject to revision based on inputs from wiser individuals:

- Emergence is a property of the natural world. It exists and will impact all natural and engineered systems whether the discipline of systems engineering accounts for emergence poorly or well. Emergence is a bit like gravity; ever present and influential, but not typically center-stage in engineers' minds.
- Emergence may either create or destroy value in engineered systems. Value-creating and value-destroying emergence don't point to different types of causality, just whether the behaviors and properties that emerge at the system level are perceived as good or bad in the eyes of system stakeholders.
- Early consideration of emergence can be the source of significant innovation in solution concepts, particularly when framed as explicit decisions to be made (front-end system concept and technology trade studies).
- The ability to manage emergence depends on the observability and the predictability of the emergent phenomena. The ability to engineer depends on the trail blazed by science. We can't predict with confidence what we haven't observed with sufficient frequency and resolution to develop estimation heuristics or equations.

- Many potentially efficacious phenomena (powerful, efficient, safe, smart) are stuck in a research and development (R&D) pipeline waiting for investments to improve their observability, predictability and controllability to the level needed to create a mature technology.
- The observability/predictability of an emergent phenomenon is 100% independent of its impact on value in the eyes of the system stakeholders.
- Although emergence is defined in context of a SOI, emergence cuts across (laughs at) any boundaries that we define for our SOI. Such boundaries, mental models all, while useful in simplifying an engineering problem, do nothing to limit the interactions that will occur in the physical world where our SOI is a part of many other systems.
- Much mischief (overlooked emergent phenomena) may occur the interfaces deemed to be external to the SOI. Context Analysis, a technique within System Requirements Analysis, seeks to uncover all external interfaces, the environment surrounding the interfaces and the items being passed between the SOI and external actors. Engineers should consider the unexpected and undesirable emergent properties of the SOI, external system and enveloping environment associated with each external interface.
- Many engineering and analysis techniques exist for anticipating and modeling emergence. None ensure that a novel combination of existing technologies or solution elements won't produce an emergent phenomenon that is discovered after system integration or during system operation. But a diverse portfolio of such techniques, combined with incremental development and integration strategies and Systems Engineering Management disciplines, e.g., TPM, can reduce the risk of late and hard-to-correct discoveries of emergence.

PPI SyEN welcomes your feedback on this brief article.

- Where are the flaws in our musings on emergence?
- What lessons have you learned that have enabled you to successfully exploit emergence in your system designs and avoid unpleasant surprises from unexpected emergence?

Feel free to email your insights to PPISyEN@PPI-Int.com.

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About the Author

John Fitch is a Principal Consultant and Course Presenter for Project Performance International. John brings over four decades of systems engineering, engineering management, consulting, and training experience to the PPI team. In 2012, John was certified by INCOSE as an Expert Systems Engineering Professional (ESEP).

Within the field of systems engineering, John's career has focused on decision management, requirements management, risk management, systems design & architecture, product/technology road-mapping and innovation. In addition to defense/aerospace, John has guided initiatives in domains such as communications systems, software, energy, nanotechnology, medical devices, manufacturing systems, knowledge management and business process improvement.

Upcoming PPI Live-Online ™ Systems Engineering Five Day Courses

Click here to view the full schedule or register for an upcoming course.

P006-890-1	North America UTC -4:00 (EDT 8:00) PPI Live-Online	12 Sep - 16 Sep 2022
P006-890-2	South America UTC -3:00 (BRT 9:00) PPI Live-Online *(Only available in South America)*	12 Sep - 16 Sep 2022
P006-892-1	Asia UTC +8:00 (SGT 6:00) PPI Live-Online	12 Sep - 16 Sep 2022
P006-892-2	Oceania UTC +10:00 (AEST 8:00) PPI Live-Online	12 Sep - 16 Sep 2022
P006-891-1	Europe UTC +2:00 (CEST 9:00) PPI Live-Online	19 Sep - 23 Sep 2022
P006-891-2	United Kingdom UTC +1:00 (BST 8:00) PPI Live-Online	19 Sep - 23 Sep 2022
P006-891-3	South Africa UTC +2:00 (SAST 9:00) PPI Live-Online *(Only available in South Africa)*	19 Sep - 23 Sep 2022
P006-894	São José dos Campos, Brazil (BRT 8:00) *(Only available in South America)*	03 Oct - 07 Oct 2022
P006-895-1	Turkey UTC +3:00 (TRT 8:00) PPI Live-Online	17 Oct - 21 Oct 2022
P006-895-2	Saudi Arabia UTC +3:00 (AST 8:00) PPI Live-Online	17 Oct - 21 Oct 2022
P006-896	Netherlands UTC +1:00 (CET 8:30) - Holiday Inn Eindhoven	31 Oct - 04 Nov 2022
P006-897-1	Asia UTC +8:00 (SGT 5:00) PPI Live-Online	07 Nov - 11 Nov 2022
P006-897-2	Oceania UTC +11:00 (AEDT 8:00) PPI Live-Online	07 Nov - 11 Nov 2022
P006-898-1	North America UTC -7:00 (MST 8:00) PPI Live-Online	14 Nov - 18 Nov 2022

SYSTEMS ENGINEERING RESOURCES

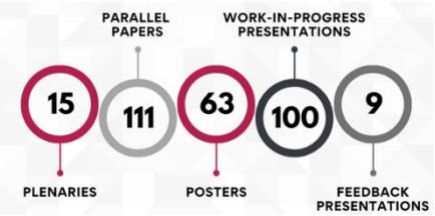
Useful artifacts to improve your SE effectiveness

Recordings Available for the 2022 International System Dynamics Conference

ISDC 2022

The System Dynamics Society has announced that recordings are now available for all registered participants of the 2022 International System Dynamics Conference (ISDC 2022) that was held on 18-22 July in Frankfurt, Germany and online. Recordings include plenaries, parallel sessions, workshops, award ceremonies and other conference sessions.

Registered attendees may log in to access the ISDC 2022 recordings here. *Recordings will be available only through 30 September 2022.*



Individuals that were unable to attend SDC2022 may still register as virtual attendees and receive access to all recorded content.

Join the System Dynamics Society to receive the member discount associated with ISDC 2022.

INCOSE AI Explorer Talks

The goals of the INCOSE Artificial Intelligence (AI) Systems Working Group goals are to: 1) identify and communicate emerging AI technologies that can be applied to the engineering of systems (AI for SE), including AI that appertains to industries of the Future, and 2) develop and communicate advances in SE methods needed to effectively engineer systems with embedded AI (SE for AI). The Working Group has been hosting a series AI Explorer talks during 2022. These talks have covered a wide range of AI-related topics that are relevant to the design of AI-enabled systems. The talks shared in 2022 include:

27 July 2022: *Co-design of Trustworthy AI and Systems*
(Dr. Zoe Szajnfarber, George Washington University)
The Designing Trustworthy AI Systems (DTAIS) program is built around a core tension between the opportunity for ubiquitous AI to transform work for social good and the emergent risks around bias, security and privacy that arise as AI tools are increasingly embedded in core routines and value generating institutional functions. This presentation will provide an overview of DTAIS research on trust and system architecture, focusing on two in-progress studies. First, in the context of image classification, we explore how a typical focus on accuracy scores (this classifier is 89% accurate) can hide critical differences in the distribution of classification errors (when it's wrong, how wrong is it?). We relate differences in error distribution to the formation of trust among end-users.

Second, in the context of human in/on-the-loop AI systems, we examine perceived and revealed differences between human control over the systems and discuss the implications of these differences for policy.

27 July 2022: *Responsible Artificial intelligence*
(Dr. Anjana Susarla, Michigan State University)
The talk will discuss algorithmic bias, fairness metrics and bias mitigation practices and end with a discussion of algorithmic harms to evaluate fairness metrics. The specific example of digital health literacy will be examined. Studies suggest that one in three US adults use the Internet to diagnose or learn about a health concern. However, such access to health information online could exacerbate the disparities in health information availability and use. Health information seeking behavior (HISB) refers to the ways in which individuals seek information about their health, risks, illnesses, and health-protective behaviors. For patients engaging in searches for health information on digital media platforms, health literacy divides can be exacerbated both by their own lack of knowledge and by algorithmic recommendations, with results that disproportionately impact disadvantaged populations, minorities, and low health literacy users. I will report on exploratory investigation of the above challenges by examining whether responsible and representative recommendations can be generated using advanced analytic methods applied to a large corpus of videos and their metadata on a chronic condition (diabetes) from the YouTube social media platform.

15 June 2022: *Introduction to Trustworthiness in Computing Systems*
(Tom McDermott, SERC)
General concepts of trust in AI and autonomous systems can be derived from engineering concepts of dependable and secure computing systems. In computing systems, trust is formally defined as the dependence of one system on another, and the acceptance that the other system is also dependable. [Avižienis, et al, 2004]. This dependence can be either human/machine or machine/machine. Resilience is related to trustworthiness as the ability of the system to withstand instability, unexpected conditions, and gracefully return to predictable, but possibly degraded, performance. This is a system-of-systems concern, and trust must be considered as both a characteristic of an individual system or subsystem and as relationships between the system and other systems including humans. In systems engineering, trust can be categorized into a set of dependability and security attributes: the ability of a system to avoid service failures and cover the interrelated foundational attributes of availability, reliability, safety, integrity, confidentiality, and maintainability. These attributes work together to ensure the system's successful application, and demonstration of those attributes over time engenders trust. Thus, trust is a systems engineering concept. In this talk we will explore modeling trust as a set of system attributes.

Download the presentation.

15 June 2022: *The Confiance.AI Program*
(Guillermo Chalé Góngora, Thales)
Confiance.AI is a French national program launched within the framework of the French National Grand Challenge "Security, dependability and certification of AI-based systems" managed by the French Innovation Council. Confiance.AI is the largest technological research program of the #IAforHumanity plan. The program brings together a unique community of actors across industry, start-ups, education, and research to design and industrialize trustworthy AI-based critical systems, with the final goal of ensuring the competitiveness and sovereignty of the French industry.

The main objective of the program is to design and deliver a "trustworthy environment" for engineering industrial AI-based products and systems.

The environment relies on methodological and technological bricks that complement the existing development environments of the industrial partners of the program. It supports the design, verification, validation, qualification, and deployment

of AI-based systems in an industrial context and at large scale. Industrial sectors participating to the program include aerospace, automobile, maritime, energy, IT, defense, security, and manufacturing.

In this webinar, we will present the scope, organization and expected outcomes of the Confiance.AI program, with a focus on the systems approach that has been defined within the program.

Download the presentation.

4 May 2022: *A System Engineer's Guide to Explainable AI*
(Dr. Ali Raz, CSEP, George Mason University)
System Engineers (SEs) are faced with incorporating Artificial Intelligence and Machine Learning (AI/ML) based solutions into modern systems for meeting complex technological and societal needs. It is imperative for SEs to characterize the behavior of AI/ML based components that often appears as black boxes even to the component designers. This talk will introduce key concepts of Explainable AI (XAI) that creates a window into the black-box nature of AL/ML based component. We will debunk some common myths about explainability and discuss how SEs can utilize XAI for test and evaluation of systems with AI/ML-components.

4 May 2022: *Everything I Know about Artificial Intelligence I Learned from the Movies*
(Dr. Barclay R. Brown, ESEP, Collins Aerospace/Raytheon Technologies)
Much of what most people "know" about artificial intelligence traces its source to science fiction mythology. Science fiction representations of robots, created minds, and intelligent machines spans a wide range of perspectives. Speculative books may describe possible futures of AI, but movies and TV series can show what a world would be like if these scenarios became reality. Star Wars and Star Trek, show nearly polar opposites in how AI turns out in a highly advanced human (and non-human) civilization.

INCOSE members may view the AI Explorer presentations at the AI Systems Working Group public page.

Learn more about the INCOSE AI Systems Working Group.

INCOSE INSIGHT Practitioners Magazine: Security in the Future of Systems Engineering

Volume 25, Issue 2 of INSIGHT, INCOSE's Practitioner Magazine published by Wiley, was released in June. Electronic subscriptions to INSIGHT are available as a member benefit to INCOSE members. Hard-copy subscriptions to INSIGHT are available for purchase by INCOSE members for one membership year, and to the public.

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The issue theme is the *security in the future of systems engineering*. Content includes:

- Setting the Current Context for Security in the Future of Systems Engineering (Rick Dove)
- Measuring Stakeholder Alignment to Overcome Control System Cyber Vulnerability (Aleksandra Scalco, Steve Simske)
- Functionally Interpreting Security (Michael McEvilley, Mark Winstead)
- Capability Engineering vs. 'Problemeering' and 'Solutioneering'- Prioritizing Stakeholder Needs over Requirements" (Matthew Hause, Mitchell Brooks)
- Very Small Entities (VSE): Outsourcing Risk to the Supply Chain Is Placing Systems Security Engineering on a Clay Foundation, but Playing Games May Help (Roar Georgsen, Geir Køien)
- Framework for Operational Resilience in Engineering and System Test (FOREST) Part I: Methodology - Responding to 'Security as a Functional Requirement' (Tom McDermott, Megan Clifford, Tim Sherburne, Barry Horowitz, Peter Beling)
- Framework for Operational Resilience in Engineering and System Test (FOREST) Part II: Case Study (Tom McDermott, Megan Clifford, Tim Sherburne, Barry Horowitz, Peter Beling)
- Multilayered Network Models for Security: Enhancing System Security Engineering with Orchestration (Adam Williams)
- Modeling for Trustworthiness (Mark Winstead)
- Making the Puzzle Pieces Fit - Utilizing UAF to Model a Cybersecurity SoS (Mitchell Brooks, Matthew Hause)
- Analyzing System Security Architecture in Concept Phase Using UAF Domains (Juan José López García, Daniel Patrick Pereira)
- Cyber Supply Chain Risk Management (C-CRM) a System Security Engineering Role in the Future of Systems Engineering (Holly Dunlap, Catherine Ortiz)

INCOSE members may login and view the entire 66-page issue of INSIGHT Volume 25, No. 2 in the INCOSE Connect Library or in the Wiley Online Library.

Systems Engineering Journal July 2022 Edition

SYSTEMS ENGINEERING
The Journal of The International Council on Systems Engineering

INCOSE

In July, INCOSE, through the Wiley online library, published Volume 25, Issue 4 of the Systems Engineering Journal. This edition includes six articles, a mix of open access content and papers that require an institutional login, e.g., via INCOSE membership. There is no published unifying theme for this edition. SyEN has included abstracts to guide our readers to which of these diverse topics best fit their interests.

Intent integration for human-agent teaming

Authors: Michael F. Schneider, Michael E. Miller, Thomas C. Ford, Gilbert Peterson, David Jacques

Abstract: Knowledge of intent is critical in high performing human teams. The fundamental question addressed by this research is, how should intent be integrated into future human-artificial agent (AA) teams to improve coordination among team members? A brief review of the use of intent for improving performance within human-human teams is conducted to provide a better understanding of this term. This review differentiates intent estimation from intent application, as well as the differentiation of "why," "what" and "how" based intent. A taxonomy of intent-based systems is then developed through a review of existing examples in the literature.

Together these reviews demonstrate that intent has been modeled in a variety of ways without a cohesive understanding of intent and its different forms. Based upon these reviews and our understanding of multi-agent system architectures, we propose "operationalized intent" as a method of modeling intent regarding "how" the operators would like to execute the team's tasks. We propose including an Intent Agent (IA) dedicated to estimating intent of each operator and embedding knowledge of how to execute within the Functional Agents (FAs) of a multi-agent system. The proposed Operationalized Intent Ontology provides a means of modeling human-agent teams as an intent informed system.

Impacts of work-at-home policies on systems engineers and the general population

Authors: Maria Jose Perez-Pereda, Pouria Babvey, Jose Ramirez-Marquez, Kara Pepe, Dinesh Verma
Abstract: The COVID-19 pandemic presented many challenges, one of them being the imposition of "work-at-home" policies in March 2020. The Systems Engineering Research Center (SERC) and the International Council on Systems Engineering (INCOSE) conducted two online surveys—one during the first months of the pandemic in 2020 and the second survey 1 year after, in March 2021—to understand the impact of these policies within the systems engineering community. The surveys' format consisted of multiple-choice questions and open-answer questions, which were analyzed using LDA for topic modeling. Data were also collected from social media during the same timeframes to compare the feelings and experiences of systems engineers with those of the general population.

An experimentation framework for validating architectural properties as proxies for the ilities

Author: Alejandro Salado
Abstract: Desired system ilities, understood as lifecycle properties, generally drive the value of a system's architecture. However, ilities are hard to predict during system architecture development before the architecture has been instantiated with a system design. In this paper, an experimentation framework that can be employed to validate the adequacy of using architectural properties as proxies for ilities is presented. The experimentation framework builds upon a theoretical, generic conceptualization of ilities, which helps to formally justify the difficulties of and limitations in predicting how architectural choices influence system ilities. Application of the experimental framework is showcased with a notional scenario, where the framework is used to evaluate how different system topologies influence the integrability of a system.

Comparative analysis of model-based and traditional systems engineering approaches for simulating a robotic space system architecture through automatic knowledge processing

Authors: Paulo Younse, Jessica Cameron, Thomas H. Bradley
Abstract: Model-based Systems Engineering (MBSE) case studies in the literature assert that there are benefits to MBSE when applied to modeling and simulating space systems. This research evaluates the benefits of an MBSE modeling and simulation approach over a traditional, non-MBSE approach through modeling and simulation of an orbiting sample Capture and Orient Module (COM) architecture for potential Mars Sample Return (MSR). The COM architecture was modeled, simulated, and evaluated against nominal load power and output data rate requirements to compare the two approaches.

A new modeling and simulation-centric V-model was synthesized from existing V-model and modeling and simulation process models to map out the modeling and simulation activities within the context of the system development lifecycle and used as a tool to compare the non-MBSE and MBSE approaches. A three-phase modeling and simulation process consisting of an analysis and modeling phase, computer programming and implementation phase, and experimentation phase was used to model and simulate the COM. The total number of manual and automatic knowledge processed was calculated for both approaches and used to quantify the benefits of the MBSE approach relative to the non-MBSE approach.

In the non-MBSE approach, all knowledge elements were manually processed during the modeling and simulation process. In the MBSE approach, 49% of total knowledge processing was automated.

The MBSE approach showed user experience benefits with modeling and simulating the COM robotic space system through providing a higher level of support for automation, reducing the burden of systems engineering tasks, and reducing effort.

Safety system design and overfill protection for loading asphalt onto trucks

Authors: Wendy Ampadu, Hassan Malik, Ray Diezmos, Jeremy Hyslob
Abstract: There are several technologies out there for use as high-level switches as part of a system for shutting down flow to a vessel. Given that asphalt truck loading poses issues such as poor visibility, coating, condensation, and fumes, a solution that is robust enough to last in these conditions is often needed in industries. Furthermore, the design of the loading arm, rack, and process equipment may need to be changed to allow for the safety to work as needed. This report would not just be selecting an overflow technology but completing the redesign of structures for use at loading facilities. This report is based on loading facilities at a bitumen production company based in Toronto, Canada with over 25 locations across the country. The engineering design approach was used to create multiple redesign concepts for the loading dock system. Research on overfill systems was also completed by surveying the existing market for technologies and securing quotes from over 20 Canadian and United States instrumentation companies. A final loading dock redesign and level transmitter for overfill protection solution were chosen.

Characterizing integration challenges in mission engineering to form solution strategies

Authors: Alejandro S. Hernandez, Anthony G. Pollman
Abstract: This paper presents a systematic approach to characterize integration challenges when implementing mission engineering and discusses some specific techniques to address these issues. With the introduction of mission engineering in the DOD science and technology lexicon, integration assumes a new dimension beyond the system product level. First, the authors offer a more precise definition of integration that focuses on incorporating a new technology or military capability into an existing organization's infrastructure. Using a collection of system integration literature and a set of examples, the authors define major problem areas regarding integration. Analyses of these issues present opportunities to identify specific methods to avoid or mitigate them. The resultant process is a foundation for mission engineering practitioners to plan successful integration of a new system. Acceptance of these procedures in the mission engineering community may lead to inclusion as standard practices in the DOD Mission Engineering Guide.

INCOSE members in good standing may access all Systems Engineering Journal content through their INCOSE Connect login (using the Wiley Online Proceedings Library link after login). Non-members may subscribe to the journal, use institutional logins from their university or place of employment, or purchase access to individual articles at the URLs associated with the article titles, above.

Books and Resources on Axiomatic Design

In the 1980's Dr. Nam P. Suh developed and began teaching an axiomatic approach to engineering design at the Massachusetts Institute of Technology (MIT). His study of design science eventually reduced a large set of candidate design axioms to just two:

- Independence Axiom: Maintain the independence of the functional requirements (FRs).
- Information Axiom: Minimize the information content of the design.

Axiomatic Design has been taught at universities around the globe and summarized in numerous written works including books and journal articles.

A dozen international conferences have been held since 2000 to explore Axiomatic Design theory and applications. Dr. Suh has written or co-authored four books on Axiomatic Design.

Suh (1990), *The Principles of Design*, Oxford University Press, 1990, ISBN 0-19-504345-6

Suh's first book introduces the principles of industrial design and their application in all phases of planning and production. It presents basic principles and constitutes an exposition of these fundamental axioms and their application. The emphasis is on identifying problems in a clear, scientific manner, so that the correct solution may be arrived at regardless of the mathematical treatment involved. In particular, the importance of conceptualizing design approaches - a uniquely human, intellectual skill - is highlighted, since too often educators and engineers try to limit this process to computer techniques. Case studies are extensively presented to illustrate the significance as well as the use of the axioms in solving real problems. The work is based on extensive experience at M.I.T's Laboratory for Manufacturing and Productivity.

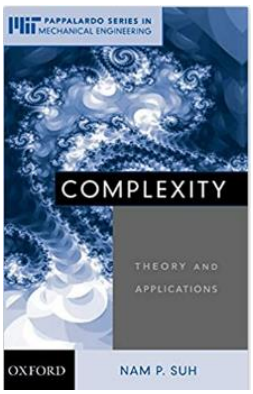
Read book review on ResearchGate. Access through Amazon. Access through Google.

Suh (2001). *Axiomatic Design: Advances and Applications*, Oxford University Press, 2001, ISBN 0-19-513466-4

Suh's second book begins with a three-chapter review of the fundamental principles of axiomatic design. Subsequent chapters offer a complete treatment of the design of systems, software, materials and materials processing, manufacturing systems, and product design. Suh shows how a scientific and systematic approach to design improves efficiency, productivity, savings, reliability, and quality for industries that currently rely on ad hoc design systems. Suh asserts that Axiomatic Design contains the principles and practical knowledge necessary to achieve these improvements.

Read book review. Access through Amazon.

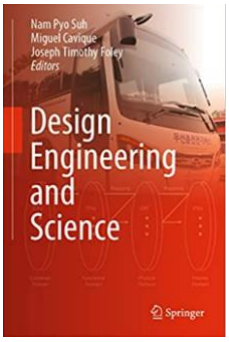
Suh (2005). *Complexity: Theory and Applications*, Oxford University Press, 2005, ISBN 0-19-517876-9



Dr. Suh, best known for his systems that aim to speed up and simplify the process of design for manufacturing, focused his axiomatic design theories on methods to understand and deal with complexity. The 'axioms' in axiomatic design refer to a process to help engineers reduce design specifications down to their simplest components, so that the engineers can produce the simplest possible solution to a problem. Complexity, besides being a key area of burgeoning research in disciplines interested in complex systems and chaos theory (like computer science and physics), is a complicating factor in engineering design that many engineers find difficult to overcome.

Suh's multidisciplinary exploration of complex systems is meant to eliminate much of the confusion and allow engineers to accommodate complexity within simple, elegant design solutions.

Access through Oxford University Press. Access through Amazon.
Suh, N. P., Cavique, M., Foley, J.T. *Design Engineering and Science*, Springer, 2021



In this recent elaboration of Axiomatic Design, Dr. Suh collaborates with Dr. Miguel Cavique (Escola Naval, Lisbon) and Dr. Joseph Foley (University of Reykjavík) to show how a logical framework and scientific basis for design can generate creative solutions in many fields, including engineering, materials, organizations, and a variety of large systems. The book is divided into two parts. Part I provides detailed and thorough instruction in the fundamentals of design, discussing why design is so important. It explains the relationship between and the selection of functional requirements, design parameters and process variables, and the representation of design outputs. Part II presents multiple applications of AD, including examples from manufacturing, healthcare, and materials processing.

Access through Springer. Access through Amazon.

Technical papers presented at the International Conference on Axiomatic Design (ICAD) are available in PDF format for ICAD 2000 – 2016 here.
Access ICAD 2017 papers and other Axiomatic Design publications at ScienceDirect.
Access ICAD 2018 papers here.
Access ICAD 2019 papers here.

See additional recommended Axiomatic Design books here.

The global systems engineering community is actively seeking to improve the scientific foundations of its disciplines, as evidenced by the work of the INCOSE Systems Science and Complex Systems working groups and Future of Systems Engineering (FuSE) projects.

PPI SyEN believes that engagement with the global Axiomatic Design community might be a path the acceleration of these goals.

Aerospace Corporation Systems Engineering Forum

During 2022, the Aerospace Corporation hosted a Systems Engineering Forum, a 4-event virtual series that focused on applying Model-Based Systems Engineering (MBSE) across the space enterprise, contributing to mission success while fulfilling the digital engineering vision.

Each event included two presentations addressing important MBSE-related themes.

Febuary 2022 - *ARCHITECTING ENTERPRISE SOLUTIONS*: Higher-level decision-making requires higher-level engineering and integration and the ability to abstract information.

- Enterprise Architecture Based Portfolio Management (Dr. James Martin)
- Agile Enterprise Engineering Analytics (Jodene Sasine, Dr. Julie Fant)

April 2022 – *AGILITY IN ACQUISITIONS: Flexibility, adaptability, and resilience in capabilities requires agility in how we acquire them.*

- Agile Verification and Validation (Dr. Supannika Mobasser)
- Digital Engineering Workflow (Robert Crombie)

June 2022 – *DIGITAL ENGINEERING IN PRACTICE: Practical instances of where Digital Engineering facilitates innovation and where it adds barriers.*

- What Did I Do Wrong? An Episode in Agile Anti-patterns (Dr. Supannika Mobasser)
- Verification and Validation of SysML Models (Myron Hecht, Jaron Chen)

August 2022 – *DIGITAL ENGINEERING STANDARDS: Bringing current and future standards to the community.*

- Establishing Authoritative Sources of Truth (ASOTs) (Dr. Matthew Daskilewicz)
- GENESYS Management of Standards (Daniel Winton)

View the 2022 and 2021 SE Forum series on YouTube.
Learn more about the Systems Engineering Forum here.
Recommend SEF topics for 2023.

SERCTALKS - Secure Cyber Resilient Engineering for the Era of Competition

On 15 June, the Systems Engineering Research Center (SERC) hosted the third of its Spring 2022 SERC TALKS focusing on the topic of Cyber Resilience. Moderated by Dr. Peter Beling of Virginia Tech, the series sought to stimulate an ongoing and more collaborative dialogue between academia, government, and industry sectors on this important topic.

Ms. Melinda K. Reed, the Director, Systems Security, Science and Technology Program Protection (STPP) Office in the Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)) delivered the third talk, titled "***Secure Cyber Resilient Engineering for the Era of Competition***"

The presentation highlighted the evolving and complex nature of challenges presented by critical systems operating in contested cyberspace environments. These challenges demand unique workforce skills beyond those addressed by information technology security education; gaps that must be filled by organizations that engineer for systems for safety, security, and resilience in the face of cyber adversaries.

Although focused on the cyber-resilient needs of weapon systems, the principles and framework presented may be applicable to other systems under threat from cyber-attack.

Download slides. View the talk.
See previous SERC TALKS series and topics here.

Webinar - Practical and Proven Software Architecture Analysis and Evaluation Fundamentals

On 20 July, the Carnegie Mellon University (CMU) Software Engineering Institute (SEI) conducted its third webinar in the Lunch 'n Learn Series, titled *Practical and Proven Software Architecture Analysis and Evaluation Fundamentals*. Shared by Philip Bianco of the SEI's Technical Staff, the presentation highlighted the Architecture Tradeoff Analysis Method (ATAM) as a proven architecture analysis and evaluation method.

Abstract:
Architecture is critical for business success. A solid architecture helps prevent defects and system failures. It helps a development effort save money and get quality products to the market faster. Most software-reliant systems are required to be modifiable and reliable. They may also need to be secure, interoperable, and portable. Many organizations are struggling with the results of making poor architectural choices and inadequately managing architectural decisions. How do you know whether your software architecture is suitable or at risk relative to its target system qualities? This session covers practical and proven architecture analysis and evaluation fundamentals that should be incorporated into any software architecture evaluation process. We will demonstrate these principles that identify risks early in the development lifecycle using fundamentals and techniques from the Architecture Tradeoff Analysis Method (ATAM), a tested process that has been used in many evaluations over the past 20 years.

Conducting an ATAM consists of nine steps:

- *Present the ATAM*. The evaluation leader describes the evaluation method to the assembled participants, tries to set their expectations, and answers questions they may have.
- *Present business drivers*. A project spokesperson (ideally the project manager or system customer) describes what business goals are motivating the development effort and hence what will be the primary architectural drivers (e.g., high availability or time to market or high security).
- *Present architecture*. The architect will describe the architecture, focusing on how it addresses the business drivers.
- *Identify architectural approaches*. Architectural approaches are identified by the architect but are not analyzed.
- *Generate quality attribute utility tree*. The quality factors that comprise system "utility" (performance, availability, security, modifiability, usability, etc.) are elicited, specified down to the level of scenarios, annotated with stimuli and responses, and prioritized.
- *Analyze architectural approaches*. Based on the high-priority factors identified in Step 5, the architectural approaches that address those factors are elicited and analyzed (for example, an architectural approach aimed at meeting performance goals will be subjected to a performance analysis). During this step, architectural risks, sensitivity points, and tradeoff points are identified.
- *Brainstorm and prioritize scenarios*. A larger set of scenarios is elicited from the entire group of stakeholders. This set of scenarios is prioritized via a voting process involving the entire stakeholder group.
- *Analyze architectural approaches*. This step reiterates the activities of Step 6, but using the highly ranked scenarios from Step 7. Those scenarios are considered to be test cases to confirm the analysis performed thus far. This analysis may uncover additional architectural approaches, risks, sensitivity points, and tradeoff points, which are then documented.
- *Present results*. Based on the information collected in the ATAM (approaches, scenarios, attribute-specific questions, the utility tree, risks, non-risks, sensitivity points, tradeoffs), the ATAM team presents the findings to the assembled stakeholders.

Download the slides here.
Learn more ATAM about here.

View the Lunch and Learn Series webinars on the INCOSE GLNC YouTube Channel.
The 12-Session Lunch 'n Learn Series featuring speakers from Carnegie Mellon University (CMU) Software Engineering Institute (SEI) are held monthly on third Wednesdays at 12pm-1:30pm EDT.

Prior sessions include:

- SEI's Zero Trust Journey: Systems Engineering for Cybersecurity (Timothy Morrow)
- Moving Machine Learning into Production Systems (Dr. Jeffrey Chrabaszcz)

Sessions are planned through May 2023.

SEI Blog - Posts on Systems Engineering

The Software Engineering Institute (SEI) at Carnegie Mellon University (CMU) publishes informative blog posts on numerous topics relevant to systems and software engineering. Although most systems today contain some level of software content, topics (with example posts) of particular interest to the systems engineering community include:

- Artificial Intelligence Engineering: Creating Transformative and Trustworthy AI Systems Requires a Community Effort
- Cyber-Physical Systems: Systems Engineering and Software Engineering: Collaborating for the Smart Systems of the Future
- Cybersecurity Engineering: How Do You Trust AI Cybersecurity Devices?
- Enterprise Risk and Resilience Management: System End-of-Life Planning: Designing Systems for Maximum Resiliency Over Time
- Software Architecture: Tactics and Patterns for Software Robustness
- Software Engineering Research and Development: Technical Issues in Navigating the Transition from Sustainment to Engineering Software-Reliant Systems
- Technical Debt: Managing the Consequences of Technical Debt: 5 Stories from the Field

SyEN readers are encouraged to explore articles in the SEI Blog. A 4 July 2022 post summarized recent works including:

- SEI Year in Review: The SEI leads research and direct transition of software engineering, cybersecurity, and artificial intelligence technologies at the intersection of academia, industry, and government. The 2021 SEI Year in Review highlights the work of the institute undertaken during the fiscal year spanning October 1, 2020, to September 30, 2021. Read the SEI Year in Review. Download as PDF.
- *Explainable AI Explained*: The field of AI is developing and deploying increasingly complex opaque models to solve hard problems. When such models fail or do not behave as expected or hoped, it can be hard for developers and end-users to pinpoint why or determine methods for addressing the problem. Explainable AI (XAI) meets the emerging demands of AI engineering by providing insight into the inner workings of these opaque models. Listen to the XAI podcast from Violet Turri and Rachel Dzombak. Related the post on the current state of XAI.
- *Digital Engineering (DE) Effectiveness*: This paper explores why developers of Cyber-Physical Systems (CPS) have been slow to embrace DE, how DE methods should be tailored to achieve their stakeholders' goals, and how to measure the effectiveness of DE-enabled workflows. Access the DE white paper.

The SEI Blog supports a Search feature based on strings, topics, tags, dates, and authors. For example, searching on *MBSE* yields twenty-one items including a February 2021 post on Requirements in Model-Based Systems Engineering and an April 2022 post titled A Case Study in Applying Digital Engineering. PPI SyEN, though not agreeing with all positions presented, finds these posts to be well-

written and containing significant levels of crosslinking to other relevant articles. For example, the latter post contained twelve links to related posts or SEI resources.

PPI RESOURCES

PPI offers a multitude of resources available to all of our clients, associates and friends! Click on any of the links below to access these resources today.

Systems Engineering FAQ: https://www.ppi-int.com/resources/systems-engineering-faq
Industry-related questions answered by PPI Founder and Managing Director Robert Halligan.

Key downloads: https://www.ppi-int.com/keydownloads/
Free downloadable presentations, short papers, specifications and other helpful downloads related to requirements and the field of Systems Engineering.

Conferences: https://www.ppi-int.com/resources/conferences-and-meetings/
Keep track of systems engineering-relevant conferences and meeting dates throughout the year.

Systems Engineering Goldmine: https://www.ppi-int.com/se-goldmine/
A free resources with over 4GB of downloadable information relevant to the Engineering of systems and a searchable database of 7,800+ defined terms. You can expect the content of the SE Goldmine to continue to increase over time.

Systems Engineering Tools Database (requires SEG account to log in from the Systems Engineering Goldmine): https://www.systemsengineeringtools.com/
A resource jointly developed and operated by Project Performance International (PPI) and the International Council on Systems Engineering (INCOSE). The SETDB helps you find appropriate software tools and cloud services that support your systems engineering-related activities. As a PPI SEG account holder, you have ongoing free access to the SETDB.

PPI SyEN Newsjournal (actually a substantial monthly SE publication): https://www.ppi-int.com/systems-engineering-newsjournal/
You're already reading our monthly newsjournal! However click on the link to access the history of 100+ monthly newsjournals containing excellent articles, news and other interesting topics summarizing developments in the field of systems engineering.

INCOSE Smart Cities Initiative - Call for Modelers

The INCOSE Smart Cities Initiative (SCI) is a transformational working group that draws upon the experience and knowledge of INCOSE members to support communities in developing their Smart Cities Concepts, Applications, Technology and Services (CATS) by leveraging systems engineering tools and principles.

On 16 June, Jennifer Russell and Marcel van de Ven, Chair and Co-chair of the SCI respectively, provided an overview of the SCI to the INCOSE Sweden chapter and issued a Call for Modelers to support this effort.

Four topics were addressed with key points shown below:

Smart Cities Overview

- Smart Cities are a moving target; many initiatives have been unsuccessful.
- Technology focused smart cities are rethinking their approach and becoming more people centric.
- A common definition of a smart city and associated metrics are needed.

INCOSE Role

- The goal of the SCI is to create a model that illustrates the city resources that enables interconnectivity, reuse, and consistency. The SCI hopes to leverage INCOSE's diverse and deep pool of working groups to inform this model.
- The SCI has spent several years investigating the Smart City space, building knowledge and relationships and framing the current direction of initiative.
- The SCI product plan includes definitions, metrics, case studies, stakeholder list/management plan, MBSE model(s) and providing inputs to external Smart Cities publications.
- The SCI is collaborating broadly, with standards organizations (e.g., IEEE, IEC/ISO), municipalities and global Smart Cities organizations.
- As first principles, the alignment of the smart city with resident needs is accomplished by keeping humans as central, supporting dynamic objectives, and effectively linking digital data solutions to human needs with a feedback loop.

Definition, Framework, and Metrics

- Per the SCI's new definition, "A smart city is capable of identifying its problems and mitigating root causes by generating and processing engineered quality data in a continuous and inclusive manner." Note that this has nothing to do with technology.
- Engineered quality data (real-time, verifiable, integratable, uniform, inclusive, aligned) as opposed to Big Data is used to identify and mitigate root causes.
- Human Fundamental needs are the basis for a Smart City's goal. The SCI is using the Neef needs framework).

- The purpose of a smart city is to create and maintain an environment that enables its residents to satisfy their fundamental needs by interacting in fair, mutually beneficial, and sustainable ways.
- The SCI has proposed a single set of holistic metrics to provide a consistent benchmark for evaluation and comparison of smart cities and their progress. These include both common/unified metrics for comparing city-to-city progress and tailorable indices based on ISO standards for well-being and UN Sustainable Development goals. (SDGs).
- The INCOSE-TUS Reference Model is a robust, tailorable, and systematic way to view and evaluate a smart city as an integrated complex social system comprised of multiple interacting stakeholders.

Next Steps and Outreach

- *The SCI is demonstrating the human-centric framework and top-level goals in partnership with one or more demonstration cities. Work is underway with Ulaanbataar, Mongolia.*
- *The SCI is working with IEC on modeling the INCOSE Smart City Reference Architecture as a Unified Architecture Framework (UAF) model.*
- *The SCI is also seeking to develop a set of smart city solution architectures.*
- *A Call for Modelers has been issued to support Smart City modeling efforts.*

View the video on here.
Learn more about the INCOSE Smart Cities Initiative.
Join the INCOSE Smart Cities Initiative here.

Registration Open for NIST 2022 Disaster Resilience Symposium

The U.S. National Institute of Standards and Technology (NIST) will be hosting its fifth annual (and third virtual) Disaster Resilience Symposium on 14-15 September. The Symposium will feature the work that has been performed by the 2018 NIST and 2020 NIST/NSF Disaster Resilience Grant Research Program awardees.

Look for presentations on disaster resilience topics including:

- Disaster and Failure Studies
- National Earthquake Hazards Reduction Program
- Wind Impact Reduction
- Reduced Ignition of Building Components in Wildland-Urban Interface (WUI) Fires Project
- Community recovery
- Infrastructure resilience

Learn more about the 2022 Disaster Resilience Symposium.
Register for this free virtual event.

Worcester Polytechnic Institute Hiring Professor & Director of SE Program

Worcester Polytechnic Institute (WPI) in Worcester, Massachusetts, USA, invites applications and nominations for the position of Professor and Director of the Systems Engineering Program. The Systems Engineering program plays a critical role in WPI's graduate education environment, offering Master of Science degrees in Systems Engineering and Systems Engineering Leadership, the Ph.D. degree in Systems Engineering, and graduate level certificates.

Qualifications for this position include:

- An earned doctorate in engineering, computer science, or closely related area; Systems Engineering experience is preferred.
- Strong research experience in the general areas of systems engineering, including but not limited to: systems thinking, system modeling, complex systems, risk management, system safety, security, and reliability.
- Commitment to excellence in teaching and a distinguished record in scholarship and funding commensurate with a tenured appointment at the full professor level.

View the full position description.
Learn more about WPI here.

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Engineering process is useless in the absence of a knowledge of solution technologies relevant to the problem, and creativity in applying that knowledge.

Robert Halligan

FINAL THOUGHTS FROM SYENNA

Dear PPI SyEN Readers,

About 35-40 years ago (please don't guess my age), I stumbled upon a learning level model that looked something like the model in Figure 1. below. The learning model constitutes 6 stages to learning any new concept or skill namely: rote, recognition, restatement, relation, realization and reproduction.

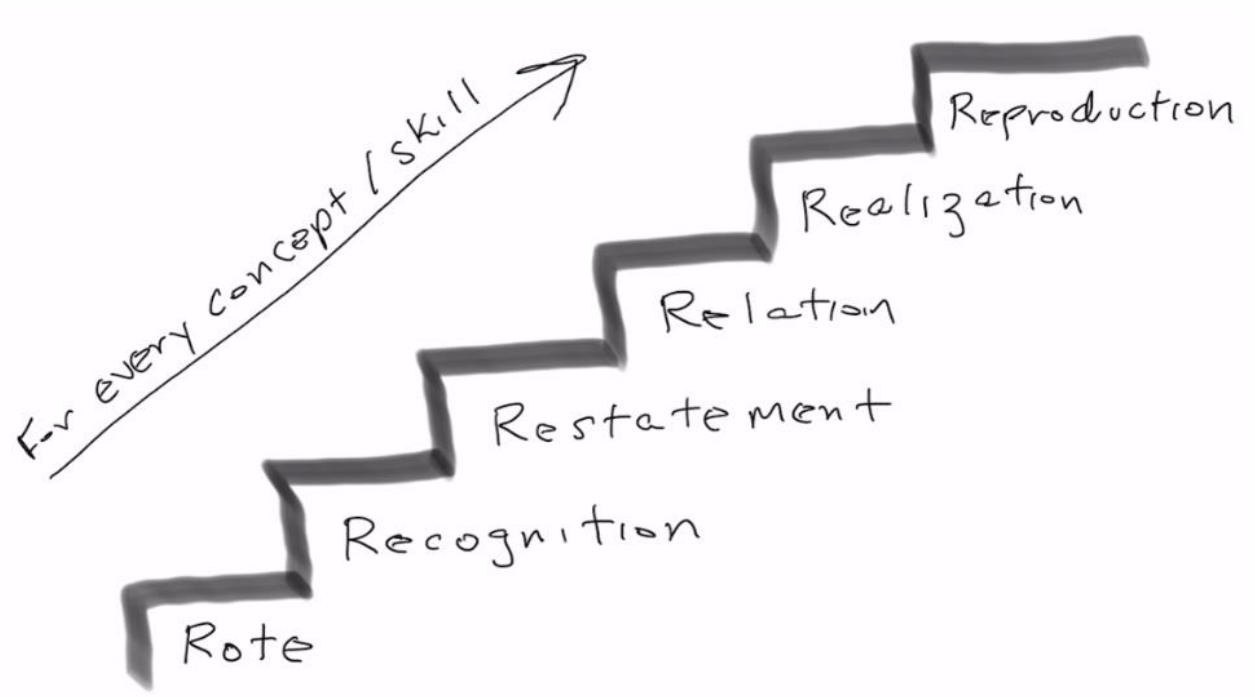

Figure 1. Learning Level Model

Recently I've been reflecting upon ways to deconstruct or demystify learning. I think there is a major shift taking place as engineers are moving from mainly relying on company-initiated training to taking more control of their individual career development as part of a continuous improvement mindset/

This shift in paradigm requires a relentless pursuit of learning. In my view, having an unfathomable capacity to learn is one of the perks of being a human. The capacity to learn is like a muscle - it can be engaged or neglected. Taking the decision to learn about learning is something that we all can do to make us more effective and proficient learners so that we can gain mastery towards a certain skill or increase our awareness about the rich and dynamic world around us

Coming back to the 6 steps mentioned previously, let's apply these steps to a non-engineering topic, let's use the scenario where we are trying to learn French as a second language and we are a first language English speaker. Let's use the established 5 levels of language proficiency to rate our level of skill in speaking French as we climb along the learning ladder:

0 – No Proficiency
1 – Elementary Proficiency
2 – Limited Working Proficiency
3 – Professional Working Proficiency
4 – Full Professional Proficiency
5 – Native / Bilingual Proficiency
Read more about language proficiency levels here

1. Rote

The first thing we would have to do is learn sentence structure, grammar rules, and some vocabulary. This stage can be quite tedious. The largest amount of people will give up at this stage if the value to be gained does not seem with the energy and if the subject being learned is deemed non-essential.

While rote learning, we are building latent energy even though we may still be considered to have 'no proficiency' as concepts are not integrated.

2. Recognition

The next step in the process is recognition or 're-cognition' as I like to think of it. That is to be able to frame your mind from a different perspective, to re-engage our minds. We may be able to notice the major differences between English and French from a syntactical and grammatical level and we are fully appreciating new concepts such as masculinity and femininity in nouns.

At this stage we are migrating from having 'no proficiency' to having 'elementary proficiency' as we are starting to integrate concepts and form cogent sentences.

3. Restatement

The next step would then be for us to be able to restate, or put into our own words what you have learned from steps 1) and 2) above.

At this stage we may have developed 'limited working proficiency' as we are equipped to communicate using a very elementary set of tools.

4. Relation

The relation step involves describing our external world using our newly acquired knowledge. We have started to relate or describe the world using what we have learned.

At this stage we may consider ourselves to have 'professional working proficiency'. Not only can we convey ideas but we can move easily between professional and personal topics and use a higher register in a formal context.

5. Realization

Realization is really just internalization. This is when the knowledge or skill becomes a part of us and shifts from being conscious to unconscious. We can think thoughts in French and we've even started blurting out ideas in French, we are naturals.

At this stage we consider ourselves to be 'native' or to have 'full professional proficiency' as we are able to switch from professional to personal topics, discuss arts and culture. Our English accents may even be starting to disappear when we speak French.

6. Reproduction

The best way to show proficiency is to teach another or synthesize something from scratch in a novel way. When we can write effortlessly, relay messages, speak smoothly and explain French concepts using our own reflections on the language, we are native speakers. Our English accent is basically unrecognizable even to locals in France.

In this case we consider ourselves native. The fewest amount of people aiming to learn a new language will make it to the 6th stage.

It's important to note that not everyone wants to be a native speaker in a language they're learning e.g. if you're traveling to Paris for two weeks versus if you're moving to France indefinitely. That emphasizes the importance of knowing the extent of knowledge the level of proficiency you would like to have in learning about a new concept or skill. With limited time available to us, there is an opportunity cost for everything learned (we are sacrificing learning something else) and not learned (we could be missing out on finding our purpose or contributed meaningful value to this world in ways that are important to us). Taking a methodological approach to learning and using frameworks such as this can help us in shaping our professional careers and becoming more and more proficient so as to reduce the extent of that opportunity cost.

Speaking about professional development….

CTI's René King and Michael Gainford recently did a presentation on 'How to Learn Systems Engineering (or Anything)' for INCOSE/GfSE. If you enjoyed these abstract meanderings of Syenna contained in this month's Final Thoughts, you may enjoy the 60 min webinar available for viewing on our website. Log your interest for the presentation and get instant access to the video via the following link.