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Pushing Boundaries: Exploring New Frontiers in Technology-Based Projects

Complexity Thinking: Should Systems Engineers Take Up Systems Gardening?

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WELCOME

Dear PPI SyEN Readers,

I'm thrilled to welcome you to the March 2024 edition of our Newsjournal, your definitive source for all things systems engineering. This issue is brimming with updates, resources, and events designed to keep you informed and engaged with the latest in our field.

In our news section, stay abreast of the latest developments from the Object Management Group, including community news and key specification updates that impact our industry. Additionally, read about how the Systems Engineering Research Center continues to lead with its ground-breaking research, how NAFEMS is conducting a survey on the current state of AI readiness within the simulation community, and how the Systems Engineering Tools Database continues to grow with new tools and vendors added every month.

Mark your calendars for significant events such as IEEE SYSCON 2024, the Society of Decision Professionals Annual Conference 2024, and more. Ensure your spot at pivotal events like MBSE-CON-2024, the MBSE Cyber Systems Symposium 2024, and others. These gatherings are invaluable opportunities for networking, learning, and collaboration.

Dive into the heart of a paradigm shift with our thought-provoking Feature Article, "Complexity Thinking: Should Systems Engineers Take Up Systems Gardening?" by Clark Stacey. At a time when traditional systems engineering approaches face scrutiny, this article invites us on an exploratory journey beyond conventional boundaries.

In our resources section, explore upcoming NAFEMS e-Learning courses, dive into the latest editions of the INCOSE Systems Engineering Journal and INSIGHT Practitioners Magazine, and enhance your knowledge with resources such as the new book on Human Activity Systems.

As you delve into this edition, we hope you find valuable insights, opportunities for growth, and a deeper connection to the systems engineering community.

Warm regards,

René

Managing Editor

Views expressed in externally authored articles are not necessarily the views of PPI nor of its professional staff.

START A NEW CHAPTER IN YOUR CAREER?

Already an outstanding SE professional?
Ready for a career and lifestyle change?

Project Performance International (PPI) seeks top-notch SE Professionals worldwide to meet the skyrocketing demand for our training and consulting. Opportunities exist for online and in-person delivery in most regions. A rigorous qualification process applies; this itself is career-boosting.

There are opportunities to join our team through one of three engagement models:

- *full-time employment*
- *part-time employment*
- *independent contractor, perhaps with your own trading entity, with exclusivity to PPI for SE-related training, otherwise free to consult independently.*

Interested? *managingdirector@ppi-int.com*

PPI Systems Engineering Newsjournal (PPI SyEN) seeks:	**PPI defines systems engineering as:**
➢ 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	*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

New OMG Managed Communities

The Managed Communities Program of the Object Management Group (OMG) is designed to provide a competitive advantage to OMG Managed Community members by enabling them to obtain valuable knowledge about best practices and future technologies through networking and participation in the development of community products.

In addition to the OMG Systems Modeling Community (SMC) launched in 2023, the OMG has announced the launch of two new communities.

Model-Based Acquisition User Group Community (MBAcq)
The Model-Based Acquisition User Group Community (MBAcq) will enable participating members to access cutting-edge insights at the forefront of the industry, working on projects shaping the future of MBSE specifications and reference architectures.

The user community will guide engineering and acquisition professionals on how to use MBSE standards and reference architectures to create and respond to Request for Proposals (RFPs).

View the MBAcq charter.

Read the MBAcq press release.

Enterprise Knowledge Graph Forum (EKGF) community
The Enterprise Knowledge Graph Forum (EKGF) community enables participating members to explore the revolution in enterprise knowledge management by codifying industry best practices into OMG specifications and advancing the development of essential tools and methodologies such as EKG Principles and Maturity Models.

The purpose of EKGF community is to enable collaboration in support of various promotional or open collaboration activities relating to defining, promoting, and improving the understanding, adoption, and maturity of Knowledge Graph and related technology, approaches, and standards in enterprises.

Learn more about the EKG Platform Task Force.

Read the EKGF press release.

Membership in OMG Managed Communities is open to all OMG members. Investigate Managed Communities membership.

Object Management Group (OMG) Specification Updates

The Object Management Group® (OMG®) is an international, open membership, not-for-profit technology standards consortium representing government, industry, and academia. OMG has spearheaded the development of over 250 standards. Recent updates include but are not limited to the following:

- Automated Technical Debt Measure V2 (ATDM2), 1.0 beta (October 2023)
- Business Architecture Core Metamodel (BACM), 1.0 beta (October 2023)
- Commons Ontology Library (Commons), 1.1 beta (January 2024)
- FACE Profile V2 (FACEv2), 1.0 beta (December 2023)
- Multiple Vocabulary Facility (MVF), 1.0 beta 2 (October 2023)
- Open Architecture Radar Interface Standard (OARIS™), 2.0 (September 2023)
- Robotic Service Ontology (ROSO), 1.0 beta (November 2023)
- Structured Assurance Case Metamodel (SACM™), 2.3 (October 2023)
- Software Fault Pattern Metamodel (SFPM), 1.0 beta 2 (January 2024)

View the OMG® Specifications Catalog to search for other standards.

Learn more about OMG®.

SERC Updates

Recent updates from the Systems Engineering Research Center (SERC) include reports and articles exploring important topics at the leading edge of systems engineering practices.

AI4SE & SE4AI

The final report has been published for the SERC AI4SE & SE4AI Research and Application workshop that took place in September 2023. This 20-page document elaborates the workshop activities and outcomes associated with the event's theme of "*Balancing Opportunity and Risk: The Systems Engineer's Role in the Rapid Advancement of AI-Based Systems*". Recommendations for future research include:

- Seamless integration of AI systems into human workflows
- Robust testing methodologies to identify vulnerabilities in AI systems
- Development of comprehensive ethical frameworks and guidelines for responsible AI development
- Enhanced methods for model explainability and interpretability
- Robust assessment and assurance of the quality of datasets used in AI training
- Standardization of AI infrastructure, development tools, and data formats
- Educational programs and workforce training to equip professionals across disciplines
- Development of AI systems that exhibit dynamic learning and adaptability
- Measurement of trust in AI systems
- Active learning methods and adaptive systems.

Digital Materiel Management (DMM) Industry Association Consortium (IAC) Kick-off

A summary report has been published for the initial forum to establish an Industry Association

Consortium (IAC) focused on Digital Materiel Management (DMM) capabilities. The 15-page report summarizes the goals, conduct and outcomes associated with this 23 November 2023 event that brought together a range of U.S. Department of Defense (DoD) stakeholders.

Interview with Dr. Valerie Sitterle
This February 2024 article summarizes an interview with Dr. Valeria Sitterlee of Georgia Tech which highlights research to improve engineering decision-making processes through use of digital engineering and dynamic modeling capabilities.

Good Reads About Systems
The SERC community often publishes its recommendations for "Good Reads About Systems". Recent candidates to consider include:

- Marcus Glowasz, Leading Projects with Data: Overcome Behavioral and Cultural Barriers to Unlock the Hidden Value of Data in Projects
- Bent Flyvberg and Dan Gardner, How Big Things Get Done: The Surprising Factors That Determine the Fate of Every Project, from Home Renovations to Space Exploration and Everything In Between
- Irene Bratsis, The AI Project Manager's Handbook: Develop a Product that Takes Advantage of Machine Learning to Solve AI Problems
- Carol Sanford, No More Gold Stars: Regenerating Capacity to Think for Ourselves
- Institute for Apprenticeships and Technical Education, UK, "Systems Thinking Practitioner"

Access the latest SERC news here.
Follow SERC on LinkedIn.

NIST Cybersecurity Framework 2.0 Released

In February 2024, the U.S. National Institute for Standards and Technology (NIST) released the NIST Cybersecurity Framework (CSF) 2.0. This update is the outcome of a multiyear process of discussions and public comments aimed at making the framework more effective.

CSF now explicitly aims to help all organizations - not just those in critical infrastructure, its original target audience - to manage and reduce risks. NIST has updated the CSF's core guidance and created a suite of supplementary resources to help all organizations achieve their cybersecurity goals, with added emphasis on governance as well as supply chains. The full suite of CSF resources now includes:

- CSF 2.0
- Quick Start Guides
- CSF 2.0 Profiles
- CSF 2.0 Informative References
- Cybersecurity & Privacy Reference Tool (CPRT)
- CSF 2.0 Reference Tool
- CSF 2.0 Website (Homepage)
- Official NIST News Announcement

NAFEMS Simulation AI-Readiness Survey

NAFEMS has launched a survey to investigate how ready the engineering simulation community is to adopt Artificial Intelligence (AI) and Machine Learning (ML) into its daily workflows.

By completing this 5-minute survey on your organization's readiness, you will contribute to vital research that will give everyone involved in engineering simulation real insight into how the community is preparing for the increased prevalence of AI and related technologies.

Respondents to this survey will receive access to its findings and other AI-related resources.

Take the survey here.

SE Tools Database (SETDB) Updates

The Systems Engineering Tools Database (SETDB), developed by PPI in partnership with INCOSE, provides a virtual platform for engineering tool vendors to communicate their latest offerings and for tool users to research tools and their capabilities.

Recent SETDB updates, including both new tools and updates to existing tools, include:

Vendor: BCPG PLC

- Supplier Portal: The supplier portal makes it easy to work with your suppliers, by gathering all your product's and packaging's data, and centralizing the related documents.

Vendor: Eclipse Foundation AISBL

- Capella: A comprehensive, extensible, and field-proven open source MBSE tool and method to successfully design systems architecture. Capella relies on Arcadia a field-proven model-based methodology that covers each engineering phase.

Vendor: IncQuery Group

- IncQuery Cloud: An enterprise-class, scalable application framework that helps you break the silos by maintaining a vendor-neutral and open knowledge graph as representation of all digital engineering data and metadata.

Vendor: Obeo

- Team for Capella: Enables simultaneous authoring of Eclipse Capella models by your team members.
- Cloud for Capella: Benefit from a pre-installed Capella environment that is already integrated with useful add-ons.
- Publication for Capella: Provides a seamlessly integrated view between your system architecture and related engineering activities (IVVQ, Requirements, etc...).

- SysML Bridge for Capella: Automatically transforms Capella models in SysML (and vice versa) according to rules that can be adapted to your context.

Vendor: Project Jupiter

- Jupyter Lab: Free software, open standards, and web services for interactive computing across all programming languages.

Vendor: SENSmetry

- SysIDE: SysIDE includes a language server for SysML v2 and KerML 2023-02 release specifications. Together with VS Code, SysIDE serves as integrated development environment (IDE) for SysML v2. SysIDE (pronounced "seaside") provides SysML v2 language support in VS Code.

Vendor: Siemens Polarion

- Polarion RM: Complete Requirements Management Solution. Effectively gather, author, approve and manage requirements for complex systems across entire project lifecycles.

Vendor: The REUSE Company

- SES ENGINEERING Studio: Software Tool designed to orchestrate the development of all kinds of systems (hardware, hybrid, software). It allows interoperability between an unlimited number of existing Systems Engineering Tools (RM), MBSE tools, Simulation Tools, Risks Management, RAMS Management, MS Office, etc.).
- SES KM - KNOWLEDGE Manager: Allows you to manage knowledge from the systems engineering point of view and to store valuable information from requirements, models, system architectures and other documents in a common System Knowledge Base.
- SES RAT - AUTHORING Tool: Help authors composing requirement statements or other documentation, hence improving the overall quality of the projects. RAT is available for multiple engineering tools, like PTC Integrity, IBM DOORS and DNG, Microsoft Excel and Word, Capella and IBM Rhapsody.
- SES Requirements Engineering for MS Word: This connector to Microsoft Word allows you to define, measure, improve, and manage the quality of your requirements specifications. It allows assessment of Correctness, Consistency and Completeness (CCC), as well as full traceability of requirements.
- SES TRACEABILITY Studio: Traceability Studio users can trace links between key processes to be efficient and effective, such as V&V, requirements definition, architecture definition, design definition or risk management, among others, as defined in the ISO/IEEE 15288/12207 standard.
- SES RQA - QUALITY Studio®: Tool to automate the routine quality inspection and analysis of different types of engineering items minimizes the cost of quality appraisals while increasing the consistency and overall quality of the projects.
- SES V&V Studio: Merges the three concepts of verification, validation and quality assurance & management and offers V&V by managing the corresponding verification and validation actions through quality measures and other measures.

Vendor: Softwareideas

- Software Ideas Modeler: A lightweight and powerful CASE tool for advanced diagramming. It helps you to describe and design your software and processes using UML 2.5, BPMN 2.0, SysML 1.5, ERD, flowcharts and other diagrams.

Vendor: two pillars

- iQUAVIS: iQUAVIS was developed into a real system engineering tool that uses MBSE models. It doesn't matter whether it's structure diagrams, behavioral diagrams or task planning. It is a lightweight system engineering platform that can be individually configured to meet your requirements.

PPI SyEN readers are encouraged to check out these new and updated systems engineering tool offerings.

Access the SETDB website.

PPI RESOURCES

PPI offers a multitude of resources available to all 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 resource 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 (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.

CONFERENCES, MEETINGS & WEBINARS

IEEE SYSCON 2024

The IEEE Systems Council facilitates interactions among communities of interest on system-level problems and applications. The Council addresses the discipline of systems engineering, including theory, technology, methodology, and applications of complex systems, system-of-systems, and integrated systems of national and global significance.

The program is being finalized for the 18th Annual IEEE International Systems Conference (SYSCON2024) that will take place over 15-18 April 2024 in Montreal, Quebec, Canada.

Keynote speakers for the conference include:

- James H. Lambert (University of Virginia)
- Sidney Givigi (Queen's University, Canada)

SYSCON2023 will feature tutorials on topics such as:

- Advances in the Assessment and Certification of AI Ethics (Ali Hessami, Vega Systems)
- Re-Thinking Risk using Systems Engineering and Systems Thinking (Anthony Nelson, UK Chartered Engineer)
- Distributed Fiber-Optic Sensing (Jyotsna Sharma, Louisiana State University)
- Systems Modeling and Analysis Using Colored Petri Nets - A Tutorial Introduction and Practical Applications (Vijay Gehlot, Villanova University)
- Utilizing System Adaptability to Minimize Long-Term Costs through Trade Studies (Haifeng Zhu, Boeing and Eileen Arnold, United Technologies Corporation - Retired, INCOSE Fellow, ESEP).

Learn more about SYSCON2024.
Register for SYSCON2024.

Society of Decision Professionals (SDP) Annual Conference 2024

The Society of Decision Professionals (SDP) is dedicated to enhancing professional decision-making within various organizations and industries. Registration is open for the SDP Annual Conference 2024 to be held in Arlington, Virginia, USA on 15-19 April 2024. The theme of this event is "*Effective Decision-Making in a Dynamic World*" complementing the SDP's celebration its thirty-year anniversary.

The keynote speaker for the conference is David John Snowden, founder and Chief Scientific Officer of the Cynefin Co. Snowden's topic, *Decision-Making, Forecasting and Community Engagement*, will unveil strategies for fostering responsive decision processes capable of swift action in times of crisis. These approaches include anticipatory alerts designed to capture decision-makers' attention at critical junctures where minor interventions can yield significant impacts.

Pre-conference and post-conference workshops to be held on 15 and 19 April include:

- Mastering Bias: Identification, Impact, and Mitigation
- Ready, Aim, Frame – Becoming Powerful Decision Framers
- Estuarine Mapping and the Evolutionary Potential of the Present
- An Introduction to Decision Analysis
- When Things Go Wrong: Project Rescue Decision Support
- Hurdles to Growing and Sustaining a Decision Quality Organization.

Presentation sessions on 16-18 April will be organized into tracks, including:

- AI / Analytics
- Cases Studies / Technical
- Classic Application Cases
- Data in Government Decision-Making
- Evidentiary Decision-Making
- Fundamentals
- How to Advance the Profession
- Innovation
- New Perspective on DQ
- Organizational Transformation
- Personal & Societal Decisions.

View the summary agenda and full details.

View an invitational video from David Matheson, SDP President.

Register for the SDP Annual Conference.
Join the Society.

Free NAFEMS Simulation Webinars in April

NAFEMS, the international modeling and simulation association, is offering three free webinars in April 2024.

In Silico Tests/Trials of Medical Products for the Digital Era (9 April)
Novel medical technologies are being introduced at unprecedented rates, demanding scientific evidence of their safety and efficacy at an unprecedented pace to ensure patient safety and benefit. With success in both in-vitro/in-vivo studies, products are tested on clinical trials assessing use in humans. Predicting low-frequency side effects has been difficult because such side effects may not become apparent until many patients adopt the treatment. When medical devices fail at later stages, financial losses can be catastrophic. Testing on many people is costly, lengthy, and sometimes implausible (e.g., pediatric patients, rare diseases, and underrepresented or hard-to-reach ethnic groups).

Computational Medicine underpins In-silico trials (IST), i.e., computer-based trials of medical products performed on populations of digital twins (aka virtual patients). Computer models/simulations are used to conceive, develop, and assess devices with the intended clinical outcome explicitly optimized from the outset (a-priori) instead of tested on humans (a-posteriori). This talk will introduce this world of new possibilities and summarize progress made in this new paradigm among academia, industry, regulators, and policymakers. Register here.

Earthquake Response Analysis: From Action Definition to Structural Response (10 April)
Seismic calculation requires the correct definition of the seismic action as well as its adequate incorporation into the design. The exhibition will review the ways that can be found to define seismic action, when regulations or a specific study are used, as well as the calculation methods that can be used, which must be in accordance with the type of definition as well as the requirements of the design. We will review concepts such as seismic hazard, response spectrum, accelerogram, modal and directional combination, residual modes or lost mass. It will also explain when a time-domain vs. frequency-domain analysis is useful, what an incremental thrust analysis is, the importance of ductility, and how to take it into account.

Register here for this NAFEMS Iberia chapter event (conducted in Spanish).

Simulation of Large-Scale Assets Using Reduced Order Models (18 April)
Akselos provides Digital Twins of industrial equipment in a range of industries, including energy (oil & gas, wind hydro), marine, mining, chemicals, and aerospace. The Akselos platform is based on RB-FEA, which is a unique combination of the Reduced Basis method for fast and accurate reduced order modeling of parametrized PDEs and a domain decomposition framework that enables large-scale component-based analysis. RB-FEA has similarities to supervised machine learning (ML), in which "full order" solutions are used as the "supervisor" during RB-FEA training. In this presentation we will discuss the similarities and differences between RB-FEA compared to other ML methods, and demonstrate applications of the RB-FEA methodology to industrial Digital Twins. Register here.

Investigate membership in NAFEMS.

Upcoming System Dynamics Society Webinars

System Dynamics Society

The System Dynamics Society (SDS) is hosting two upcoming webinars in April and May that address systems thinking applications and tools.

Integrating Systems Thinking into Science Education and Curriculum (24 April)
Systems thinking approaches offer a convenient platform for teaching and learning science through rich-contexts and complex real-world scenarios. This framework can be well integrated into problem-based learning, learning from case studies, project-based approaches etc. Compared to reductionist approach, systems approach will also facilitate students' holistic and interdisciplinary understanding about a complex problem. Along these lines, this seminar focuses to explore the scope of applying systems thinking concepts into science teaching and curriculum with a focus in the context of chemistry teaching and learning.

Learn more and register here. Free for SDS members.

How Did En-ROADS Get 755,000 users? Lessons on Modeling, Interface Design, and Facilitation (8 May)
In this participatory webinar, Drew Jones of Climate Interactive will share insights on how to create a System Dynamics model and online simulator that will succeed at improving mental models and system performance at scale. The teams at Climate Interactive, MIT Sloan, and Ventana Systems designed its System Dynamics models C-ROADS and En-ROADS with the goal of improving the understanding of climate policy choices amongst decision-makers around the world, leading to deliberate strategies in three major areas: 1) modeling, 2) interface/UX design, and 3) facilitation, workshop design, game creation, training, and user support. This webinar will cover the design decisions made over the ~30 years of the project, generalizing the more universal insights for any system dynamics project.

Learn more and register here. Free for SDS members.
Join the SDS.

Registration Open for MBSE-CON-2024

The Lifecycle Modeling Organization (LMO) develops and maintains an open-source modeling language that is structured and behavioral, the Lifecycle Modeling Language (LML). Registration is open for the LMO-hosted Model-Based Systems Engineering Conference (MBSE-CON-2024) in Orlando, Florida, USA from 1-2 May 2024. *The conference will support both in-person and virtual participation.*

The theme of this hybrid conference is "*Modernizing MBSE through Digital Engineering, Mission Engineering, and Modeling and Simulation".*

The keynote speakers for the conference include:

- Eugene Fleeman, author of the textbook, Missile Design and Systems Engineering. Mr. Fleeman has 50+ years of government, industry, academia, and consulting experience in the design, development, and system engineering of missile systems.
- Dr. Jeremy Lanman, Assistant Program Executive Officer (APEO) for Project Support at the U.S. Army Program Executive Office for Simulation, Training and Instrumentation (PEO STRI) and member of the Army Science Board.

Learn more about MBSE-CON-2024. Be on the lookout for an updated program agenda.

Learn more about LML here.
Register here.

MBSE Cyber Systems Symposium 2024

Registration is open for the Dassault Systèmes MBSE Cyber Systems Symposium to be held in Dallas, Texas, USA on 13-16 May 2024. This four-day CATIA-focused systems engineering user conference will provide attendees with the opportunity to engage with experts in MBSE, Product

Lifecycle Management (PLM), Product Line Engineering (PLE), Systems Engineering and Enterprise/Business Architecture.

Featured speakers include:

- Sanford Friedenthal (SAF Consulting)
- Frédéric Bourcier (CATIA R&D Cyber Systems Vice-President, Dassault Systèmes)
- Olivier Sappin (CATIA CEO, Dassault Systèmes)
- Michelle Gilbert (Chief Engineer, US Army FVL Future Long Range Assault Aircraft).

A sample of the training opportunities available during the symposium include:

- Introduction to MBSE with SysML
- Model-based Capability Planning with UAF
- Mastering SysML and MagicGrid for Systems Engineering
- Handshake of MBSE, Model-based Design, and Analysis
- Harnessing the power of Models - Customizing Tables, Dependency Matrices, and Maps
- Model-Based System Failure Mode Assessment using FMEA and FTA
- Bridging MBSE to MBD w/ Requirement in the Loop Simulation.

Technical presentations and workshops will address diverse topics including:

- Modeling of Uncertainty in System and Enterprise Models
- FTA Analysis
- Architecture Evolution Management Through Roadmapping
- What-if Analysis for Safety and Reliability with Model-Based Impact Analysis in Nuclear Power Plant
- Trade Space Analysis.

Explore the full agenda here.

Learn more here. Register here.

Institute of Industrial and Systems Engineers (IISE) Annual Conference

The Institute of Industrial and Systems Engineers (IISE) has released the detailed program and agenda for the IISE Annual Conference and Expo 2024 to be held in-person in Montreal, Quebec, Canada on 18-21 May.

IISE is offering two pre-conference events on 18 May:

- The Artificial Intelligence Symposium that will address both the ethics and risk side of AI as well as the possibilities and reduction to practice dimensions of AI in business, industry, government, healthcare.
- The Lean and Six Sigma Symposium will explore cutting-edge topics such as the integration of
- artificial intelligence with Lean Six Sigma, digital transformation, and industry-specific case studies.

Keynote speakers for the main conference on 19-21 May include:

- Prathibha Rajashekhar, Senior Vice President, Innovation & Automation, Walmart U.S.
- Benoit Montreuil, Professor and Coca-Cola Material Handling & Distribution Chair, Stewart School of Industrial & Systems Engineering, Georgia Tech
- Tom Woods, Corporate Board Member, Bank of America Corp. and Alberta Investment Management Corp.

Program details are emerging. Look for an update concerning the topics and timing of the slate of technical presentations in the April edition of PPI SyEN.

In the meantime, conference plans have solidified concerning numerous aspects of the event:

- Society/Division Town Hall Meetings
- Honors and Awards recognition sessions
- IISE 2024 Volunteering Event
- IISE Innovation Cup Competition
- IISE / Rockwell Student Simulation Competition

Learn more. Register here.

Join IISE.

Registration Open for MBSE Summit 2024

Registration is open for the MBSE Summit 2024 to be held in Traunkirchen, Austria over 10-11 June 2024.

Organized by LieberLieber and Johannes Kepler University (JKU) Linz, this conference offers attendees the opportunity to hear from experts in MBSE research, development and practice.

Three keynotes are featured:

- Tim Weilkiens, oose Innovative Informatik eG: *The Impact of SysML v2*
- Cristina Olaverri-Monreal, JKU, President IEEE Intelligent Transportation Systems: *Topic TBA*
- Florian Beer, Robert Bosch GmbH: *The beauty of MBSE – reducing efforts by extending the scope.*

Other presentation topics include:

- MBSE and Standards - The Power of Standards: Unleashing the Potential of MBSE
- Safety and Security by MBSE - Securing the Future: How MBSE Supports Safety and Security in Complex Systems
- MBSE Process and Quality Assurance Guidance
- MBSE and the Agile Mindset - Guarantees for Successful System Development in the Age of Complexity.

Learn more here.

Download the 2023 Summit report: The Future of Systems Engineering.
Register here.

System Dynamics Summer School

The System Dynamics Society (SDS) is offering two members-only opportunities to learn system dynamics concepts and skills and gain application experience in the form of the System Dynamics Summer School that will be held online in on 8 – 11 July 2024.

Introductory Track
The Introductory Track is for individuals with no or very limited System Dynamics knowledge. The purpose is to teach the System Dynamics methodology and not specific software syntax. There will be models available in Vensim, Studio, and Stella. Free versions of modeling software that are limited in capability or limited in duration of use will be available. I Introductory Track instructors include:

- Larissa Calancie, Tufts University
- Birgit Kopainsky, University of Bergen
- Rod MacDonald, James Madison University
- Oleg Pavlov, Worcester Polytechnic Institute
- Raafat Zaini, James Madison University.

Introductory Track Daily Schedule

Day One	Day Two	Day Three	Day Four
Modeling Steps & Problem Definition Modeling Feedback Mechanisms Conceptual Modeling with Stocks and Flows Workshop: Introduction to System Dynamics Modeling Software	Formal Modeling of Stocks and Flows Information Delays Workshop: Accumulation, Feedback, and Information Delays Applications Lecture	Nonlinear Relationships Policy Modeling Model Validation Applications Lecture	Model Analysis Model Use Workshop: Common Pitfalls and Best Practices Applications Lecture

Participants in the Introductory Summer School may attend online classes held at times that are convenient for European or American time zones. Both tracks will cover the same material. Each track will convene three times per day for 90-minute sessions.

Intermediate Track
To qualify for the Intermediate track, registrants must pass a placement test over the basics of system dynamics. The Intermediate track focuses on software (Studio, Vensim, and Stella). It presents more advanced modeling techniques. Free versions of System Dynamics modeling software that are limited

in capability or limited in duration of use will be made available. Intermediate Track instructors include:

- Willem Auping, TU Delft
- Bob Eberlein, isee systems
- Ying Qian, University of Shanghai for Science and Technology.

Intermediate Track Daily Schedule

Day One	Day Two	Day Three	Day Four
Steps of Modeling: Problem Description Model Building: Stocks and Flows Checking Results with Equilibrium Diagrams Diagrams to Show Feedback Loops	Simulating Nonlinear Relationships Simulating the Flow of Information Checking Results with Delays in the Flow of Information Applications Lecture	Recognizing and Avoiding Common Pitfalls Validation Testing: For Us & Our Client Applications Lecture	Model Improvement Applications Lecture

Live, instructor-led online sessions of the Intermediate Summer School will be scheduled to accommodate participants from around the world, with final timing based on participant preferences once the roster is finalized.

See the Timing Plan for both tracks.

Both courses require significant pre-work in the form of watching videos and tutorials prior to the week of synchronous class sessions.

Learn more about and join the SDS to participate in the Summer School.

See more details on the System Dynamics Summer School and register prior to 7 June 2024.

A limited number of scholarships are available for SDS members. Apply here prior to 15 April 2024.

Call for Presenters: PDMA 2024 Inspire Innovation Conference

The Product Development & Management Association (PDMA) has issued a Call for Presenters for the PDMA 2024 Inspire Innovation Conference to be held on 14-17 September 2024 in St. Louis, Missouri, USA. Submissions are also sought for the concurrent JPIM Annual Research Forum.

The Call for Presenters is seeking speakers to deliver engaging and interactive content for three types of conference sessions:

- 45 Minute Interactive Presentation
- 45 Minute Case Study
- 120 Minute Mini-Workshop.

Content topics sought include:

- Front-end innovation: Market research and user needs exploration, idea generation, initial concept development and conceptual prototypes, proof of feasibility, business case development
- Back-end innovation: Detailed product/service development, prototype testing and validation, pilot production and manufacturing transfer, market launch.
- Innovation governance and operational excellence: strategic planning and implementation, innovation risk management, innovation portfolio management, innovation teams and culture

Presentation proposals are due by ***10 April 2024*** using the online submission form. Acceptance letters will be sent by 6 May.

The 2024 JPIM Annual Research Forum Call for Papers seeks various types of conference submissions (e.g., competitive papers, developmental papers, posters, and special session proposals) from scholars from all disciplines who share a common interest in new in new product development and innovation management research.

Submissions are due by ***15 April 2024***. Acceptance/rejection decisions will be made by 15 July. Submissions should be made through EasyChair.

"

Systems engineering management is the activity of management - planning, organizing, allocating resources, directing and controlling – where engineering using a systems engineering approach is the primary activity which is being managed.

Robert Halligan

Complexity Thinking: Should Systems Engineers Take Up Systems Gardening?

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Authored for PPI SyEN

As Systems Engineers and Systems Thinkers we have a unique perspective on the social issues and global challenges that dominate the media. Rather than just seeing isolated symptoms, our professional training and expertise enables us to perceive complicated interdependencies that act across layers of systems within systems. Rather than reducing a problem to a single cause with a simple solution, our insight tells us that issues most often occur at interfaces and that progress requires the effective integration of underlying systemic structures. However, despite this enhanced view of social systems, there are a growing number of people that not only don't see Systems Thinking as the solution, but along with the application of an engineering mindset, they see it as part of the underlying problem.

I first came across an alternative way of thinking about systems at the launch event for a book, 'Embracing Complexity' (Boulton, Allen, and Bowman 2015), hosted at the Institute of Physics in London back in 2015. I am going to refer to this alternative way of thinking as 'Complexity Thinking', but it is also often given a slightly difference emphasis and referred to as either 'Complexity Theory' or 'Complexity Science'. After having read that book, my interest was further fueled by watching recordings of talks by Dave Snowden, the charismatic author of the Cynefin Framework (Snowden and Boone 2007; Kurtz and Snowden 2003). I believe that increasing numbers of Systems Engineers are becoming aware of the Cynefin Framework, which is intended to help with making sense of problem situations in order to decide upon the best way forward. But I have observed that many of us still interpret this framework as suggesting that Systems Thinking represents the best approach for addressing complex situations, whereas my own interpretation is that Dave has been reasonably explicit on many occasions that this is not his view. He suggests, along with many others, that there are substantial issues with applying the causal view of systems found within Cybernetics and Systems Dynamics to systems that are actually inherently dispositional in nature (Snowden 2017).

So, as far as I can see, this raises three questions for us as Systems Engineers: What is 'Complexity Thinking' all about? What is it that is supposed to be wrong with Systems Thinking? What, if anything, from Complexity Thinking might be useful for us as Systems Engineers? My hope is that this review will act as a catalyst for a dialogue on where we stand on Complexity Thinking and whether we see it as within the scope of our profession going forward.

What is 'Complexity Thinking' all about?
Complexity Thinking is not just a rebranding or evolution of Systems Thinking. It is a fundamentally different way of thinking that leads to very different approaches to complex problems. As every experienced Systems Engineer knows, agreeing on terminology is essential at the start of any endeavor, and this is especially the case when it comes to discussing Complexity Thinking. Many of the approaches suggested by Complexity Thinking are not new and can be found as far back as the philosophies of Ancient China (Puett and Gross-Loh 2016). But over the past several decades this way of thinking has been given more weight and justification as new theories have developed within mathematics and the natural sciences. These theories have led to a meaning for the word 'complexity' that is far more specific than its normal everyday usage.

The word 'complexity' within Complexity Thinking refers to a type of paradoxical behavior that can be exhibited by nonlinear dynamic systems. The use of the term 'nonlinear' requires some clarification, as it is often misleadingly used without the accompanying word 'dynamics'. In this case, 'nonlinear' is not referring to something like a cyclical approach to project lifecycles versus a linear 'waterfall' lifecycle. That would be equivalent to nonlinear equations versus linear equations. When we are talking about nonlinear dynamics, then we are normally referring to nonlinear *differential* equations versus linear *differential* equations. When nonlinear differential equations are used to model a system, then despite the equations being deterministic, the equations have the potential to describe behaviors that are inherently unpredictable. Surprisingly, this can even be the case for structurally simple nonlinear differential equations with as few as only three variables. The practical cause of this unpredictability usually takes the form of internal resonances or positive reinforcing feedbacks that mean very small differences can very quickly lead to big effects (such as the well-known and often misunderstood example of the butterfly and the storm). When the parameters of the equations have values meaning the system is close to equilibrium, then the system's behavior is stable and the discipline of Systems Dynamics can be used to make reliable predictions. When the parameters' values mean that the system is far from equilibrium, then behavior can be effectively random and predictions are not possible. However, within these types of dynamic systems there can also be found values for the parameters, known in Chaos Theory (Gleick 1988) as 'strange attractors', that produce behaviors that are unpredictable in terms of their detail, but still predictable in terms of their overall tendencies and patterns of behavior. In order to be able to make reliable long-term predictions within these regimes, it would require us to have knowledge of the system's history or starting position with unobtainable levels of precision and accuracy. But by repeatedly running the equations through computer simulations and using tiny differences in starting values, then knowledge of the system's tendencies or disposition can be discovered. This paradoxical form of predictably unpredictable state is not understood as just being a balance between the stable and random states of the system, but rather as completely different type of dynamics, which is often referred to as 'mathematical chaos'.

So, if internal positive reinforcing feedback can lead to structurally simple systems being either unpredictable or paradoxically predictably unpredictable, then what does this actually mean for the type of systems with which we might engage as Systems Engineers? Well, following Chaos Theory, the second of the three main chapters in the story of the development of Complexity Thinking was Dissipative Structures. This evolution in Complexity Thinking emerged from observations of nonlinear chemical systems that were pushed out of equilibrium through the application of energy (Prigogine and Stengers 1984). It was found that with certain values of the experimental parameters, physical structures or patterns would emerge through self-organization. The nature of these emergent structures could be observed and repeated, but the precise detail of the structures could still not be predicted. The reason they are referred to as 'dissipative' structures is due to it requiring the dissipation of significant amounts of energy to maintain them, even though it takes only a small amount of energy for them to undergo a change. The new idea beyond Chaos Theory was that small fluctuations within the system could be amplified by positive reinforcing feedback and cause the system to self-organize into new emergent structures, without the need to an externally applied intervention beyond the application of energy. In this context, the term ‘emergent’ refers the structure being produce as a consequence of the properties of interactions and without any form of system-level design or recipe.

The third major development, and the basis of much of the current thought within Complexity Thinking, is the concept of Complex Adaptive Systems (Kauffman 1995). This development relates to systems composed of many individual ‘agents’, each of which behaves according to its own set of rules and adjusts its behavior based on the behaviors of the other agents around it. These types of nonlinear dynamic systems can exhibit macro patterns of behavior where all the agents appear to be acting in collaboration to create and evolve system-wide order (such as the flocking patterns of certain types of birds). A Systems Thinking based approach to understanding such a system would be to look for some form of macro-level set of rules or design in order to explain this systems-wide ordered behavior. But a Complexity Thinking approach would instead employ agent-based modelling that only takes into account the local interactions and then observes the system-wide behavior as emerging through self-organization. This emergent systems-wide order can then be understood without the requirement of any form of macro-level rules or coordination. In the earliest of these agent-based simulations (Reynolds 1987), all the agents would follow the same set of simple rules (such as modelling of the aforementioned flocking birds). But eventually simulations were developed where the agents could each also evolve and adapt their simple rules in response to the behaviors of the other agents (Ray 1993). The findings from this work suggests that the creation of novelty and innovation requires: micro-diversity; high levels of connectivity; and conflicting constraints (Kauffman 1995). These complex adaptive systems can be unpredictable and can rapidly undergo significant shifts in structure without apparent warning or foreseeable causes, but agent-based modelling is able to provide some information on their statistical tendencies. The relevant takeaway for us is that for a system of highly connected agents, even when each is following only a small number of simple rules, given the right values of critical parameters, it can spontaneously exhibit sophisticated and novel patterns of emergent system-wide behaviors, without anyone having designed it and without anyone being in control.

The final step towards understanding the implications for our organizations and social systems is the acceptance that, despite what many economists might have us believe, humans do not just follow a set of simple rules. Each person within any social system could legitimately be understood as themselves being a complex adaptive system that exhibits emergent behaviors that are predictably unpredictable. Each person will respond and adapt to both the system-level order and to the behaviors of other people around them. As all these predictably unpredictable people become increasingly connected and interdependent through a combination of both competing and collaborative interactions, then it becomes increasingly unrealistic to think that we can make precise predictions in order to command and control them. From a Complexity Thinking perspective, the idea that we can design and implement macro-level solutions to complex global challenges and social injustices no longer makes any sense.

So, if we are not able to *design* a better future, then where does that leave us? Should we just give up and let everything slide into chaos (the normal kind, rather than the aforementioned ‘mathematical chaos’)? Well, no, this is where Dave Snowden comes to our rescue with his Cynefin Framework (Kurtz and Snowden 2003; Snowden and Boone 2007; Snowden, Blignaut, and Goh 2022). The good news is that not all systems exhibit complex nonlinear dynamics. The Cynefin Framework aims to help us make sense of which type of system we are dealing with, and what types of approaches we should take to influence its future evolution. It identifies four types of systems: two that are ordered and referred to as 'Clear' and 'Complicated'; one that is 'Complex'; and one that is 'Chaotic' (again, more like the normally understood idea of chaos, rather than 'mathematical chaos').

Clear: A 'Clear' system is identified by there being fixed rigid constraints and everyone knowing what they are supposed to be doing. When working in a 'Clear' system, the approach is to apply 'best practice'.

Complicated: A 'Complicated' system is identified by the requirement for expertise and analysis in order to understand what to do. When working in a 'Complicated' system, the approach is to apply 'good practices' and employ governing constraints to set limits and provide confidence. The type of mechanistic technological system on which Systems Engineers would normally work could be examples of 'Complicated' systems. If we were to build an airplane with a certain set of components and following a certain set of procedures, and we then repeated the same process with the same components and same procedures, we would expect to get another airplane, and not something completely different. The same cannot always be expected from a system that is 'Complex'.

Complex: Within the Cynefin Framework a system that is 'Complex' is one that: has nonlinear dynamics; has causality, constraints and connections that cannot be seen at the macro level; has permeable boundaries; and exhibits behaviors that emerge through local self-organization. A system that is 'Complex' is predictably unpredictable. When working in a 'Complex' system, Dave Snowden's suggested approach is to "probe, sense and respond" by taking small steps and continually monitoring the situation. Rather than making a single plan with a specific macro-level goal, it is likely to be better to try multiple safe-to-fail experiments, monitoring for favorable emergent behaviors and also for negative unintended consequences. The focus is on influencing the emergence through managing boundaries and introducing catalysts. Once there is some understanding of the system's tendencies and a potential direction for improvement has been identified, then the next step is to put more energy into those experiments that have the best chance of moving the system to the next step in the desired direction. Large investments in new tools and technologies are not always appropriate without a detailed knowledge of an intended end goal, so where possible it can be better to repurpose existing technologies and maintain an emphasis on flexibility.

Chaotic: The fourth and final type of system is 'Chaotic' and is characterized by unconstrained random behaviors where novelty can arise easily, but it can be hard to capture and exploit due to the lack or any form of ordered structures. Often, the most practical approach when working with a 'Chaotic' system is to apply short-term emergency constraints that quickly force a transition to one of the other types of systems.

If we know we are working with a 'Complex' system, then the inherent lack of ability to design and control can offer significant challenges for our existing ways of thinking and organizing. But it should not always be seen as being something to avoid. If we are looking for creativity, novelty and innovation, then we may want to be operating within the complex domain, as this is where meaningful change requires less energy. The 'Complex' domain is also where organic life tends to evolve and flourish. As Systems Engineers, due to the transformative technological achievements to which we contribute, we can often see ourselves as the pinnacle of working with systems. But there are other professional disciplines that work with organic systems, in which they face different types of challenge and cannot rely on being able to engineer a solution. Disciplines such as Ecology and Evolutionary Biology may offer us a different metaphor for our social systems, as an alternative to the idea that our organizations should be run like a 'well-oiled machine'. And these metaphors may suggest another way of communicating the types of approaches to working with complex dynamics for which Dave Snowden is advocating.

The idea of using organic systems as a metaphor for our social systems offers a lot of tempting agricultural analogies to some of the approaches for working with 'Complex' systems that are suggested within the Cynefin Framework. The small-scale experiments and catalysts could be thought of as analogous to the planting of seeds. The management of boundaries and enabling constraints could be thought of as analogous to placing a cane or trellis to act as a scaffold that guides and supports the early growth of plants. Similarly, the supply of funding and resources could be thought of as analogous to the application of fertilizers, water and nutrients. However, industrial agricultural usually requires a stable climate and can result in very energy expensive and unsustainable approaches that are still based upon an attempt to control the system and bring it in line with our own design. More useful for understanding 'Complex' systems is the idea that, although we can have an image of roughly how plants may emerge from seeds, their exact details and how they will evolve cannot be predicted. We wouldn't expect plant life to develop in the same way within every type of environment. And we cannot *make* plant life, we can only nurture it by providing the types of environmental context in which it can flourish. For managing social systems, this might suggest that rather than trying to create rigid processes and procedures that apply in all organizational situations, we should take a more principle-based approach and allow the flexibility for context dependent variation. Modern day ecologists often try to develop approaches that influence and utilize an organic system's natural tendencies for self-organization, to let the system itself do the hard work and evolve into its own dynamically stable state (Webb et al. 2010; Penn 2016). Possibly a more easily accessible example of this approach is that of garden design and 'elephants paths' described by Sonja Blignaut in a book by "David Snowden and Friends" (Snowden, Blignaut, and Goh 2022, p82). Sonja describes two very different approaches to designing the paved paths within a garden. The first approach would be for us to make a plan of the garden and then design where we would like people to walk. Once the garden opens, it is very likely that additional unintended 'elephant' paths will develop across the grass, as visitor's footsteps wear it down along the routes that they naturally desire to walk. The alternative approach would be to start without any paved paths, adding them in later once visitors have marked the 'natural' routes by following their own preferences and propensities. This second approach allows the locations of paths to emerge based upon the cumulative effects of the individual visitors' interactions with all the features of the garden.

What is it that is supposed to be wrong with Systems Thinking?

Firstly, it should be said that the challenges to Systems Thinking (Rittel and Webber 1973; Stacey and Mowles 2015) do not relate to its application to the 'Complicated' types of mechanistic engineered systems with which many of us mainly work. Systems Engineering and Systems Thinking are proven methodologies that have put people on the moon and helped create many global technological infrastructures. However, the challenges become far greater the more that human agency and interdependencies are thrown into the mix, and as we try to apply Systems Thinking to organizations and social infrastructures. And again, in the spirit of trying to be clear about terminology, when I am referring to Systems Thinking as it is applied to social systems, I am thinking of the body of knowledge that started with General Systems Theory (Bertalanffy 1973) and Cybernetics (Beer 1967), and then continued developing through: Systems Dynamics (Forrester 1971); Learning Organizations (Senge 1990); Organizations as Practice or Process (Chia and Holt 2009); Second-Order Systems Thinking (Foerster 1984); Soft Systems Methodology (Checkland and Scholes 1990); and Critical Systems Thinking (Flood 1990; Jackson 2019).

The main criticism of Systems Thinking as it is applied to social systems, is that it attempts to holistically understand and manage systems-level order through identifying and controlling systems-level causes and structures. Whereas the system-level order within complex social systems is actually in a constant state of flux and emerges through nondeterministic processes that depend more upon patterns of local interactions and interdependencies (Stacey and Mowles 2015). Since Cybernetics started to be applied to organizations in the 1960s, the assumption has been that organizations are 'goal seeking' systems and the role of leaders is to set those goals and keep the people within the organization on the right track. In an engineered mechanistic system the components are designed with a specific purpose, and this same idea was applied to the roles of people within organizations. This would have been seen as a reasonable approach back in the early part of the twentieth century when Taylor developed Scientific Management. And it probably continued to be appropriate through the 1960s and 1970s when many people still worked on assembly lines. But as people increasingly have far greater agency in their work and more improvisation is required, then it is likely to become increasing problematic to view people as simultaneously both creative individuals and mechanistic components within a system. Even a CEO who sets the goals for a company will have conflicting and higher priorities, such as personal career development, financial remuneration and social status. We all 'play along' to greater or lesser extents with socially constructed rituals in order to gain social identity, as well as gain the means to obtain food, shelter and other benefits. And the organizational goals themselves will have been derived from the CEO's own interpretation of partial knowledge of complex sets of demands from a wide variety of stakeholders. The idea of 'evidence-based decision making' is an admirable one, but there is rarely reliable evidence for the future, and even less so when it is the future behaviors of large groups of highly-connected individual people. Just because a person in a position of authority decides something should be a certain way, doesn't necessarily mean that the emergent reality can or will end up being that way. It is considered a significant weakness of Systems Thinking that due to its focus on systems-level causes and structures, it ignores the agency of each individual and their potential to create the possibility for systems to spontaneously tip into new states through interdependence and the nonlinear consequences of reinforcing feedback.

One way of forcing an organization to be more amenable to the application of Systems Thinking might be to make it highly constrained and regimented. But this would be at the expense of flexibility, creativity and the potential for innovation. Another criticism levelled at Systems Thinking is that it has an underlying assumption that stability and efficiency are the most productive states for an organization. The models of Systems Dynamics can only produce reliable predictions for stable systems and are not able to work with the 'strange attractors' of nonlinear dynamics. But in a world where responsiveness and adaptation are increasingly important, then stability and efficiency are likely to significantly increase the energy cost of change. So in some more dynamic situations it may be preferable to operate within the 'Complex' domain, despite the associated lack of predictive power and direct control.

Systems Thinking is also accused of creating too much focus on second-order abstractions and viewing leaders as the architects of an organization (Stacey and Mowles 2015, Chapter 16). In this case a first-order abstraction could be the understanding that an individual person has of a particular practical situation. This understanding will be simplified compared with the inherent complexity of the actually situation. A second-order abstraction would be the policies and procedures that inform the individual how to deal with the situation. These policies and procedures are likely to be even more simplified and generalized than individual's own first-order abstractions. If too much emphasis and reliance is placed on these second-order abstractions, then small details that could result in significant consequences may be ignored. It can also lead to individuals being put into roles without sufficient experience and creative autonomy to interpret these simplified second-order abstractions within the context of each specific situation. There is also criticism that it is unrealistic to assume that a leader can stand as if they were outside of the system, gain a holistic understanding of all the interdependent interactions, and then be able to design its operation to achieve a predetermined goal. Even though Soft Systems Methodology tries to be more egalitarian by having decisions designed by representative groups from across an organization, these groups are still required to develop an understanding of all the hidden complexities and then decide what is best for everyone else. A more realistic and helpful alternative might be to view leaders as just another participant within the system, albeit one with more influence through being more connected and having more power over resources. And the value of Soft Systems Methodology might come more from the process of conversations and diffusion of ideas, rather than the eventual design of macro-level interventions.

Finally, Systems Thinking can often encourage us to look for definitive solutions to problems that are really ongoing tensions or social paradoxes (Smith and Lewis 2011) that can only be managed, rather than solved.

What, if anything, from Complexity Thinking might be useful for us as Systems Engineers?

Putting aside the discussion of which approach is most appropriate for thinking about organizations and global challenges, is there anything from Complexity Thinking that we can usefully apply to our development of engineered systems, especially when these systems have significant sociotechnical interfaces? One often used example of Systems Engineering delivering a successful outcome, is NASA's Apollo Program during the 1960s and 1970s (NASA 1971). From one perspective, putting people on the moon could be viewed as 'Complicated', rather than 'Complex'. The moon's position could be predicted within the required timeframes, the laws of physics were not subject to dramatic shifts or reversals, and the goal was reasonably well defined. If everything was executed correctly, then the procedures and technologies that got astronauts to the moon on one mission, would also get them there on the next mission. NASA's approach of analyzing, modelling, prototyping, simulating and scenario testing as much as possible in advance, in order to achieve success on the first attempt, is often contrasted against the trial-and-error approach that had been successfully employed by the Russians up until the race to the moon. The approach successfully employed by NASA was the most appropriate for the situation, as learning by repeated failure would not have been either politically acceptable or morally acceptable, if many astronauts had lost their lives in through a process of trial-and-error. However, there are situations where significant amounts of upfront planning and analysis may not be as appropriate. This may be the case for complex megaprojects that are developing infrastructure over multiple decades. The HS2 high-speed railway project in the United Kingdom was announced in 2009 with a budget of £20 billion, but the estimated cost then gradually rose to near £100 billion (Tetlow and Pattison 2023). During that time there were significant political, economic and technological changes which probably mean that much of the detailed planning and analysis undertaken at the start was a waste of time, and out of date almost immediately after it was completed. A better approach might have been to commit to the intention of linking London by rail to the north of the England and then, rather than spending so much time on planning, instead spending more time on seeding the emergence of a shared narrative about the value of the project? Then proceeding step-by-step, based upon parallel safe-to-fail experiments, as the best route forward emerged along with the continually evolving requirements and context? But then again, maybe it is not that simple…?

One of the attractions of a Systems Thinking approach, based upon well-defined system-level structures and rules, might be that it provides us with a sense of certainty, a feeling of being in control and having a simple narrative. Maybe part of the psychological attraction of long-term plans are that they provide us with something almost tangible that we can directly control and manipulate, even if they are just a simplified abstraction of the actual situation. The idea of having a false sense of certainty sounds like something we should be seeking to avoid if we want to make the best decisions and deliver the best possible results. But we, as humans, have a very strong instinct to avoid uncertainty (Lotto 2017) and to identify causal relationships, even where there may not actually be any (Matute et al. 2015). Even though operating in the 'Complex' domain is where there is the best chance for creativity and innovation, it is likely to require us to cope with the psychological discomforts of maintaining a state of uncertainty or accepting a lack of predictability. When writing about scientists, Thomas Kuhn referred to this state of uncertainty as being the "essential tension" required for achieving scientific breakthroughs (Kuhn 1979). Similarly, having the ability to inhabit both extremes of opposing behavioral stances, such as rebelliousness versus tradition, was suggested by Mihaly Csikszentmihalyi as being required in order to maximize creative achievement (Csikszentmihalyi 2013). Especially when considering very large systems of diverse peoples with conflicting values and priorities, there may always be continual emotional and political pressures trying to pull us out of 'Complexity' and towards some kind of enforced order. When it comes to our global challenges, maintaining this 'essential tension' and vulnerability across societies and over time, might be the fundamental existential challenge of our age…?

Although not sure that I understand exactly how we can maintain the application of Complexity Thinking within the very large types of undertakings that Systems Engineers are often involved, I do think there is scope and examples for applying it to smaller-scale endeavors, especially those with human interfaces or requiring radical innovation. For these smaller projects it is more likely to be possible to develop the trust and insight required to sustain appropriate levels of uncertainty and intelligent failure (Edmondson 2023), as well as establish leadership that can act as an effective source of positive influence. Mary Uhl-Bien and colleagues have some interesting ideas on a form of 'adaptive space' and 'adaptive leadership' that can help with managing creative tension in organizations (Lichtenstein et al. 2006; Uhl-Bien 2021).

A nice practical example from historian Trent Hone can be found in a chapter within the book by "Dave Snowden and Friends" (Snowden, Blignaut, and Goh 2022, pp213-228) and also his own book, "Mastering the Art of Command" (Hone 2022). Trent relates a story from the Second World War about a U.S. Navy Admiral successfully employing an approach to operational design that very much resonates with the ideas of Complexity Thinking. The introduction of two new technologies, radar and VHF radio communication, was expected to dramatically improve coordination between ships, but the reality was that radar signals were being misinterpreted and the radio communication was causing information overload and confusion. In addition to the inherent volatility of night-time naval battles, the complexity arose from the variability of timings, sources, reliability, relevance and types of information that needed to be combined to form an integrated picture of the situation. The nature of the decisions required of the officers and the coordination between ships would also continually vary as the situation and priorities evolved. This led Admiral Chester W. Nimitz, an experienced leader with a reputation of empowering his subordinates, to initiate the introduction of a new operational structure on each ship, which would become known as Combat Information Centers. Rather than getting a team of expert engineers to design and implement an appropriate solution for how these Combat Information Centers should operate, he instead simply framed the problem and allowed each ship's captain to implement their own solution. Apart from constraining the solution to being "a center, in which information from all available sources can be received, assimilated, and evaluated", the captains were not provided guidance on how these centers should operate. In many ways this resembles the previously mentioned 'elephant path' approach to establishing paved paths in a garden, and also the idea of managing boundaries and catalysts. Each ship's Combat Information

Center evolved through trial-and-error in combat situations (not exactly 'safe-to-fail', but still parallel experiments that were the best available approach given the situation) and also through informal networks between officers of different ships when they returned to port. The U.S. Pacific Fleet also managed formal feedback and information gathering in order to capture what was being learned. This approach led to the eventual emergence of different styles of Combat Information Centers being best suited to different types of ship, as well as the integration of some existing techniques that were adapted for the new operating model. Through 1943 Admiral Nimitz continued to influence and support the development of the Combat Information Centers. As they had started life as emergent solutions that were co-created by the users, it was natural that they continued to evolve, and they eventually became "a system of distributed cognition fully integrated with the ship's command functions". It would be hard to imagine that such a context sensitive, integrated and continually evolving solution could have been designed on the drawing board and then implemented with the level of success and impact achieved through the leadership of Admiral Nimitz and this adaptive form of co-creation.

Whether or not you agree with the criticisms of Systems Thinking as it is applied to complex social systems, and whether or not you feel that Complexity Thinking offers us some useful alternative approaches to traditional Systems Engineering, my hope is that this review has raised some interesting questions and planted some ideas that might blossom into fruitful discussions...

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About the Author

Clark Stacey is a Chartered Engineer and Chartered Physicist with over twenty-five years of experience in designing scientific instrumentation and facilities. He is a practicing Systems Engineer and has been a member of INCOSE in the UK since 2017. Clark also has a Master’s degree in Management Studies and is currently undertaking research on the management of applied scientific research projects as part of a part-time PhD at University College London.

SYSTEMS ENGINEERING RESOURCES

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INCOSE Systems Engineering Journal January 2024 Edition

In January 2024, INCOSE, through the Wiley online library, published Volume 27, Issue 1 of the Systems Engineering Journal. This edition includes thirteen articles, a mix of open access and free-to-read content, plus full access papers that require an institutional login, e.g., via INCOSE membership. There is no published unifying theme for this edition. PPI SyEN has included abstracts to guide our readers to which of these diverse topics best fit their interests.

Open Access Articles

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[Energy planning in sub-Saharan African telecom networks: Decision support using a soft systems methodology]

Authors: Mbiika Ceriano, Jörg Lalk, and George Alex Thopil

Abstract: This research paper narrates the application of the soft systems methodology (SSM) as a problem structuring tool, as well as the first step of a methodological approach that will provide decision support based on multi-criteria decision analysis in the planning of energy for telecom networks across sub-Saharan Africa. To ensure applicability of the methodology to a real-world issue, an international telecom tower company based in East Africa was selected as the case study. The SSM is utilized to characterize the decision problem context precisely, identify major stakeholder groups and their connections, and to discover each one's interests. This helps to achieve appropriate and holistic energy planning and management unlike the current trends which employ a reductionist approach. The outcome of the work leads to a model using SSM where stakeholder inputs can be captured, for the telecom company.

[Joint Offering Evaluation Framework for Assessing the Feasibility and Business Value of a Digital Twin Use Case]

Authors: Leila Saari, Minna Räikkönen, Eemeli Hytönen, and Katri Valkokari

Abstract: The complexity of industrial challenges is emerging together with the exponentially developing information and communication technologies (ICT) that provide several implementation approaches for systems engineering. It is difficult for a single company to follow technological development and remain a pioneer in every topic. Still, the industrial challenges require experts in each technology. Therefore, collaboration among technology providers is an opportunity to gather all resources and competences needed for full delivery. A joint offering (JO) is a solution, that is, co-created in collaboration between two or more actors that usually have complementary technological skills or value-creation logics. A JO has several doubts relating to the use case (UC) in hand, the feasibility of the joint solution to be co-created, the resources and skills needed to deliver the joint solution, the partners, the business value creation, the elements of the contract and the ownership of the outcome, just to mention a few. The Joint Offering Evaluation Framework (JOEF) uncovers these issues and supports decision-making before the development of a JO starts. The JOEF comprises the Joint Offering Playbook and the Business Value Toolset (BVT). The Playbook offers seven viewpoints with checklists and tools for IT solution providers considering collaboration and co-creation for a solution that they cannot deliver or sell alone. The BVT evaluates and illustrates the business value of a JO from the viewpoints of both creation and delivery, together with value capture and assessment. The JOEF was piloted with a digital twin (DT) UC from the pulp and paper industry.

MBSE adoption experiences in organizations: Lessons learned
Authors: Kaitlin Henderson, Thomas McDermott, and Alejandro Salado
Abstract: Lessons learned through MBSE adoption efforts is one of the key ways of communicating best practices and recommendations for MBSE. This study compiles lessons learned from published case studies and practitioner interviews. Lessons are summarized into categories such as adoption strategy, modeling practices, and communication. This paper provides a source for future adopters of MBSE to review best practices and recommendations from a multitude of different experiences. This should improve the adoption and implementation of MBSE.

Minimizing conflicts among run-time non-functional requirements within DevOps
Authors: Souvick Das, Novarun Deb, Nabendu Chaki, and Agostino Cortesi
Abstract: Significant contributions in the existing literature highlight the potential of soft goal interdependency graphs towards analyzing conflicting non-functional requirements (NFRs). However, such analysis is often at a very abstract level and does not quite consider the run-time performance statistics of NFR operationalizations. On the contrary, some initial empirical evaluations demonstrate the importance of the run-time statistics. In this paper, a framework is proposed that uses these statistics and combines the same with NFR priorities for computing the impact of NFR conflicts. The proposed framework is capable of identifying the best possible set of NFR operationalizations that minimizes the impact of conflicting NFRs. A detailed space analysis of the solution framework helps proving the efficiency of the proposed pruning mechanism in terms of better space management. Furthermore, a Dynamic Bayesian Network (DBN) - based system behavioral model that works on top of the proposed framework, is defined and analyzed. An appropriate tool prototype for the framework is implemented as part of this research.

Simulating a sterilization processing department to evaluate block schedules and tray configurations
Authors: Sean Harris, Valentina Nino, and David Claudio
Abstract: Discrete event simulation is a well-established tool for examining the effect of different operating room (OR) block schedules on various performance metrics within the OR suite and adjacent units. However, one unit that has rarely been studied is the sterilization processing department (SPD), which cleans and assembles reusable OR instruments. As part of a larger research study, we developed a series of OR block assignment models that sought to reduce the workload of the SPD and developed a tray optimization model to reduce the number of instruments on increasingly bloated instrument trays. While initial numerical experiments were promising, a comprehensive simulation model of the OR and SPD was needed to more thoroughly examine how potential changes to the block schedule and/or more efficient tray configurations could improve SPD processing times. In this article, we incorporate the SPD into an existing simulation model of an OR suite, which is the first of its kind, and examine the effect that different block schedules and tray configurations have on SPD processing times. Simulation results confirm earlier numerical computations. Furthermore, simulation results suggest that more efficient instrument tray configurations are a much better and more viable method for improving SPD processing time than reconfiguring block schedules.

Statistical modeling to relate technology readiness to schedule

Authors: C. Robert Kenley, Shrividya Subramanian, and Katherine M. Adams

Abstract: Projects from U.S. National Aeronautics and Space Administration and Department of Energy technology development activities provide historical data on project completion timelines versus technology readiness levels that were assessed during the life cycle of a program. A statistical analysis was performed to develop a method to forecast future project completion timelines based on technical maturity assessments. The goodness-of-fit of the model used for forecasting also was evaluated, and the null hypothesis that the data follows the probability distribution used for the forecasting model could not be rejected at a Type I error level of 0.05. Several potential extensions to the model using product forecasting methods, semi-Markov processes, and Bayes nets are presented. The limitations of the statistical modeling and of the potential extensions are also discussed.

Team and communication impacts of remote work for complex aerospace system development

Authors: Sharon Ferguson, Eric van Velzen, and Alison Olechowski

Abstract: Remote work is becoming increasingly common, a trend accelerated by the global COVID-19 pandemic. Existing remote work research fails to address the challenges and needs of engineers working remotely in Complex Aerospace System Development (CASD), the field responsible for creating and operating aerospace systems. This article presents an exploratory study to understand the challenges, benefits, and strategies when working remotely in CASD. We interviewed 12 CASD engineers working remotely at a major aerospace corporation. We ground our findings in six characteristics of CASD work (complex systems; design paths and feedback loops; relationships with suppliers, customers and regulators; distinct knowledge and skills; one-off innovation; and high cost of experimentation) and discuss how each of these characteristics challenges remote work. The findings show that CASD requires many teams to work together, and this is encouraged through informal communication, which almost disappears in a remote setting. CASD requires frequent feedback, and we found that feedback was slow when working remotely. Participants found it challenging to demonstrate systems to customers and verify drawings with suppliers, and the interpersonal relationships, which help to bridge disciplinary divides, were harder to maintain remotely. The one-off nature of the systems designed meant that conceptual work was important, but participants lacked the virtual tools to do this effectively. Lastly, testing hardware components required close virtual communication between technicians and engineers, which was tricky in a detail-oriented context. This study motivates areas for future work to better understand and address the nuances of remote work by engineers in CASD.

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Cyber oriented digital engineering

Authors: Joseph Mitola III and Mark Prys

Abstract: The purpose of cyber oriented digital engineering (CODE) is to provide a repeatable systems-engineering process for systems to resist Stuxnet-class advanced persistent threat (APT) cyberattacks. CODE integrates cyber thinking with systems thinking. CODE accomplishes this by extending the US Department of Defense (DoD) digital engineering (DE) framework with functional mission analysis for cyber (FMA-C), hybrid cloud architecture, zero trust (ZT) principles, threat analysis, and hardware cyber hardening (HCH). The lack of success of red team attacks conducted in our laboratory against an exemplar system demonstrates how following the CODE systems engineering process actually does “bake cybersecurity into the system”, making the resulting systems architecture and implementations

more resilient. In a recent Pilot Project, CODE enhanced the systems requirements document of the top left side of the systems engineering Vee. CODE Pilot requirements embodied ZT principles, including machine to machine (M2M) credential exchanges and internal self-checking. We anticipate working with International Council on Systems Engineering (INCOSE), the object management group (OMG) and others towards standardizing CODE's cyber-systems engineering processes for broader use of the global systems engineering community.

Measuring the digital transformation maturity level independently with the design science research methodology
Authors: Tining Haryanti, Nur Aini Rakhmawati, and Apol Pribadi Subriadi
Abstract: This study uses the Design Science Research Methodology (DSRM) approach in creating an artifact on the perspective of the Information System. Design Science is a valuable tool for creating a new artifact or developing an existing artifact through research. The DSRM Framework described in this study discusses the implementation of each stage, namely, Explicated Problem, Define Requirement, Design and Development, Demonstration, and Evaluation and is complemented by the implementation of case studies of artifact creation in DSRM stages. The Digital Maturity Measurement in question is a service to measure digital maturity in various dimensions. Each DSRM stage is mapped to a case study of that service. Canvas visualization is presented to describe a complete picture of how the artifacts of Digital maturity services are built with the DSRM approach. This research also provides guidance on the principles, procedures, and characteristics needed to build effective research.

Optimal verification strategy for general development plans using a belief-based approach
Authors: Aditya U. Kulkarni, Ashley Girod, Peng Xu, and Alejandro Salado
Abstract: Verification activities are intended to reduce the costs of system development by identifying design errors before deploying the system. However, subcontractors in multi-firm projects are motivated to implement locally cost-effective verification strategies over verification strategies that benefit the main contractor. Incentivizing verification activities is one mechanism by which the contractor can motivate subcontractors to implement verification strategies desirable to the contractor. In this paper, we present a belief-based modeling concept for determining optimal verification strategies for general development plans. The results show that the optimal incentives are a function of the subordinate firm's beliefs and the influence exerted by the subordinate firm on the supervising firm with respect to verification activities.

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Interpreting integrability
Author: Alejandro Salado
Abstract: Most systems engineers have likely heard of or pursued integrability when developing systems. It is also likely that systems engineers perceive that, in general, integrability is a desired quality to attain. But what is integrability, really? While there is likely a consensus within the systems engineering community about the general idea of integrability, this paper poses that reasoning about integrability requires a deeper, comprehensive interpretation of what integrability is and entails. Recognizing that the meaning of integrability is subjective, this paper provides a deep dive into understanding and interpreting integrability. The findings presented in this paper could be used as a guide for others to find clarity on what they mean by achieving integrability when developing systems.

Model-based architecting evaluation method for the delivery of complex nuclear projects
Authors: Jérémy Bourdon, Pierre Couturier, Vincent Chapurlat, Robert Plana, Victor Richet, and

Benjamin Baudouin
Abstract: Facing the organizational and technological complexity of nuclear infrastructures (NI), the public reluctance in nuclear technology and the increasing restrictive regulatory environment, improving the conceptualization and evaluation of NI architecture is crucial for the successful completion of NI projects. Indeed, many technical engineering difficulties or delays in delivery can be avoided by deepening the design and evaluation of NI architectures. In a context where model-based systems engineering (MBSE) is becoming more and more relevant, it is interesting to integrate evaluation into this process. Although the architecture evaluation (AE) process is rather well defined in the literature and linked to system analysis practices, it is quite difficult to deploy and pilot within complex NI projects. This article proposes a model-based method, EVAluation for Critical Infrastructure Model Based System Engineering (EVA-CIME), to facilitate the deployment of AE processes on a project. The components of this method are described and illustrated in a study of a NI design. The benefits and limitations of EVA-CIME in its state of development are discussed and lead to the conclusion that the method should be extended to foster an AE culture within the company itself.

Model-based risk analysis for system design
Author: J. Pedro Mendes
Abstract: Despite being the dominant risk analysis paradigm, event guessing is useless for systems design. In management, no event guessing has ever preempted the launch of policies that are decided, not designed. In engineering, events are not guessed; rather, they are created for testing purposes. Events provide inputs to which systems respond according to their structure, as described by state-space or equivalent System Dynamics models. A new risk analysis framework draws design support information from model attributes. Risk-informed dynamic models help design physical architectures or organizational policies that capably respond to arbitrary events. The approach builds on the notion that all inputs carry energy. Physical or policy systems change states by trading energy with the surroundings, through expected transactions and unexpected disturbances. A non-probabilistic risk framework supports the design by showing that the system exhibits intended functionality when responding to arbitrary inputs. Instead of guessing countless hypothetical events, the framework systematically and comprehensively analyzes weaknesses in the system model using a programmed algorithm. It applies to any state-space dynamic model by defining risk as a function of the energy needed to move the system from an acceptable to a faulty state. Robust systems dissipate excess energy, whereas vulnerable systems lose functionality. Fuses and cushions are generic classes of protections. Placing them into system models at identified weak points helps improve design. Two published simple models of business policies illustrate the framework, which is extended to define measures for consequence and uncertainty as functions of acceptable and faulty states.

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INCOSE INSIGHT Practitioners Magazine: SE for Sustainability

The February 2024 edition (Volume 27, Issue 1) of INSIGHT, INCOSE's Practitioner Magazine published by Wiley, has been released. 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.

The focus of this issue is *Systems Engineering for Sustainability*. Contents of this 84-page document include:

Sustainability: A Complex System Governance Perspective
by Charles B. Keating, Polinpapilinho F. Katina, Joseph M. Bradley, Richard Hodge and James C. Pyne
This paper explores the sustainability field from a complex system governance (CSG) perspective. In general, sustainability suggests maintenance at a specific rate or level. It is also frequently held as maintaining ecological balance to negate the depletion of natural resources. CSG offers sustainability a theoretically grounded, model based, and methodologically sound approach to better inform sustainability design, execution, and development for complex systems. CSG examines sustainability as an outcome-based product resulting from effective governance of an underlying system which produces sustainability. Thus, sustainability is proposed as a 'systems engineered product', whose design, execution, and development will be favored by CSG systems engineering. Following an introduction, two primary objectives are pursued. First, systems theory is used to provide an alternative view of sustainability. Second, a perspective of sustainability is developed through the paradigm of the emerging CSG field. The paper closes with the contributions, opportunities, and challenges for deployment of CSG for enhanced development, transition, and maintenance of sustainable systems.

Towards an Approach to Co-Execute System Models at the Enterprise Level
by Jovita Bankauskaite, Zilvinas Strolia and Aurelijus Morkevicius

Industry 4.0, the Internet of Things, and large-scale system-to-system interactions are driving digital transformation in the industry. Model-based systems engineering (MBSE) is one of the core paradigms behind this transformation. MBSE practices are widely applied to enterprise (including system of systems and mission) architectures, which become a crucial part of successful digital transformation. The core challenge today is not only how digital continuity can be maintained by connecting different layers of models (such as system models to system-of-systems models), but also how to perform detailed analysis and simulation at the enterprise level model. This paper studies Systems Modeling Language (SysML®) as the standard language to model systems, Unified Architecture Framework (UAF) as the framework, Unified Architecture Framework Modeling Language (UAFML) as the language to model enterprise architectures and proposes an approach for end-to-end co-execution of the integrated enterprise model.

A Geo-Spatial Method for Calculating BEV Charging Inconvenience using Publicly Available Data
by Aaron I. Rabinowitz, John G. Smart, Timothy C. Coburn and Thomas H. Bradley

As governments and the automotive industry push towards electrification, it becomes increasingly critical to address the factors which influence individual car buying decisions. Evidence suggests that operational inconvenience or the perception thereof plays a large role in consumer decisions concerning battery electric vehicles (BEVs). BEV ownership inconvenience and its causal factors have been relatively understudied, rendering efforts to mitigate the issues insufficiently informed. This paper presents a method of producing an empirical equation which relates operational inconvenience to a small number of housing and local electric vehicle supply equipment (EVSE) infrastructure factors. The paper then further provides a method of applying the equation in a geo-spatial context allowing for the evaluation of the effects of policies in a geographical manner. this method enables future quantitative analyses concerning investment in EVSE infrastructure to be directly sensitive to BEV operational inconvenience due to charging.

Carbon Considerations for Systems Evolution
by David Flanigan and Kevin Robinson

In the early stages of systems development, systems engineers will typically evaluate alternatives based on performance, cost, risk, and schedule to evaluate the solution space of alternatives. While these criteria have proven to be successful, there is growing interest in the analysis of carbon costs as well to contribute to the decision making. These decision criteria are very good to help the decision maker select the best alternative within the solution space in which to develop a system concept. We offer another criterion for consideration to account for carbon expenditure throughout the systems engineering lifecycle. We believe that including this dimension can influence decision makers to evaluate a richer portion of the solution space. This approach is developed and exercised with a notional example.

Model-Based Framework for Data and Knowledge-Driven Systems Architecting Demonstrated on a Hydrogen-Powered Concept Aircraft
by Nils Kuelper, Thimo Bielsky, Jasmin Broehan and Frank Thielecke

Aircraft development is a protracted process over many years. Novel concept aircraft with new energy sources and disruptive systems technologies are investigated during the aircraft conceptual design phase with the goal to achieve sustainable aviation. Current development cycles need to be accelerated to reduce time to market and development costs of novel aircraft, while still handling complexity and uncertainty of systems technologies. Therefore, a holistic framework for knowledge-based systems architecting using a model-based systems engineering approach is presented. This framework has the purpose to conserve and provide knowledge, that is, information, data, and experiences about existing systems architectures, to the engineer. The developed framework consists of a database concept, a method for model-based systems architecting, and an interface to the overall systems design software tool GeneSys. Based on evaluating different modeling languages and tools, MathWorks System Composer is selected as most suitable tool for knowledge-based systems architecting. The developed framework is then demonstrated by conserving and reusing formalized knowledge for the design of a novel hydrogen-powered concept aircraft. On-board systems architecture models are saved in a database and automatically recreated reducing development time. The complete graphical representation could not yet be stored in a formalized manner partly reducing the advantage of a clear representation of model-based systems architecting. However, this did not reduce automatic recreation and evaluation capabilities.

Applying a System of Systems Perspective to Hyundai-Kia's Virtual Tire Development
by Sunkil Yun, Shashank Alai, Yongdae Kim, Jaehun Jo, Tae Kook Kim, Dahyeon Lee, Lokesh Gorantla and Michael Baloh

Systems engineering has become important in almost every complex product manufacturing industry, especially automotive. Emerging trends like vehicle electrification and autonomous driving now pose a system of systems (SoS) engineering challenge to automotive OEMs. This paper presents a proof-of-concept (PoC) that applies a top-down SoS perspective to Hyundai-Kia Motor Corporation's (HKMC) virtual product development process to develop a performance-critical component of the vehicle, the tire. The PoC demonstrates using the Arcadia MBSE method to develop a consistent, layered, vehicle architecture model starting from the SoS operational context down to the lowest level of system decomposition in the physical architecture thereby capturing top-down knowledge traceability. Using the concept of functional chains, several vehicle performance views are captured that serve as the basis for architecture verification orchestration across engineering domains using a cross-domain orchestration platform thereby validating key vehicle/tire performance metrics that influence the tire design parameters. Preliminary results of the study show that applying a method-based modeling approach could provide several benefits to HKMC's current product development approach such as reduced time to model, SoS knowledge capture and reusability, parameter/requirement traceability, early performance verification, and effective systems engineering collaboration between the OEM, tire design supplier, and tire manufacturers.

Think Like an Ecosystem: Transitioning Waste Streams to Value Streams
by Rae Lewark, Allison Lyle, Kristina Carroll and Casey Medina

To meet the material demands of the future, transitioning waste streams to value streams is a vital step in ecological and economic sustainability. Linear production design disposes of resources before their optimal value have been realized and loses recyclable resources to waste streams. The economic infrastructure of the planet needs to be reimagined to meet human and ecological needs. The development and implementation of circular systems is key to the creation of sustainable global production. Through the analysis of the copper used in medical devices, we illustrate considerations systems engineers can take to close the waste-resource gap. Developing wasteless design mimics the resiliency seen in ecosystems and accelerates the evolution of the global economy to meet the needs of companies, the environment, and humankind.

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Requirements Elicitation in Modern Product Discovery

Requirements Engineering Magazine
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The International Requirements Engineering Board (IREB) publishes the Requirements Engineering (RE) Magazine multiple times per year. Articles are welcome from Business Analysis and Requirements Engineering professionals, regardless of IREB membership status. Publication is free of charge for the authors.

In the February 2024 edition, Nuno Santos, PhD, and Senior Business Analyst, authored an article titled "*Requirements Elicitation in Modern Product Discovery - Classifying product techniques by requirements type*.

Abstract:
If you are working on products, you have realized product management handles requirements in a different way. When a business analyst or a product owner is eliciting requirements, there is a shift from eliciting stakeholders' wishes to discovering better and faster ways to solve stakeholders' problems. This article presents how discovery techniques, popular within product management, fit in the three types of requirements: business, stakeholder and solution. If your organization is shifting from project-led to product-led, this article presents an understanding where the techniques fit in this spectrum and will allow a better understanding of how and when to use them.

The techniques presented are:

- "How Might We" (from Design Sprint)
- Jobs-To-Be-Done (JTBD)
- User Journey
- Kano Analysis
- Continuous Customer Interviews
- Opportunity Solution Tree
- Story Mapping
- Epic Alignment.

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Book: System of Human Activity Systems - A Novel Way to Visualize Invisible Risks

Takafumi Nakamura is a Special Appoint Professor of Management at Daito Bunka University and is renowned for his research in risk management. Springer has recently published his latest work, *System of Human Activity Systems - A Novel Way to Visualize Invisible Risks*, in which Nakamura proposes a framework to overcome System of System Failures (SOSF) and extends this framework for use in complex societal challenges, i.e., systems of human activity systems (SOHAS).

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- Survey of Current Methodologies
- Proposal of a New Methodology to Overcome Current Methodological Shortcomings
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- Discussion of the Application Results
- Transformation of SOSF Space into Topological Space to Quantify and Visualize Risk
- Reconsidering SOSF from the Perspective of HAS
- Viewing Human Error as a HAS (Proposed Framework for Ensuring Holistic Measures and its Application to Human Error)
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INCOSE offers a Mentoring Service for its members that brings experienced systems engineering professionals alongside less experienced "mentees". Guidance provided is mentee-driven (based on mutually-agreed objectives) and could be technical, advice on advancement or navigating in an organization, or help navigating INCOSE. Mentees select mentors from a pool of INCOSE volunteers.

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INCOSE International Workshop IW2024 Recordings

The INCOSE International Workshop (IW2024) took place on 27-30 January 2024 in Torrance, California, USA. INCOSE has made available recordings from the numerous working sessions conducted during this event. INCOSE members may access these resources in the INCOSE Library by searching the Category field for "IW2024". As of 7 March, this search yielded 103 resources – a rich trove of information for systems engineering practitioners who desire to understand key developments in their discipline.

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P006-940	Las Vegas, USA PDT 8:00 (UTC -7:00) In-Person	17 Jun - 21 Jun 2024

FINAL THOUGHTS FROM SYENNA

Navigating the Common Pitfalls of Systems Engineering

1. "I Thought You Had the Specs!" Syndrome

Ah, the classic mix-up—akin to two partners assuming the other has the house key, only to find themselves locked out in a rainstorm. In the high-stakes world of systems engineering, this is less about getting wet and more about projects stalling faster than a car out of gas. Miscommunication or assumptions about specifications can lead to the infamous redesign tango. One step forward, two steps back, and a whole lot of "I thought you had the specs!" in between.

2. Integration, Integration, Integration

Integration is the bread and butter of systems engineering—except when it's more like trying to spread cold butter on too-soft bread. You aim for a seamless melding of components, but instead, you find yourself tearing the whole project apart. It's the moment when you realize that, yes, all those components you've lovingly crafted must work together. And no, they stubbornly refuse. It's the systems engineering equivalent of herding cats, if each cat were a complex subsystem with its own opinion.

3. Scope Creep: The Silent Project Killer

Scope creep is like that one guest at your party who not only arrives uninvited but also decides to live in your guest room indefinitely. What started as a manageable project slowly transforms into a sprawling behemoth, devouring budgets, timelines, and sanity with the voracious appetite of a black hole. Remember, the first step in dealing with scope creep is admitting you have a problem. The second step? Strict boundaries and maybe a lock on the project's metaphorical door. To further combat this unwelcome visitor, incorporating proactive planning and regular review sessions into your project management strategy can be a game-changer. These practices act as the early warning system and the regular check-ins necessary to ensure your project stays on course, effectively keeping scope creep at bay and your project tightly within its intended boundaries.

4. The Documentation Desert Mirage

Ah, documentation, the bane of many an engineer's existence and yet the lifeline of any project wishing to outlive its creators. Navigating the Documentation Desert has become a rite of passage in systems engineering. At first glance, the landscape appears manageable, even inviting. "We'll document as we go," we say, filled with the optimism of a traveler with a full canteen. But as the project marches on, that oasis of well-intentioned documentation often turns out to be a mirage. Before we know it, we're lost in a desert of code with no comments, designs as cryptic as hieroglyphs, and user manuals that are more abstract art than instruction. The mirage of "we'll do it later" leads many projects to wander, parched and directionless, in search of the oasis of clarity that only thorough documentation can provide. Let's remember to drink deeply from the well of documentation early and often, lest we find ourselves with a project that's all sand and no substance.

In the grand tapestry of systems engineering, these mistakes are but a few threads that, despite their potential to unravel projects, also hold the power to bind teams together in shared purpose and perseverance. They remind us that behind every great engineering feat lies a trail of lessons learned, often learned the hard way. So, as we forge ahead, let's wear these lessons not as scars but as medals of honor, symbols of our commitment to pushing the boundaries of what's possible, one misstep—and correction—at a time.

5. The Overpromise Underdeliver Conundrum

Lastly, we come to the siren song of systems engineering: the temptation to promise the moon (because technically, we could engineer a way to get there) and deliver, well, a handful of moon dust. It's a tale as old as time, driven by enthusiasm, optimism, and sometimes a tad too much caffeine. The key to avoiding this pitfall? Under promise, overdeliver, and keep a healthy stash of reality checks in your toolkit. Specific reality checks could include regularly consulting with your team about what's achievable in the given timeframe, using historical data to set realistic deadlines, involving stakeholders in milestone reviews to align expectations, and performing risk assessments to identify potential hurdles ahead. These strategies ensure that while your ambitions are sky-high, your project's feet—and indeed, its deliverables—remain firmly planted on the ground.

As we navigate the complex landscape of systems engineering, it's clear that our journey is fraught with potential pitfalls—from the silent encroachments of scope creep to the desert mirages of documentation. Yet, each challenge presents us with a unique opportunity to grow stronger, wiser, and more resilient. By recognizing these common mistakes and arming ourselves with strategic planning, clear communication, and a commitment to our goals, we transform these obstacles into stepping stones towards excellence.