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New Beginnings and Uncharted Waters

FEATURE ARTICLE

Applying Decision Patterns to Courseware Development

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WELCOME

Dear Readers,

Welcome to the first 2025 edition of SyEN. Our theme for this edition is **"New Beginnings and Uncharted Waters."**

Beginnings often bring change and opportunity and I'm excited to step into the role of managing editor, succeeding the very capable René King. One valuable insight from our many interactions was a reminder of Stoic wisdom and a recommendation to read The Daily Stoic by Ryan Holiday. A quote from Epictetus resonates deeply as I reflect on the past year and anticipate the year ahead:

"Progress is not achieved by luck or accident, but by working on yourself daily."

This sentiment aligns with Syenna's musings on the virtue of iteration—provided we focus on learning from small mistakes to prevent the big ones. Speaking of growth and improvement: don't miss our section on conferences, meetings, and webinars in 2025.

This month's feature article by John Fitch combines his expertise in Decision Patterns with his passion for courseware development. With decades of experience teaching thousands, John demonstrates how systems engineering applies across fields—a passion I share.

Reflecting on my journey, I inherited an intuitive love for systems thinking from my father, a respected medical doctor who appreciated the interplay of biological, social, political, and economic systems in patient outcomes. Our frequent discussions on science, physics, and technology naturally gravitated toward the systems surrounding these concepts.

After graduating from Engineering, I worked on an early GPS and GSM tracking system for the then RACAL, now Thales. Facing numerous challenges, a mentor introduced me to Systems Engineering. Besides turning the program around, this sparked a lifelong passion. Shortly after I connected with INCOSE, helped establish a local branch, met Robert Halligan, developed the initial training course for PPI/CTI's INCOSE Certification program in 2009 and have been fortunate to work with PPI/CTI in various roles since.

As we embrace 2025, my hope for each reader is a year of steady improvement and the joy of applying systems engineering knowledge in new and exciting ways that benefit society.

Warm regards,

Francois

Managing Editor (on behalf of the PPI SyEN Team)

> *Collaboration is a voyage from the known to the unknown, with people of common commitment, who both steer and follow.*
>
> **Donald Staff**

PPI Systems Engineering Newsjournal (PPI SyEN) seeks:

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

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

SYSTEMS ENGINEERING NEWS

Recent events and updates in the field of systems engineering

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 the following standards that may be of interest to systems engineering practitioners:

APIs for Knowledge Platforms (API4KP), 1.0 (August 2024)
This OMG specification defines the Application Programming Interfaces for Knowledge Based Systems and Platforms (API4KP), in response to the OMG's Application Programming Interfaces for Knowledge Bases (API4KB) RFP. The purpose of these APIs is to facilitate the development and integration of knowledge graphs and knowledge-based systems in a broader enterprise framework. They provide a standard interface between client applications, knowledge resources and the platforms used to manage and deliver them - including but not limited to editors, repositories and reasoners/ rule engines.

Automated Technical Debt Measure V2 (ATDM2), 1.0 beta 2 (September 2024)
The purpose of this specification is to establish a standard for automating a measure of Technical Debt that can be computed by source code analysis technologies which have implemented the CISQ Quality Characteristic measures.

Business Architecture Core Metamodel (BACM), 1.0 (August 2024)
The specification defines metamodel concepts for modeling businesses and other kinds of organizations intended for strategy formulation and planning, business transformation and business analysis. It is intended for use in conjunction with other OMG business-related specifications such as BMM, VDML, BPMN etc., and with common business methodologies. Its primary concept is the business capability - an abstraction representing what a business does but not how. It surrounds business capability with concepts of value delivery (value streams), customer behavior, products, organization design and strategy impact. It provides a means to associate information from other models and business documents with concepts in the business architecture model.

Commons Ontology Library (Commons), 1.1 (August 2024)
The Commons Ontology Library provides a set of small ontologies designed to provide a useful set of modeling constructs that are reusable in different modeling and data deployment environments with minimal commitments. It is intended to be extensible such that new ontologies and potentially other models (for example, UML models corresponding to the ontologies) can be added as cross-domain requirements present themselves. These requirements may come from other OMG standards efforts, such as the Multiple Vocabulary Facility (MVF), Languages, Countries and Codes (LCC), APIs for Knowledge Platforms (API4KP) platform specifications as well as from domain specifications such as the Retail Industry Ontology (RIO) and Financial Industry Business Ontology (FIBO), or potentially from external users of the library.

Decision Model and Notation (DMN), 1.6 beta (September 2024)
DMN provides two tools for modeling decision-making: a graphical notation and an expression language. The notation shows the dependencies between a set of related decisions, and on the business knowledge and input data required to make them. It is simple enough to be readily understandable by all business stakeholders, including business analysts, designers, developers, and business owners. The expression language defines the decision logic underlying the decisions and business knowledge in sufficient detail to allow execution. It includes many convenient and expressive features, including decision tables, and is compatible with Java, PMML and ONNX. DMN is designed to be usable alongside the standard business process notation BPMN and also ensures that decision models are interchangeable across organizations via an XML representation.

Essence (ESSENCE), 2.0 beta (June 2024)
The Kernel provides the common ground for defining software development practices. It includes the essential elements that are always prevalent in every software engineering endeavor, such as Requirements, Software System, Team, and Work. These elements have states representing progress and health, so as the endeavor moves forward the states associated with these elements progress.

Precise Semantics for Uncertainty Modeling (PSUM), 1.0 beta 2 (June 2024)
The Precise Semantics for Uncertainty Modeling (PSUM) version 1.0 builds the foundation for developing uncertainty modeling solutions, to guide the implementation of uncertainty modeling tools, to provide the basis for developing training materials and resources in the application of uncertainty modeling, and to serve as the cornerstone of proposing future revisions and extensions of uncertainty modeling solutions. The PSUM metamodel is defined using the MOF meta-modeling language, to be consistent with other models defined by OMG.

Risk Analysis and Assessment Modeling Language (RAAML), 1.1 beta (June 2024)
The RAAML Version 1.1 specification defines extensions to SysML needed to support safety, reliability and security analysis. It provides the modeling capabilities for tool vendors to build safety, reliability, and security modeling tools that provide traditional representations (e.g. trees, tables, etc.) while using a modern model-based approach. The RAAML specification can provide the foundation for conducting various safety and quality engineering activities including safety, reliability and security analysis methods. Besides the method support, linkages to the SysML model-of-interest are provided, enabling integration with and traceability to the analyses. The spec describes the RAAML core concepts and shows:

- That simple concepts are powerful enough to unite all safety, reliability and security information across a variety of analysis methods,
- The approach to automating several safety and reliability analyses, which is built on leveraging existing SysML functionalities to ensure that the profile and library is usable with existing tooling,
- Specific safety and reliability analysis methods and application domains that are supported, including FMEA, FTA, STPA, GSN, RBD, ISO 26262 Road Vehicles Functional Safety, and Extension Mechanisms that are typically needed by the industry to apply the specification in practice.

Specification Common Elements (SCE), 1.0 beta 2 (September 2024)
Specification Common Elements (SCE) generalizes structural elements and patterns that have been introduced by the Business Process Model and Notation (BPMN) 2.0 specification and were later

adopted by other standards, such as Decision Model and Notation (DMN). The concept of defining SCE emerged during the development of Shared Data Model and Notation (SDMN), which is the first specification directly based on SCE and a good example of how it is applied. SCE is backwards compatible with BPMN and DMN, which may adopt SCE as they are updated in the future to eliminate redundancy. Other specifications may leverage SCE components, especially if they want to be compatible with BPMN's ecosystem of standards.

Shared Data Model and Notation (SDMN), 1.0 beta 2 (June 2024)
A Shared Data Model is a collection of DataItems and ItemDefinitions to be used (referenced) by the other BPM-Plus (BPM+) data elements: Such as BPMN Data Objects, CMMN Case File Items, DMN Data Inputs, etc. The DataItems and ItemDefinitions can be created once and maintained in a single location and can then be distributed across multiple models (This eliminates the manual synchronization burden of working with the BPM+ models without a Shared Data Model). A Shared Data Model is a model because there are relationships between the DataItems and ItemDefinitions (e.g., parent-child). Diagrams can be included to visualize the DataItems and their relationships or ItemDefinitions and their relationships. The primary goal of SDMN is to provide a set of structural elements that are common to other Object Management Group (OMG) specifications. SDMN has been structured to be dependent on the elements defined in Specification Common Elements (see the SCE specification for more information). Other Business Modeling and Integration (BMI) Task Force and Healthcare Domain Task Force (HDTF) specifications may also utilize the elements of SCE as they are updated in the future.

Software Fault Pattern Metamodel (SFPM), 1.0 (August 2024)
This specification describes the Software Fault Pattern (SFP) approach to building machine-consumable knowledge of software weaknesses. In the SFP approach, weaknesses are not studied as some abstract objects; instead, the SFP approach focuses on computations that exhibit certain "faults". The objective of the SFP approach is to reveal the invariants of such computations, and to provide a framework for describing and cataloguing "faults" in terms of these invariants. This specification uses the term "software fault" as it refers to an identified - adjudged or hypothesized - cause of a failure of the service performed by a piece of software under investigation. SFP apparatus is developed to provide formal, constructive definitions to the class of software faults that can be identified in the software alone.

System Package Data Exchange (SPDX), 3.0 beta 2 (October 2024)
The System Package Data Exchange (SPDX®) specification defines an open standard for communicating bill of materials (BOM) information for different topic areas. SPDX defines an underlying data model as well as multiple serialization formats to encode that data model. SPDX metadata includes details about creation and distribution, including the following: + software composition, for collections of software (Packages), individual Files, and portions of files (Snippets) + software build information + artificial intelligence (AI) models + datasets + creator, supplier and distributor identity information + provenance and integrity + licenses and copyrights, including a curated list of licenses and exceptions + security vulnerabilities, defects, and other quality data + relationships between system elements + software usage and lifecycle + mechanisms to enable annotating SPDX elements and linking between multiple SPDX Documents

Structured Patterns Metamodel Standard (SPMS™), 1.3 beta (September 2024)
The Structured Patterns Metamodel Standard (SPMS) specification defines a common standard for the definition and description of patterns as used in architecting, designing, and implementing software systems, working with software faults or security issues, and any situation where a pattern is

appropriately applied.

OMG System Modeling Language (SysML®) 2.0 beta 2 (April 2024)
SysML is a general-purpose modeling language for modeling systems that is intended to facilitate a model-based systems engineering (MBSE) approach to engineer systems. It provides the capability to create and visualize models that represent many different aspects of a system. This includes representing the requirements, structure, and behavior of the system, and the specification of analysis cases and verification cases used to analyze and verify the system. The language is intended to support multiple systems engineering methods and practices. The specific methods and practices may impose additional constraints on how the language is used.

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

Learn more about OMG®.

System Dynamics Society launches French Chapter

The System Dynamics Society (SDS) has announced the launch of its French Chapter. Although a System Dynamics conference took place in France as early as 1975, the creation of the French Chapter has been a long-awaited achievement.

Chapter objectives include:

- Promote the development of the field of systems dynamics in France
- Extend knowledge of system dynamics to public institutions, businesses and local communities
- Experiment with system dynamics in different areas of sustainability
- Develop educational programs in French for Systems Dynamics and Systems Thinking

A variety of useful resources, e.g., case studies, recommended readings, online courses and models are identified here.

Interested parties may access the SDS French Chapter web page for more details.

Learn more about other SDS chapters.

Systems Engineering Research Center (SERC) Updates

The December 2024 update from the Systems Engineering Research Center (SERC) highlights this organization's research-driven contributions to systems engineering practices.

SERC Research Review and SERC Doctoral Student Forum
On 12-13 November 2024 the SERC hosted its 16th SERC Research Review and the companion SERC Doctoral Student Forum (SDSF). Presentations focused on five thematic areas:

- Digital Engineering and Digital Acquisition
- Test and Evaluation
- Cyber Resilience
- Agile Development
- AI and Systems Engineering

All presentation slides from the SERC Research Review are available for download on the event page.

The SDSF included research presentations from five doctoral students, with Ms. Casey Eaton of the University of Alabama in Huntsville judged as the winner of the Dr. Barry Boehm Award for Doctoral Student Research Excellence for her presentation, Impact of Technical Measure Omission in Systems Design Frameworks.

AI4SE & SE4AI Research and Application Workshop

A summary report has been published for the AI4SE & SE4AI Research and Application Workshop that was conducted on 17-18 September 2024 with the theme "*Safer AI-Enabled Complex Systems: Responsible Deployment of AI through Systems Engineering*". The 14-page report highlights results of discussions on how SE can support the development of robust, efficient, and ethical AI systems, and how AI tools can support SE processes by enabling enhanced decision-making, optimization, validation, and verification.

The Future of Megaproject Management

In November 2024, the Acquisition Innovation Research Center (AIRC) published a research report titled *The Future of Megaproject Management*.

The following results of this research are available for download:

- Executive Summary, Findings, and Recommendations (24 pages)
- Playbook for Megaproject Management (26 pages)
- Technical Report - Full Research Results (168 pages)
- Research Forum: Megaproject Lessons Learned (recording)
- Research Forum: Megaproject Lessons Learned (presentation slides)

Setting Reliability Requirements for Subsystems

In December 2024, AIRC published an incubator report titled *Setting Reliability Requirements for Subsystems*.

Download the Executive Summary and Full Report.

Trusted Artificial Intelligence Systems Engineering Challenge

A research report has been published concerning a novel approach to improving the performance of AI-enabled systems through the Trusted Artificial Intelligence Systems Engineering Challenge. Student teams were given the challenge to develop engineering methods that consider system reliability and trustworthiness in the design and architecture of AI-enabled systems, particularly those used in life-critical situations.

Download the full report.

Access the latest SERC news here.

Follow SERC on LinkedIn.

INCOSE Q4 2024 Highlights

INCOSE published its Q4 2024 Members Newsletter in December. A sample of various highlights is provided below.

Leadership Notes

Ralf Hartmann, INCOSE President, celebrated the record-breaking participation at two major events, the International Workshop (IW2024) and International Symposium (IS2024), and noted the 30th anniversary of the UK and Australian (SESA) chapters and the 20th anniversary of the Systems Engineering Professional (SEP) certification program.

Steve Records, INCOSE Executive Director, highlighted INCOSE membership in the World Federation of Engineering Organizations (WFEO), numerous face-to-face interactions that strengthen the organization's cohesion and ability to collaborate, and new pathways for member engagement such as the SE Lab.

Honor Lind is transitioning from her role as INCOSE Director of Marcom to Head of Business Development and passing the responsibility for the newsletter (and more) to Kelly Henseler.

Sector and Chapter Updates

INCOSE sectors and chapters continue to offer a slate of significant events and to support initiatives that improve the capabilities of their members and their societies. Examples include:

- The Systems Engineering Society of Australia (SESA) hosted the Systems Engineering Test & Evaluation (SETE2024) conference, a fitting landmark while celebrating the chapter's 30th anniversary.
- JCOSE, the INCOSE Japan chapter, conducted online seminars on the NASA JPL openCAESAR project, the NASA SE Handbook and the Arcadia/Capella methodology. The chapter has begun planning for the JCOSE Systems Conference 2025.
- The San Diego chapter participated in a joint event with the American Nuclear Society focused on using quantum computing to control nuclear fusion.
- Numerous chapters participated in the 7th Annual INCOSE Western State Regional Conference (WSRC) in Albuquerque, New Mexico and the San Diego and Los Angeles chapters co-hosted their annual Joint Conference.
- The Seattle Metro chapter noted that one of their members, Dr. Ron Carson, ESEP, was awarded Industry Engineer of the Year 2024 by the Puget Sound Engineering Council (PSEC).
- Progress is being made in formalizing the Latin America (LATAM) chapter, while its work continues on the translation of the INCOSE Systems Engineering Handbook Version 5 into Spanish.
- INCOSE Brasil is fostering environmental responsibility and sustainable practices among high-school students. The chapter's official podcast, *Systems Talk*, continues to share its members' knowledge and experiences to a broader audience across Brazil.
- Student divisions in the Los Angeles and Huntsville Regional chapters continue efforts to influence high school and university students in their pursuit of engineering careers.

- The New England chapter hosted a workshop which shared the capabilities of the Dassault Systèmes 3DExperience MBSE platform.
- The Canada chapter conducted an impressive slate of events in 2024 and launched its own quarterly newsletter.
- The NORSEC Norway chapter has collaborated with the University of South-Eastern Norway (USN) on a Systems Engineering Study Group (SESG) that focused on ecosystems during the fall of 2024. The chapter also hosted a well-attended Nordic Systems Engineering (NoSE) tour.
- INCOSE UK hosted the Annual Systems Engineering Conference (ASEC) 2024 with record attendance. Proceedings are now available to purchase from the INCOSE UK online store.
- AFIS, the French chapter, sponsored a Systems Engineering Tour 2024 that took place across five locations with the theme "*Articulation of requirements and models: where are the practices?*".
- GfSE, the German chapter, hosted its TdSE event in November with 365 participants engaging around the theme "*Boldly Shaping New Paths for the Future*".

Working Group and Initiative Updates
Various working groups and initiatives reported their progress, such as:

- The Digital Engineering Information Exchange (DEIX) Working Group announced the release of the Digital Engineering Primer. The working group will also co-lead a workshop at the AIAA SciTech Conference in January 2025, focusing on developing a Digital Engineering Taxonomy.
- The Materials in Systems Engineering (MatSE) Working Group is working to highlight the significant impact the material science has upon the engineering of products and systems.
- The Resilient Systems Working Group (RSWG) hosted a webinar to promote best practices and state-of-the-art systems engineering in modern, resilient, complex systems and also presented at the Joint Los Angeles / San Diego Chapter Mini-Conference.
- The Smart Cities Initiative was well represented at the 2024 Smart City Expo World Congress.
- INCOSE's SySTEAM Initiative launched a volunteer reviewer program (VRP) to coordinate feedback to groups creating educational resources with support to the Systems Engineering Body of Knowledge (SEBoK) as its first partner.
- The contributions of capabilities and products such as the Systems Engineering Tools Database (SETDB), SEBoK V2.11 and the Needs and Requirements Manual (NRM) Version 2 were highlighted.

The Q3 2024 Member Newsletter also included special-topic articles:

- Standing on Affinity: Adopting a Paradigm for Collective Success (Federica Robinson-Bryant)
- What is Equity Really? (Heidi Hahn)
- Digital Engineering and Human Systems Integration Come Together (Guy André Boy)

Download the full (53-page) INCOSE Q4 2024 Member Newsletter for details on these and other topics.

SEBoK Version 2.11 Update Released

The Version 2.11 update to the Guide to the Systems Engineering Body of Knowledge (SEBoK) was released on 25 November 2024. The SEBoK provides a guide to the key knowledge sources and references of systems engineering.

Updates in Version 2.11 include:

- A new article on Barriers to Successful Embedding of Systems Engineering into Organizations in Part 5
- An updated Part 6: Related Disciplines introduction
- A new article on Cost Estimating and Analysis in Systems Engineering in Part 6
- A new article on Resilience Modeling in Part 6

Updates are ongoing to align SEBoK contents with version 5 of the INCOSE Handbook and the 2023 release of the ISO/IEC/IEEE 15288 standard.

SEBoK is a knowledge resource under the joint stewardship of INCOSE, IEEE Systems Council and Stevens Institute of Technology.

System Dynamics Society 2024 Highlights

In a retrospective on its 2024 accomplishments, the System Dynamics Society (SDS) celebrated the following newsworthy events and outcomes:

- The 2024 International System Dynamics Conference achieved a milestone with a record-breaking number of submissions (500+) and 577 attendees.
- Four issues of the System Dynamics Review featured cutting edge research and practical applications. The most downloaded article was Generative AI and Simulation Modeling: How Should You (not) Use Large Language Models Like ChatGPT.
- The Seminar Series attracted over 1000 participants to 23 sessions with 135 attendees participating in the How Did En-ROADS Get 755,000 users? Lessons on Modeling, Interface Design, and Facilitation event.
- The nine-part Business Innovation Special Seminar Series explored the application of System Dynamics to drive strategic innovation and address complex business challenges.
- SDS membership reached the 1400 mark, aided by the new French, Nordic and MIT chapters.
- The University Programs and Courses database now includes 166 courses the System Dynamics and systems thinking field at 80 universities in 21 countries.

Learn more about the SDS.

Updates to the Systems Engineering Tools Database (SETDB)

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.

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

Vendor: 1000minds Ltd

- 1000minds: Designed for decision-making based on ranking, prioritizing or choosing between alternatives, in one-off or repeated applications. It implements the PAPRIKA method to help business, government and non-profit users to make decisions based on considering multiple objectives or criteria.

Vendor: agosense GmbH

- agosense.symphony: Integrates best-of-breed ALM tools into an automated development tool chain. Data Flow Automation enables End-to-End Traceability & Value Stream Management (VSM). Integrate best-of-breed development tools like: Jira, Polarion, Azure, Salesforce, Remedy and Codebeamer.

Vendor: Aligned AG

- Aligned Elements: A medical device application lifecycle management tool intended for use by medical device developers to manage the medical device development documentation in accordance with regulations such as ISO 13485 and FDA QSR 820.

Vendor: Analog Devices

- CodeFusion Studio™: An embedded software development platform based on Microsoft's Visual Studio Code. CodeFusion Studio provides an extensible and open tooling environment for embedded AI processors and MCUs, by providing intuitive tools for newcomers while enabling advanced features for expert embedded developers.

Vendor: Change Vision, Inc.

- Astah Professional: Helps you create UML diagrams, ER Diagram, Flowchart, and DFD and more to create a clear understanding of your software design among teams.
- Astah SysML: A lightweight SysML diagramming tool which is perfect for systems engineering.
- Astah UML: Will allow you to create a set of UML 2.x diagrams for your project.
- Astah System Safety: A modeling tool for safety-critical systems to support system architecture modeling, system safety assessment and analysis.

Vendor: Axosoft

- Agile Project Management Software: Implements scrum, bug tracking, help desk and wiki software for software development teams.

Vendor: avolution

- ABACUS: A cloud-based collaborative enterprise architecture tool that connects IT and business strategies; supports over 100 Enterprise Architecture Frameworks; several standard modeling languages; and standards like the ISO/IEC 42010 standard for system and architecture descriptions.

Vendor: Broadcom Inc.

- Agile Requirements Designer: A requirements engineering and test design automation tool intended for use by development teams for capturing and managing requirements and automated test data generation as test cases are created.

Vendor: Creative Decisions Foundation

- Super Decisions: Used for decision-making with dependence and feedback. It implements the Analytic Hierarchy Process (AHP) and the Analytic Network Process (ANP). It provides tools to create and manage AHP and ANP models, enter your judgments, and analyze the results.

Vendor: Decision Lens

- Decision Lens: Transforms a siloed, disconnected approach into an integrated process based on decision science which collapses silos, automates manual efforts, and organizes and structures data for action to better prioritize investments, plan for the future, and adapt funding when plans change.

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. Note: Eclipse Capella is available through the INCOSE SE Laboratory.

Vendor: Functional Specs Inc.

- Acclaro DFSS: A software toolkit of DFSS oriented tools for for implementing functional requirements analysis and decomposition processes in the Concept Phase of system development. The functional decomposition process is built on an Axiomatic Design process backbone (VOC, QFD, FMEA, TRIZ, etc).

Vendor: Infoharvest Inc.

- Criterium® DecisionPlus®: Helps you make precise, thoughtful and completely supportable decisions - even for complex problems involving hundreds of criteria and alternatives and provides a visual, structured approach to a decision making helping you to select the best choice.

Vendor: Karlton Research Group

- Geeglee: The first Augmented Human Intelligence software on the market for making the right decisions. Artificial Intelligence is useful for non-critical decisions and when data is available.

Vendor: Lumina Decision Systems

- Analytica: Visual software environment for building, exploring, and sharing quantitative models to help people make effective decisions. The experience of using it is very different from its usual alternatives: spreadsheets and scripting languages like Python and R.

Vendor: MathWorks® Inc.

- MATLAB®: A programming and numeric computing platform used by engineers and scientists to analyze data, develop algorithms, and create models. MATLAB integrates with Simulink for model based design, multiple domain simulation, code generation and test and verification of embedded systems.
- Simulink®: A block diagram environment used to design systems with multidomain models, simulate before moving to hardware, and deploy without writing code.
- Requirements Toolbox: Requirements Toolbox (formerly Simulink Requirements™) lets you author, link, and validate requirements within MATLAB or Simulink. You can create requirements using rich text with custom attributes or import them from requirements management tools.
- Stateflow: Provides a graphical state machine diagram modeling environment to design and simulate decision logic using state charts, flow charts, MATLAB functions, truth tables and state transition tables.
- Statistics and Machine Learning Toolbox: Provides functions and apps to describe, analyze, and model data. You can use descriptive statistics, visualizations, and clustering for exploratory data analysis; fit probability distributions to data; generate random numbers for Monte Carlo simulations, and perform hypothesis tests.
- Simscape: The Simscape product family provides models and solver technology for simulating physical systems. Model electrical, mechanical, fluid, and other physical systems by assembling components into a schematic.
- Simulink Fault Analyzer: Enables systematic fault effect and safety analysis using simulation.
- Simulink Test: Provides tools for authoring, managing, and executing systematic, simulation-based tests of models, generated code, and simulated or physical hardware.
- System Composer: Enables the specification and analysis of architectures for model-based systems engineering and modeling of software architectures.

Vendor: Modelon Inc

- Modelon Library Suite: Modelon offers a comprehensive suite of Modelica libraries, built on the Modelica standard, that delivers state-of-the-art system models for a wide range of industries. Modelon libraries are developed and updated in close cooperation with leading industry partners to reflect evolving industry needs.

Vendor: Pluron, Inc. (DBA Acunote)

- Acunote: An agile project management and scrum tool for use by companies to manage software development. It provides powerful analytics for data-driven project management and collaboration for small teams and enterprises.

Vendor: Siemens Polarion

- Polarion: The Polarion Unified Platform enables development organizations to streamline, automate, and optimize development processes across multiple projects and lifecycles.
- Polarion ALM: Everything you need to accelerate innovation in one Unified Solution. Connect your teams and projects, and improve application development processes with a single, unified solution for requirements, coding, testing, and release management.
- Polarion RM: Complete Requirements Management Solution to enable programs to effectively gather, author, approve and manage requirements for complex systems across entire project lifecycles.
- Polarion QA: Complete Quality Assurance and Testing Solution to help you design, coordinate, and track all your test management activities in a single, collaborative QA environment.
- Polarion PRO: Unify change management, task & issue tracking and work reporting across all project contributors across the enterprise. Leverage native ReqIF and MATLAB Simulink integration for information exchange, and comprehensive traceability.
- Polarion Reviewer: Enable internal and external stakeholders to review and comment on work items, and provide industry-compliant electronic signatures and approvals within a cloud based environment across your supply chain.
- Polarion Variants (Add-On): Evolve capabilities in development lifecycles to effectively manage variation, mass customization, and 'configured-to-order' deliverables. Polarion is the only ALM solution with variant management capability.
- Polarion for Automative: Collaborate across complex internal and supplier ecosystems. Accelerate Functional Safety compliance for ISO 26262, Automotive SPICE and CMMI standards. Model Driven development with Polarion's Diagram Editor, plus integration with Sparx Systems Enterprise Architect™ and with MATLAB® Simulink™.
- Polarion for Medical Devices: Software has become the key differentiator for manufacturers of medical devices. There are countless opportunities for software innovation but are counterbalanced by stringent quality requirements, risks of product failure, and growing regulatory complexities.
- Polarion SAFe®: Gives you means to not only to grow, but to scale exponentially. Its integration of portfolio management throughout the whole project structure is just one of the many enablers unique to the SAFe methodology. It will provide you a huge boost to your businesses scalability and velocity.
- Polarion ALM-PLM Integration: Leverages the very latest developments in integration technology, to ensure that product development organizations have a single, cohesive product ecosystem, with multi-directional linking of ALM and PLM data and processes.
- Polarion Extension Portal: Provides over 200 free and paid extensions with other software tools to enhance the functionality of your ecosystem. Connectors include Simulink, Teamcenter, Azure, Enterprise Architect, Planview, Rhapsody, Windchill, and many more.

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

Access the SETDB website.

CONFERENCES, MEETINGS & WEBINARS

Events of relevance to systems engineering

INCOSE Los Angeles Webinar: Risk Management 101

As part of its Speaker Meeting series, the INCOSE Los Angeles chapter will be hosting a hybrid presentation on 11 February 2025 featuring Randall DeGering, CSEP, formerly of the U.S. Air Force, with system engineering and risk management experience supporting military satellite acquistion. DeGering will speak on *Risk Management 101*, with the in-person venue taking place at the Aerospace Corporation in El Segundo, California, USA.

Abstract:
Risk management is the systematic process of identifying, assessing, and mitigating potential threats or uncertainties that can affect an organization.

Risk management processes typically consist of the following steps:

- Identification: Recognize and document potential risks that could impact the organization's objectives
- Assessment: Evaluate the likelihood and potential impact of identified risks
- Prioritization: Rank risks based on likelihood of occurrence and potential impact to decide which ones require immediate attention
- Treatment: Develop and implement strategies to address identified risks. Treatment options including risk acceptance, transfer, avoidance, mitigation and monitoring/review.

Effective risk management helps organizations protect assets, improve decision-making, optimize operational efficiency, and potentially drive innovation and growth.

Learn more and register here.

ISACA Virtual Conference 2025

ISACA, a global professional association focused on digital trust, is hosting its Virtual Conference 2025 on 18-20 February with day-long sessions tailored to the Asia Pacific (18 February), Americas (19 February) and Europe/Middle East/Africa (20 February) regions. Topics of interest include AI, emerging technologies and digitial transformation and their application to information security, risk and privacy.

Featured speakers include:

- Jason Lau, Chief Information Security Officer at Crypto.com and Adjunct Professor at HKBU School of Business
- Rebecca Herold, founder and CEO of The Privacy Professor® Consultancy and author of 22 books on information security, privacy and compliance

- Dr. Valerie Lyons, Director and Chief Operations Officer at BH Consulting and author of The Privacy Leader Compass

A sample of topics across the regions includes:

- Agile Auditing: Integration with Artificial Intelligence (Asia Pacific)
- Emerging Threats To and From Artificial Intelligence Systems (On-demand, all regions)
- Enhancing Trust: AI Governance Perspective (Asia Pacific)
- Enhancing Trust in Security Operations Through Maturity Assessment and Certification (EMEA)
- Ensuring Trust and Transparency in AI Systems through Human-Centered Design (Americas)
- Enterprise Innovation - Leveraging AI (EMEA)
- Securing the Digital Lifeline: Mastering Cybersecurity Supply Chain Governance (Americas)
- Shielding Privacy: Safeguarding Data in the Age of AI (Americas)
- Technical Due Diligence - Playing on the Edge of Failure and Success (EMEA)
- Unlocking Business Opportunities through Strategic Security Frameworks (Asia Pacific)

View the detailed agenda. Register here.

Ground System Architectures Workshop 2025

The Ground System Architectures Workshop (GSAW 2025) will take place on 24-27 February in Los Angeles, California, USA. The theme of this 29th annual in-person event is *Amplifying User Effectiveness: Automation, Augmentation, and AI/ML* with emphasis on face-to-face networking among the the international ground systems community.

GSAW is sponsored by The Aerospace Corporation in cooperation with the United States Space Force, NASA, ESA and NOAA to name a few of its global participants.

Tutorials will take place on 24 February with general sessions scheduled for 25-27 February. View the agenda here.

Register for GSAW 2025.

Join the GSAW 2025 email list.

NAFEMS Online Seminar: Exploring the Status of Data-Driven Engineering

The NAFEMS Engineering Data Science Working Group is hosting an online seminar on 26-27 February 2025 titled "*Exploring the Status of Data-Driven Engineering - Production-Ready and Emerging Technologies.*" During the two half-day virtual sessions that comprise this event, participants will focus on how data-driven engineering methods are transforming how we design and optimize products.
This event targets engineers, data scientists and machine learning practitioners who are eager to stay at the forefront of these rapid-evolving technologies. It is an opportunity to explore technology at the

cutting edge and engage with the community shaping the future of data-driven engineering. Learn more and register here.

System Dynamics Events in February

The System Dynamics Society (SDS) is sponsoring a variety of online events in February. These workshops and webinars offer systems engineering practitioners the opportunity to deepen their understanding of the discipline of system dynamics and its application to societal challenges and to engage with the global system dynamics community

Workshop: Process Modeling and Optimization with System Dynamics and the Theory of constraints (5 February)
Managing complex processes or projects requires a deep understanding of evolving constraints to ensure success. Traditional linear modeling tools often prove insufficient, and utilizing System Dynamics can introduce unnecessary complexities when accounting for resource competition. The iMODELER software offers an intuitive solution by allowing you to connect resources, process factors, project factors, and milestones to simulate dynamic interactions effectively.

Aligned with the Theory of Constraints (ToC), this webinar will guide you on how to identify and manage constraints, helping you make informed decisions about where to allocate resources to maximize efficiency and reduce costs.

System Dynamics in Policy Design: A Case Study from India's Renewable Energy Sector (12 February)
This webinar explores the application of System Dynamics in policy design, focusing on a case study from India's renewable energy sector. The session will delve into how System Dynamics can model complex systems to address challenges like feedback loops, nonlinearity, and time delays. By examining the internal structures and interrelationships within the system, participants will gain insights into developing policies that are both effective and grounded in real-world conditions.

Accelerating Sustainability Education with System Dynamics: A Community-Based Strategy (16 February)
In this webinar the authors of a recently published paper in Nature Sustainability will share their findings on scaling educational innovations in sustainability. While many high-quality educational resources are available, their adoption often remains limited. This session will present the System Dynamics model developed to analyze propagation strategies and highlight the potential of community-based approaches. Learn how mobilizing a network of ambassadors can drive exponential growth in adoption, with actionable insights for implementing these strategies in various contexts, including sustainability-focused initiatives.

University Fair (19 February)
Discover academic programs that integrate System Dynamics. This virtual event is designed for students and professionals looking to learn more about university offerings in our field.

During the event, university representatives will give short presentations, introducing their programs and highlighting how System Dynamics is incorporated. After the presentations, you'll have the chance to interact directly with the representatives, ask questions, and gain insights into each program. Investigate other SDS events here.

Business Analysis Webinars in February and March

A variety of business analysis learning opportunities are available in February and March.

Beyond the Business Case: Strategic Project Analysis (13 February)
In this Blackmetric webinar, Dr Alexia Nalewaik (author of Strategic Project Analysis: A Powerful Set of Cost-Benefit Tools and Techniques for Managers) presents a rationale for broadening traditional cost-focused project analysis to include non-financial planned benefits, requiring the use of both quantitative and qualitative methods. Key topics include:

- What strategic project analysis is, and how this relates to business analysis
- The danger of relying on financial analysis alone
- Tips and techniques for enhancing business cases
- The importance of stakeholders

Empowering Business Analysis with AI: A Conversation with Innovators (19 February)
Artificial Intelligence is transforming the way Business Analysts (BAs) approach their work, offering powerful tools to streamline processes, enhance insights, and drive innovation. But with so many tools and platforms available, where should BAs begin?

In IIBA-sponsored webinar, Asif Sharif and Shihan Fernando of Modern Requirements will provide a practical roadmap for leveraging AI in business analysis and highlight a specific tool designed for BAs.

Spark Your Stakeholder Sessions: Interactive Collaborative Games Workshop (19 February)
Ready to transform your brainstorming sessions from mundane to memorable? This hands-on virtual workshop, hosted by the IIBA Bluegrass Chapter, will explore dynamic collaborative games that will revolutionize how you generate ideas with stakeholders. Through live participation using online collaborative tools, you'll discover engaging techniques that can immediately enhance your stakeholder interactions and requirements elicitation processes.

Projects, Products & Business Analysis: Navigating the New Normal (20 March)
Increasingly, organizations are moving from a project-centric to a product-centric model. This changes the nature of work that is needed and how business analysis fits in. In this Blackmetric webinar, Hannah Pearson-Coats will reflect on her experiences as a BA who has worked in both project and product environments. Key topics include:

- The difference between 'project' and 'product'
- How the two can co-exist, and it's not 'either or'
- Key tools, techniques and concepts that BAs use in a product environment
- Why business analysis is still crucial

Upcoming Capella Online Training

Obeo is offering online training courses on the Arcadia method and Capella open-source MBSE software The training introduces Model-Based Systems Engineering (MBSE) and implements the Arcadia method and Capella tool on a simple case-study. It covers system definition activities such as operational analysis, functional and non-functional system analysis, logical architecture, and physical architecture.

Each course is delivered in the form of six 3.5-hour online sessions, with three series currently open for enrollment:

- 10-17 March 2025
- 7-9 & 14-16 April 2025
- 22-29 April 2025

At the end of the training, participants should be able to:

- Acknowledge the principles, key points, and expected benefits of the MBSE approach
- Describe the steps (perspectives) and the activities of the Arcadia method
- Implement Capella functionalities on a simple case
- Navigate through the different types of support on Arcadia and Capella

This Capella training is run in English by an MBSE expert who is part of Obeo's global partner network.

Learn more and register here.

2025 Society of Decision Professionals (SDP) Annual Conference & Workshops

The Society of Decision Professionals (SDP) will host its 31st Annual Conference & Workshops event on 24-28 March. The in-person portion this hybrid event will take place in Vancouver, British Columbia, Canada. The theme, *Collaborating for Better Decisions*, is at the core of this year's event, where professionals from diverse industries gather to enhance decision quality and improve outcomes.

Pre-conference and post-conference in-person workshops will take place on 24 and 28 March, with the 40+ main conference sessions occurring on 25-27 March. A series of virtual workshops surrounding the conference are also available.

Keynote speakers include:

- Eric Horvitz, Chief Scientific Officer, Microsoft
- Alan Mallory, Author, Mountain Climber, Engineer, Leadership & Teams Expert
- Chris O'Riley, CEO, BC Hydro
- Steve Begg, Emeritus Professor, Decision-Making & Economic Evaluation, University of Adelaide

A sample of the featured workshops include:

- De-risking New Technologies - Framing and Evaluating the Business Case for Pilots
- Navigating the maze of multiple perspectives
- Using AI tools and influence diagrams to help structure problems for effective decision making

Presentation sessions will address topics such as:

- Building a Game Theory Model: A Group Collaboration

- Design Thinking Decision Lab
- Foundations of Decision Quality: Developing Your Mindset, Skillset, and Toolset
- Human-AI Decision Collaborations & Interactions
- Mitigating Bias
- Realizing the Bayesian Promise for Decision Quality
- Qualitative Tools & Techniques
- Quantitative Tools & Techniques

View the conference agenda.

Learn more about the 2025 SDP Annual Conference.
Register here.

Call for Submissions: INCOSE 10th Annual Systems Engineering in Healthcare Conference

The INCOSE Healthcare Working Group (HWG) is sponsoring the 10th Annual Systems Engineering in Healthcare Conference on 29 April through 1 May 2025 in Minneapolis/St. Paul, Minnesota, USA. The theme of this in-person conference is *Advancing the Practice of Systems Engineering in Healthcare*.

The Call for Presentations, Panels & Tutorials seeks practitioners to share their knowledge and experience through presentations and collaborative sessions. Sessions focused on experience reports and case studies are highly valued. Instructional tutorials are also welcome, which are better when they include examples that help the audience apply the learning to their context. Interactive panel sessions to explore a topic are also encouraged.

The deadline for submissions is 17 February.

Watch the Whova Proposal / Abstract Submission Guide.

Call for Contributions - International System Dynamics Conference (ISDC 2025)

The System Dynamics Society (SDS) will host its annual International System Dynamics Conference (ISDC 2025) on 3-7 August 2025. The in-person portion of this hybrid event will take place in Boston, Massachusetts, USA. The theme of ISDC 2025 is *Incorporating AI into Dynamic Modeling*.

The SDS invites research papers and practical applications exploring AI's role in dynamic modeling, including System Dynamics, Agent-based, and Discrete Event modeling, applied to fields like public policy, business, health, environment, and more. Submissions may address AI's enablement of topics such as:

- Enhancement of Modeling Stages
- Automation and Efficiency
- Support and Education
- Ethical and Social Impacts
- Opportunities and Challenges

Types of submissions include:

- Conference Presentation (Research Paper, Practitioner Application, or Work in Progress)
- Workshop Proposal
- Student-Organized Colloquium Papers
- Other submissions (e.g., Roundtable)

Important dates for submissions include:

- 21 January – 18 March: Submissions Window
- 15 May: Author Notification
- 3 June: Presenter Registration Deadline

Investigate the International System Dynamics Conference (ISDC 2024) and the Call for Contributions.

View the Submission Instructions. Submit your proposed contributions here.

Call for Papers: International Modelica & FMI Conference 2025

The International Modelica & FMI Conference 2025 will take place as a face-to-face conference on 8-10 September in Lucerne, Switzerland. It is organized by HSLU, the University of Applied Sciences and Arts Lucerne, in cooperation with the Modelica Association.

The Call for Papers for this event seeks papers (4-10 pages in length) on the following topics:

- Applications of Modelica and FMI for optimization and control design
- Applications and new tool developments for the Functional Mock-up Interface (FMI) and Layered Standards (LS), System Structure and Parameterization (SSP) standard, and FMI for embedded Systems (eFMI) standard
- Applications in thermodynamic, energy/power systems and building physics
- Applications in automotive, mechatronics, robotics, medicine, biology, maritime, electric drives, aerospace, education, etc.
- Experimental language designs and implementations related to Modelica standards
- Large-scale system modeling and simulation code generation for parallel computing architectures
- Machine Learning and AI in system simulation
- Multi-engineering modeling and simulation with free or commercial Modelica libraries
- Modelica modeling, simulation and design tools
- Real-time and hardware-in-the-loop applications; Code generation for embedded control systems
- Symbolic algorithms and numerical methods for model transformation and simulation
- System Simulation as an integrative part of Model-based Systems Engineering (MBSE)
- Use of Artificial Intelligence (AI) methods in simulation; SimToReal for AI training purposes

The deadline for submissions is 17 April.

Included is a call for industrial user presentations related to Modelica Association Projects. Proposals

for hands-on tutorials (4-hours in length) are also sought.

Upcoming PPI Live-Online ™ and In-Person Systems Engineering Five Day Courses

Click here to view the full schedule or register for upcoming courses

P006-956	Eindhoven, the Netherlands CET 8:30 (UTC +1:00) In-Person	24 Feb – 28 Feb 2025
P006-957	Las Vegas, USA PST 8:00 (UTC -8:00) In-Person	03 Mar – 07 Mar 2025
P006-955-1	Asia SGT 5:00 (UTC +8:00) PPI Live-Online™	17 Mar – 21 Mar 2025
P006-955-2	Oceania AEDT 8:00 (UTC +11:00) PPI Live-Online™	17 Mar – 21 Mar 2025
P006-972-1	North America CDT 8:00 (UTC -5:00) PPI Live-Online™	17 Mar – 21 Mar 2025
P006-972-2	South America BRT 10:00 (UTC -3:00) PPI Live-Online™ *(Exclusive to South America)*	17 Mar – 21 Mar 2025
P006-958-1	Europe CEST 9:00 (UTC +2:00) PPI Live-Online™	07 Apr – 11 Apr 2025
P006-958-2	United Kingdom BST 8:00 (UTC +1:00) PPI Live-Online™	07 Apr – 11 Apr 2025
P006-958-3	South Africa SAST 9:00 (UTC +2:00) PPI Live-Online™ *(Exclusive to South Africa)*	07 Apr – 11 Apr 2025
P006-958-4	Türkiye TRT 10:00 (UTC +3:00) PPI Live-Online™	07 Apr – 11 Apr 2025
P006-958-5	Saudi Arabia AST 10:00 (UTC +3:00) PPI Live-Online™	07 Apr – 11 Apr 2025
P006-971	Izmir, Türkiye TRT 8:30 (UTC +3:00) In-Person	14 Apr – 18 Apr 2025
P006-959	Eindhoven, the Netherlands CEST 8:30 (UTC +2:00) In-Person	12 May – 16 May 2025
P006-960	Las Vegas, USA PDT 8:00 (UTC -7:00) In-Person	19 May – 23 May 2025
P006-961-1	Asia SGT 6:00 (UTC +8:00) PPI Live-Online™	23 Jun – 27 Jun 2025
P006-961-2	Oceania AEST 8:00 (UTC +10:00) PPI Live-Online™	23 Jun – 27 Jun 2025
P006-962	Eindhoven, the Netherlands CEST 8:30 (UTC +2:00) In-Person	14 Jul – 18 Jul 2025
P006-963	Las Vegas, USA PDT 8:00 (UTC -7:00) In-Person	21 Jul – 25 Jul 2025

FEATURE ARTICLE

Applying Decision Patterns to Courseware Development

by John Fitch

Project Performance International

Authored for PPI SyEN

Introduction

The author of this article has been privileged to teach several thousand technical professionals a great variety of challenging concepts, methods and skills across the last four decades. These opportunities came in the form of 200+ deliveries of approximately 30 different courses, over half of which were designed and developed "from scratch" by the author and from which a courseware design decision pattern has emerged and been refined.

It's not surprising that courseware design is amenable to the use of decisions patterns. All courses are a type of system that exists for knowledge and skill delivery, often with a modest dose of motivational energy thrown in. As such, courses share common challenges – to deliver valuable and often complex concepts and skills in the simplest and most effective way to produce lasting change and the value associated with such change. As with any system, courses have requirements and design goals that drive a design – technology choices and a logical and physical architecture that are arrived at through the process of design decision-making.
For more details on the conceptual basis and application of decision patterns and their impact on the systems engineering process, please refer to these prior articles in PPI SyEN:

- Introduction to Decision Patterns in PPI SyEN Edition #107 (December 2021)
- Decision Patterns – So What? in PPI SyEN Edition #111 (June 2022)
- Extending the Lifecycle Modeling Language (LML) to Enable Decision Patterns and Traceability in PPI SyEN Edition #125 (June 2023)

The definition of a decision found in these sources is significant:

A decision is a fundamental question or issue that demands an answer or solution.

With this definition, the design of any solution may be represented by a hierarchical pattern of decisions. By expressing decisions as part of the problem domain (rather than as the alternatives chosen), a Decision Breakdown Structure (DBS) may be developed which helps the solution developer (in this case, courseware designer) with decomposing, prioritizing and planning the **thinking** to be done by framing a set of discrete, loosely-coupled decision questions.

Each decision shares a common information metamodel that includes the decision "object" itself and associated evaluation criteria, alternatives, the estimated performance of the alternatives against the criteria and risks – ways that an alternative might fail. The choice of an alternative for any decision

leads to the next level of derived requirements/goals that inform lower-level design decisions. These derived requirements and goals will be allocated to the content of the various learning modules, the delivery media, assessment methods or interfaces.

Courseware Development Process

Developing an effective course is a lot more than just throwing together a set of PowerPoint slides, pulled from the instructor's experience or prior presentations. Successful courseware design can invoke every aspect of the systems engineering process, though typically performed with less rigor than the development of a complex mission-critical cyberphysical system.

However, treating courseware design as a simplistic application of systems engineering discipline is risky, because few situations exhibit as much variability as does the challenge of training individuals with incredibly diverse starting points and motivations to master a body of knowledge and to creatively apply that mastery to generate lasting value.

Formal processes and instructional systems development (ISD) standards exist for courseware development [1, 2], but none of these have been directly used in the development of the decision pattern described herein. The Courseware Design decision pattern is the product of 20+ cycles of learning including:

- From-scratch course design, delivery and refinement
- Reverse engineering and refinement of existing courses
- Attempts to harmonize a broader curriculum comprised of multiple linked courses

Decision Pattern Walkthrough

The primary purpose of this article is to provide PPI SyEN readers with a simple guide to courseware design, condensed in the form of an easy-to-apply decision pattern. A secondary goal is to encourage broader use of decision patterns in novel applications, particularly sociotechnical systems.

The full courseware design decision pattern may be visualized graphically as shown in Figure 1, below.

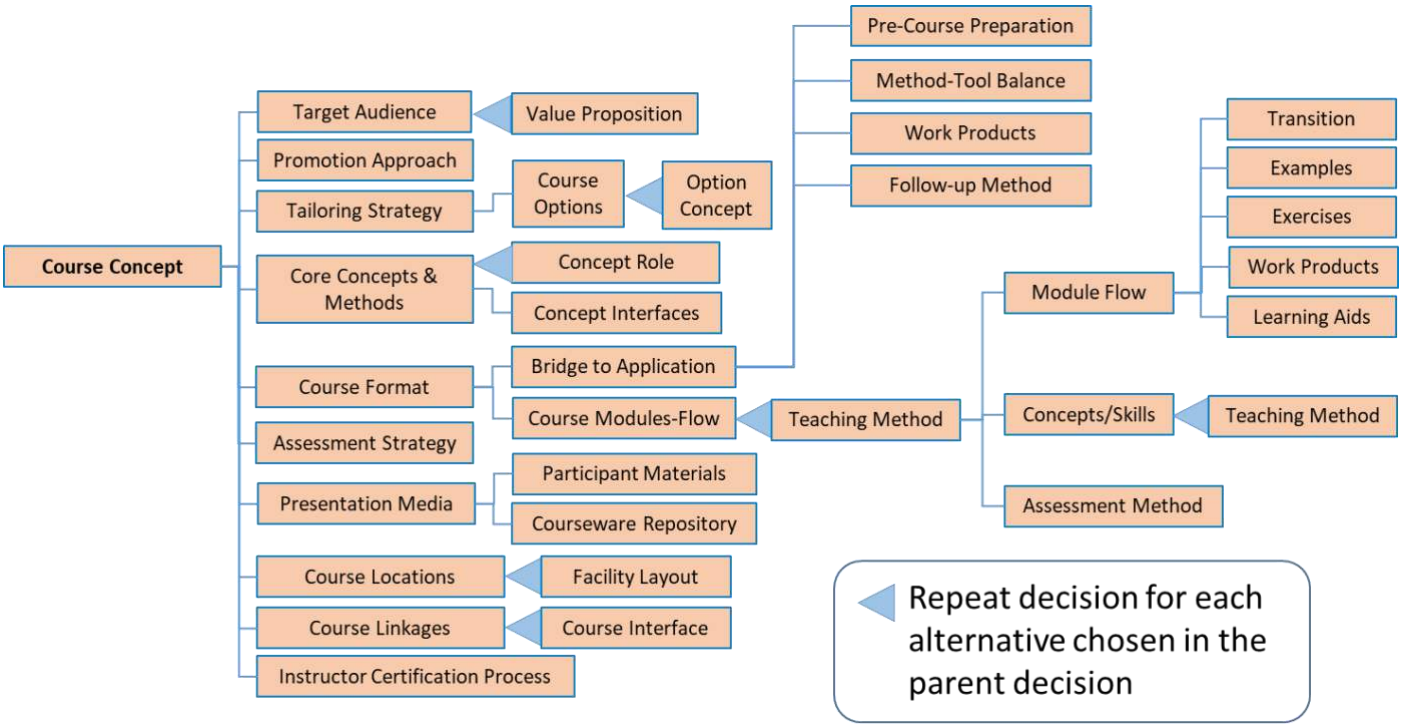

Figure 1 - Courseware Design Decision Pattern

There are three types of decisions represented in this model:

- Single Answer decisions: Designers down select to a single technology, method or solution concept
- Multiple Answer decisions: Designers select more than one alternative in a "portfolio", each of which may concurrently use resources and create independent value
- Multi-part Answer decisions: Architectural decisions for which the answer is best modeled as a set of interacting elements, i.e., boxes and arrows

Readers will note that the hierarchy contains two different types of connectors between parent and child decisions. The elaboration of a Single Answer decision into more detail by child decisions is shown as a solid line. A triangle "fan-out" icon is used when a Multiple Answer or Multi-part Answer decision is elaborated, with a branch of next-level decisions added for each alternative chosen or each element (box or arrow) in the selected architectural model.

The following sections of the article will walk through the pattern by narrating the primary decision branches and nodes in the model.

Course Scoping Decisions

Various decisions at the top of the pattern are used to bound or scope the course. These are primarily business decisions that define the purpose of the course and where it fits into a larger enterprise or curriculum.

Decision Name	Description	Decision Class
1.0 Course Concept	What is the top-level concept for this course? What makes it unique?	Single Answer
1.1 Target Audience	What groups or types of individuals are our target audience for this course?	Multiple Answer
1.1.N Value Proposition	What unique value will this course offer to this group of participants?	Single Answer
1.2 Promotion Approach	How will we promote this course to its target audience?	Single Answer
1.3 Tailoring Strategy	How will we tailor the course for different target audiences?	Single Answer
1.3.1 Course Options	*What course options will we offer?*	*Multiple Answer*
1.3.1.N Option Concept	*How will we implement this course option (content, technology, flow, delivery)?*	Single Answer
1.6 Course Linkages	*Where will this course fit into a larger curriculum? What other courses will be linked to it?*	*Multi-part Answer*
1.6.1 Course Interface	*What interface will we implement between these courses? How will we link them?*	Single Answer

Although any of these decisions might call for a full multi-attribute (multi-criteria) decision analysis method that includes the consideration of risks, in the author's experience only the top-level Course Concept decision always merits that level of analysis rigor. The typical criteria for the Course Concept decision are shown below:

- Skills coverage - The course should deliver a rich set of highly valued skills to the

participants
- Learning effectiveness - The course should help the participants master the highly-valued skills and concepts
- Compelling experience - The course should offer participants a compelling experience; something they enjoy and will recommend to others
- Target audience size - The course should deliver highly valued skills to a large target audience
- Delivery cost - The course should have a low cost of delivery
- Fit our strategy - The course should advance our strategy - grow capabilities, reinforce brand, create follow-on opportunities
- Flexible - The course should be flexible; easy to adapt to changing conditions
- Robust - The course should be robust; provide consistent results in the face of changing people, environment or inputs
- Simple - The course should be simple to deliver and easy for participants
- Long lasting - The course should provide long-lasting value for customers and competitive advantage for us before it needs to be redesigned
- Time to market - We want a course that we can get to market quickly
- Development cost - We want a course that has a low non-recurring development cost

Readers may use this criteria template as a starting point and then:

- add unique criteria from your business context
- set a threshold value and stretch goal for each criterion
- define the relative weights associated with the criteria as a set

The alternatives considered for the Course Concept decision should highlight salient aspects of the solution options across the full range of next level decisions, but typically emphasize:

- Target audience e.g., monolithic or one with diverse personas
- Course options e.g., standalone or many variants
- Course format e.g., in-person instructor-led, webinar, or self-paced online
- Course linkages e.g., its context within a larger curriculum or in support of an enterprise initiative or consulting service.

Course designers should avoid trying to pack the entire course design into the alternatives for this decision; limit alternative definitions to the high points that bound the purpose and scope of the course.

When there are multiple and diverse target audiences, it may be helpful to invest extra effort in defining unique value propositions for each audience. The derived requirements that flow from these value propositions often drive lower-level design choices on course content, such as teaching methods, examples used and learning exercises conducted.

Value-creating Engine for the Course

Given the target audience and value proposition(s), the course designer should select the core concepts and methods that will form the value-creating "engine" for the course.

Decision Name	Description	Decision Class
1.4 Core Concepts and Methods	What core concepts and methods will we use as the engine for this course?	Multiple Answer

1.4.N Concept Role	What groups or types of individuals are our target audience for this course?	Single Answer
1.4.N.N Concept Interfaces	What are the primary interfaces/interactions between this concept/method and others?	Multi-part Answer

In practice, these decisions imply that the course designer should consider these concepts/methods as building blocks, think through the role that each play in the value proposition of the course and then create a model (typically shown as a logical N-Squared Diagram) of how these various elements work together to maximize the value delivered to the participants.

The total value delivered by any course can't be understood by reductionism; it is the emergent properties of the cooperative elements (in this case their logical interactions) that generate unique value beyond the individual concepts and methods that are taught. PPI SyEN readers may want to refer to previous articles on ***emergence*** *to better understand the implications of this decision:*

- *PPI SyEN SPOTLIGHT: IS2022 Thoughts on Emergence* in PPI SyEN Edition #114 (July 2022)
- *More Musings on Emergence* in PPI SyEN Edition #115 (August 2022)

Top-Level Design Decisions

After the value-creating building blocks of the course have been identified, they must be packaged into a tangible form suitable for real-time delivery. The course delivery format decision typically addresses the

length of time, e.g., number of sessions, duration of each session, instructor role and whether the instructor and students are co-located physically or connected virtually.

Decision Name	Description	Decision Class
1.5 Course Format	What delivery format will we use for this course (including the course duration and instructional methods)?	Single Answer
1.5.1 Bridge to Application	What methods will we use to build a bridge between the key concepts/skills learned during the course and on-going use/application?	Single Answer
1.5.1.1 Pre-Course Preparation	How will students prepare for participation in this course?	Single Answer
1.5.1.2 Method-Tool Balance	How will we balance course content between concepts/methods and the use of specific tools?	Single Answer
1.5.1.3 Work Products	What deliverables and work products will the participants create during the course?	Multiple Answer
1.5.1.4 Follow-up Method	*What follow-up method(s) will we use to improve learning and retention after the course is completed?*	Single Answer

Because a primary outcome of any course is post-course follow-through, the Bridge to Application decision addresses how this follow-through will be woven into the course flow and content.

Many modern courses focused on systems engineering skills will also include hands-on use of software tools as a platform for learning. The level of such software use must be balanced against the simplicity of using lower-technology methods to communicate concepts and skills.

Learning Modules and Module Design Decisions

The physical architecture of a course may be modeled as a time sequence of course modules. Each course model may have its own primary teaching method and content flow. It may be helpful to visualize the

course physical architecture as an N-Squared Diagram to make explicit how the outputs, e.g., work products or concepts conveyed from each module, are used as inputs to "downstream" modules or serve to reinforce topics delivered in previous modules. This N-Squared Diagram may also inform the transitions between course modules; these should be designed to communicate the continuity of key concepts and to provide motivation for students to continue to build on skills that they have just learned.

Decision Name	Description	Decision Class
1.5.2 Course Modules-Flow	What learning modules will make up the course? In what sequence and timing?	Multi-part Answer
1.5.2.1 Teaching Method	What teaching method(s) will we use to deliver this learning module?	Single Answer
1.5.2.1.1 Module Flow	In what sequence will we deliver the concepts and skills?	Single Answer
1.5.2.1.1.1 Transition	How will we transition from the previous learning module into this module?	Single Answer
1.5.2.1.1.2 Examples	What teaching examples and case studies will we use during this module?	
1.5.2.1.1.3 Exercises	*What set of hands-on learning exercises will we use to convey concepts and skills during this module?*	*Multiple Answer*
1.5.2.1.1.4 Work Products	*What work products will the participants create during this module?*	*Multiple Answer*
1.5.2.1.1.5 Learning Aids	*What learning aids will we use during this module?*	*Multiple Answer*
1.5.2.1.2 Concept/Skills	*What concepts and skills will we deliver during this learning module?*	*Multiple Answer*
1.5.2.1.2.1 Teaching Method	*What teaching method(s) will we use to deliver this concept/skill?*	*Multiple Answer*
1.5.2.1.3 Assessment Method	*How will we measure/assess the students' learning during this module?*	Single Answer

The fundamental content of each learning module includes teaching examples, exercises that provide an opportunity for experiential learning, and the creation of work products that may emulate those needed on the job. The concepts and skills taught within each module are typically an elaboration of the core concepts and skills that were identified at the top-level of the course. A learning module often concludes with some method of assessing the students' level of learning – dialog with the instructor, quizzes, or exercise feedback are common alternatives for this decision.

Other Life Cycle Decisions

The pattern includes a variety of other decisions that address different aspects of the life cycle of the course. These are a subset of the life cycle decisions associated with any system that express how the system may be developed, tested, deployed, delivered or supported. The decisions shown below are representative of such choices for the types of courses that have been developed and delivered by the author. Other life cycle decisions may be more significant in different training contexts. For example, the decision on how a course will be "tested" (verified and validated) may result in a desire to trial all or part of the course with a friendly audience to reduce risk and refine the design.

Decision Name	Description	Decision Class
1.5.3 Assessment Strategy	How will we measure/assess the students' learning during this course?	Single Answer
1.5.4 Course Locations	What type of locations will we use to host this course?	Multiple Answer
1.5.4.1 Facility Layout	What training facility layout/configuration will we use for this course?	Single Answer
1.5.5 Presentation Media	What presentation media will we use to deliver the course contents?	Single Answer
1.5.5.1 Participant Materials	In what format/media will we provide participant materials?	Single Answer
1.5.5.2 Courseware Repository	*In what repository (format and tools) will we maintain courseware?*	Single Answer
1.7 Instructor Certification Process	*How will we train and certify instructors to teach this course?*	Single Answer

Other Uses of the Courseware Design Decision Pattern

Many of the decisions in the courseware design decision pattern could be applied to the design of a broader curriculum made up of multiple courses. Figure 2 illustrates such an example in which the Curriculum Format decision would identify the name and number of courses that make up the curriculum; a course concept decision model would be created for each course.

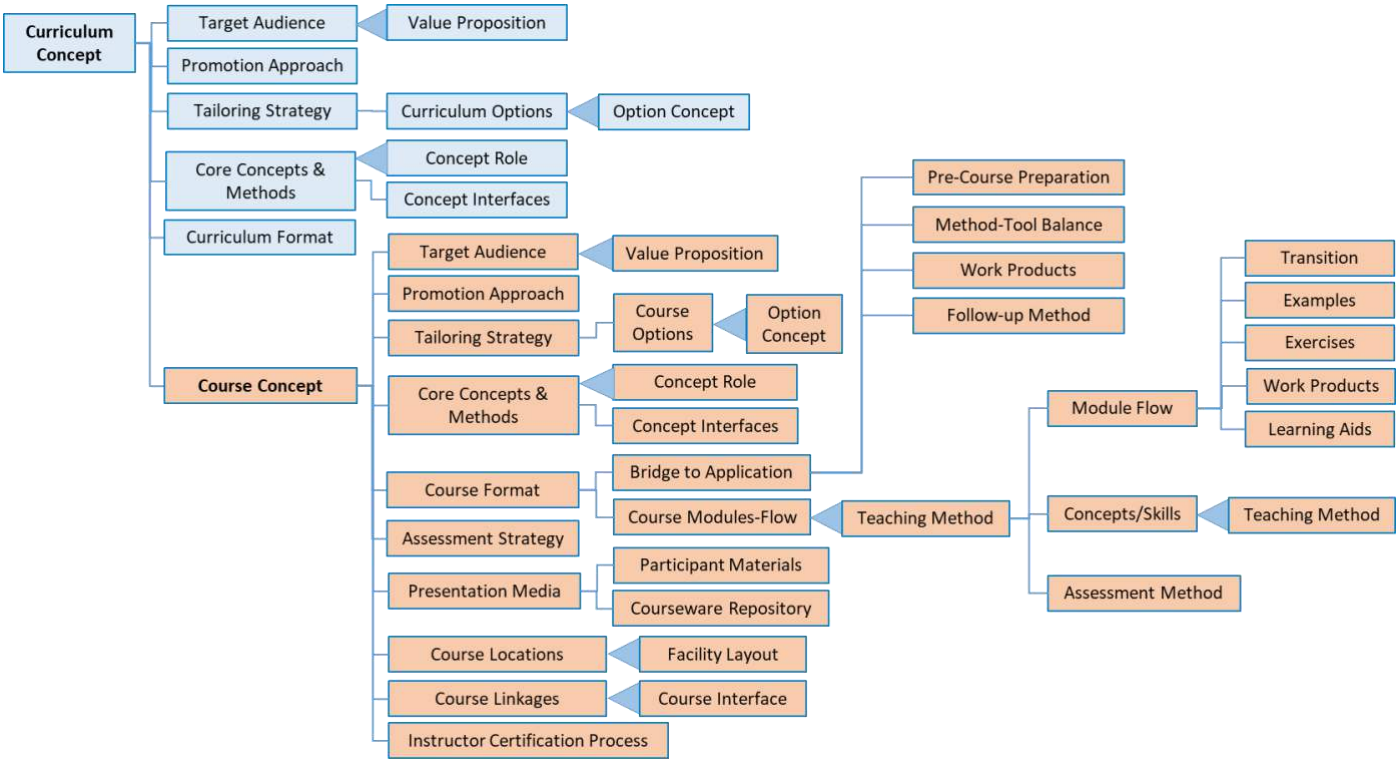

Figure 2 - Curriculum Design Decision Pattern

The courseware design decision pattern could also be adapted to rapidly outline the contents and essential message to be conveyed in any book, publication or messaging campaign. Any communication endeavor designed to educate, persuade or move people to action could benefit from

a Decision Blitz to explicitly frame the choices that will drive success or failure.

As a consultant, the author often delivered training as part of a broader consulting engagement that resulted in a handoff of work products and ongoing responsibility to the customer. In this situation, the courseware design decisions become an extension of the Service Design decision pattern shown in Figure 3.

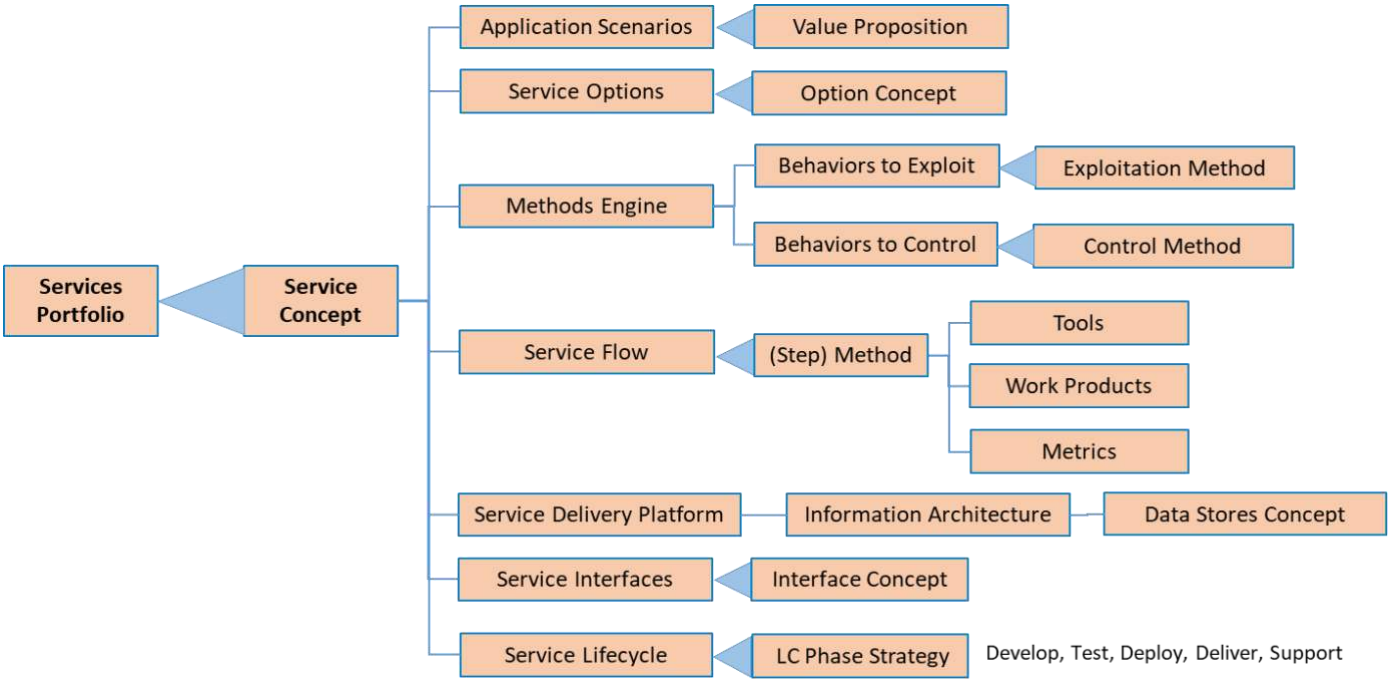

Figure 3 – Service Design Decision Pattern

A training course would be represented as one step in the Service Flow and its design decisions would be inserted into the Decision Breakdown Structure as a sibling branch to the design of the other steps in the consulting engagement flow.

Conclusions

The application of decision patterns to courseware design is a proven technique that could result in accelerated course development and improved course quality. By providing a holistic view of the thinking that goes into course design, course developers are less likely to overlook critical choices and to better able to perform tradeoffs that will drive successful course outcomes.

References

[1] Department of the Air Force Handbook 36-2675, Information for Designers of Instructional Systems, United States Air Force, www.e-publishing.af.mil, April 2022.

[2] U.S. Department of Defense, MIL-HDBK-29612/2, Instructional Systems Development/Systems Approach to Training and Education, December 2020.

About the Author

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

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

System Dynamics Review: Qualitative Aspects of System Dynamics Modelling

Volume 40, Issue 4 of the System Dynamics Review (SDR), published quarterly by Wiley on behalf of the System Dynamics Society (SDS), is a special issue that focuses on the qualitative aspects of system dynamics modeling. This issue contains ten open access articles that may be of interest to PPI SyEN readers:

A framework for using Theory of Constraints thinking processes and tools to complement qualitative system dynamics modelling
Authors: Victoria J. Mabin and Robert Y. Cavana

While the tools currently used for qualitative system dynamics (Qual SD) modelling are very powerful in providing a holistic perspective and a framework for understanding complexity and change, they are often not explicitly designed to build and implement long-term solutions based on that understanding. The Theory of Constraints (TOC) thinking processes and tools focus on these important aspects of the decision-making process. We provide a six-stage framework combining selected tools from TOC's thinking process and Qual SD's modelling process to provide a more rigorous systems thinking change process. We illustrate the methods and component tools via a case study on a complex societal issue (sale of alcohol in New Zealand supermarkets) developed for teaching purposes. We demonstrate the value of the framework, highlighting complementarities between tools, and show how specific insights emerged using each of the tools, with more insights resulting from using Qual SD and TOC collectively than separately.

Are we there yet? Saturation analysis as a foundation for confidence in system dynamics modeling, applied to a conceptualization process using qualitative data
Authors: Andrada Tomoaia-Cotisel, Samuel D. Allen, Hyunjung Kim, David F. Andersen, Nabeel Qureshi and Zaid Chalabi

Saturation is a useful concept for system dynamics, yet it has not been widely explored or integrated into the modeling process. In this article, we describe saturation as a metaphor describing the point at which a conceptual representation of a system meets the study purpose and no longer requires modification. When saturation is reached, additional data about the problem would not offer added information, thus indicating that additional data gathering and analysis would likely be redundant. We discuss two visualization techniques, “saturation curves” and “shared understanding diagrams,” for assessing saturation when conceptualizing with causal loop diagrams and show their application in a case example. Using saturation analysis during a system dynamics research process has many advantages, including: (i) identifying model structures potentially needing revisions, (ii) observing the extent to which evidence supports the current conceptualization, (iii) reflecting extensively, (iv) documenting important modeling decisions, and (v) potentially improving the problem statement.

Dealing with soft variables and data scarcity: lessons learnt from quantification in a participatory system dynamics modelling process
Authors: Irene Pluchinotta, Ke Zhou and Nici Zimmermann

System dynamics (SD) models are commonly used for structuring complex problems to support decision-making. They are used to investigate areas in which limited knowledge is available, describing nonlinear relationships and including intangible elements. Although this explorative nature is one of the key advantages, it also represents a challenge for quantifying the intangible, i.e. more qualitative aspects of an SD model, especially when it is not possible to apply conventional analytical methods due to data scarcity. Procedures to obtain and analyze information using participatory approaches are limited. First, this article outlines existing quantification methods and related open questions when dealing with soft variables and data scarcity. Secondly, it summarizes the quantification process developed during a participatory SD process, describing how we dealt with data scarcity and soft variables. Lastly, we suggest a quantification framework in relation to data availability and level of stakeholder engagement.

Descriptive design structure matrices for improved system dynamics qualitative modeling
Authors: Rameez R. Qureshi, David N. Ford and Charles M. Wolf

Qualitative modeling approaches can be useful in system information collection, model analysis, and formal model development. This is difficult when the number of elements and their interactions in the system is large. System dynamicists need additional tools and methods to conceptually model these large tightly coupled systems. We propose and test the Descriptive Design Structure Matrix (DDSM) as a qualitative system dynamics modeling tool and approach for systems with many elements and more interactions that can reasonably be modeled individually using traditional system dynamics methods. A DDSM consists of four parallel and internally consistent matrices that describe system interactions with binary relations, nontechnical text, technical text, and literature support. By including and documenting system information in multiple forms, DDSMs facilitate multiple stages of system dynamics modeling, improve modeler communication with system participants and domain experts, and improve model rigor. DDSM construction is described. A case study of the 2014 flooding in Kashmir is used to illustrate and test a DDSM and its application. Due to their compact format, DDSMs provide a useful visual communication aid, intuitive reasoning tool, and foundation for formal system dynamics modeling and analysis.

Developing theoretically grounded causal maps to examine and improve policy narratives about global challenges
Authors: Raquel Froese Buzogany, Birgit Kopainsky and Paulo Gonçalves

The Sustainable Development Goals present a call to action for all countries to accelerate the implementation of solutions to address the world's biggest challenges. While policy portfolios to achieve such goals should be varied, often dominant policy narratives cluster around limited themes. We use a grounded theory approach to elicit causality from qualitative data to visualize interactions across variables spanning multiple domains influencing global challenges. We develop a comprehensive causal loop diagram, where we assess the impact of dominant policy narratives and expand the formulation of policy options. Our approach serves as an exemplar application of qualitative system dynamics to distill the operational logic of policy narratives that can subsequently be considered in model-based policy analysis. We illustrate our approach by focusing on the interactions among poverty and hunger and compare policy implications arising from the dominant narratives only versus those arising from a more comprehensive understanding of the interactions.

Minding the abstraction gap: approaches supporting implementation
Authors: Laura J. Black and Donald R. Greer

Regardless of insights gained from building and analyzing dynamic models, the only strategies people can act on are those in their heads. The strategies people internalize are related to their perceived capacities to act - the verbs they believe they can do. If we want others to implement model-informed policies, then we must connect model abstractions with new situated, concrete actions stakeholders can take. We can emphasize opportunities to act with SD representations, navigating levels of abstraction cleanly, identifying flows as verbs, and choosing variable names that signal who is acting. By drawing on social-science theories as we offer our grammar of accumulations, activities, and relationships in the language of actions accessible to stakeholders, we help connect experiential understandings to richer, dynamic explanations people can internalize and so discover situated steps to implement policies informed by modeling.

Reflecting on Zagonel's dichotomy of microworlds and boundary objects
Authors: Laura J. Black

Aldo Zagonel's distinction between “microworld” and “boundary object” approaches to modeling suggests we ask ourselves pointed questions about what we are valuing, under what conditions, as we involve stakeholders with system dynamics representations. Reflecting on developments in both participatory modeling and large system simulations, I propose that Zagonel's dichotomous descriptions lie along a continuum, with room for scholars and practitioners to explore more explicitly the multiple ways we adapt system dynamics methods to the needs and capacities of the stakeholders with whom we are working at that time. Regardless of approach, whether simulation models or causal diagrams, modifiable in the moment or fixed by design, the goal of using system dynamics representations remains focused on fostering intelligent action among the stakeholders facing the problem of focus.

Strengthening a weak link: transparency of causal loop diagrams - current state and recommendations
Authors: Mohammad S. Jalali and Elizabeth Beaulieu

Transparency is a critical aspect of systems science. While transparency of quantitative models has been assessed, transparency of their qualitative structures has been less scrutinized. We assess the transparency of causal loop diagrams (CLDs), a key qualitative visualization tool in system dynamics. We evaluate System Dynamics Review (SDR) publications and a sample of most-cited comparable articles in other journals. We assess the inclusion of a plain-language methods statement, overall discernibility of the methods, and identification of causal link sources. Reviewing 72 articles (SDR: 36; other journals: 36), only 44%, 38%, and 25% fully satisfy each criterion, respectively. SDR articles are characterized by higher transparency in the clarity of CLD development method and communication of causal link sources, yet the potential for enhancement is evident. We provide specific recommendations to increase the transparency of CLDs. Transparent reporting benefits original research authors, future expansion of CLDs, and the systems science community.

Techniques to enhance the public policy impact of qualitative system dynamics models
Authors: Guido A. Veldhuis, Eefje M. Smits-Clijsen and Rob P.M. van Waas

This article demonstrates techniques to enhance the public policy impact of qualitative system dynamics models. We focus on the effective use of a large causal loop diagram (CLD) to explore a

multifaceted problem situation. We discuss the conditions that can lead to developing a large CLD, the challenges this presents, and techniques that can be used to overcome them. Several techniques are discussed related to an online group model-building (GMB) process, the use of quantitative data, visual model analyses using a software tool and reporting. The techniques are demonstrated using an impactful case study on the social impact of the COVID-19 pandemic. We reflect on the efficacy of the approach through the lens of systems thinking and conclude that the techniques made a positive contribution to all aspects of systems thinking. Several avenues for future work are discussed.

Using causal loop diagrams to develop evaluative research propositions: opportunities and challenges in applications to nature-based solutions
Authors: Miriam Alvarado, Jo Garrett, James Fullam, Rebecca Lovell, Cornelia Guell, Tim Taylor, Ruth Garside, Marianne Zandersen and Benedict W. Wheeler

Causal loop diagrams (CLDs) are often used to provide an overview of important systemic elements related to an issue, rather than to inform empirical evaluations (studies which assess changes following an intervention using observed data). We suggest that empirical evaluations may benefit from the development of systems-informed research propositions (specific testable causal assumptions with an emphasis on feedback loops) used to guide subsequent data collection, hypothesis testing and interpretation. We describe a qualitative systems-thinking informed approach building on preexisting CLDs, published evidence, and expert/stakeholder consultation and reflect on our experience applying this to the early stages of two nature-based solution (NBS) evaluations. We reflect on our experience and suggest that CLDs can be usefully employed to develop systems-informed research propositions to inform subsequent empirical evaluation. This may lead to novel policy-relevant research propositions which differ substantially from effectiveness-oriented ("did it work?") research questions.

This issue of the SDR adds members-only content including:

- An analysis of participants' introductory experience with causal loop diagrams (CLDs) using group model building (GMB) scripts
- ARCHIVE PAPER: Micro worlds versus boundary objects in group model building: evidence from the literature on problem definition and model conceptualization (2007)
- Building confidence in exploratory models
- Capturing the science behind the craft: a reporting framework to improve quality and confidence in nonsimulated models
- Participatory modeling for high complexity, multi-system issues: challenges and recommendations for balancing qualitative understanding and quantitative questions
- Uncovering the unknown with REMODEAL: A systematic method for reference mode elicitation

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AI Assistants in Requirements Engineering

Requirements Engineering Magazine
The Magazine for RE Professionals from IREB

The Requirements Engineering (RE) Magazine is published by the International Requirements Engineering Board (IREB) 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 December 2024 edition, Michael Mey, Managing Consultant at Obvious Works, authored an article titled "*AI Assistants in Requirements Engineering*. This is Part 1 of a two-part AI-focused series.

Overview:
Artificial Intelligence (AI) is playing an increasingly critical role in various industries, and Requirements Engineering (RE) is no exception. Large Language Models (LLMs) are AI systems trained on vast amounts of text data that can understand, generate, and manipulate human language with remarkable capability. With the advent of advanced LLMs like ChatGPT, Copilot, Claude, Llama, Perplexity, and Gemini, professionals in this field have new tools at their disposal to improve efficiency, accuracy, and overall quality in their work. These AI systems can support tasks ranging from writing user stories to automating documentation, making the complex process of gathering and managing requirements more streamlined and effective.

Topics addressed include:

- The Art of Effective Prompting
- AI Assistants
- Understanding CustomGPTs

Benefits of Creating Your Own CustomGPT

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SYSTEMS ENGINEERING
The Journal of The International Council on Systems Engineering

INCOSE

INCOSE Systems Engineering Journal: January 2025 Edition

INCOSE has published, through the Wiley online library, the January 2025 edition of the Systems Engineering Journal. Volume 28, Issue 1 includes both open access articles, plus full access papers that require an institutional login, e.g., via INCOSE membership. There is no published overriding theme for this edition, though the application of MBSE to various domains is a common focus. PPI SyEN has included abstracts to guide our readers to which of these diverse topics best fit their interests.

Open Access Articles
Open Access articles are available to view and download in PDF format without any restrictions.

A framework for developing systems engineering management for process plant acquisition projects
Authors: Denver Moodley and Rudolph Oosthuizen

Abstract: South Africa has a history of poor performance on process plant acquisition projects in the process industry that applies chemical processes within large processing facilities to convert raw

materials such as crude oil into fuel and by-products. The most recent failures include the highly publicized Medupi and Kusile projects. This research is based on the acquisition or expansion of large process plants within petrochemical, mining, and energy, typically Systems of Systems integration projects. A significant component of their failings can be attributed to poor systems engineering and systems engineering management capabilities. Acquisition in the context of this study refers to all processes within the stage-gate project development model from project inception to the beneficial operation of the acquired facility. Due to a lack of systems and tools to guide the development of systems engineers and systems engineering managers within the sector, this research was undertaken to develop an industry-specific framework based on the INCOSE framework to support development and recruitment processes. A conceptual model derived from a literature survey was validated and improved with qualitative data gathered using structured open-ended interviews with industry specialists and experts from organizations within the petrochemical, mining, and energy sectors. Insights regarding current recruitment practices and development processes were analyzed to validate the need for a tool and develop an appropriate model for its application. Finally, the analysis and general causes of project failures validated the contents of the framework by highlighting critical competencies and traits required to succeed within the sector.

An explorative Bayesian analysis of functional dependencies in emergency management systems
Authors: Raffaele Cantelmi, Riana Steen, Giulio Di Gravio, and Riccardo Patriarca

Abstract: The study of emergency or crisis management practices acquires strategical relevance for resilient decision-making under uncertainty. The assessment of system resilience is an asset to identify potential design or operational improvements of a complex socio-technical system, such as an Emergency Management (EM) system. This research aims at analyzing the functional properties of an EM system recurring to a novel integration of the Functional Resonance Analysis Method (FRAM) and Bayesian Belief Networks (BBN). The FRAM is used to model and display the actors and the interactions in the system, while the BBN, dynamically updated when new data becomes available, supports a complementary quantitative assessment. The methodology is iterated in the analysis of an EM procedure, issued by a second-line Emergency Response organization for Oil and Gas (O&G) operators in Norwegian continental shelf. The results of the study show that the proposed stochastic methodology compensates the drawbacks of traditional FRAM modeling, via the outcomes of BBN quantitative analyses. The findings, contextualized in EM, can be transferred to different socio-technical contexts, both military and civil ones.

Green communication systems via a wavefront multiplexing technique
Authors: Hen-Geul Yeh and Joe Lee

Abstract: A green communication scheme using an orthogonal wavefront (WF) multiplexing (Muxing) scheme spatially combined with orthogonal frequency-division multiplexing (OFDM) techniques is proposed. It forms a spatial WF OFDM transceiver. The WF Muxing technique serves as the preprocessing and postprocessing method of the WF OFDM transceiver. With coordinated multiple point forward transmission, this spatial WF OFDM system establishes a communication network. It can be applied to multiple base stations (BSs) with down links to single or multiple mobile units (MUs). Although signals are received non-coherently due to different distances between BSs and MUs, they can be compensated and coherently combined via adaptive equalizers at MUs. This is achieved by using pilot signals with an optimization method at the receiver of MUs. Simulation results demonstrate that the WF OFDM scheme obtains the same bit error rate (BER) as predicted by theory in an additive white Gaussian noise (AWGN) channel. Moreover, the required effective equivalent isotropically radiated power (EIRP) from BSs to the MUs is significantly reduced due to multiple non-

coherent transmission. Accordingly, the interference to adjacent frequency bands' signals will be low. This green communication network is achieved via the combination of WF Muxing, OFDM, and optimization at the receiver together. More investigations are needed to show that this WF OFDM transceiver can be applied to frequency selective mobile fading channels.

OntoCPS4PMS: Ontology modeling for collaborative cyber-physical threat defense in power monitoring system
Authors: Jing Teng, Ruge Yang, Tian Wang, Junzhe Du, and Quan Z. Sheng

Abstract: Given the deep interconnection between information and physical aspects of power systems, escalating cyber-attacks pose significant threats to both grid information systems and electrical equipment. The context highlights the importance of risk perception and defense mechanisms in information and functional security for Power Monitoring System (PMS). To address this, we introduce an innovative ontology framework designed for comprehensive cyber-physical security in PMS (OntoCPS4PMS). OntoCPS4PMS identifies risks from cross-domain attacks and supports a collaborative defense strategy. It offers a multifaceted assessment method for PMS security events, considering vulnerabilities, cyber-attack impacts, and physical domain risks. Through simulated PMS attack scenarios, we validate the framework's effectiveness in dynamic cyber-physical security analysis. The results demonstrate OntoCPS4PMS's ability to trace attacks, locate affected equipment, and recommend mitigation measures, confirming its utility in enhancing PMS security and decision-making.

A systematic literature review on the mathematical underpinning of model-based systems engineering
Authors: Paul Wach, Taylan G. Topcu, Sukhwan Jung, Brandt Sandman, Aditya U. Kulkarni, and Alejandro Salado

Abstract: The International Council on Systems Engineering (INCOSE) has initiated a Future of Systems Engineering (FuSE) program that includes a stream for advancing the theoretical foundations of the discipline of Systems Engineering (SE). A near-term goal of FuSE is to assess the adequacy of current theoretical foundations of SE. The discipline of SE is converging toward model-based practices (i.e., MBSE) that have not yet reached the maturity of model-based practices in other engineering domains. For example, finite element analysis and computational fluid dynamics are grounded in mathematical theory, while, generally, MBSE is not. However, some attempts have been made to underpin MBSE with theoretical richness. This article presents a systematic literature study that surveyed state of the art on providing MBSE with mathematical foundations. Our protocol collected over 2000 publications that were reviewed for inclusion/exclusion, categorized, and analyzed. We provide insights to the type of mathematical theories used, domains of applications, and areas of SE to which the math was applied to, among other analysis. We also provide a synthesized discussion about the field moving forward, emphasizing positive trends along with the negatives and areas of concern. Overall, we found the field to be nascent.

Full Access Articles
Full Access articles are available through an institutional login such as INCOSE membership.

Application of data element mapping and analysis for system definition to enable model-based systems engineering
Authors: Allison Ledford, Gregory Harris, Susan Askew, and Gregory Purdy

Abstract: In the connected age of the model-based enterprise and model-based systems engineering (MBSE), new systems engineering tools are needed to move from a functional, document-centric, hierarchical view of data and information to the individual units of data or data element level view. Data element mapping and analysis (DEMA) is a technology-agnostic analytical methodology that combines traditional functional analysis techniques, systems engineering elicitation practices, and novel data mapping techniques to provide a holistic view of a system's data and information flows at the individual units of data (data element level). In this research, DEMA was utilized to enable an enhanced system definition for the development of a verification and validation process as applied to a modeling and simulation environment. DEMA uncovered and visually mapped the hidden flow of approximately 1600 data vessel occurrences as inputs or outputs to 79 functional activities in 23 disparate storage locations. The results reveal that DEMA is a practical tool for both improving existing systems and defining new systems. The data element level view captured by DEMA can be used to define the interconnections between the system elements that are input to systems modeling language (SysML) models. Therefore, DEMA is a necessary and novel tool that can be used to enable system digitalization.

Applications and challenge of digital twin in life cycle of municipal pipe networks
Author: Yingjian An

Abstract: Digital twin is the key technology to promote the life cycle digitalization and intelligent management of municipal pipe networks. To achieve intelligent closed-loop management for the life cycle of municipal pipe networks, this paper first analyzed the meanings of “process-oriented” and “object-oriented” of digital twin and gave the connotation for the life cycle management of the digital-twin-driven municipal pipe networks. Second, on the basis of the application paradigms in typical scenarios of design, construction, operation, and maintenance of the life cycle management of the municipal pipe networks, this paper proposed the technical framework of digital twin-driven municipal pipe networks. Finally, the existing challenges were discussed for the digital twin in the life cycle management of municipal pipe networks. The research shows that digital twin is the technical guarantee for the life cycle management of municipal pipe networks, and high-fidelity digital “twinning” is an important prerequisite for realizing the function of digital twin.

Evaluating the tipping point of a complex system: The case of disruptive technology
Authors: Christine M. Edwards, Roshanak Rose Nilchiani, Anirban Ganguly, and Maximilian Vierlboeck

Abstract: Complex systems often operate in equilibriums that can be disrupted under specific conditions, driving the system to undergo an irreversible phase transition (aka tipping point) into a new equilibrium. Disruptive technology, as introduced in the book Innovator's Dilemma, is a new emerging technology that can successfully displace incumbent technologies and push the market through phase transition into a new equilibrium. In this paper, the authors model the market disruption caused by a disruptive technology as a complex system, with dynamics that show a phase transition or tipping point, after which the system shifts into a new equilibrium aiming at assessing the success or failure of a disruptive technology. The purpose of this study is to mathematically model a tipping point measure of complex networks and a theoretical framework for disruptive technology dynamics. A predator–prey model is used to emulate the behavior of a disruptive technology versus an incumbent technology, and a resilience index is integrated to measure the tipping point in the market where the disruptive technology will overtake the incumbent technology. This methodology is applied to a historical case study of film versus digital versus cell phone cameras, demonstrating the application of this methodology. The study's contribution can be applied to both systems engineering and disruptive innovation management. The proposed approach can help stakeholders assess the

impact of a potential new disruptive technology and use the resulting resilience index as a measurement for adjusting technology requirements and systems management approaches to achieve a desired outcome.

Life cycle models for university-scale sounding rockets: A three-dimensional review
Authors: Ahmad Nayef Salih Alsudairi, Azmin Shakrine Mohd Rafie, Abdullah Mohammad Algarni, Syaril Azrad Bin Md Ali, Ezanee Bin Gires, Amini Amir Bin Abdullah, and Ibrahim Mohammad Aljuhaiman

Abstract: Designing a sounding rocket is an interdisciplinary activity, involving many domains and many stages. The alignment between the disciplines and life cycle stages is not straightforward. Much effort is required in life cycle model management and tailoring processes. In this article, an objective was set to make a comparative study and analysis of life cycle concepts related to Malaysian university-scale sounding rocket development, to assist in any future life cycle tailoring. Toward that goal, a comprehensive review and analysis of the related life cycle models was performed. The review covered three dimensions: engineering standards, aerospace vehicle design (AVD), and actual sounding rockets projects. Many reviewed models were re-prescribed using model-based systems engineering (MBSE) diagrams. This allowed greater insight and better assistance for any future tailoring. This expedition stresses the importance of the proposed three-dimensional reviewing of life cycles. Unconventional life cycle models (e.g., Western vs. Eastern) have also been included. It is argued that mapping the standards onto actual projects improved insight. One of the important outcomes is the demonstration of the importance of the concept of the centrality of the values in the development process, which shall govern the stakeholders' requirements.

Natural Language Processing to assess structure and complexity of system requirements
Author: Maximilian Vierlboeck, Roshanak Nilchiani, and Mark Blackburn

Abstract: The development process of a system is shaped by numerous variables that influence its progress and outcome. As a result, complexity can increase throughout the development process, potentially leading to negative consequences, which makes the management of complexity critical. Most development processes begin with the definition of needs and requirements. In this paper, the authors present a novel approach that enables the automated extraction of structure from requirements specifications. The approach uses Natural Language Processing to elicit three structural layers from a set of requirements, which are subsequently analyzed using metrics to assess complexity. In a case study, the approach is demonstrated using a set of 79 requirements, within which 246 individual entities are identified. These entities and the requirements are structured and analyzed using network density and spectral entropy. The metrics allow for interpretation and insight generation, such as identifying an increase in the number of potentially problematic loops. The approach achieved a detection and structural accuracy of over 98% in the given case study and is planned to be expanded with future cases.

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

SPEC Innovations Community Blog: 2024 Content

SPEC Innovations, a leading provider of systems engineering services and the Innoslate and Sopatra software solutions, maintains a community blog that provides a diverse range of useful information for systems engineering practitioners (beyond their immediate customers). A sampling of posts from 2024 finds the following categories of topics:

How-to Guides

These 3-5 minute overviews provide a compact reference that recommends best practices on leveraging MBSE capabilities.

- How to Involve Stakeholders in Requirements Validation
- How to Write Good Requirements: 10 Tips and Examples
- How to Ensure Requirements Are Clear and Unambiguous
- How to Use a Requirements Traceability Matrix (RTM)
- How to Make Better Decisions in Complex Systems Engineering Projects
- How to Manage Changes to Requirements
- How to Verify and Validate Requirements
- How to Perform a Model-Based Review (MBR) - A Digital Transformation

Checklists

The SPEC Innovations team often provides Mutually Exclusive Collectively Exhaustive (MECE) checklists on topics. These lists can help systems engineering practitioners "get their heads around" a topic quickly.

- 6 Reasons You Need Branching and Forking in Requirements Management
- 8 Ways to Manage Unrealistic Stakeholder Expectations
- 9 Ways to Align Requirements with Stakeholder Needs
- 9 Methods for Requirements Gathering

Webinar Recordings

Recordings of recent webinars provide viewers with an overview of key system engineering capabilities and concepts in exchange for an investment of approximately 45 minutes:

- Functional Modeling 101 Webinar
- Requirements Management 101 Webinar
- PLM + MBSE: Better Together Webinar

General MBSE Topics

Additional posts cover a diverse range of MBSE-related topics:

- A Guide to Agile Application Lifecycle Management (ALM)
- A Quick Guide to CAD for Model-Based Systems Engineering
- A Use Case for Digital Engineering
- AI Tools to Support Requirements Engineering & Test Case Developments
- Configuration Management Guide for Data-Driven Systems Engineering
- Digital Transformation: Develop a Digital Transformation Strategy
- Drawing ≠ Models: What Is Real MBSE (Model-Based Systems Engineering)

- Non-Functional vs. Functional Requirements: When to Use Each Type
- Plan Verification & Validation Early in the Lifecycle
- Stakeholder Roles in Requirements Management
- The Role of Simulation in Informed Decision-Making
- Verification and Validation Guide for Data-Driven Systems Engineering
- What Is the Capability Maturity Model Integration (CMMI)?
- Why Quality Assurance Matters in the Requirements Management Phase
- Why Data-Driven Decisions Are the Future

Relevant external content
The SPEC Innovations team also re-posted three relevant articles from PPI SyEN:

- Extending LML to Enable Decision Patterns and Traceability
- Rethinking Requirements Derivation: Part 1
- Rethinking Requirements Derivation: Part 2

In addition to the blog, SPEC Innovations maintains an impressive library of additional content, including:

- Webinars
- Whitepapers
- User Stories
- eBooks
- Datasheets
- Guides

The company also provides an online resource, The Ultimate Guide to MBSE, that discusses methods, tools, and languages that can assist an organization in its journey towards effective systems engineering.

Capella Days 2024 Video and Slides

The videos and presentation slides from Capella Days 2024 are available for online viewing and download. Capella Days 2024 was the free online gathering of the Capella (MBSE tool) and Arcadia (MBSE method) community that took place on 19-21 November 2024.

Available 2024 content includes:

- Accelerating Railway Digitization: Scaling Up MBSE in a High-Paced Organization (Video)
- Adoption of ARCADIA and Capella to Develop an Elimination Process of Radioactive Waste by Melting (Video) (Slides)
- Application of the Arcadia Method on a Bulk Carrier with Siemens Teamcenter PLM Integration (Video) (Slides)
- Enabling MBSE with Simulation to Perform System Analysis for SOLARIS (Video) (Slides)
- Enhancing Industrial Equipment Reengineering with Model-Based Systems Engineering (Video) (Slides)

- Example of How Capella Can Be Used for CubeSat Development (Video) (Slides)
- Implementing Systems Engineering in Brazilian Synchrotron: A Workflow for Enhanced Beamline Design (Video) (Slides)
- Leveraging Capella and ARCADIA for Satellite System Design and Integration (Video) (Slides)
- Leveraging System Architecture Models for Diagnosis of High-Tech Systems (Video) (Slides)
- MBSE-Based IVV Approach (Video) (Slides)
- MBSE Confidentiality Management and Security Analysis of Capella Designs (Video) (Slides)
- Realizing the Full Value of MBSE Models through Digital Thread Implementation at Applied Materials (Video)

Investigate content from previous Capella Days events:

- Capella Days Online 2023
- Capella Days Online 2022
- Capella Days Online 2021
- Capella Days Online 2020

Business Analysis (BA) Digest

Blackmetric Business Solutions, a UK-based training and consulting firm, publishes a quarterly Business Analysis (BA) Digest. In keeping with its theme as *your regular round of useful BA content*, the 73-page Q4 2024 edition addresses topics such as:

- A Security Mindset + A Business Analyst Mindset = The next Wave of Business Analysis
- Business Analyst and Product Owner Partnership as a Key to Product Success
- Choosing Elicitation Techniques Effectively
- Elicitation Ingredients & Spices for a Tasty Business Requirements Document (BRD)
- Implementation of Peer Reviews: A Game-changer for Our Business Analysts
- Lessons Learned from Navigating Enterprise Change Management
- Maximizing Efficiency in the Digital Age: The Untapped Potential of Existing Technologies
- Solving Problems with Business Architecture
- The Stakeholder Network Effect: Strategies for Managing Communication Challenges
- Using AI to Develop System Requirements
- Using Group Construct Analysis to Understand Stakeholder Worldviews in Ambiguous Situations, Part 14

Typical articles are a quick read at 2-4 pages in length.

Download PDF versions of prior editions of the BA Digest (back through 2020) and a previous newsletter (through 2016) here. Other 2024 editions include:

- BA Digest Q3 2024
- BA Digest Q2 2024
- BA Digest Q1 2024

Subscribe to the BA Digest here.

Blackmetric also makes available webinar videos with recent topics that include:

- Business Architecture: Laying the Foundations for Faster and More Accurate Business Analysis
- Increase Efficiency with Business Rules
- Product-Centric Organization: Path to Advancing People and Value

Additional webinar recordings are available on the Blackmetric YouTube channel.

Check out additional business analysis resources including whitepapers and upcoming webinars.

NAFEMS Blog: Quantifying the Business Impact of Simulation

NAFEMS, the International Association for the Engineering Modelling, Analysis and Simulation community, maintains an active and informative blog.

In a recent post, *A Story to Remember: Quantifying the Business Impact of Simulation, Sinothile Baloyi discusses the role that storytelling can play in moving an engineering organization away from physical prototyping toward a simulation-led process. The post points to a recent* ASSESS *Insight webinar by Mark* Meilli of Procter and Gamble titled "Driving Increased Simulation Applications Through Better Business Impact Quantification". The webinar identifies six ways to quantify the business value of a simulation-led approach to engineering.

View the webinar here*. A free NAFEMS login is required.*

Other posts from 2024 include:

- Modelling and Simulation of Cyber-physical Systems
- Is Engineering Simulation Ready for AI?
- The Evolving World of Simulation- When, How, How Much, and If

Subscribe to the NAFEMS blog here.

Visure Solutions 2024 Resource Recommendations

Visure Solutions, provider of a popular Requirements Application Lifecycle Management (ALM) platform, has recommended its "best of 2024" published resources, including a mix of online blog posts, whitepapers and webinar recordings. These resources generally focus on the application of AI to systems engineering challenges and include:

- AI In Requirements Management: Benefits and its Processes (blog)
- How Can AI Enhance Requirements Management Processes and Outcomes? (blog)
- The Comprehensive Handbook on Efficient Generative AI for Safety-Critical Development (whitepaper)
- Mastering The Verification Challenge in IC SoC Design (blog)
- Maximizing Project Success With AI (webinar)

- Risk Management & FMEA - A Comprehensive Guide
- What is Model-Based Systems Engineering (MBSE) (guide)

Calling All Systems: Requirements Renaissance - Designing Tomorrow's Systems Today

INCOSE continues with its Calling All Systems series of online panel discussions that brings together systems engineering thought leaders from around the globe to address topics that are important to systems engineering practitioners.

The video recording of the most recent (20 November 2024) event, "Requirements Renaissance - Designing Tomorrow's Systems Today" has been posted. Hosted by Dr. Tami Katz, Senior Principal Systems Engineer, BAE Systems, Inc., this discussion included panel members:

- Robin Yeman, Executive Space Lead at Carnegie Mellon Software Engineering Institute
- Dr. Tina P. Srivastava, Lecturer at MIT and Co-Founder of Badge Inc.
- Dr. Jeffery L. Williams, Lecturer, Industrial & Systems Engineering and Engineering Management at University of Alabama in Huntsville
- Cary Bryczek, Director of Aerospace and Defense Solution Architecture at Jama Software

Overview
In the face of accelerating technological advancements and complex system interdependencies, traditional requirements engineering approaches often fall short. This panel discussion delves into the transformation of requirements development, advocating for a paradigm shift in how we approach developing requirements when engineering complex systems. The discussion additionally focuses on the significant shift from traditional, static methods of requirements documentation to a more fluid and adaptive approach, mirroring the swift pace of technological progress. This panel of experts is being brought together to exchange ideas, discuss challenges, and collaborate on solutions through innovative techniques and emerging practices in capturing and managing requirements. By showcasing real-world case studies and forward-thinking methodologies, we will explore how a modernized approach to requirements can drive successful, future-ready system designs.

Replays are available for two prior Calling All Systems events that took place in 2024:

- Accelerating MBSE Adoption: Can SysMLv2 Be the Game Changer? (23 October 2024)
- Complex, Costly, and Challenging: The Science of Resilient Systems (22 May 2024)

FINAL THOUGHTS FROM SYENNA

Iteration

Syenna has often heard variations of the common saying:

"*There's never enough time to do it right, but always enough time to do it over*."

Systems engineering practitioners are familiar with the pervasive pressure to cut corners early in a project and to get moving on designing (and sometimes coding or building) a solution before gaining a sufficient understanding of the stakeholders' problem. It's not that project managers and their corporate overlords are necessarily evil and bent on failure; they simply may not understand the perils of *doing* before *thinking*. And the Pied-Pipers of various methods that are best-suited to user interface design of software applications may have convinced project sponsors that *doing* is the always the best way to inform *thinking*.

Sigh …

There are obvious times when iteration is a wonderful, even optimum course of action. Many things are learned by firsthand experience and customers and end users often can't express well what they need or want until they have a picture, mock-up or partially-functioning prototype in their hands. Innovation also typically proceeds in an incremental fashion – or as Thomas Edison may have put it:

"Genius is 99% perspiration and 1% inspiration"

His 9000+ trials on filament materials for an electric lamp give credence to his firsthand perspiration that eventually triggered a payoff in the form of inspiration that was born of frustration.

Duh! Get rid of the oxygen that is burning up the filament material.

Syenna's monthly pearls of wisdom are also primarily the result of iteration. Starting from a keyword or phrase, ideas are committed to electrons and flow to the screen; only to be trashed and replaced with reckless abandon. However, the dead-ends and trashed electrons come at little cost to Syenna's mental health or life and limb. And mission failure on page 40+ of a monthly publication is a mere blip in a long and mostly successful career.

My challenge to our readers this month is to build a Top-Five or Top-Ten list of situations where iteration is either unacceptable or extremely costly and there is a huge premium associated with **doing it right** compared with **doing it over**. I'll start:

1. The doctors and biomedical engineers designing the protocol and operating equipment for my first "open-brain" surgery
2. Over to you …

Regards,
Syenna