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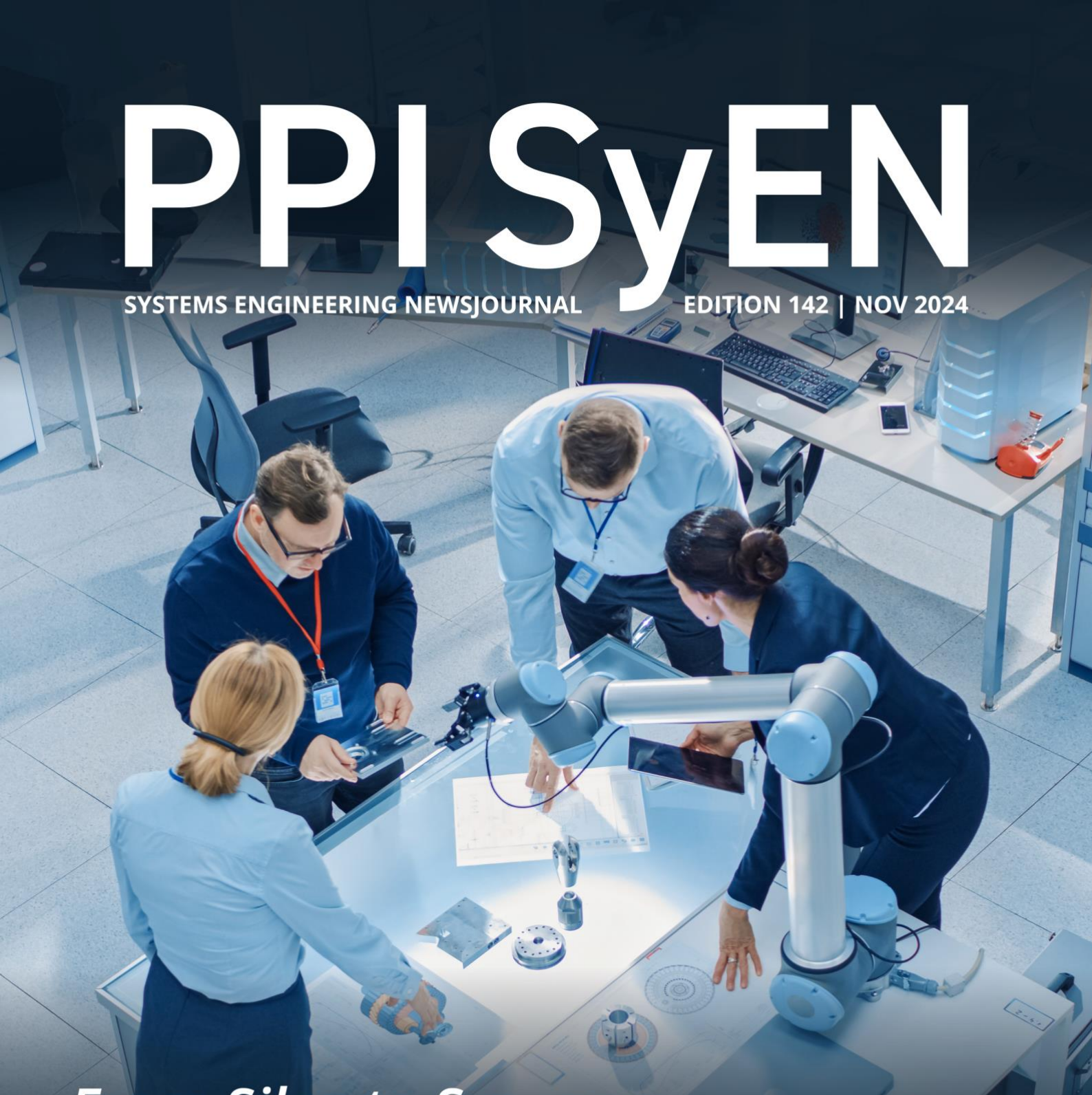

From Silos to Synergy: Advancing Collaboration in Systems Engineering

Requirement Structure Patterns - A Comparison of Methods

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PPI SyEN

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WELCOME

Dear Readers,

Welcome to the November edition of *PPI SyEN*! This month, we embrace the theme **"From Silos to Synergy: Advancing Collaboration in Systems Engineering."**

The systems engineering landscape is a rich tapestry of methodologies, tools, and innovations. Yet, despite its diversity, the field still faces a critical challenge: achieving a unified approach to key SE activities that combines the strengths of individual methods into a cohesive, globally applicable framework.

This month's feature article, "Requirement Structure Patterns - A Comparison of Methods," by John Fitch exemplifies this challenge and opportunity. The article delves into four requirement structure patterns, exploring their strengths, shared characteristics, and potential for standardization. It highlights several key insights, emphasizes the need for further research and refinement and invites skilled practitioners to contribute their insights, fostering a collaborative effort toward identifying additional high-value patterns and enhancing global standards.

Beyond the feature article, this edition explores efforts from societies and organizations to build synergies. Contributions from the Resilience Engineering Association, NIST Cybersecurity Framework updates, and cross-consortia AI initiatives underscore the importance of collaboration in driving innovation and progress. Practical tools like the Systems Engineering Tools Database, Capella case studies, and System Dynamics Society resources are spotlighted to help practitioners tackle complex challenges effectively. Our *Syenna* feature brings a humorous perspective to one the challenges inherent in collaboration that emphasizes the need for structured, intentional collaboration to prevent "hot messes of confusion" and foster synergy instead.

At PPI, we are proud to play a role, however small, in fostering this convergence, supporting the synthesis of ideas, and encouraging shared progress across disciplines. By embracing the spirit of collaboration, we can achieve synergies that push the boundaries of systems engineering and deliver solutions to complex, global challenges. As always, we encourage readers to share their expertise by submitting feedback to ppisyen@ppi-int.com, helping advance this ongoing dialogue!

Warm regards,

René

Managing Editor (on behalf of the PPI SyEN team)

> *Operational Effectiveness is a measure usually beyond requirements that brings together individual, use-related, measures of effectiveness (MOEs) into an overall measure.*
>
> **Robert Halligan**

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

Resilience Engineering Association (REA) News

According to the Resilience Engineering Association (REA), *resilience* describes how well a system can handle troubles that were not foreseeable by the designer. Resilience Engineering (RE) as a field emerged from the safety science community. A recurring theme in Resilience Engineering is about reasoning holistically about systems, i.e., *systems thinking*, as opposed to breaking things up into components and reasoning about components separately. Recent REA news includes:

REA on LinkedIN
A new LinkedIn home page for REA has been launched to improve networking and community engagement.

REA Foundations video series
The fundamentals of RE are now available in multiple videos, with an interactive map of the connected topics to assist in navigation and research. Topics include:

- Overview
- Introduction pt 1 - It's all about viability
- Tangles, Tradeoffs, and Robust yet Fragile
- Synchronization, an antidote to system breakdown
- The Science and Pragmatics of RE through the lens of Complexification
- A Resilience Engineering look at Tradeoffs
- The Laws of Fluency and Stretched Systems
- Tradeoff Between Seeking Opportunity and Managing Challenges
- High-Frequency Trading, a Case Study in Growth and Complexification

Resilience Engineering workshop track
RE thought leaders participated in a workshop aimed at re-architecting the internet for survivability. See pages 39-42 of the workshop report for details.

REA Young Talents in Asia community
The association launched a Young Talents branch in in Asia June 2024, providing opportunities for graduate students who are interested in and/or working in resilience engineering to learn, discuss, and develop their studies around resilience engineering.

Upcoming Events
The REA highlights multiple events that may be of interest to the RE and broader systems engineering communities in 2025:

- Applied Ergonomics Conference (17-20 March in Orlando, Florida, USA)
- International Symposium on Human Factors and Ergonomics in Health Care (30 March – 2

April in Toronto, Ontario, Canada)
- Human Factors and Ergonomics Society – Europe Conference (9-11 April in Bologna, Italy)
- European Safety and Reliability Conference (15-19 June at University of Stavanger, Norway)
- AHFE 2025 International Conference (26-30 July in Orlando, Florida, USA)
- Joint REA Symposium and Resilient Health Care Society Meeting (20-24 October in Canela, Brazil)

See prior REA Newsletters here.
Learn more about the REA.

Waters Center Launches New Systems Thinking Blog

The Waters Center for Systems Thinking (WCST) is a non-profit foundation with forty years of delivering systems thinking know-how to a diverse set of communities and individuals (from kindergarten students through Fortune 500 CEOs). The Center recently launched a new blog to increase the exchange of ideas between members of the systems thinking community.

The inaugural post was titled "Systems-Inspired Curiosity - What does it mean to be truly curious?". In this piece, Sheri Marlin, Waters Center Executive Director, identified factors that stifle the natural in-born curiosity of human beings and how various Habits of a Systems Thinker can stimulate continued curiosity across a life and work career.

View Habits of a System Thinker course offerings.

Read previous PPI SyEN articles summarizing these Habits:

- A Rapid Immersion in Systems Thinking - Part 1 (Edition #131, December 2023)
- A Rapid Immersion in Systems Thinking - Part 2 (Edition #132, January 2024)

Bookmark the Water Center blog to check out future posts.

Join WCST (create a free account) here to access Systems Thinking course content.

INCOSE Canada Q3 Highlights

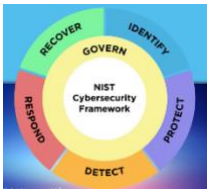
The INCOSE Canada chapter has published its Q3 newsletter. Items of interest include:

- Chapter President Elect Tony Wu highlighted the progress of the chapter in 2024, evidenced by in-person events in Vancouver and Toronto, with a similar event planned for Montreal. The organization also was recognized with the INCOSE Silver Chapter Award for outstanding chapter practices for the second consecutive year.
- On 29 July the chapter held a "virtual happy hour" event during which Ivan Rodrigues, Ivan Taylor, Ray Barton, and Stéphane Lacrampe, shared their experiences from the 34th Annual INCOSE International Symposium (IS2024) in Dublin, Ireland.
- Ivan Taylor delivered two presentations at the IS2024 in Dublin on the topics *A System*

Dynamics

- *Model of Organizational Resilience* and *Modeling Cybersecurity Operations to Improve Resilience*.
- The chapter's technical presentation program continues with session #8: Complex Systems as Boundary Work in Multi-perspective Imagination by Randall Anway on 21 October and session #9: Think Like an Ecosystem: Deploying MBSE within your Organization by Allison Lyle and Rae Lewark on 4 November.
- The chapter will host a 2 December webinar: Why Systems Engineering is a Smart Investment - Managing Complexity, Reducing Risk, Saving Money, presented by Ivan Taylor, president of Policy Dynamics Inc.
- Ten new members were added to the chapter in the third quarter. Fourteen chapter members received with INCOSE ASEP or CSEP certifications.
- Elections for a full slate of Canada chapter officers took place from 14 October through 15 November. Results are pending.

NIST Cybersecurity Framework (CSF) Updates



The U.S. National Institute for Standards and Technology (NIST) continues to enhance the resources that support the NIST Cybersecurity Framework (CSF) 2.0 that was released in February 2024.

In conjunction with Cybersecurity Awareness Month, the following new resources have announced:

- Three new Quick Start Guides
- Transition Spreadsheet between CSF 1.1 and 2.0
- Translations of the CSF into Portuguese and Spanish
- Explanatory videos
- Updated CSF FAQs

Download the CSF News announcement.

View more CSF news and events.

Systems Engineering Research Center (SERC) Updates

The October 2024 update from the Systems Engineering Research Center (SERC) focused on this organization's efforts at human capital development in addition to its research-driven contributions to systems engineering practices.

Transforming the DoD Workforce through Policy, Skills, and Culture
SERC and the Acquisition Innovation Research Center (AIRC) co-published an overview of their research and innovation initiatives to transform the acquisition and sustainment workforce. Cross-cutting themes of these initiatives included:

- Data drives informed policy and decisions

- Enhancing and upskilling the defense workforce
- Preparing the future workforce through strategic planning and partnerships
- Developing community resources
- Understanding and incentivizing cultural changes

Research projects involving more than twenty universities were highlighted including topics such as:

- Model-Driven Policy Innovations to Enhance STEM Pipeline
- Fostering Innovation through Improved Intellectual Property (IP) Understanding
- Digital Engineering Bootcamp
- Defense Data Grand Prix competition
- Systems Engineering Body of Knowledge (SEBoK)
- Addressing Systemic Factors That Influence Risk Aversion

Engineering practitioners and managers outside of the defense community may glean valuable principles and innovative ideas from this report.

AI4SE & SE4AI Workshop

The fifth edition of the SERC's AI4SE & SE4AI Research and Application Workshop took place in September with more than 200 in-person participants. Keynote speakers, panel discussions and technical presentations blended insights from academia, government and industry.

AI4SE topics addressed included:

- Safety Frameworks
- Ai "-ilities"
- Test & Evaluation (T&E) of AI
- AI for Design and Governance of Complex Systems
- AI at the Enterprise Level
- AI4SE in Digital Engineering

SE4AI topics addressed included:

- Human Autonomy Integration and Trust
- SE Methodologies for AI
- LLM's for SE Artifacts
- AI-aided Systems Engineering and Design

Download workshop presentations here.

AIRC Reports

Reports recently published by AIRC include:

- Advanced Model-Based Tools for Portfolio Management and Analytic
- Collective Intelligence Decision Making via Dynamic Knowledge Graph with Trusted Cross-Organizational and Privacy Preserving Integration
- Cognitive Assistant for Training Cost Estimators

AIRC Innovation Projects

Four universities have received over $500K for five innovation research projects, including:

- AI-based DPCAP FAR/DFARS Change Support Tool (Stevens Institute of Technology and Virginia Tech)
- Designing a Functional Information Retrieval System for Dynamic Organizational Use (Georgetown University)
- Enabling Digital Rights Management (DRM) of Intellectual Property Licenses for the Department of Defense (George Mason University)
- Identifying Novel Ways to Incentivize Industry in Defense Acquisition (George Mason University)
- Options for Strengthening the Use of Defense Production Act (DPA) Title VII in the Department of Defense (George Mason University)

Experts Join the SERC Research Council
Three experts have joined the SERC Research Council to deepen its diversity of experience in systems engineering and related fields. New members include:

Dr. Michael Orosz directs the Decision Systems Group at the University of Southern California's Information Sciences Institute and is a research associate professor in USC's Department of Civil and Environmental Engineering. His research interests include systems engineering, decision systems, open-source intelligence analytics, data analytics, cyber-physical security, and intelligent human-computer interfaces.

Dr. Daniel (Dani) Selva is an assistant professor in the Department of Aerospace Engineering at Texas A&M University, where he directs the Systems Engineering, Architecture, and Knowledge (SEAK) Lab. His research interests address the intersection and the union of space systems, artificial intelligence, and engineering system design.

Mr. Christopher Yukins has served as a trial attorney with the U.S. Department of Justice and taught at the George Washington University School of Law, particularly with the Government Procurement Law Program.

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

OMG Announces Cross-Consortia Joint AI Working Group

The Object Management Group (OMG) has announced the formation of a cross-consortia Artificial Intelligence Joint Working Group, that brings together the collective intelligence of OMG's consortia to advance AI integration with digital twins, augmented reality (AR) and related technologies. The working group will focus on four main areas:

- Standardization and Semantics
- Interoperability and Intelligent Automation
- eXtended Reality (XR)
- Responsible AI

Participating consortia include:

- OMG Standards Development Organization (SDO)
- Digital Twin Consortium (DTC)
- Augmented Reality for Enterprise Alliance (AREA)

Read the AI Working Group press release.

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: Eclipse Foundation AISBL

- Eclipse Papyrus™: An open source model-based engineering solution intended for industrial and academic applications to enable techniques like model-based simulation, model-based formal testing, safety analysis, performance/trade-offs analysis, architecture exploration, etc.

Vendor: Dassault Systemes

- Reqtify: A requirements management tool intended for use by teams for managing requirement, traceability and impact analysis across different systems, programs and project levels across the entire hardware and software development lifecycle.
- CATIA No Magic: Global Model Based Systems Engineering solution to model and simulate the system virtual twin. The CATIA Magic portfolio is the rebranded No Magic Portfolio (CAMEO, MagicDraw) The CATIA No Magic Portfolio is in Controlled Availability for legacy Customers
- Collaborative Designer for CATIA Magic: Enables MBSE collaboration on 3DEXPERIENCE Platform with single access control and system models change management.
- Magic Cyber-Systems Engineer: An Industry leading collaborative Model-Based Systems Engineering (MBSE) environment. It enables standard based visual modeling for System modeling and requirements definition. It is the most compliant solution on the market to OMG SysML/UML
- Magic Software Architect: A business process, architecture, software and system modelling tool intended for use by Business Analysts, Software Analysts, Programmers, QA Engineers, and Documentation Writers in the analysis and design of Object-Oriented (OO) systems and databases.
- Dymola: A solution, based on open Modelica language, for the modeling and simulation of integrated and complex systems within automotive, aerospace, robotics, and more. It has a unique multiple-engineering capability that enables physical models from different domains to be simulated.

Vendor: Jama Software Inc

- Jama Connect: Creates Living Requirements™ that form the digital thread through development, test and risk to provide end-to-end compliance, risk management, and process improvement. Our customer base spans automotive, medical, semiconductor, A&D, industrial manufacturing, finance and insurance.
- Jama Connect Interchange: An integration platform that integrates Jama Connect with other best-of-breed tools, like Jira and Excel. JCI is deeply integrated with Jama Connect configurations and workflows, providing seamless sync. It also is used for ReqIF file exchanges.
- Data Exchange for Jama Connect: nables the transfer of requirements and associated metadata between customers and suppliers, using the industry standard ReqIF file format.

Vendor: MathWorks® Inc.

- Requirements Toolbox: 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.
- System Composer™: Enables the specification and analysis of architectures for model-based systems engineering and modeling of software architectures.

Vendor: SOFTEAM

- Modelio Platform: A Collaborative Business or Software Modeling Platform intended for business architects to do business architecture modelling compliant to the latest version of the ArchiMate 3.2 standard with the availability of auditing rules to facilitate the detection of errors in enterprise models.
- Modelio BA ArchiMate: An enterprise architecture modelling tool intended for business architects working on enterprise architecture modelling and using the ArchiMate, BPMN and UML modeling languages to capture requirements and goals.
- Modelio BA - Business Architecture: A modelling tool intended for business architects to model data, business processes and architectures compliant with "metamodels" defined by the OMG UML and BPMN standards. providing analysts with all the standard diagrams enabling them to express ideas.
- Modelio SD - Software Development: A modelling tool intended for software developers to manage the software development process from requirements analysis through to generated code.

Vendor: TechnoSolutions Corp.

- Visual Use Case: A tool for application developers for rapidly defining clear and accurate requirements of an application or a system using the Use Case Modeling technique.
- TopTeam Requirements: Comprehensive Requirements Management Tool with end-to-end Traceability, SysML and UML modelling, use case development, change management, traceability customization, trace matrix generation, custom taxonomy and advances branching and merging.
- TopTeam Analyst: An end-to-end solution for requirements definition and requirements management with an integrated agile process. Single source of truth with all requirements,

user stories, use cases, SysML diagrams, UML diagrams, change management and traceability in one tool.

Vendor: The Gaphor Project

- Gaphor: An open source UML, SysML, RAAML, and C4 modeling application. It is designed to be easy to use, while still being powerful. Gaphor implements a fully-compliant UML 2 data model, so it is much more than a picture drawing tool.

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

Access the SETDB website.

PPI RESOURCES

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

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

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

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

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

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

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

CONFERENCES, MEETINGS & WEBINARS

Events of relevance to systems engineering

Webinar: Accelerating MBSE Adoption - Can SysML v2 Be the Game Changer?

As part of its Calling All Systems online series, INCOSE has posted the video of the 23 October panel discussion titled "*Accelerating MBSE Adoption: Can SysMLv2 Be the Game Changer?*" This panel explored the potential of SysMLv2 to drive the widespread adoption of Model-Based Systems Engineering (MBSE). The panel discussed how SysMLv2's key advancements - enhanced usability, greater precision and expressiveness, and seamless integration - may simplify MBSE processes and address real-world engineering challenges.

Panel participants include noted MBSE experts:

- Daniel Siegl, Business Development at Syntevo GmbH (host)
- Chris Schreiber, Chief Engineer at Lockheed Martin Space
- Daniel Hettema, Director of Digital Engineering, Modeling & Simulation (DEM&S) at the Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E))
- David Long, President at Blue Holon
- Gan Wang, Vice President, Systems Engineering Ecosystem at Dassault Systemes
- Sandy Friedenthal, Principal Systems Engineer at Lockheed Martin

Watch the video replay here.

Systems Engineering with Arcadia and Capella

Obeo has scheduled an additional December series of its popular training course on the Arcadia method and Capella open-source MBSE software. This online course consists of 6 sessions of 3.5 hours each held from 2-11 December.

The course will be delivered in English by a Thales MBSE expert, teaching Arcadia/Capella beginners how to effectively use the method and tool. Course content includes:

- Presentation of the MBSE approach and the Arcadia method
- General presentation of Capella
- Initialization of a case-study project on Capella
- Implementation of Capella to analyze and model system architectures at different levels

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

Learn more here. Contact Obeo at sales@obeosoft.ca to register.

AI Day: Artificial Intelligence and the Future of Work in Engineering

The prostep ivip Association is an international association headquartered in Darmstadt, Germany. The association has committed itself to developing innovative approaches to solving problems and modern standards for product data management and virtual product creation.

In support of that mission, the Association, in conjunction with the it's owl network, is sponsoring an online AI Day on 3 December with the theme of *Artificial Intelligence and the Future of Work in Engineering*. Topics addressed during this English-language event include:

- AI in Engineering – Foundations for Intelligent Production
- Generative AI: Opportunities and Applications in Engineering
- hAIrmann – intelligent assistant for data analysis
- Automatically hygienic: How AI improves working conditions in industrial laundry

Learn more and register here.

PMBA Global Virtual Conference

The International Institute of Business Analysis™ (IIBA®) has endorsed the Project Management - Business Analysis (PMBA) Global Fall virtual conference that will take place on 10-13 December 2024.

Keynotes for this conference include:

- The Productivity Challenge: Achieving the Flow State at Work (Mark Hollingworth, President, 5i Strategic Affairs)
- The Microsoft Productivity Experience: Turn 4 hours of work into 4 clicks (Vickie Sokol-Evans, Founder, RedCape)

View the detailed conference program here.

Workshops will address such topics as:

- 10 Essential Team Needs As We Move Past Crisis and Business Disruption
- Clearer Comms, Faster Wins: Quicken & Clarify Your Project Communication
- Effective Hybrid Practices
- Leveraging Design Thinking to Drive Value
- Power and Influence in Project Management
- Right Requirements, Right Now

Download the conference brochure.
Learn more and register.

INCOSE Webinar: Systems Integration - A Complex Challenge

INCOSE, as a part of its Sector III (Asia & Oceania) Speaker Program, will host a webinar titled *Systems Integration - A Complex Challenge* on 13 December. David Hetherington, author and publisher of the Simple for Beginners series on SysML and Arcadia will share his insights on this topic.

Contents of this presentation will include:

- Translating academic theories on systems integration into more concrete, real-world terms.
- Exploring the current understanding of the political, sociological, and cognitive challenges that often lead large projects to failure.
- Personal experiences with large-scale systems integration projects: a shipbuilding effort and a brand-new infotainment system for minivans.
- Actionable strategies and practical tactics to mitigate risks in less-than-ideal project environments.

Learn more and register here.

NAFEMS December Webinars

NAFEMS, the international modeling and simulation association, has announced the availability of two additional free webinars in December 2024.

VMAP - A Vendor-neutral Standard for CAx Data Storage (17 December)
The VMAP standard, led by the VMAP Standards Community, is an initiative to standardize data exchange in computer-aided development processes, where engineers are confronted with continuously growing number of software tool as well as experimental testing data along their development process from product design, optimization, and validation.

VMAP is a vendor-neutral standard for CAx data storage to enhance interoperability in virtual as well as physical engineering workflows. The VMAP standard can be used to transfer data between simulation codes as well as to store data from physical experiments or machine monitoring, filling the gap by creating the world's first CAx workflow interface standard.

This webinar will address the following VMAP topics:

- Motivation
- Introduction to VMAP Standard
- VMAP Standard Detail & VMAP IO - Lib
- Implementation examples using Python
- VMAP Ontologies

Integration and Democratization of Digital Tools to enable Multifunctionality (19 December)
The design, manufacture, testing and validation of high performance, engineered structures and materials are painstaking, resource-hungry, time-consuming processes requiring many skills involved to realize a multifunctional structure. What used to be an asynchronous, disconnected journey, passing information from lab-to-lab, presents an opportunity for integration and acceleration of the

innovation cycle if digital tools are adopted.

Sponsored by the NAFEMS ASSESS Initiative, this webinar will address two pillars of this simulation journey, Integration and Democratization. The webinar will share experiences in the integration of different technologies and techniques to digitalize the design, manufacture, testing and validation of products and systems to speed up their development process.

Registration Open for INCOSE International Workshop (IW2025)

Registration is open for the INCOSE International Workshop (IW2025) that will take place in Seville, Spain from 1-4 February 2025. At the IW, systems engineering practitioners at all levels and from all backgrounds engage in working sessions and contribute their knowledge and experience to take the discipline forward.

IW2025 will be held as a hybrid event allowing for in-person and virtual participation, subject to session hosts. Hybrid sessions will strive to include virtual attendees as much as possible, yet individual experiences will vary. IW2025 is open to INCOSE members and non-members are encouraged to join INCOSE prior to the IW.

Focus areas for IW2025 include:

- Energy Transition
- Digital Twins
- MBSE
- SysML v2

Program details are evolving as Working Groups submitting their meetings and workshops. These focused workshop sessions will include small group breakouts, interspersed mini-presentations, interactive dialog, and input from multiple areas of expertise to produce key outcomes and decisions (e.g. advance a product, create a new product, broaden knowledge).

Learn more and register for IW2025.

Innoslate Innovation Bootcamp

SPEC Innovations, the creators of Innoslate and Sopatra, will host an Innoslate Innovation Bootcamp on 12-13 February 2025 in Chantilly, Virginia, USA. This in-person immersive workshop will teach innovation skills from concept to completion, leveraging the Innoslate MBSE platform. Topics addressed will include:

- System Modeling - Learn to develop models with SysML, LML, DoDAF and over 25 diagram types
- Simulation - Execute models for cost, time, resources, assets, variance etc.
- Program Management - Create tasks, Kanban boards, Gantt Charts, WBS, and more.
- Requirements - Develop, manage, and analyze all your requirements in digital document

The course will be presented by Dr. Steven Dam, ESEP, a leading expert in the field of Model-Based Systems Engineering and Requirements Management and Analysis.

Learn more here.

NAFEMS ASSESS Summit 2025

The vision of the NAFEMS Analysis, Simulation & Systems Engineering Software Strategies (ASSESS) Initiative is to lead every aspect of engineering simulation toward a more valuable and accessible future in the medium to long term. The initiative leverages the expertise and knowledge of top-level figures in industry, government, and academia to accomplish this. To that end, thought leaders in the engineering simulation community will gather on 10-12 March 2025 in Atlanta, Georgia, USA for the ASSESS Summit 2025.

The keynote for ASESS Summit 2025 will be presented by Dr. Carmen Torres-Sanchez of Loughborough University on the topic: *Multifunctional structures: A journey from Physics-based simulations to Data-driven approaches*

In addition to technical presentations from other industry leaders, the Summit will be organized working sessions that address the following NAFEMS themes and questions:

Business:

- What are the current items that are limiting broader business benefits enabled by Engineering Simulation including organizational limitations of Engineering Simulation driven business benefits and how can we address them?
- How can we broaden the audience regarding Engineering Simulation driven business benefits?

Certification:

- What makes Certification by Engineering Simulation different from credibility & confidence?
- How can the Certification by Simulation procedures used, for instance, in the Aerospace and Nuclear fields be exploited in other sectors?

Credibility:

- How can we address the organizational, social and cultural challenges with establishing confidence (internal) and credibility (external)?
- Can organizations make design decisions based on simulation alone, if not why and how can we move here?

Democratization:

- What are the technological and organizational barriers to democratization?
- How do we foster broader use of Advanced Technologies (e.g., accuracy driven adaptivity, AI, Quantum Computing, meshless) to support democratization?

Integration:

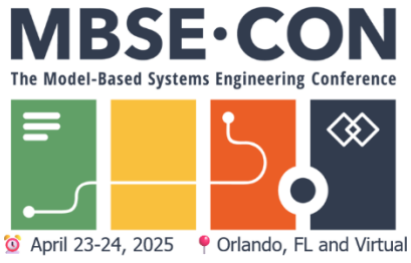
- What are the concerns and possibilities of integrating multi-fidelity models to drive Physics Informed AI?
- How can we leverage an understanding of model "appropriateness" to improve integration of multi-fidelity models and associated information?

Twins:

- Which scenarios/activities can benefit from an Engineering Simulation (ES) Digital Twin?
- How to integrate across multi-fidelity ES Digital Twins?

Learn more about ASSESS Summit 2025 and register here.

Call for Presentations: MBSE-CON 2025



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FEATURE ARTICLE

Requirement Structure Patterns - A Comparison of Methods

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Authored for PPI SyEN

Introduction

While momentum has been building toward Model-Based Systems Engineering (MBSE), there remains a high likelihood that the use of Natural Language (NL) requirements will persist as a central technique in defining the problem to be solved in any system development effort.

Multiple patterns for structuring the contents of an individual requirement have been defined and promulgated among systems engineering practitioners in the past several decades. However, none of these patterns has achieved a dominant position in the marketplace. Indeed, most system requirements written today appear to be written without the benefit of such a pattern. The result of this ad hoc process is poor requirements in terms of their completeness, clarity and consistency, with significant downstream impacts on stakeholder value delivery and project budgets and schedules.

This article will compare a variety of requirement structure patterns, while highlighting both common elements across the patterns and the distinguishing features of specific patterns. The relative merits of the patterns will be compared, along with lessons learned that might be applicable if such a pattern were incorporated in the SysML 2.0 standard. Additional research needed to complete a SysML 2.0 "gap analysis" will be identified.

To support this comparison, we will generate requirement statements using each pattern for a previously used example, the Energy Absorbing Deceleration Barrier (aka Fitch Inertial Crash Barrier) [1]. Please refer to the articles, *Rethinking Requirements Derivation – Part 2*, in PPI SyEN Edition #130 (November 2023) and *A Common Notation for Capturing States & Modes Requirements and Design* in PPI SyEN Edition #139 (August 2024) for more details on the Crash Barrier system example.

This article is intended as an introduction to a broad and significant topic in systems engineering. Look for follow-on articles as we address the research questions posed herein and dive deeper into the use cases for requirement structure patterns.

INCOSE Guide to Writing Requirements

The INCOSE Guide to Writing Requirements (GtWR), Revision 4 – July 2023, states that a requirement pattern is represented by a series of building blocks (also called pattern slots) including all the elements envisioned to represent a well-formed, singular, and complete need or requirement [2].

The GtWR sees the benefits of a requirement pattern as including:

- Improving requirements quality including clarity, conciseness, singularity, completeness, consistency and non-redundancy.
- Providing actionable information to resolve deficiencies in individual requirements.
- Providing actionable information to improve requirements development processes.
- Validating that a requirement effectively communicates the intent of the stakeholder need(s) on which that requirement is based.
- Supporting modeling, analysis and implementation.
- Supporting automation of requirements development and management activities.

The Guide doesn't promote a specific pattern (aka boilerplate or statement-level template), but provides a variety of examples, many of which share common structural elements. The basic pattern recommended is:

> *The <subject (entity)> shall <verb (action)><object><response - measurable outcome>*

This basic pattern is well suited to a functional and performance requirement, i.e., containing a measure of performance (MOP). A typical extension to this pattern is addressed by the inclusion of qualifying or condition clauses that identify in which situations the requirement applies.

> *When <condition clause>, the <entity> shall <action verb> <object> <response - measurable outcome> <qualifying clause>*

The distinction between qualifying clauses and condition clauses isn't precisely defined in the GtWR, rather being addressed by multiple examples embedded with the Rules portion of the document. Based on these examples, it appears that the qualifying clauses represent constraints on HOW an action is accomplished, e.g., do X <*in accordance with*> standard Y, whereas condition clauses specify WHEN a requirement is in force. Examples of conditions include event-driven or state-constrained system behaviors.

The GtWR notes that the "slots" in the pattern are often filled with elements, such as entity, action, measurable outcome or condition, that are elsewhere defined in the system specification and system model. This observation supports the assertion that using a requirement structure pattern has the potential to improve clarity and conciseness and to provide a jump-start for other modeling, analysis and verification activities that are part of a Model-Based Systems Engineering (MBSE) methodology.

Alternative patterns are given as examples for different types of requirements, although no universal or common requirements classification scheme is promoted. However the GtWR recognizes the importance of having a defined set of requirement types on which the patterns may be overlaid:

> *"A necessary first choice for any organization is to clearly define a unique taxonomy of requirement types and their associated patterns."*

The GtWR rules are focused on writing high quality requirements, but indirectly reinforce the need for a requirement to contain the slots/elements in the basic pattern.

GtWR Rule 1 (Structured Statements) supports the need for a requirements pattern to be in force for a project:

Need statements and requirement statements must conform to one of the agreed patterns, thus resulting in a well-structured complete statement.

GtWR Rule 2 (Active Voice) states that the **subject** of the requirement sentence should be the **entity** that is responsible for achieving a requirement:

Use the active voice in the need statement or requirement statement with the responsible entity clearly identified as the subject of the sentence.

GtWR Rule 3 (Appropriate Subject-Verb) expects a requirement to have both a **subject** and **verb**:

Ensure the subject and verb of the need or requirement statement are appropriate to the entity to which the statement refers.

GtWR Rule 11 (Separate Clauses) implies the need for **conditions** and **qualifications**:

Use a separate clause for each condition or qualification.

GtWR Rule 20 (Purpose Phrases) and Rule 21 (Parentheses) recognizes and advises against the tendency to add **non-requirement** intent or purpose information or parenthetical statements to a requirement:

20: Avoid phrases that indicate the "purpose of ", "intent of", or "reason for" the need statement or requirement statement.

21: Avoid parentheses and brackets containing subordinate text.

GtWR Rules 27 & 28 elaborate how **conditions** are best expressed:

27: State conditions' applicability explicitly instead of leaving applicability to be inferred from the context.

28: Express the propositional nature of a condition explicitly for a single action instead of giving lists of actions for a specific condition.

GtWR Rule 28 reinforces the need for singularity. It is acceptable to associate multiple conditions with a single action within a requirement statement, but unacceptable practice in one requirement to include multiple actions that are applicable to one or more conditions. Singularity should also be applied to the actor (subject) and object of action (noun or noun phrase acting as a direct object) within any requirement statement.

GtWR Rule 34 (Measurable Performance) *suggests that a requirement pattern should include some way to* ***quantify performance****, i.e., how well an action is performed or a* ***measurable characteristic*** *of the output produced.*

Provide specific measurable performance targets appropriate to the entity to which the need or requirement is stated and against which the entity will be verified to meet.

Though not specified by a GtWR rule, the recommended pattern also contains a **Qualifying Clause** element as a placeholder for information that is needed to clearly communicate the intent of a requirement.

How might the GtWR structure pattern apply to an example system?

The essential purpose of the Fitch Inertial Crash Barrier, our example system, is to reduce the injury to the occupants of an errant vehicle by providing a smooth deceleration experience. In a typical system requirements specification (SyRS), the relevant physical parameters of the errant impacting vehicle would be defined in a Standard Profile in terms of mass, center of mass, height of front "hood", angle of incidence, etc. In addition, for the deceleration function to be achieved successfully, the barrier must ensure that the impacting vehicle doesn't bypass the barrier units by going airborne during the deceleration process. This is achieved by delivering a downward force on the impacting vehicle as it "plows" through the barrier.

Taking these two functional/performance requirements from the Crash Barrier example and mapping them to the basic GtWR pattern yields:

R1: The crash barrier, having entered Intercepting State from Protecting State, shall decelerate a Standard Profile vehicle from a velocity of 30 meters per second to 0 meters per second in no more than N seconds with a deceleration force on vehicle occupants of not greater than 3g at any time during the deceleration process.

Element (Slot)	***Text***
Condition clause	*having entered Intercepting State from Protecting State*
Subject (entity)	*The crash barrier*
Verb (action)	*shall decelerate*
Object	*a Standard Profile vehicle*
Response – measurable outcome	*from a velocity of 30 meters per second to 0 meters per second in no more than N seconds*
Qualifying clause	*with a deceleration force on vehicle occupants of not greater than 3g at any time during the deceleration process*

When multiple performance parameters are needed to fully express the intent of a requirement, the "split" between which parameters are communicated in the ***Response – measurable outcome*** *slot or the* ***qualifying clause*** *slot may be a matter of experience-based judgment. In the case of the crash barrier, it must decelerate the vehicle while limiting the rate of deceleration to prevent harm to the occupants.*

Because the requirement structure pattern exists as an aid to communication, it should not be considered an inflexible set of rules that will always yield a deterministic outcome of one and only one valid requirements structure.

R2: The crash barrier, when in Intercepting State and Decelerate Vehicle mode, shall impart a downward force of at least 500 newtons on a Standard Profile impacting vehicle.

Element (Slot)	***Text***
Condition clause	*when in Intercepting State and Decelerate Vehicle mode*
Subject (entity)	*The crash barrier*
Verb (action)	*shall impart*
Object	*a downward force*
Response – measurable outcome	*of at least 500 newtons*
Qualifying clause	*on a Standard Profile impacting vehicle*

Easy Approach to Requirements Syntax

The Easy Approach to Requirements Syntax (EARS) was developed at Rolls-Royce PLC by a team led by Alistair Mavin. First published in 2009, the EARS notation has been widely adopted across multiple industries and taught in multiple universities. [3, 4]

The basic structure of a requirement that is written using EARS is:

> *While <optional pre-condition>, when <optional trigger>, the <system name> shall <system response>*

EARS rules demand that a requirement have:

- Zero or many **preconditions**
- Zero or one **trigger**
- One **system name**
- One or many **system responses**

Variants of the pattern depend on the types of requirements be communicated:

- Ubiquitous requirements: The <system name> shall <system response>
- State driven requirements: While <precondition(s)>, the <system name> shall <system response>
- Event driven requirements: When <trigger>, the <system name> shall <system response>
- Optional feature requirements: Where <feature is included>, the <system name> shall <system response>
- Unwanted behavior requirements: If <trigger>, then the <system name> shall <system response>
- Complex requirements: While <precondition(s)>, When <trigger>, the <system name> shall <system response>

The GtWR highlights as a key takeaway from EARS that "many of the requirements, specially at sub-system and system element levels, are not ubiquitous, but are normally triggered by a given event, and only when the SOI is in a given state."

Mapping the previously-stated functional/performance requirements for the Crash Barrier to the basic EARS pattern yields:

R1: The crash barrier, having entered Intercepting State from Protecting State, shall decelerate a Standard Profile vehicle from a velocity of 30 meters per second to 0 meters per second in no more than N seconds with a deceleration force on vehicle occupants of not greater than 3g at any time during the deceleration process.

Element	***Text***
Preconditions	*having entered Intercepting State from Protecting State*
Trigger	
System name	*The crash barrier*
System response	*shall decelerate a Standard Profile vehicle from a velocity of 30 meters per second to 0 meters per second in no more than N seconds with a deceleration force on vehicle occupants of not greater than 3g at any time during the deceleration process*

Because a system states and modes model for the Crash Barrier has been elsewhere defined, there is no need in this requirement to restate the state and mode transition events as the Trigger. This example reinforces the benefits of defining a set of formal states and modes requirements for a system, i.e., the ability to succinctly and precisely define the conditions under which other requirements are applicable.
R2: The crash barrier, when in Intercepting State and Decelerate Vehicle mode, shall impart a downward force of at least 500 newtons on a Standard Profile impacting vehicle.

Element	***Text***
Preconditions	*when in Intercepting State and Decelerate Vehicle mode*
Trigger	
System name	*The crash barrier*
System response	*shall impart a downward force of at least 500 newtons on a Standard Profile impacting vehicle*

In this case, the trigger is also unstated, but implied by the event (vehicle impact) that transitions the barrier from its Protecting state to the Intercepting State.

Based on these examples, one obvious concern with the EARS notation is the amount of information embedded in the System response element in the form of phrases representing different parts of speech - verbs, adverbs and adjectives.

PPI Parsing Template

PPI uses a template for requirements structuring that originated as a Verification and Validation (V&V) tool developed by Logicon in the 1980's. PPI founder Robert Halligan extended the application of this pattern to requirements authoring and requirements quality measurement in 1992. PPI has delivered this pattern and subsequent PPI refinements to over 15,000 systems engineering practitioners since 1995 as a key element of various course offerings. [5] A Chinese language variant of the PPI template was defined in 2020.

The PPI "Parsing Template" includes 8 types of elements:

- **Actor**: noun or gerund that is grammatically the subject of the sentence.
- **Conditions for Action (CfA)**: Conditions during which the characteristic is required to be present, or the triggering and/or initiating/terminating conditions.
- **Action**: The verb, as it relates to the Actor, including any auxiliary verb, "shall" or adverbs such as "not".
- **Constraints of Action (CoA)**: Qualifies the Action. May appear at 3 different points in a typical English requirement statement to improve readability and clarity.
- **Object of Action (OoA)**: The thing acted upon (noun or gerund).
- **Refinement of Object (RoO)**: Phrase that further qualifies the Object of Action.
- **Exceptions to Action (EtA)**: Limits the applicability of the requirement
- **Other**: Non-requirement information that may belong in a Rationale attribute or definition elsewhere in the specification. Used only when analyzing requirements "as written".

When used as part of the Requirements Analysis process, the Parsing Template provides a "form" on which to map stakeholder originating requirements in order to uncover gaps and to trigger a set question to be posed to the stakeholders. The template may then be used as a requirements authoring guide to draft refined requirements statements and gain stakeholder validation of these

new and improved requirements.

Using the PPI Parsing Template (less the other element that is needed only when analyzing originating requirements from stakeholders), the two example requirements map as follows:

R1: The crash barrier, having entered Intercepting State from Protecting State, shall decelerate a Standard Profile vehicle from a velocity of 30 meters per second to 0 meters per second in no more than N seconds with a deceleration force on vehicle occupants of not greater than 3g at all times during the deceleration process.

Element	***Text***
Actor	*The crash barrier*
Conditions for Action	*having entered Intercepting State from Protecting State*
Action	*shall decelerate*
Constraints of Action 1	
Object of Action	*a Standard Profile vehicle*
Constraints of Action 2	*from a velocity of 30 meters per second to 0 meters per second in no more than N seconds with a deceleration force on vehicle occupants of not greater than 3g at all times during the deceleration process.*
Refinement of Object	
Constraints of Action 3	
Exceptions to Action	

The distribution of Constraints of Action across its three instances in the Parsing Template is driven by understandability from the perspective of the recipients of the specification. In this case, assignment to the second Constraints position yields sufficient clarity.

R2: The crash barrier, when in Intercepting State and Decelerate Vehicle mode, shall impart a downward force of at least 500 newtons on a Standard Profile impacting vehicle.

Element	***Text***
Actor	*The crash barrier*
Conditions for Action	*when in Intercepting State and Decelerate Vehicle mode*
Action	*shall impart*
Constraints of Action 1	
Object of Action	*a downward force*
Constraints of Action 2	
Refinement of Object	*of at least 500 newtons*
Constraints of Action 3	*on a Standard Profile impacting vehicle.*
Exceptions to Action	

Schindel Transfer Function Model

In the INCOSE INSIGHT Practitioners Magazine, (Volume 27, Issue 5, October 2024), INCOSE Fellow William (Bill) Schindel wrote an article titled "*Requirements Statements Are Transfer Functions: An Insight from Model-Based Systems Engineering*". [6] Noting that transfer functions describe the relationships between system inputs and outputs, addressing requirements as non-linear extensions of a transfer function yields a unique requirements syntax.

System shall operate (to produce output X given input Y under conditions Z)

The methodology described by Schindel grew out of research seeking the minimal information that is necessary to describe a system. In this model all the requirements on a system are ultimately expressed in the form of system interaction behavior at external system boundaries, i.e., as externally visible behavior. In such a model a system doesn't have functions, it has requirements for functional interactions with external actors. The basic structure (metamodel) of a requirement statement becomes:

- Subject system
- Input(s)
- Output(s)
- Relationships (between inputs and outputs), typically the verb phrase "shall operate"
- Attribute(s) that parameterize the relationships

The minimum content of any requirement includes just three of these elements, one subject system, one relationship and one of the other three (input or output or attribute).

Based on the other patterns discussed herein, it stands out that the core Transfer Function model doesn't have an explicit "location" for capturing the conditions under which a requirement applies other than by specifying in detail the inputs (data, energy or matter) that are relevant to any relationship. However, Schindel addresses this gap by noting that additional elements, extensions to the basic metamodel, are needed to fully populate the requirements models for any system.

Such extension elements may include:

- Domain Model
- Stakeholder and Needs Model
- Feature Model
- State Model
- Functional Interaction Model
- Logical Architecture Model

Any or all of these may find themselves added to a prose requirement statement to fully define the system characteristics that are required at the system boundary.

A variety of sequencing options existing using the core elements of the Transfer Function pattern:

- The <subject system> shall operate using <inputs> to create <outputs> with <attributes>
- The <subject system> shall operate > with <attributes> using <inputs> to create <outputs>
- The <subject system> shall generate <outputs> with <attributes> using <inputs>

Rewritten in the Transfer Function style, the decelerate vehicle functional interaction becomes:

R1: The crash barrier, having entered Intercepting State from Protecting State, shall operate so as to decelerate a Standard Profile vehicle from a velocity of 30 meters per second to 0 meters per second in no more than N seconds with a deceleration force on vehicle occupants of not greater than 3g at any time during the deceleration process.

Element	*Text*
Subject system	*The crash barrier*
Relationship	*shall operate*
Input(s)	
Output(s)	*so as to decelerate a Standard Profile vehicle from a velocity of 30 meters per second to 0 meters per second in no more than N seconds*
Attribute(s)	*with a deceleration force on vehicle occupants of not greater than 3g at any time during the deceleration process*
Other Models (States)	*having entered Intercepting State from Protecting State*

Similar to the GtWR example, judgment is needed to determine which parts of a requirement map to the system outputs vs the attributes of the "*shall operate*" relationship.
Rewriting the crash barrier functional requirement to impart a downward force in the form of an externally observable transfer function yields:

R2: The crash barrier, when in Intercepting State and Decelerate Vehicle mode, shall operate so as to impart a downward force of at least 500 newtons on a Standard Profile impacting vehicle.

Element	*Text*
Subject system	*The crash barrier*
Relationship	*shall operate*
Input(s)	
Output(s)	*so as to impart a downward force on a Standard Profile impacting vehicle*
Attribute(s)	*of at least 500 newtons*
Other Models (States, Modes)	*when in Intercepting State and Decelerate Vehicle mode*

In both cases, the existence of a defined states and modes model for the Crash Barrier invokes use of the Other Models element to specify when a requirement is applicable. This appears to be a significant gap in the core Transfer Function notation because many requirements are not ubiquitous, i.e., not "always on". Some issues of semantics also exist: "shall operate" means "shall do something" (anything); "so as to" is a statement of purpose, but not a statement of requirement.

Differences to Explore

The Comparison Table below provides an initial mapping between the four structure patterns described earlier.

INCOSE GtWR	EARS	PPI Parsing Template	Transfer Function Model
Condition clause	*Preconditions* Trigger	*Conditions for Action* *Exceptions to Action*	Environmental or control Input(s) Other model elements, e.g., domains, system states or functional interaction model
Subject (entity)	*System name*	Actor	Subject system
Verb (action)	*System response*	*Action*	Relationship

Object	*System response*	*Object of Action* *Refinement of Object*	Output(s)
Response – measurable outcome	*System response*	*Constraints of Action*	Attribute(s)
Qualifying clause	*System response*	*Constraints of Action*	Attribute(s)

Methods Comparison Table

Key takeways from this comparison include:

- There is strong agreement supporting the need for all the basic elements of each of the four patterns, despite differences in their naming conventions.
- The closest alignment exists between the GtWR basic pattern and PPI Parsing template with the GtWR making a distinction between system response – measurable outcomes and the qualifying clause that the PPI template would cover as different instances of the Constraints of Action. However, the PPI template is more granular in providing for two different types of conditions (Conditions for Action, Exceptions to Action) and distinguishing between the Object and Refinement of Object elements.
- Not surprising, EARS, focused on simplicity, lumps multiple diverse elements (Verb/action, Object of Action, Refinement of Object, Constraints of Action, Response – measurable outcome and Qualifying clause) in the System response. This lack of granularity may be problematic, but no data exists that demonstrates that this lack of specificity is a poor tradeoff across a range of system/project types.
- The Transfer Function pattern is novel, but supplementing it with numerous system model extensions, e.g., States, beyond the core pattern of 5 elements makes evaluating the merits of this style a significant research project. It's unlikely that the 5 core elements would suffice for completely defining a significant percentage of the requirements for a typical system.

One of the complicating factors in evaluating the merits of a requirements structure pattern is lack of consensus concerning how to categorize requirements into types. PPI's recommended scheme for assigning requirements to types includes:

- State/Mode
- Functional
- Performance (combined with Functional except for global performance requrements)
- External Interface
- Environmental
- Resource
- Physical
- Other Quality
- Design

An effective and efficient scheme that classifies requirements by type should not expose significant gaps nor inconsistencies in a requirements structure pattern. Additional research is needed to clarify the impact of a requirements categorization scheme on the requirement structure patterns discussed

in this article.

Use Cases to Consider

PPI has identified three primary uses cases for our Parsing Template that are likely applicable to any requirement structure pattern:

- Parsing Analysis during System Requirements Analysis: Use the Parsing Template to analyze originating requirements "as-written" or "as-given" by stakeholders in order to uncover gaps, ambiguities and inconsistencies in the form of precise questions to stakeholders. Use the Parsing Template to work with stakeholders to either validate each originating requirement or to refine it.
- Requirements Quality Assessment: Use the Parsing Template on a relevant sample of the originating requirements from stakeholders to generate quality metrics based on judgments on how each of the seven elements in the template has been satisfied. Use the resulting score (typically on a 0-1.0 scale) to estimate the overall quality of the originating requirements, as an input to plan the level of resources and focus of System Requirements Analysis efforts. Provide feedback (and even training) to stakeholders to improve their skills in the areas of the Template where a pattern of poor performance is discovered.
- Requirements Authoring Guide: As envisioned in the GtWR, provide an authoring guide for a project team that facilitates the team developing consistently structured, complete and high quality requirements. This may also include alignment of the template with the information metamodels being used to capture system models of the problem definition, solution design and system verification plans and procedures.

Future research should include evaluation of various patterns for their ability to support these use cases. In addition, the potential for AI-enabled automation of all or part of these use cases should be considered.

Implications for SysML 2.0

Many of the structural elements defined in the patterns that have been explored in this article will exist as entities within any MBSE model of a system. The Actor will typically be the System of Interest or a subsystem within a system breakdown structure/block diagram. Actions will map the activities or system functions with associated measures of performance. Objects of Action could be other systems/actors that are transformed by Actions or potentially item flow (inputs/outputs of energy, matter or information) between the activities/functions.

PPI is engaged in performing via its membership of the Object Management Group (OMG) a gap analysis between the PPI Parsing Template and the SysML 2.0 Beta standard to determine how our requirement structure pattern might better align with and be incorporated within the standard. [7] Look for future versions of this article to report on the progress made in this analysis.

Conclusions

This initial comparison between four requirement structure patterns is necessarily incomplete, but numerous top-level conclusions may be drawn from the work to date:

- Multiple patterns exist for structuring a requirement to improve its completeness and clarity.

- Many of these patterns have achieved widespread adoption by systems engineering practitioners, but none is in a dominant position as a global standard.
- The most widely recommended and used patterns share much in common, implying an underlying structure that many experienced requirements analysts and authors would recognize as beneficial.
- It appears both feasible and beneficial to the systems engineering community to invest in further synthesis and refinement of requirement structure patterns with an aim toward a standard that delivers maximum value across the broadest set of requirement types and problem domains.
- There are almost certainly additional high-value patterns beyond those discussed in this article; additional research is needed to identify these patterns and add their distinctive elements to such a standard.

Although limited difficulty was encountered in mapping sample requirements to the GtWR, EARS and Transfer Function patterns, the author makes no claim to proficiency with these patterns on this first attempt and invites skilled practitioners to respond with insights and clarifications to these examples and any conclusions drawn from them. Please submit your comments to PPISyEN@PPI-Int.com so that they may be addressed in future version of this article.

Future research should include a broader set of requirement structure templates such as those presented by Dick and Lorens (2012) [8] and a review of related practices from the perspective of the business analysis and agile software development communities.

References

[1] Fitch, J.C. *Energy Absorbing Deceleration Barriers*. U.S. Patent #3,606,258. Filed 2 January 1969. Awarded 29 September 1971.

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[5] PPI Parsing Template, embedded in PPI's System Engineering Five-Day (SE5D) and Requirements Analysis and Specification Writing Five-Day (RASW5D) course materials.

[6] Schindel, W. 2024. "Requirements Statements Are Transfer Functions: An Insight from Model-Based Systems Engineering." *INCOSE INSIGHT Practitioners Magazine* (Volume 27 , Issue 5).

[7] Object Management Group. 2023. About the OMG System Modeling Language Specification version 2.0 beta. https://www.omg.org/spec/SysML/2.0/Beta1

[8] Dick, J. and Llorens, J. 2012. Using statement-level templates to improve the quality of requirements. Paper presented at the 24th International Conference on Software & Systems Engineering and their Applications.

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.

SYSTEMS ENGINEERING RESOURCES

Useful artifacts to improve your SE effectiveness

INCOSE INSIGHT Practitioners Magazine: Theoretical Foundations - Impacts on Practice Part II

The October 2024 edition (Volume 27, Issue 5) of INSIGHT, INCOSE's Practitioner Magazine published by Wiley, has been released. Electronic subscriptions to INSIGHT are available as a member benefit to INCOSE members. Hard-copy subscriptions to INSIGHT are available for purchase by INCOSE members for one membership year, and to the public.

This issue continues a series of papers by William (Bill) Schindel, INCOSE Fellow and chair of the MBSE Patterns Working Group, on various theoretical foundations of the systems engineering discipline and how these foundational principles can and should affect engineering practices. Contents of this 52-page resource include:

Innovation Ecosystem Dynamics, Value and Learning I: What Can Hamilton Tell Us?
Held in Dublin, Ireland, IS2024 invites us to refresh understanding of contributions to systems engineering by Ireland's greatest mathematician - Sir William Rowan Hamilton (1805–1865), professor of astronomy at Trinity College Dublin and royal astronomer of Ireland. His profound contributions to science, technology, engineering, and math (STEM) deserve greater systems community attention. Supporting theory and practice, they intersect foundations and applications streams of INCOSE's future of systems engineering (FuSE) program. Strikingly, key aspects apply to systems of all types, including socio-technical and information systems. Hamilton abstracted the energy-like generator of dynamics for all systems, while also generalizing momentum. Applied to the INCOSE innovation ecosystem pattern as dynamics of learning, development, and life cycle management, this suggests an architecture for integration of the digital thread and machine learning in innovation enterprises, along with foundations of systems engineering as a dynamical system.

Realizing the Promise of Digital Engineering: Planning, Implementing, and Evolving the Ecosystem
Gaining benefits of digital engineering is not only about implementing digital technologies. An ecosystem for innovation is a system of systems in its own right, only partly engineered, subject to risks and challenges of evolving socio-technical systems. This paper summarizes an aid to planning, analyzing, implementing, and improving innovation ecosystems. Represented as a configurable model-based reference pattern used by collaborating INCOSE working groups, it was initially applied in targeted INCOSE case studies, and subsequently elaborated and applied to diverse commercial and defense ecosystems. Explicating the recurrent theme of consistency management underlying all historical engineering, it is revealing of digital engineering's special promise and enhances understanding of historical as well as future engineering and life cycle management. It includes preparation of human and technical resources to effectively consume and exploit digital information assets, not just create them, capability enhancements over incremental release trains, and evolutionary steering using feedback and group learning.

Requirements Statements Are Transfer Functions: An Insight from Model-Based Systems Engineering

SYSTEMS ENGINEERING RESOURCES

Traditional systems engineering pays attention to careful composition of prose requirements statements. Even so, prose appears less than what is needed to advance the art of systems engineering into a theoretically based engineering discipline comparable to electrical, mechanical, or chemical engineering. Ask three people to read a set of prose requirements statements, and a universal experience is that there will be three different impressions of their meaning. The rise of model-based systems engineering might suggest the demise of prose requirements, but we argue otherwise. This paper shows how prose requirements can be productively embedded in and a valued formal part of requirements models. This leads to the practice-impacting insight that requirements statements can be non-linear extensions of linear transfer functions, shows how their ambiguity can be further reduced using ordinary language, how their completeness or overlap more easily audited, and how they can be "understood" more completely by engineering tools.

Feelings and Physics: Emotional, Psychological, and Other Soft Human Requirements, by Model-Based Systems Engineering

Traditionally, engineering encourages requirements statements that are objective, testable, quantitative, atomic descriptions of system technical behavior. But what about "soft" requirements? When products deliver psychologically or emotionally based human experiences, subjective descriptions may frustrate engineers. This challenge is important for products appealing to senses of style, enjoyment, fulfillment, stimulation, power, safety, awareness, comfort, or similar emotional or psychological factors. Automobiles, buildings, consumer products, packaging, graphic user interfaces, airline passenger compartments and flight decks, and hospital equipment provide typical examples. This paper shows how model-based systems engineering helps solve three related problems: (1) integrating models of "soft" human experience with hard technical product requirements, (2) describing how to score traditional "hard" technology products in terms of "fuzzier" business and competitive marketplace issues, and (3) coordinating marketing communication and promotion with the design process. The resulting framework integrates the diverse perspectives of engineers, stylists, industrial designers, human factors experts, and marketing professionals.

Failure Analysis: Insights from Model-Based Systems Engineering

Processes for system failure analysis (for example, FMEA) are structured, well-documented, and supported by tools. Nevertheless, we hear complaints that FMEA work feels (1) too labor intensive to encourage engagement, (2) somewhat arbitrary in identifying issues, (3) overly sensitive to the skills and background of the performing team, and (4) not building enough confidence of fully identifying the risks of system failure. In fairness to experts in the process, perhaps such complaints come from those less experienced - but even so, we should care how to describe this process to encourage better technical and experience outcomes. This paper shows how model-based systems engineering (MBSE) answers these challenges by deeper and novel integration with requirements and design. Just as MBSE powered the requirements discovery process past its earlier, more subjective performance, so also can MBSE accelerate understanding and performance of failure risk analysis - as a discipline deeply connected within the systems engineering process.

Download INSIGHT Volume 27, Issue 5 from the INCOSE iNet.

View this issue in the Wiley online library.

Recommended System Dynamics Resources

The System Dynamics Society (SDS) hosts or recommends a variety of system dynamics resources in the form of blogs, videos, webinars and papers. Here are some of the latest recommended resources to check out:

Analyzing Climate "Silver Bullets" With System Dynamics (blog post)
This post from the Climate Interactive blog illustrates the use of the En-ROADS solution simuator (model of climate dynamics) in analyzing the impact of various proposed climate solutions in achieving a 1.5°C future consistent with the Paris climate agreement. Five interventions are analyzed as standalone solutions, along with a few potential combinations:

- Electrifying transport - transforming our roads and rails
- Nuclear fission - building next-generation large nuclear reactors
- Nuclear fusion - creating our own sun here on Earth
- Bioenergy - growing fuel out of the ground
- Carbon dioxide removal - putting the genie back in the bottle

Because the modeling indicates that no "silver bullet" solution exists, a prioritized set of interconnected actions is recommended.

Building the Bridge: How System Dynamics Models Operationalise Energy Transitions and Contribute towards Creating an Energy Policy Toolbox (journal paper)
The complexity and multi-dimensionality of energy transitions are broadly recognised, and insights from transition research increasingly support policy decision making. Sustainability transition scholars have been developing mostly qualitative socio-technical transition (STT) frameworks, and modelling has been argued to be complementary to these frameworks, for example for policy testing. We systematically evaluate five system dynamics (SD) energy models on their representation of key STT characteristics. Our results demonstrate that (i) the evaluated models incorporate most of the core characteristics of STT, and (ii) the policies tested in the models address different levels and aspects of the multi-level perspective (MLP) framework. In light of the increasing emergence of energy (transition) models, we recommend to systematically map models and their tested policy interventions into the MLP framework or other sustainability transition frameworks, creating an overview of tested policies (a "policy navigator"). This navigator supports policy makers and modellers alike, facilitating them to find previously tested policy options and related models for particular policy objectives.

Building up a First Stock & Flow Communicable Disease Transmission Model (video)
This 66-minute teaching video by Professor Nathaniel Osgood illustrates the techniques and tools used to create a stock & flow model of communicable disease transmission. Incrememental addition of model elements is presented starting from a "blank sheet".

Causal Loops to System Structure Diagram: Sharper Insights via Added Structural Assumptions (video)
In this 28-minute teaching video, Professor Nathaniel Osgood of the University of Saskatchewan differentiates three types of system dynamics models and their associated diagrams:

- Causal Loop Diagram
- System Structure Diagram
- Stock & Flow Diagram

The progressive elaboration of a system dynamics model is explained and the value (model completeness and precision) vs effort in capturing new modeling constructs is discussed.

Dynamic Business Models in Systems Engineering (webinar)
In this eighth webinar of the System Dynamics for Business Innovation series, Kim Warren focuses on how system dynamics can be integrated with systems engineering to address enterprise-level challenges. The session explains the role of systems engineering in enterprise-level issues, emphasizing how System Dynamics can help simulate, plan, and manage strategies in business contexts.

Loop Dominance Analysis and Leverage Point Identification with Loops That Matter™
In this webinar, participants have the opportunity to learn how to do loop dominance analysis and leverage point identification using Loops that Matter (LTM). Loops that Matter identifies and measures the feedback loops responsible for model behavior. The purpose of this workshop is to give modellers the skills they need to learn why their models do what they do, and a method for learning how to intervene in their models to change behavior.

Modelling Cybersecurity Operations to Improve Resilience
Ivan Taylor of Policy Dynamics shares a presentation that was first given at the INCOSE International Symposium in Dublin on 2 July 2024. The conceptual model of cybersecurity that was presented herein was originally developed by Keith Willett and then converted by Taylor into an exploratory System Dynamics Model.

Resilience and Supply Chain Disruptions
Ivan Taylor's presentation to the INCOSE Resilient Systems Working Group that discusses a model that combines System Dynamics and Operational Research and shows how to develop a resilient maintenance system when there is a supply chain disruption.

Strengthening Cyber Risk Management and Oversight through Digital Twin Technology and Simulation Gaming
This Security Insight article focuses on the need for organizations to have a comprehensive understanding of cyber risk. The complex nature of cyber risk necessitates a holistic approach to effectively mitigate risk and take appropriate action. Decision-makers can enhance their understanding and foresight in managing cyber risk through exploratory and interactive technologies.

Using AI in Systems Thinking and System Dynamics in K-12 Education (webinar)
In this 86-minute webinar, sponsored by Systems Thinking in Education, three experienced educators share their applications of AI to Systems Dynamics modeling within K-12 education.

PDMA Resource Recommendations

kHUB PDMA Knowledge Hub

The Product Development Management Association (PDMA) hosts a Knowledge Hub (kHUB) that offers a wide variety of product development and innovation management resources in the form of blogs, podcasts, videos, conference presentations, feature articles and whitepapers.

Recent recommendations include:

- Aligning Product Portfolios with Strategic Plans (article)
- An Innovation Culture or a Culture of Continuity (blog)
- Antecedents and outcomes of open innovation over the past 20 years: A framework and meta-analysis (JPIM research article)
- Capturing innovation opportunities: Learning from growth leaders (JPIM research article)
- Competition from informal firms and new-to-market product innovation: A competitive rivalry framework (JPIM research article)
- Find Pearls and Drive More Innovation in Your Portfolio (article)
- Innov8rs (blog)
- Introduction to Exploratory Product Development (article)
- Steve Jobs: A Product Developer's Perspective (article)
- The Back End of Innovation: The Neglected Stepchild of NPD (webcast)
- Innovate Your Planning Process with Quartz (webcast)

Access to kHUB is free and open to the public. Full text access to JPIM research articles requires a PDMA membership or institutional access to the JPIM through the Wiley Online Library; however, kHUB publishes JPIM article abstracts and key takeaways.

Create a guest account or join PDMA here.

IIBA Analyst Catalyst Blog

The International Institute of Business Analysis (IIBA) is a non-profit professional association that helps business analysts develop their skills and advance their careers by providing access to relevant content. IIBA publishes an Analyst Catalyst Blog that is open to non-members. Recent posts include:

Cybersecurity Awareness Month: What Business Analysis Professionals Need to Know
In recognition of Cybersecurity Awareness Month, this post highlights the state of cybersecurity in 2024 and its implications for business analysis professionals. Practical steps are offered in the face of highly publicized and extensive security breaches that have affected many industry sectors. The IIBA's Certificate in Cybersecurity Analysis is offered as one proactive solution.

A Framework for Integrating Cybersecurity Within Business Analysis: Moving From Insight to Implementation
In this article, Bindu Channaveerappa, author of Cybersecurity and Business Analysis - An essential guide to secure and robust systems, argues for viewing cybersecurity as a source of business value and differentiation, rather than as a cost center. It focuses on the need for cross-functional collaboration across an organization, while detailing important roles that business analysts play in integrating cybersecurity into core business processes. A *continuous security* mindset is recommended to keep organizations ready to address new cybersecurity threats.

The Intersection of Business Ethics and Business Analysis: Making Decisions
Zola Brunner of Ethics Institute of South Africa explains how business analysis involves a critical interplay between decision analysis and ethical considerations. A five-step model of ethical decision-making is offered:

- Assessment
- Alternatives

- Analysis
- Action
- Analysis (post-action reflection)

A set of questions is provided that may be used to judge the moral soundness of a proposed solution.

Business Analysis Blueprint
In this regular feature of the blog, Agnieszka Balcerzak, president of the IIBA Poland chapter, is interviewed concerning her business analysis journey on topics such as mentorship, professional development, work-life balance and plans for the chapter's 2024 Business Analysis Summit.

The Analyst Catalyst blog has almost 500 posts, searchable by content categories, publication date ranges, and keywords.

Data Distribution Service (DDS) Standard Resources

The Object Management Group (OMG) has conducted eight webinars during 2024 concerning the Data Distribution Service (DDS) Standard. After completion, these talks are made available on the OMG's BrightTALK channel.

The most recent talk, delivered on 17 October, was titled "Edge Intelligence and Beyond: Transforming Systems with DDS". This webinar explored how the DDS can revolutionize software architectures. It provided an in-depth look at the architectural advantages of DDS over MQTT (OASIS standard for IoT connectivity) and the OPC Unified Architecture (UA), illustrating its impact on system design, performance, scalability, and real-time decision-making at the edge.

On-demand viewing is available for prior webinars concerning DDS:

- Designing your DDS System for Performance and Scalability (19 September)
- Connecting MBSE with Interface Design Using DDS: A best practice approach (14 August)
- The Past, Present and Future of the DDS Standard (1 August)
- Exploring DDS X-Types (20 June)
- What's New in the DDS Security Standard (2 May)
- Introduction to the Data Distribution Service (DDS) Standard (22 February)
- DDS, the US Navy, and the Need for Distributed Software (18 January)

OMG Journal of Innovation: Pioneering Innovations in Aviation and Aerospace

The Object Management Group (OMG) published the 25th edition of its Journal of Innovation in August 2024. The theme of this edition is "*Pioneering Innovations in Aviation and Aerospace*".

Articles to consider include:

- Guiding Supply Chain Security in Aeronautic Development
- Advancing Space Technology for ISAM Maturity and Success

- Digital Engineering Enables Innovative Hardware Integration Opportunities in Aerospace

Prior editions of the Journal have tackled diverse leading-edge topics such as:

- Bringing Creativity, Agility, and Efficiency with Generative AI in Industries
- The Role of IoT in Shaping the Future of Supply Chain
- Toward a Greener Planet Through IoT
- Business Outcomes of Utilizing Innovative Technologies
- Trustworthiness
- Role of AI in Industry
- Rapid Advancements in Digital Transformation
- Applying Solutions at the Digital Edge

Join the OMG mailing list.

Book: Architecting Resilient Systems, 2nd Edition

Wiley has published the 2nd edition of Architecting Resilient Systems. In this edition, INCOSE Fellow Scott Jackson expands his description of a systematic approach to handling the design of resilient systems.

This book provides a comprehensive list of design principles for creating systems where resilience is essential. With a detailed approach to both these general principles and their practical applications, it permits the creation and management of resilient systems in virtually any key area or industry.

Updates from the first edition, published in 2009, include case studies for Apollo 11 and US Airway Flight 1549 and design principles such as drift protection, repairability, and loose coupling.

The chapter outline includes topics such as:

- Resilience Abstractions
- Methodology
- Techniques
- Case Studies
- State Model
- Organizational Factors
- Culture
- Executing Resilience
- Governance
- Infrastructure

ISBN: 978-1-394-25820-8

Case Studies: Using Capella For Large-Scale MBSE

Obeo has published three case studies that illustrate the use of Capella open-source MBSE software and its associated Arcadia method for large-scale systems design. Each study summarizes the context (problem situation), solution (How Capella/Arcadia was employed) and results (benefits achieved). Examples include:

- Thales Australia: Collaboration and innovation on an integrated Civil and Military Air Traffic Management System (CAMTS)
- Deutsche Bahn AG: Modernization of the future Railway System by sharing knowledge and expertise across multiple domains.
- UKAEA: Establishing an authoritative source of truth for the architecture of a Fusion Energy Plant prototype.

Each case study leveraged Obeo's multi-user Team for Capella add-on to Capella 7.0.

Capella 7.0 was released in June 2024. Watch the What's New in Capella 7.0 feature videos:

- Advanced Color Settings
- Auto-select Chains & Paths Elements
- New Graphical Paste Options
- Predefined Layout of Newly Created Elements

Read the Capella 7.0 release notes

INCOSE New Zealand Chapter Videos

The INCOSE New Zealand chapter has been building a library of its chapter videos - addressing a diverse set of systems engineering topics. The chapter YouTube channel captures the "meet-up" videos and in some case slide presentations. Here are a sample of the 2023-2024 topics that may be of interest to PPI SyEN readers:

- An Introduction to Human Systems Integration - the dual perspectives of Systems Engineering and Human Factors. (Grace Kennedy, Chair of INCOSE Human Systems Integration working group)
- A systems approach to assessing critical facility functionality post earthquake (Dr. Megan Boston, University of Waikato)
- Intelligent Transport Systems: Red-Amber-Green – How Systems Engineers make the complex traffic signals look simple (Dhanush Laxman, Aurecon)
- Resilience, floods, mobility, and systems thinking (Shashini Ranabahu, Massey University)
- Requirements schemas for large multidisciplinary projects (John Welford, WSP)
- So Far as is Reasonable Practicable Guidance in New Zealand Rail (Russell McMullan, City Rail Link Ltd)
- Systems Engineering practice in Transport for NSW (Richard Fullalove,Transport for New South Wales)
- Systematically Pulverised EARS - Improvements in requirements authoring and presentation (John Welford, WSP)

SYSTEMS ENGINEERING RESOURCES

- System of Systems Conference Debrief (Nick Pickering, University of Waikato)
- Understanding Interface Criticality in Large Infrastructure Projects (John Welford, WSP)

Learn more about the INCOSE New Zealand chapter.

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

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

P006-950-1	North America EST 8:00 (UTC -5:00) PPI Live-Online™	09 Dec – 13 Dec 2024
P006-950-2	South America BRT 11:00 (UTC -3:00) PPI Live-Online™ *(Exclusive to South America)*	09 Dec – 13 Dec 2024
P006-953	Las Vegas, USA PDT 8:00 (UTC -7:00) In-Person	16 Dec – 20 Dec 2024
P006-954-1	North America CST 8:00 (UTC -6:00) PPI Live-Online™	13 Jan – 17 Jan 2025
P006-954-2	South America BRT 11:00 (UTC -3:00) PPI Live-Online™ *(Exclusive to South America)*	13 Jan – 17 Jan 2025
P006-955-1	Asia SGT 5:00 (UTC +8:00) PPI Live-Online™	17 Feb – 21 Feb 2025
P006-955-2	Oceania AEDT 8:00 (UTC +11:00) PPI Live-Online™	17 Feb – 21 Feb 2025
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
P006-958-1	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

FINAL THOUGHTS FROM SYENNA

Collaboration Exposed as Secret Cause of Chaos in Systems Engineering

In a shocking study that's left the systems engineering community reeling, researchers have discovered that when multiple engineers work together on a project, the resulting mess is exponentially worse than when they worked in isolation. It's as if the collective IQ of the team is inversely proportional to the number of people involved. "We were astounded by our findings," said Dr. Jane Smith, lead researcher on the project. "We thought we were doing something wrong, but it turns out that when you put multiple systems engineers in a room together, the outcome is akin to a catastrophic collision of cluelessness." The study, which observed teams of engineers working on complex system designs, found that the more people involved, the more tangled the system diagram became. "It's like they were competing in some bizarre, dysfunctional game of system design limbo," Dr. Smith explained. "How low can our understanding of the system go?"

The researchers identified several contributing factors to the chaos, including "Coffee-Fueled Confusion Syndrome," "Methodology Mix-Up Madness," and "Acronym Overload Anxiety." But the leading cause, they found, was "Meeting-Induced Brain Freeze," which occurs when engineers are forced to sit through hours of meetings, resulting in a collective brainpower nulla Laudem. "It's like watching a swarm of cats trying to solve a puzzle," said Dr. John Doe, a collaborator on the study. "You'd think that with all those brilliant minds in one room, something amazing would happen. But nope, it's just a hot mess of confusion and contradictions." The study's findings have left many in the systems engineering community scratching their heads, wondering how something that's supposed to make things better can actually make them worse. In response to the study, a leading council on SE has issued a statement urging engineers to "Proceed with Caution (and a Strong Dose of Humor)" when collaborating on projects. "We understand that collaboration is essential to delivering complex systems, but we also acknowledge that it can be a recipe for disaster," said the spokesperson. "So, take a deep breath, grab an extra cup of coffee, and remember: it's okay to laugh at the absurdity of it all."