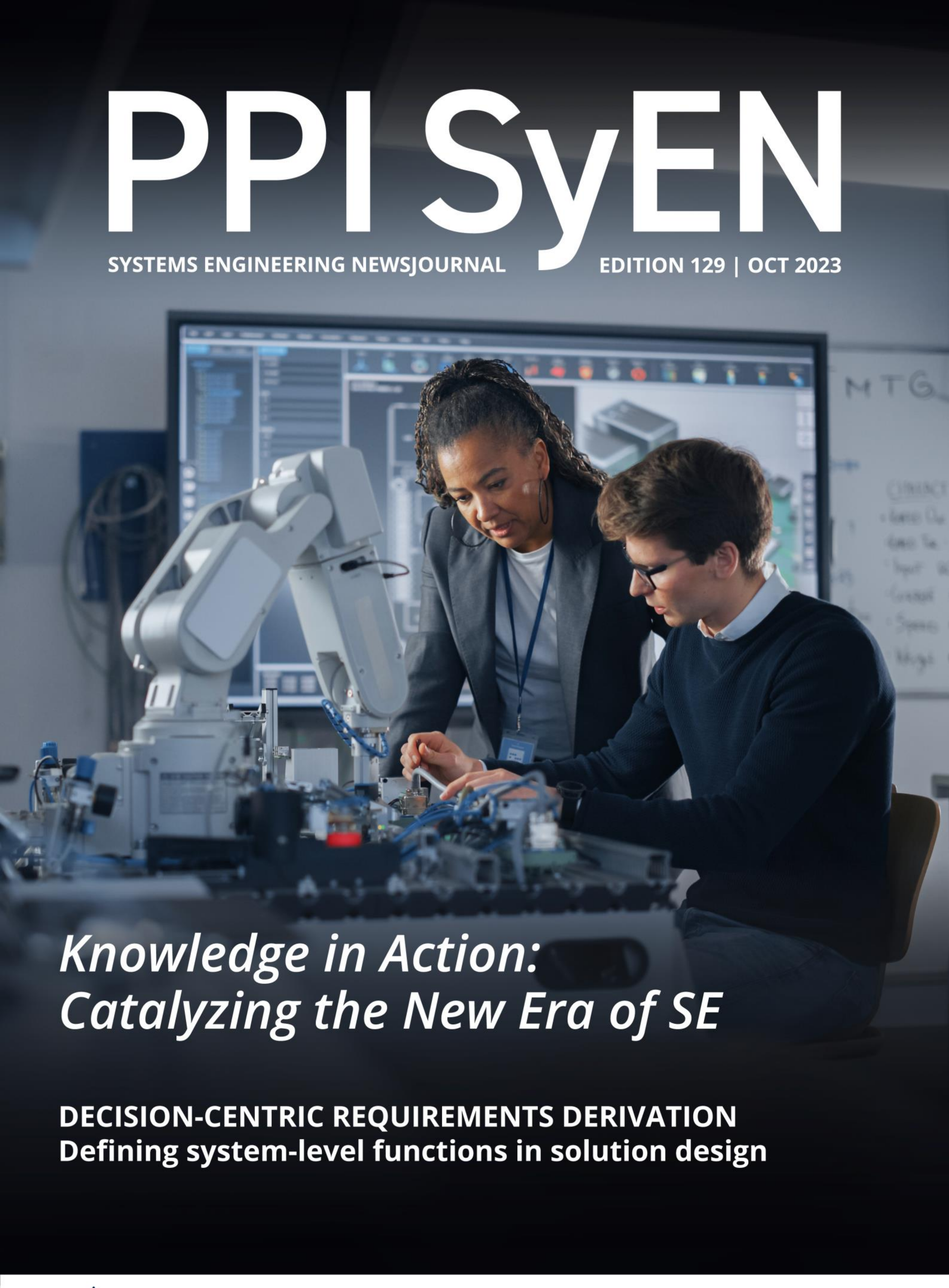


PPI SyEN

SYSTEMS ENGINEERING NEWSJOURNAL

EDITION 129 | OCT 2023

Knowledge in Action: Catalyzing the New Era of SE

DECISION-CENTRIC REQUIREMENTS DERIVATION
Defining system-level functions in solution design

A PROJECT PERFORMANCE INTERNATIONAL PUBLICATION | PPI-INT.COM

PPI SyEN

EMAIL: PPISyEN@PPI-Int.com

PUBLISHER

PROJECT PERFORMANCE INTERNATIONAL

Project Performance International
2 Parkgate Drive
Ringwood, Vic 3134 Australia
Tel: +61 3 9876 7345

Tel Brazil: +55 12 9 9780 3490
Tel UK: +44 20 3608 6754
Tel USA: +1 888 772 5174
Tel China: +86 188 5117 2867

www.ppi-int.com

PPI SyEN (PPI Systems Engineering Newsjournal) is published monthly.

Archived editions and subscriptions to future editions are available for free at: https://www.ppi-int.com/syen-newsjournal/

WELCOME

Dear Readers,

I'm thrilled to extend a warm welcome to our PPI SyEN community. This month, under the theme of "knowledge in action," we articulate the transformative power and dynamicism of systems engineering. By channeling our insights into initiatives, we not only stay up-to-date with the state of the art of systems engineering but catalyze the new era of SE.

In the news section, the INCOSE Election Results shine light on the outstanding individuals who will shape the direction of the Council over the next few years. Learn about how the Society of Women Engineers (SWE) acknowledges invaluable contributions of women in engineering with the SWE Awards and how INCOSE's Smart Cities Initiative and 2023 Mid-Year Impact Statement demonstrate INCOSE's dedication to addressing real-world challenges. The proposal from NIST Researchers to expand modeling of physical interaction in complex systems is yet another milestone in the world of MBSE.

The conference section is rich with opportunities for immersive learning and collaboration. From understanding the intricacies of the new INCOSE SE Handbook in Los Angeles to joining the discourse at SERC Research Review 2023, there are ample opportunities to connect with like-minded people and contribute to the growing body of knowledge. Calls for papers from organizations like NASA, IISE, and IEEE beckon – this is your chance to share your discoveries, ideas and challenges with the community.

Our feature article, "Rethinking Requirements Derivation - Part 1," expands on the series of Decision Pattern articles by John Fitch. In this article, read about how decisions are the main source of requirements and how understanding the decisions to be made upfront can lead to lower risk, higher value delivery. In the resources section, we have the latest INCOSE INSIGHT Practitioners Magazine content overview and some exceptional courses from the Waters Center, amongst others. There is a multitude of avenues through which knowledge can be gained and applied.

Closing on a contemplative note, Syenna shares some thoughts on "Transforming turnips into blood", the perfect way to wind down one of the most exciting PPI SyEN editions of 2023 so far.

P.S. A huge thanks goes out to the PPI SyEN team for making this publication possible every month, especially our exceptional Editor, John Fitch. Hats off to you, cobber!

Here's to knowledge in action.

Warm regards,

René

Managing Editor, PPI SyEN

PPI Systems Engineering Newsjournal (PPI SyEN) seeks:

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

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

SYSTEMS ENGINEERING NEWS

Recent events and updates in the field of systems engineering

INCOSE 2023 Election Results

INCOSE has announced the results of its 2023 leadership election. The following individuals will join the INCOSE Board of Directors on Saturday, 27 January 2024, when they are installed during the opening plenary of the 2024 International Workshop.

Name	Position	Term of Office
Mike Watson	INCOSE President-Elect	President-Elect 2 years / President 2 years
Alice Squires	INCOSE Treasurer	2 years
Bernardo Delicado	INCOSE Director for Outreach	3 years
Quoc Do	INCOSE Director for Asia Oceania	3 years

Follow the hyperlink to view each officer's strategic vision statement.

Congratulations to the newly elected officers.

View the current INCOSE Leadership here.

Society of Women Engineers (SWE) Awards

The Society of Women Engineers (SWE) has announced the recipients of its annual awards program, recognizing those who are making significant contributions to the STEM community and the advancement of women in engineering. SWE award recipients include professionals and collegiates from influential businesses, corporations, and universities across the globe. This year's award recipients will be recognized at WE23, the world's largest conference and career fair for women engineers and technologists that takes place on 26-28 October 2023 in Los Angeles, California, USA.

A sampling of this year's awards include:

Achievement Award
The highest award given by the Society of Women Engineers. It is presented annually to an individual who has made significant and progressive technical contributions.

- Thea Feyereisen, Honeywell

Distinguished Engineering Educator Award
Honors an individual who has made significant contributions in the fields of engineering, engineering technology, or science related to engineering. They must have instructional experiences in an engineering, engineering technology, or science related to engineering educational institute.

- Anabel Fraga, Ph.D., Universidad Carlos III de Madrid
- Lizabeth Thompson, Ph.D., California Polytechnic State University, San Luis Obispo

Entrepreneur Award
Awarded to an individual who went out on her own to start and/or maintain her own engineering, engineering technology or science related to engineering-based business, and in doing so, serves as a role model to all women who have ever risked financial security for the possibility of uncertain rewards.

- Melanie Lang, FormAlloy Technologies Inc.

Fellow Grade
Honor conferred on SWE members professional membership in recognition of significant and long-term service to the advancement of women in the engineering profession.

- Marie Cole, IBM
- Carol Coppa, Eversource Energy
- Helene Finger, P.E., California Polytechnic State University, San Luis Obispo
- William Goodin, Ph.D., University of California, Los Angeles

Other SWE award categories include:

- Advocating Women in Engineering Award
- Distinguished New Engineer Award
- Distinguished Service Award
- Diversity, Equity & Inclusion Program Award
- Emerging Engineering Educator Award
- Emerging Global Leadership Award
- Emerging Leader Award
- Global Leadership Award
- Global Team Leadership Award
- Outstanding Collegiate Member Award
- Outstanding Faculty Advisory Award
- Outstanding SWE Counselor Award
- Patent Recognition Award
- Prism Award
- Resnik Challenger Medal Award
- Rising Technical Contributor Award
- Rodney D. Chipp Memorial Award
- Spark Award
- Suzanne Jenniches Upward Mobility Award

View the full set of SWE award announcements here.
Scan SWE member news.

INCOSE Launches the Smart Cities Initiative

INCOSE has launched the Smart Cities Initiative which introduces *the INCOSE-TUS Smart Cities Framework; a human-centric framework* that aims to help city authorities to make decisions with human needs in mind.

The INCOSE Smart Cities Initiative draws upon the experience and knowledge of INCOSE members to support communities in developing their Smart Cities

Concepts, Applications, Technology and Services (CATS) by leveraging systems engineering tools and principles.

The initiative has been prepared by a core team, led by Jennifer Russell, who stated *"We cannot underestimate how important taking a holistic and smart approach to the development of our cities is going forward. We hope that municipalities and public agencies will find the INCOSE Tailored Unified System Framework a useful aid helping them to secure our futures."*

Learn more about the Smart Cities Initiative here.

Download the Initiative overview from the INCOSE Store. Free for INCOSE members; available to non-members for $15 USD.

INCOSE Releases 2023 Mid-Year Impact Statement

The International Council on Systems Engineering (INCOSE) has released its 2023 Mid-Year Impact Statement. The document seeks to demonstrate with significant evidence that INCOSE is the premier choice for development of systems engineering professionals based on its size (> 22K individual members, 134 corporate members, 50+ working groups, 66 chapters worldwide and 75 countries represented), programs, products, publications, community, events, engagement, and proactive influence of the future of systems engineering as a discipline and on society in general.

View the current and previous Impact Statements.
Download the 2023 Mid-Year Impact Statement.

Learn more about INCOSE membership.

NIST Researchers Propose Expanded Modeling of Physical Interaction in Complex Systems

The U.S. National Institute for Standards and Technology (NIST) has developed a method to expand the modeling of physical interactions in complex systems design. NIST has developed new component libraries that extend the Object Management Group's (OMG's) SysML Extension for Physical Interaction and Signal Flow Simulation (SysPhS) standard. SysPhS augments OMG's Systems Modeling Language (SysML) for one-dimensional simulation, which is widely used to design and test complex systems.

New component libraries, which aid the modeling of mechanical systems and heat flow, include:

- Translational mechanics: Includes translational inertia, springs, and dampers.
- Rotational mechanics: Defines the rotational analogs of the translational components above.
- Heat transfer: Includes conduction, convection, and radiation.

These component libraries may be translated to OpenModelica and Simscape simulators using a NIST-developed translator.

Learn more about the NIST Systems Analysis Integration (SAI) project under which these extensions were developed.

See the full NIST newsletter here.

Updates to SE Tools Database (SETDB)

The Systems Engineering Tools Database (SETDB), developed by PPI in partnership with INCOSE, provides a virtual venue for engineering tool vendors to communicate their latest offerings. Recent SETDB updates, including both new tools and updates to existing tools, include:

Vendor: Ansys Inc.

- Ansys SCADE Architect: Specifically developed for system engineers. It provides full support of industrial systems engineering processes, such as ARP 4754A, ISO 26262 and EN 50126. SCADE Architect features functional and architectural system modeling and verification in a SysML-based environment.

Vendor: eQ Technologic, Inc.

- eQube® Analytics Suite: eQube®-DaaS Platform consists of Analytics Suite of offerings which provides a modern A / BI platform that democratizes BI, that puts the power of analytics in the hands of the end users. Our Analytics Suite consists of eQube®-BI (Business Intelligence), eQube®-ADA (Augmented Data Analytics) and eQube®-DP (Data Profiler) products.
    - eQube®-BI: A modern A / BI platform that democratizes BI and puts the power of analytics in the hands of end users. It unshackles end users to analyze live enterprise-wide data on-demand while honoring the security rules of the underlying applications.
    - eQube®-ADA: eQube®-ADA works with the rest of our eQube® offerings to augment data profiling and data quality, harmonization, modelling, manipulation, enrichment / inference, metadata development, and data cataloging.
    - eQube®-Data Profiler: eQube®-DP assesses the quality, quantity, composition, anomalies, similarities, and patterns of your data which could be stored in multiple systems. It is instrumental in the data discovery phase for understanding the facets of data and for data curation i.e., data-prep for processing.
- eQube® Integration Suite: This suite consists of three integrated product offerings: eQube®-MI (Migration & Integration),eQube®-AG (API Gateway) and eQube®-TM (Transformation Modeler). In 3 simple steps, an API and / or an interface can be rapidly published without having to write any code.
    - eQube®-MI: A powerful Low / No-code integration platform that establishes a Digital Backbone of integrated applications. It provides a comprehensive and efficient infrastructure for APIs, enterprise application integration, federation, orchestration, synchronization, and migration.
    - eQube®-TM: The Transformation Modeler provides unprecedented capabilities to establish a catalogue / knowledge base of 'models' and 'transformation maps' for data federation, 'For-Purpose' Apps, application integration and migration solutions.
    - eQube®-AG: eQube®-API Gateway efficiently creates, publishes, monitors, maintains and secures APIs. Its visual and intuitive user interface provides a complete governance framework for API lifecycle management in any

organization.

- eQube® Connectors: We have 75+ pre-built Connectors use application specific APIs. With these Connectors, eQube® suite of products can leverage the entire OOTB object model as well as customized object model. It honors data security rules of the application without any custom coding required.

Vendor: Intercax LLC

- Syndeia: Digital thread platform for model-based engineering. It enables model and data federation from diverse ecosystems of modeling and simulation tools, enterprise applications, and data repositories. It also enables a digital thread for complex products and systems.
- Melody™: SysML parametric solver and integrator plugin for IBM Rational Rhapsody. With Melody™, system engineers can execute parametric models in Rhapsody to explore system performance, measures-of-effectiveness (MoEs), verify requirements, run trade studies, orchestrate simulations and more.
- Solvea™: SysML parametric solver and integrator add-in for Enterprise Architect. With Solvea™, system engineers can execute SysML parametric models in Enterprise Architect to compute system performance, cost, reliability, and run automated trade studies to select best-in-class alternatives.
- ParaSolver™: SysML parametric solver and integrator plugin for Artisan Studio. With ParaSolver™, system engineers can execute parametric models in Artisan Studio.
- ParaMagic®: A plugin for MagicDraw that makes SysML models come alive. By executing constraint relationships in SysML parametric diagrams, systems engineers can run simulations and trade studies for complex systems from concept through final test.

Vendor: The Modelica Association

- Functional Mock-Up Interface (FMI): A free standard that defines a container and an interface to exchange dynamic models using a combination of XML files, binaries and C code zipped into a single file. It is supported by 170+ tools and maintained as a Modelica Association Project on GitHub.

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

Access the SETDB website.

“

Tests are no substitute for requirements specifications.

Bertrand Meyer

CONFERENCES, MEETINGS & WEBINARS

INCOSE Los Angeles: Understanding and Applying the INCOSE SE Handbook Fifth Edition

The INCOSE Los Angeles chapter will be hosting a hybrid tutorial on 4 November 2023 featuring David Walden (of Sysnovation, LLC) presenting on *Understanding and Applying the INCOSE SE Handbook Fifth Edition*.

Abstract:
The objective of the International Council on Systems Engineering (INCOSE) Systems Engineering Handbook (SEH) is to describe the state-of-the-practice for Systems Engineering (SE). It also serves as the basis for the INCOSE certification examination.

The objective of this tutorial is to provide an overview of the 2023 edition of the SEH and explain how it can be used to plan, manage, and realize complex systems within the context of demanding business constraints. Participants are introduced to key SE terminology, concepts, and principles in the handbook. The participants will complete several team-based exercises to solidify the concepts being presented. Each student will receive a complete set of lecture notes and an annotated bibliography. All participants are asked to purchase or download a copy of the handbook from the INCOSE Store prior to class. The handbook download is free for INCOSE members.

Note: *this tutorial is an overview of the handbook and does not include the level of detail typically presented in an INCOSE Systems Engineering Professional (SEP) preparation course.*

Learn more. Register here.

Registration Open for SERC Research Review 2023

Registration is open for the annual Research Review of the Systems Engineering Research Center (SERC) that will take place from 14-15 November 2023 in Crystal City, Virginia. This hybrid two-day event will begin with the SERC Doctoral Student Forum (SDSF) on 14 November. The SERC Research Review (SRR) will be held on 15 November.

This event unites a national network of defense practitioners and researchers across US government, industry, and academia to discuss issues of national and global significance and present updates on research addressing the most challenging issues facing the USA Department of Defense and other federal departments and agencies.

Keynote speakers for the 2023 Research Review include:

- Mr. Andrew P. Hunter, Assistant Secretary of the Air Force for Acquisition, Technology and Logistics
- Dr. Jagadeesh Pamulapati, Director, Science and Technology Foundations, Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E))
- Dr. Steven G. Wax, Performing the Duties of the Assistant Secretary of Defense for Science and Technology

Register here.

Capella Days 2023: Registration and Full Program

The annual free online gathering of the Capella (MBSE tool) and Arcadia (MBSE method) community, Capella Days 2023, is scheduled for 14-16 November 2023. Capella Days bring together the creators of Capella/Arcadia, providers of Capella add-on and services, and MBSE experts and industrial users. Registration is open and the full program for this four-day event has been announced.

Session #1 (14 November)

- Collaborative Model-Based Engineering and Large Systems Development, by Catherine Morlet and Alberto González Fernández (European Space Agency)
- Introducing MBSE in an Organization Successfully, by Erik Visser (Thales Communications)
- Model-driven Design and Development of an Electromechanical Actuation System, by Elena García Llorente (CESA - Heroux Devtek) and Luis Cárdenas González (Anzen Engineering)

Session #2 (15 November)

- Practice in COMAC to Conduct MBSA in Avionics System Based on Capella, by Wang Ran (COMAC) and Yan Weizhen (PGM)
- Capella for Modelling CubeSat: Tailored SE Process for Leveraging Model-Based Systems Engineering, by Suvigya Gupta, Dhirendra Singh and Stueti Gupta (BlueKei Solutions)
- Enterprise Modelling for Lifecycle Engineering on the Example of Sustainability, by Chantal Sinnwell and Michael Bitzer (Siemens Digital Industries Software)

Session #3 (15 November)

- Capella MBSE Integration for Robotic Arm Development, by Vinayak Vadlamani (Redwire Space Europe)
- Enhance the Efficiency of Systems Engineering with a Tailoring of SE processes and ARCADIA Method, by Bruno Vuillemin (Capgemini Engineering)
- In Pursuit of Robust Failure Mode Effects Analysis in the Design Phase, by Steven Huang (ManTech) and Alice Cellamare (p2m berlin)

Session #4 (16 November)

- Use of Capella as Digital Twin to Perform Complex Systems Simulation, by Christopher Cerqueira (Instituto Tecnológico de Aeronáutica)
- Efficient and Comprehensive FMECAs: Harnessing the Power of MBSE Models in Capella, by Sushim Koshti and Neela Ayalasomayajula (Applied Materials)
- Lean Startup with Capella MBSE, by Brent Bailey (StarFish Medical)

View the full program including presentation overviews and speaker biographies.

Register here.

System Dynamics Society November Webinars

The System Dynamics Society (SDS) is hosting two informative online webinars in November that address the finer points of systems thinking.

Navigating Client Dissatisfaction (1 November)

Every consultant has their share of success stories, but what happens when the client doesn't like the analysis? Dive deep into the realities of professional consultancy where not every project ends with a fairy tale conclusion. In this session, Dennis Sherwood will share his personal journey of a decade-long engagement with a government client. Through this lens, he will shed light on the complexities and challenges faced when results don't align with client expectations. Join us to:

- Delve into the intricate dynamics of client relationships beyond conventional success narratives.
- Unpack strategies to manage, navigate, and turn around situations when clients are dissatisfied with the outcomes.
- Engage in an open forum to share your own experiences of when project outcomes diverged from client expectations.

Learn more and register here. Free for SDS members.

Systems Thinking Through Storytelling (15 November)

Join us for a free seminar with Linda Booth Sweeney and Philip Ramsey, systems educators and authors whose books help teach about systems thinking through storytelling.

Linda will share "Curious about Connections," a simple, inquiry-based teaching framework that fosters collaborative, inclusive dialogue while promoting systems thinking, critical thinking, communication skills, and empathy. She'll demonstrate how to use this facilitation method using picture books as well as everyday scenarios. She is excited to share this facilitation method with our System Dynamics community and to explore ways families, teachers, and professionals can use it in a variety of settings.

Phil will share about his newly published Billibonk and Frankl book series, a collection of captivating jungle-based fables that showcase principles of systems thinking through the experiences of various animal characters. The stories are engaging and relatable to both children and adults, as they demonstrate how different species in the jungle learn to collaborate and solve problems together. The Billibonk and Frankl stories aim to help children see systems and interdependencies in the world around them.

Learn more and register here. Free for all participants.

Join the SDS.

Agendas for NAFEMS Multiphysics and Multibody Dynamics Conferences

The full agendas have been released for the International Multiphysics Conference 2023 and the International Multibody Dynamics Conference 2023, two co-located and coordinated in-person conferences hosted by NAFEMS in Munich, Germany on 14-15 and 15-16 November respectively. These events address recent advances in engineering and simulation disciplines and unmet challenges for the simulation community.

International Multiphysics Conference 2023

The Multiphysics Conference will feature two keynotes and 26 technical presentations from industry and research. Topics addressed include:

- The Role of Machine Learning and Numerical Simulations in the Digitalization of Manufacturing Industry (Keynote)
- Efficient Frequency Sweeps for Optimization of (Vibro-)Acoustic Radiation Problems (Keynote)
- Multi-Physics Systems Simulation for Fusion
- Coupled Simulations of Tribological Systems using a Multiphysics Computational Method
- Short Circuit Analysis on Distribution Transformer Tank – Simulation Study
- Prediction Methods for Sound Radiation from Loudspeaker Enclosures
- Multiphysics Simulation of the Direct Effects of Lightning on Airborne Platforms
- Internal Short Circuit Analysis of Lithium-Ion Batteries

View the full agenda and register here.

International Multibody Dynamics Conference 2023
The Multibody Dynamics Conference will feature 22 technical presentations from industry and research. Topics addressed include:

- Improving the Sustainability of Wind Turbine Gearboxes through Virtual Journal Bearing Optimization with Multi-Body Simulation
- Stretching the Limits of MBD Simulation Models
- Development of a Python based MBS Methodology for the Calculation of Multi-Stage, Resilient Mounting Systems for Large-Bore Engines
- Enhancing Robotics Solutions with Multi-Body Dynamic software: A Simulation-based Approach
- Advanced Flexible Body Technologies for Multi-Body System Simulation

View the full agenda and register here.

Join NAFEMS here.

Webinar: Enhancing Your Business Analysis Toolkit

The International Institute of Business Analysis (IIBA) is hosting a free open-access business analysis webinar on 14 November titled Enhancing Your Business Analysis Toolkit. In this webinar, author Howard Podeswa will delve into key principles and practices highlighted in three of his acclaimed business analysis books:

- The Business Analyst's Handbook (available IIBA members)
- UML for the IT Business Analyst: A Practical Guide to Requirements Gathering Using the Unified Modeling Language, Second Edition (available to IIBA members)
- The Agile Guide to Business Analysis and Planning: From Strategic Plan to Continuous Value Delivery.

Abstract
Business analysis plays a pivotal role in driving organizational success and fostering effective decision-making. Howard Podeswa's expertise comes through in his comprehensive works, which provide insights into the art and science of business analysis. Through his engaging writing style and practical approach, Howard equips professionals with a wide array of techniques, strategies and templates that can be incorporated into their business analysis practice. During this webinar, we will explore some

key concepts proposed in Howard's books, focusing on their application in real-world scenarios. Participants will have an opportunity to ask the author questions about his books and gain insights discussed within them.

Learn more and register here.

Learn more about the IIBA and its membership advantages.

INCOSE San Diego Talk: On the Lovechild of AI and SE

The INCOSE San Diego chapter will host a hybrid event on 15 November 2023 featuring Dr. Art Villanueva, Chief Artificial Intelligence and Machine Learning Technology Architect for Dell Technologies' Federal Strategic Programs, presenting a talk titled *On the Lovechild of AI and SE*.

Synopsis:
As the worlds of Artificial Intelligence and Systems Engineering increasingly converge, understanding their intersection becomes pivotal for modern engineering endeavors. This presentation journeys through the evolution of AI, from its historical underpinnings with pioneering figures like Turing and Minsky to its contemporary resurgence powered by data, advanced algorithms, and unprecedented computational capabilities. Within the systems engineering landscape, AI offers transformative potential, aiding in tasks ranging from requirements engineering using Natural Language Processing to predictive maintenance through advanced analytics.

However, the integration of AI into systems is not without its challenges. Issues related to data quality, computational needs, model validation, and ethical considerations underscore the complexities of marrying AI with systems engineering. As we project into the future, the synergy between AI and systems engineering promises advancements in human-AI collaboration, the evolution of more efficient and transparent AI models, and the development of robust ethical and regulatory frameworks. This exploration emphasizes the importance of a thoughtful and informed approach to integrating AI into systems engineering, setting the stage for innovation while ensuring responsibility and efficacy.

Learn more and register.

Calling All Systems: Future of Systems Engineering (FuSE)

INCOSE continues with its Calling All Systems series of online panel discussions that brings together systems engineering thought leaders from around the globe to address topics that are important to systems engineering practitioners. Four events have been completed with video replays available via the embedded URLs.

- The Future of MBSE (21 March 2023)
- Are You Missing a Piece in your Digital Engineering Puzzle? (11 May 2023)
- Sustainability (19 September 2023)
- Models in Space (18 October 2023)

On 17 November the series will continue with a focus on the *Future of Systems Engineering (FuSE)*.

Register here.

CONFERENCES, MEETINGS & WEBINARS

Call for Submissions: Conference on Systems Engineering Research (CSER 2024)

The 21st Annual Conference on Systems Engineering Research (CSER 2024) will be held on 25-27 March 2024 at the University of Arizona in Tucson, Arizona, USA. CSER 2024 has issued a Call for Submissions inviting researchers and practitioners to offer contributions that advance the state of the art in systems engineering.

CSER seeks four types of submissions:

- Full papers (maximum 10 pages) for full peer review and presentation
- Short papers (maximum 4 pages) for full peer review and presentation
- Abstracts (maximum 2 pages) for poster presentation and/or lightning talk
- Proposals for workshops, discussions, and/or interactive sessions (maximum 2 pages) on special topics of interest to the CSER community

Current and prospective doctoral students are also invited to attend the Systems Engineering & Architecting Network for Research (SEANET) workshop on 25 March 2024.

Suggested research topics include:

- Advances in Model-Based Systems Engineering (MBSE)
- Advances in requirements engineering, systems architecture, systems integration, and verification and validation.
- Artificial Intelligence for Systems and Software Engineering (AI4SE)
- Cybersecurity and System Security Engineering
- Digital Engineering, Digital Twins
- Digital Transformation
- Human-Systems Integration
- Scientific Foundations of Systems Engineering
- Social Systems Engineering
- Systems and Software Engineering for Artificial Intelligence (SE4AI)
- Systems of Systems
- Systems Thinking
- Trust and Autonomous Systems
- Uncertainty and Complexity Management
- Value-based and Agile Systems Engineering

Deadlines:

- Draft paper submission: 15 November 2023.
- Review comments to authors: 5 January 2024.
- Final paper: 15 February 2024.

View the CSER 2024 Call for Submissions.

Learn more about CSER 2024.

INCOSE Los Angeles/San Diego One-Day Conference

The INCOSE Los Angeles and San Diego chapters will be jointly hosting an in-person conference on Saturday, 2 December 2023 at the Dassault Systemes Biovia Corp. building in Sorrento Valley, San Diego, California, USA.

Keynote:
The keynote talk for this event will be *What a Systems Engineer Should Know about Artificial Intelligence* by Dr. Rick Hefner, Program Director for the Caltech Center for Technology and Management Education. Dr. Hefner is credited with over 200 presentations and publications, and is a past President of the INCOSE Los Angeles chapter.

As the integration of Artificial Intelligence (AI) continues to reshape industries, including the emergence of ChatGPT, it becomes increasingly important for systems engineers to possess a foundational understanding of AI technologies and their implications. This presentation provides a comprehensive overview of the key concepts, challenges, and opportunities that AI brings to the world of systems engineering.

The presentation begins by elucidating the fundamental principles of AI, including machine learning, neural networks, and deep learning. It emphasizes the significance of data in training AI models and explores the spectrum of AI capabilities, from narrow to general intelligence. Recognizing the collaborative nature of systems engineering, the presentation delves into the interdisciplinary aspects of AI integration, shedding light on how systems engineers can effectively collaborate with data scientists and AI specialists to design, develop, and deploy AI-powered systems. Examples from current industry efforts are presented, and the presentation concludes with a discussion of how AI is changing the SE process.

This keynote will equip systems engineers with the knowledge they need to make informed decisions about AI integration within the systems they design and manage, fostering a harmonious synergy between traditional engineering principles and cutting-edge AI technologies.

Check back here to view the evolving program.

Registration is limited to 90 individuals. Register here.

Call for Papers: NASA Formal Methods Symposium 2024

The 16th NASA Formal Methods Symposium (NFM 2024) will be held on 4-6 June 2024 at the NASA Ames Conference Center at Moffett Field, California, USA. The NASA Formal Methods Symposium is a forum to foster collaboration between theoreticians and practitioners from NASA, other government agencies, academia, and industry, with the goal of identifying challenges and providing solutions towards achieving assurance for such critical systems. The focus of this symposium is on formal techniques for software and system assurance for applications in space, aviation, robotics, and other NASA-relevant safety-critical systems. This year's symposium extends the focus to safety assurance of machine learning enabled autonomous systems, formal methods for digital transformation, and accessibility for new industries.

NFM 2024 has issued a Call for Papers that includes topics of interest such as:

- Advances in Formal Methods
- Integration of Formal Methods

- Formal Methods in Practice
- Safety Assurance of Autonomous Systems
- Formal Methods for Digital Transformation
- Accessibility of Formal Methods for New Industries

NFM 2024 seeks two types of submissions:

- Regular papers (15 pages including references), describing fully developed work and complete results.
- Short papers (6 pages including references) on tools, case studies or emerging ideas.

Important Dates:

- Abstract submission: 1 December 2023.
- Full paper submission: 8 December 2023.
- Notification: 16 February 2024.
- Camera-ready version: 15 March 2024.

Learn more about NFM 2024.

Call for Papers: 10th International Conference on Rigorous State Based Methods (ABZ 2024)

The 10th International Conference on Rigorous State Based Methods (ABZ 2024) will take place on 25-28 June 2024 in Bergamo, Italy. The ABZ conference is dedicated to the cross-fertilization of state-based and machine-based formal methods, like Abstract State Machines (ASM), Alloy, B, TLA, VDM, and Z, that share a common conceptual foundation and are widely used in academia and industry to design and analyze hardware and software systems. The conference aims to exchange knowledge and experience among the research communities around different formal methods.

ABZ 2024 has issued a Call for Papers that seeks the following types of submissions for the Main Track of the Conference (with page count limitations shown in parentheses):

- Full research papers (16 pages excluding references).
- Short papers to present and validate a work in progress or tool demonstrations. (6 pages excluding references).
- Application in industry papers that report on work or experiences on the application of state based formal methods in industry (8 pages excluding references).
- Journal-First papers that summarize recently published papers in high-quality journals (6 pages excluding references).

Important Dates for Main Track Submissions:

- Abstract submission (optional): 3 February 2024.
- Paper submission: 10 February 2024.
- Notification: 6 April 2024.
- Final version: 20 April 2024.

Separate calls for other portions of the Conference are shown below with first submission deadlines:

- Tutorials and Workshops (1 December 2023)
- Case Study (3 February 2024 abstract; 10 February paper)
- Doctoral Symposium (24 February 2024)

Learn more about previous ABZ conferences.

Call for Papers: IISE Annual Conference and Expo 2024

The Institute of Industrial and Systems Engineers (IISE) is the global association of productivity and efficiency professionals specializing in industrial engineering, healthcare, ergonomics and other related professions. IISE is where these varied fields come together to advance the engineering profession through networking, training, and knowledge sharing.

The IISE Annual Conference and Expo 2024 will be held on 18-21 May 2024 in Montreal, Canada. IISE has issued a Call for Papers that invites diverse practitioners to share their insights and solutions with their peers. Presentations should cover overall content of the profession instead of focusing specifically on research or applied solutions.

Important Dates:

- Abstract submission: 17 November 2023.
- Abstract decision: 29 December 2023.
- Paper submission: 9 February 2024.
- Paper decision: 15 March 2024.
- Final schedule: 12 April 2024.

Learn more about the 2024 Conference and Expo.

Call for Contributions: IEEE International Requirements Engineering Conference (RE'24)

The 32nd IEEE International Requirements Engineering Conference (RE'24) will take place in Reykjavik, Iceland from 24-28 June 2024. The theme of RE'24 is *Exploring New Horizons: Expanding the Frontiers of Requirements Engineering*. The conference invites submissions that challenge existing perceptions of requirements engineering, shed light on its intersections with other software engineering activities, fields, and endeavors, and push beyond its established boundaries.

Content for RE'24 is organized into the following tracks, with first submission due dates shown in parentheses.

- Workshop proposals (10 November 2023)
- Research Track (19 January 2024 for abstracts; 26 January 2024 for papers)
- RE@Next! and Industrial Innovation Papers (2 February 2024 for abstracts; 9 February 2024 for papers)
- Tutorial proposals (9 February 2024)
- Doctoral Symposium (8 March 2024).
- Journal-First (8 March 2024).
- Posters, Tool Demos, Artifacts and Workshop papers (27 March 2024)

See the RE'24 Call for Contributions.

Learn more about RE'24.

FEATURE ARTICLE

Rethinking Requirements Derivation – Part 1

by John Fitch

Project Performance International

Authored for PPI SyEN

Introduction

Three prior articles in PPI SyEN have laid the foundation for this topic.

In the article *Introduction to Decision Patterns* in PPI SyEN Edition #107 (December 2021), a decision was defined as a "fundamental question or issue that demands an answer or solution", the Decision class (of information) was distinguished from the Alternative class, and the concept of *decision-to-requirements derivation traceability* was introduced.

In the article *Decision Patterns – So What?* in PPI SyEN Edition #111 (April 2022), a decision-centric information architecture (metamodel) was elaborated that explained the conceptual basis behind decision-to-requirements derivation traceability. Derived requirements were stated to be the inherent consequences that flow from the definition of the solution alternative that has been chosen in an "upstream" decision. In other words, "all requirements are derived requirements" and "decisions create requirements".

In the article *Reverse Engineering Stakeholder Decisions from Their Requirements* in PPI SyEN Edition #113 (June 2022) decision-to-requirements traceability was presented as the basis for the ability to reverse engineer stakeholder choices and to validate and refine a set of stakeholder requirements. A requirements derivation heuristic was introduced in the form of a question to be applied to each "upstream" decision:

"How does the chosen alternative's Structure, Behavior, Footprint, Interfaces and Lifecycle impose constraints on the rest of the system?"

In the second article, four assertions were stated as "givens" based on the author's experience with capturing decision-to-requirements traceability across 150+ customer projects:

- There is a decision pattern behind any strategy or design.
- Decisions (through the alternative chosen) are the source of all requirements.
- The Decision -> chooses -> Alternative -> results in -> Requirement traceability thread may be traversed in either direction.
- Elaborating alternatives in the form of detailed textual descriptions and models (physical, logical, 3D, etc.) is useful in understanding their derived requirements consequences.

PPI SyEN readers are encouraged to take a quick read through these prior articles to gain a fresh grasp of these foundational ideas.

This article will explore in more detail how different types of requirements may be derived from a pattern of six decisions that must be made when defining how system-level functions will be delivered by a solution design. This six-decision pattern within the broader system/product design decision pattern forms a reusable *solution design kernel* that may be applied to elaborate the physical and functional design of any system.

Part 1 of this topic will summarize the theory and principles behind decision-centric requirements derivation using the six-decision pattern. Part 2 (to be published in a subsequent edition of PPI SyEN) will provide a working example of the theory in practice.

System/Product Design Decision Pattern

The System/Product Design decision pattern was the first pattern developed by the author and has been the most frequently used pattern across multiple industries and domains. [1], [2] The full pattern has ~100 decisions.

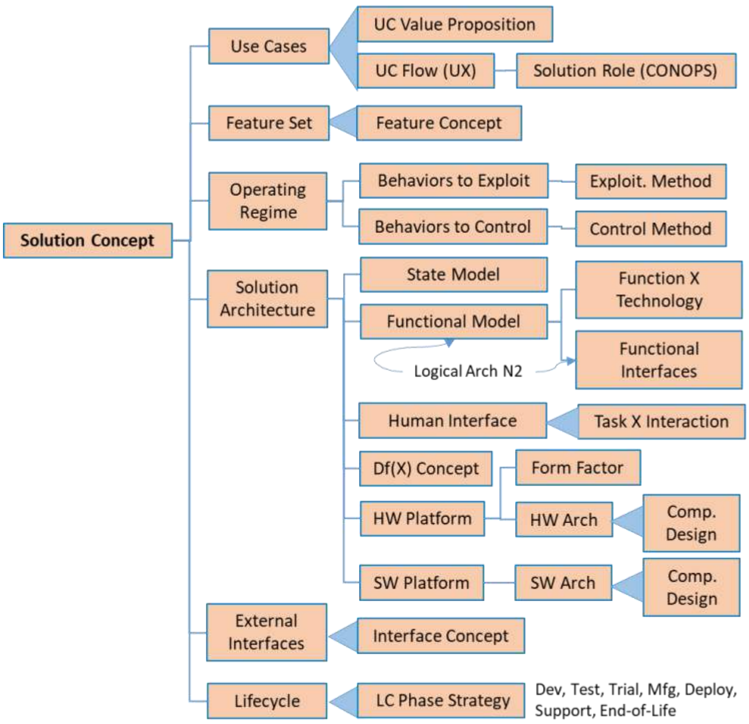


Figure 1 – Generalized Top-Level System/Product Design Decision Pattern

Experience in using decision patterns across a wide variety of projects has taught the author the importance of flexibility; the pattern should not be applied rigidly with every branch and node captured with the same rigor or level of detail. In some cases, a "flat" Top Five or Top Ten Decisions List is sufficient to guide the decision-making on a project. In other cases, a fifty or one hundred decision hierarchical model is called for based on the problem at hand, e.g., a mission-critical system with high novelty and technical complexity. Refactoring the model is also a common occurrence; decisions may be merged or split depending on the nature of the problem being addressed and judgments as to where more or less detail will reduce complexity and improve decision quality and decision analysis efficiency.

The six-decision pattern described below is an example of such refactoring to match the need to provide a reusable design kernel that illustrates the typical decision-to-requirement-to-decision interactions between the design choices.

Reusable Design Kernel

Few products deliver a single system-level function or lend themselves to *mirroring* in which the physical decomposition (Component 1-N) of the solution precisely matches the functional decomposition (Function 1-N) of the problem.

Complete alignment is needed between the physical and functional models; the functional model is always the logical representation of the physical solution concept. If the functional and physical models are not aligned, one or both of them are wrong.

Engineering would be simpler if we could represent all the thinking that it takes to transform a problem definition into a full solution as a single decision for each branch of the system decomposition. However, this is impractical. That single decision would have too many criteria (hundreds?) and alternatives (thousands?) to consider in a single decision analysis. Whether using a formal decision pattern or done in an ad hoc fashion, design is generally broken down into a manageable set of decisions. The advantage of a pattern is the ability to reuse lessons learned during previous designs and reduce the cognitive effort needed on the current project.

Table 1 summarizes the six decisions that will be made (preferably as a result of explicit analysis) during the design of an implementable physical solution to virtually any problem. Note that this is a decision pattern; there may be multiple instances of these decisions made during a design project.

Decision Name	Decision Description	Decision Class
Function X Technology	What technology, method, design approach or algorithm will be used to deliver this function?	Single Answer
Logical Architecture / Functional Model	What is the solution's top-level functional model/architecture (functional flow, relationships)?	Multi-part Answer
Physical Architecture	What is the solution's physical architecture (hardware/software components, allocated functions)?	Multi-part Answer
Component N Supplier / Model #	Who will supply this hardware component? What model number will we use?	Single Answer
Interface Concept	How will this Component-Component interface be implemented?	Single Answer
Form Factor / Packaging / Layout	What form factor (mechanical packaging or layout concept) will be used for the solution?	Single Answer

Table 1 – Decision Pattern – Design Kernel

Function X Technology

Products and systems are typically part of a larger portfolio of solutions. Each product fills a niche in that portfolio based on its value proposition relative to other offerings. Given that role (the essence of the product concept), system-level functions are derived from use case, feature set, external interface and life cycle decisions that "scope" the product. [3] Each system-level function (those that have been allocated to the system-of-interest within an approved use case) will require a decision that addresses how the function will be delivered by the system of interest. Typically this decision is expressed as a "How?" choice between technologies (in the case of most hardware systems), methods (in the case of process design), algorithms (in the case of software) or overall solution design approaches.

External interface decisions "bound" the functionality of the system of interest by specifying the inputs that the system has to able process and the outputs that the system has to be able to generate to interact as desired (by the stakeholders) with the outside world.

Life cycle decisions "birth" new system functions that support system functional interactions with enabling systems such as testing, manufacturing, deployment, support and end-of-life.

As shown in Figure 2, these product scoping decisions set the context for using the solution design kernel recursively down the system breakdown structure one "branch" at a time. Used first at the system-level to define next-level system elements, the pattern may then be reapplied for the design of each system element until no more design effort is required, i.e., when off-the-shelf (OTS) components or non-developmental items (NDI) are all that are needed to describe a buildable solution.

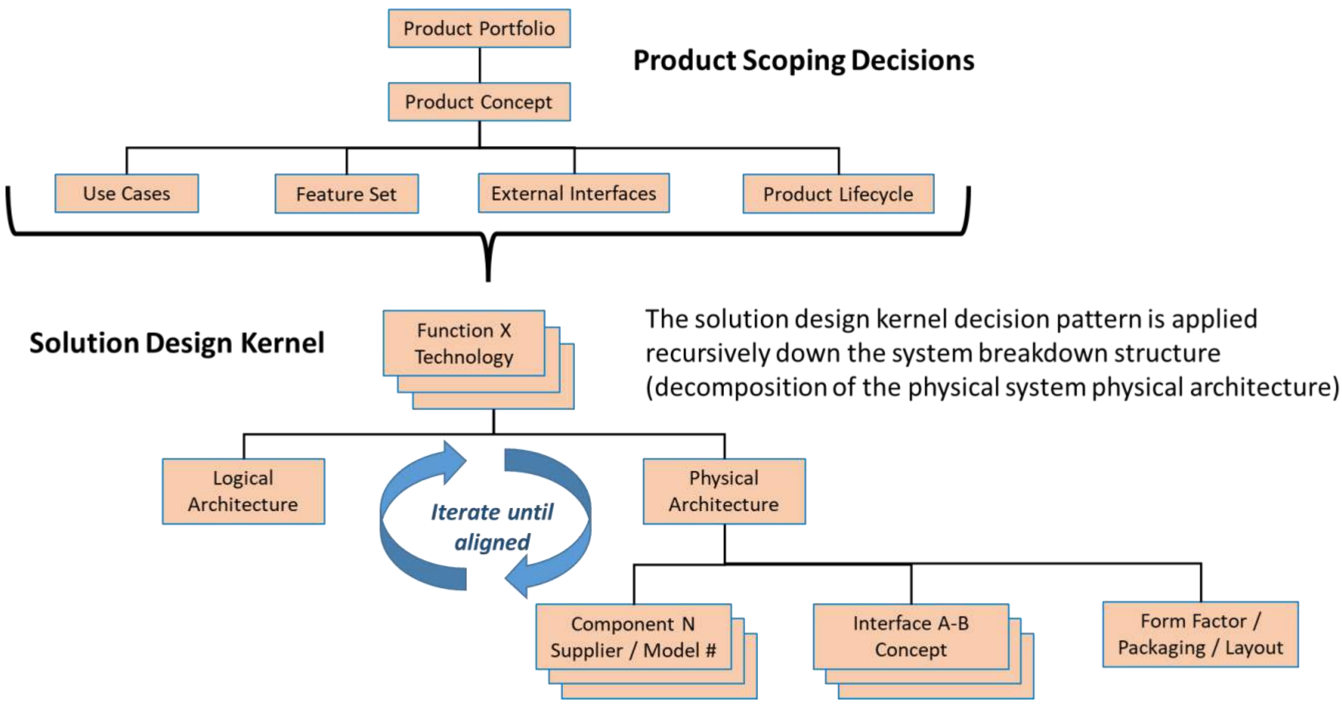


Figure 2 – Product Scoping Decisions Set the Context for Recursive Use of the Solution Design Pattern Kernel

Multiple functions may be addressed in a single decision analysis (Choose Technologies for Functions X, Y & Z), but every system-assigned function must be covered in at least one such decision. "How" must be decided; it is better if that is done through an explicit decision-making process rather than being buried within a system architectural model that lacks recorded rationale that can be revisited if/when things change.

The *Function X Technology* decision expects a single answer (one alternative, committed for implementation; down-selected from all other options) except in cases where functional redundancy is demanded.

As shown in Figure 3, the *Function X Technology* decision is the primary source of derived functional requirements (FRs) and associated performance requirements (Measures of Performance – MOPs) on the next-level system elements. As such, each such decision drives the decomposition of the system functions into solution-level functions and also drives the mathematical relationships (flowdown) between system-level MOPs and solution-level MOPs.

It is important to remember that decisions create requirements based on the alternative chosen. When using decision patterns, a decision is a fundamental question or issue that demands an answer or solution. It is the alternative that emerges as the winner from the decision analysis process that has inherent consequences based on the alternative's structure, behavior, footprint, interfaces and lifecycle.

Consequences that were "attached" to not-chosen alternatives are moot as soon as the decision is made unless the chosen alternative doesn't "pan-out" and the decision has to be revisited.

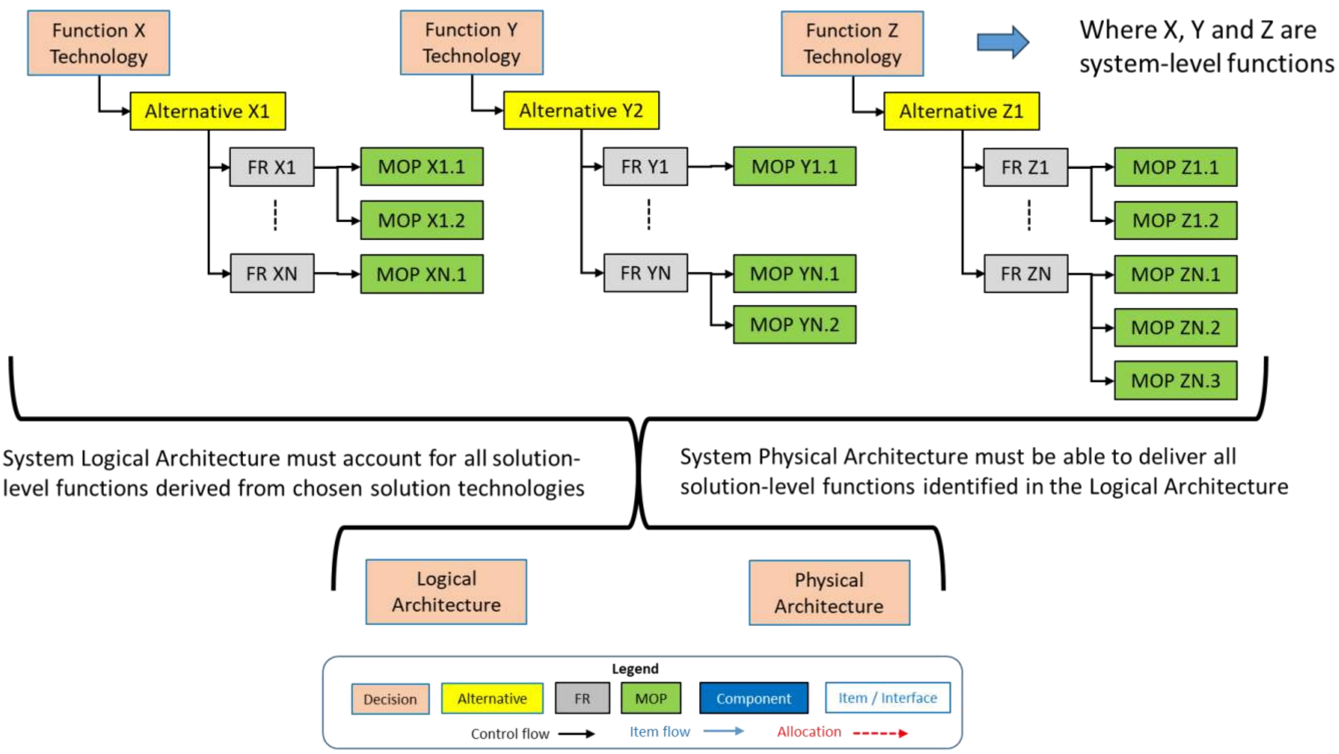


Figure 3 – Requirements Derivation from Technology Decisions

Logical Architecture / Functional Model

The *Function X Technology* decision may drive the functional decomposition and performance flowdown, but it doesn't typically populate and resolve all aspects of the solution-level functional model. A technology or method may be implemented in multiple ways, each of which might yield variants in control flow (sequencing of functions), item flow (of information, material or energy between functions) or handling of anomalous inputs or system faults.

More significantly, the system's logical architecture must balance the needs of all system functions. The best technology (and therefore next-level decomposition) for Function X may not mesh well with the best decomposition of Function Y and Function Z, leading to design iteration resolved through a higher-level tradeoff. Such a multi-decision tradeoff is common when combinations of new technologies are being evaluated.

The *Logical Architecture / Functional Model* decision is a multi-part answer decision for which the best representation of each alternative is some form of functional model (e.g., boxes and arrows). In a very simple case, a functional decomposition hierarchy may suffice, but typically a more comprehensive and notationally-rigorous model is needed such as a Functional N-Squared Diagram, Functional Flow Block Diagram (with control and item flow) or Activity Diagram.

The *Logical Architecture / Functional Model* decision creates behavioral requirements consistent with the previously-chosen technologies. These requirements express dependencies between functions and precisely specify functional interactions in terms of inputs/outputs and their characteristics.

Physical Architecture

The functional and performance requirements derived from the *Function X Technology* and *Logical Architecture / Functional Model* decisions must eventually be realized in physical entities, e.g., hardware components, software modules, facilities, human actors or data stores. The *Physical Architecture* decision creates:

- The physical implementation and configuration of chosen technologies.
- Allocation of functional and performance requirements to newly-defined system elements.
- Requirements for physical interfaces between these elements to pass the item flow represented by the functional model.

There is often a high-degree of iteration needed between the logical and physical architectures of the system. The functional model, by detailing out the behavior needed by the system, helps refine the physical architecture by specifying what has to pass between functions and the characteristics (e.g. bandwidth, geometry, etc.) of the physical interfaces needed to ensure that this item flow delivers what is needed from each allocated function. The specification of the item flow between functions also helps to clarify the definition of each function by making explicit which inputs will be transformed into which outputs when each function is performed.

Figure 4 illustrates this complementary relationship between logical and physical system models. The logical architecture model is shown in the form of a Functional Flow Block Diagram with both control and item flow. The physical architecture model is shown as a Schematic Block Diagram. The red arrows represent allocation of functional requirements (and associated MOPs, not shown) to system elements, aka Configuration Items (CIs).

Control flow (functional dependencies) is shown as black arrows. Item flow (e.g., Item A, B, etc.) is shown as blue arrows. If two functions (with item flow between them) have been allocated to two different system elements, there must be a corresponding physical interface (e.g., IF1-2, IF2-3) between those system elements that can “pass” the items.

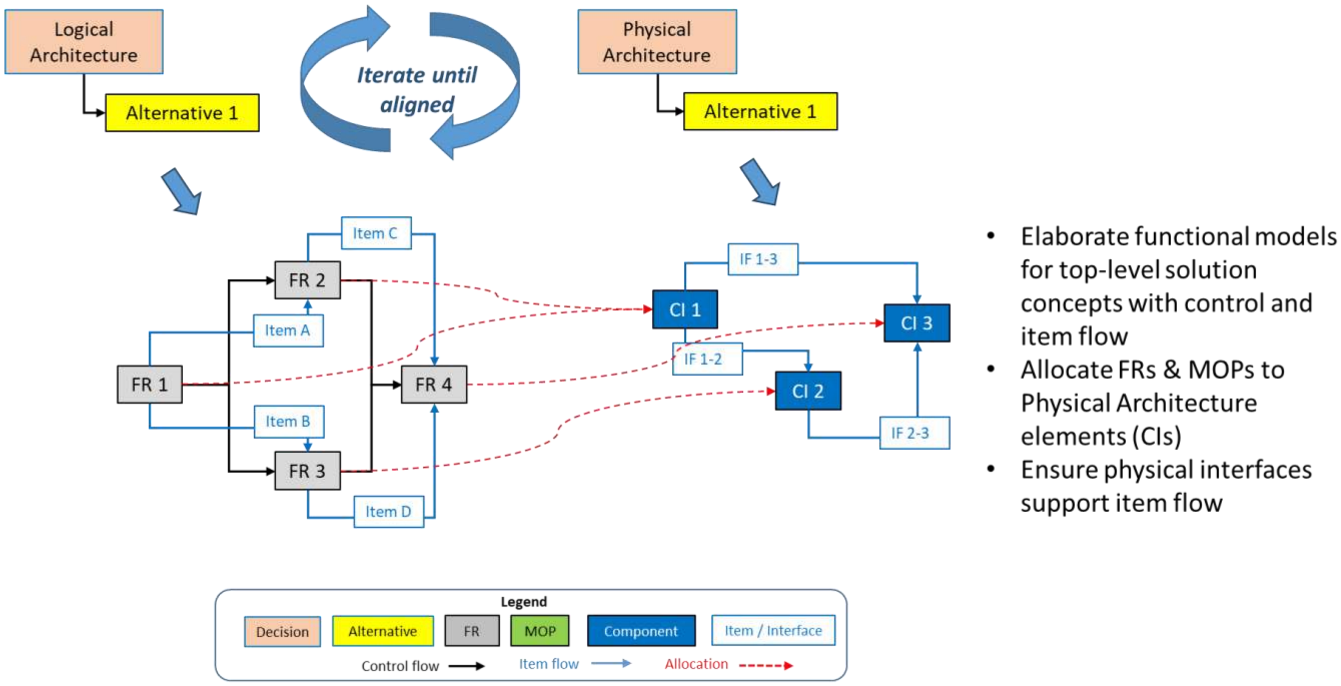


Figure 4 – Aligned Logical and Physical Architecture Viewpoints Linked by Allocation

The *Physical Architecture* decision is a multi-part answer decision for which the best representation of each alternative is some form of architectural model. In a simple case, a system breakdown structure (hierarchy of system elements) may suffice, but typically a more comprehensive and notationally-rigorous model is needed such as an physical N-Squared Diagram or Schematic Block Diagram.

The *Physical Architecture* decision gives birth to all system elements and the interfaces between them. As such, this decision is the point where the physical decomposition of the system into next-level elements occurs and "existence" requirements are created that define the next-level structure of the solution.

<u>*Component N Supplier / Model #*</u>

Each system element conceived in the *Physical Architecture* decision must be "sourced" as either an off-the-shelf (OTS) component or non-developmental item (NDI) or as a developmental item that requires design, verification and validation effort. If the *Physical Architecture* decision committed to an architecture comprised of ten system elements, we would expect ten discrete *Component Source/Model #* decisions. Each of these decisions, aka *Make (by whom)/Buy (from whom)* choices, will result in commitment to a particular sourcing strategy. In the case of an OTS/NDI solution, the alternatives are represented by a vendor name, component name, its associated model number and likely some form of data sheet that describes the characteristics of the component.

The *Component Source/Model #* decision is a typically single answer decision unless multiple vendors/sources are sought to mitigate risks to component availability or from vendor turnover.

OTS/NDI solutions create footprint, interface and lifecycle constraints. These are already-designed solutions that:

- Have a known footprint (e.g., take up space in 3D, consume power, require cooling or communications bandwidth).
- Have defined interfaces (e.g., mechanical, electrical, thermal, hydraulic, data, user).

- Must have lifecycle characteristics that support their manufacturing, testing, deployment, upgrade, support or disposal/recycling.

If the sourcing decision commits to the use of developmental items, these same characteristics must be captured in the developmental item's specification so that the impact on overall system constraints (e.g., footprint budgets, interfaces, lifecycle compatibility) may be managed.

Interface Concept

As noted above, the *Physical Architecture* decision gives birth to all the interfaces between system elements. This implies an *Interface Concept* decision for each physical interace, e.g., *CI1-CI2 Interface Concept*. The number of these decisions required is entirely dependent on the system physical architecture and can be "read" quickly from the number of "off-diagonal cells" if the physical architecture is represented by an N-Squared Diagram. In many cases, these decisions lend themselves to common solutions such as a data bus or common set of OTS physical fasteners.

The appropriate format for defining an interface concept varies widely depending on whether the interface is passing information, energy or matter.

The *Interface Concept* decision is a single answer decision unless interface redundancy is required to meet reliability or failure response requirements.

The interface requirements that are derived from this decision may be documented in an Interface Requirements Specification (IRS) or as an Interface Requirements section with the specification for each system element.

Form Factor / Packaging / Layout

All physical systems have constraints, e.g., external interface and lifecycle, on their overall space claim and many have requirements, e.g., aesthetics, usability, or safety, that influence their layout/shape. The physical configuration of the system elements matters; their layout may influence the ability to achieve performance requirements.

The alternatives chosen in the *Component Source / Model #* decisions when "added" together define the volume of the system elements that must be arranged in a layout that fits within the physical constraints of the system. Most modern systems suffer from stakeholders' desire to deliver "10 pounds of functionality in a 5 pound box - yesterday". The *Form Factor / Packaging / Layout* decision attempts to fit these elements into a configuration that doesn't exceed system physical footprint (volume) or resource constraints or impede the achievement of performance requirements. Many performance requirements are impacted by the distance between parts and their relative orientation; as products are miniaturized these proximity-related effects increase.

The *Form Factor / Packaging / Layout* decision is a single answer decision unless variant form factors are needed based on business requirements.

Solution alternatives in this decision are typically captured as 3D CAD files, although sketches may suffice for simple solutions.

Conclusions

The fundamental principle highlighted in this article is that decisions (through the alternative chosen) are the source of all requirements. Different decisions (from a proven pattern) generate different types of requirements.

Requirements may be sorted into types; defining requirement by type helps requirement analysts, solution designers and specification writers. Table 2 identifies the PPI's recommended scheme for requirement types and extends that scheme by identifying which decisions in a typical decision pattern (or the six-decision design kernel) are the most likely source of each type of requirement.

Requirement Type	Definition	Derived From Which Decisions?
States & Modes	Conditions & modes of operation	*State Model* decision. Failure states may be identified as part of the risk assessment included in *Use Case* and *External Interface* decisions. Modes are aggregates of system functionality.
Functional	What is the system to do?	System-level FRs are derived from *Use Case* decisions. Solution-level FRs flow directly from *Function X Technology* decisions or indirectly as failure response FRs that come from risk assessment and mitigation planning.
Performance	How well must each function be done?	System-level MOPs are derived from *Use Case* decisions. Solution-level MOPs are "birthed" in *Function X Technology* decisions and defined mathematically through the *Physical Architecture* and *Logical Architecture* decisions (by a process too complex to be address herein).
External Interface	Boundary conditions	*External Interfaces* and *External Interface A-B Concept* decisions, represented as a system context diagram.
Environmental	Boundary conditions	From the range of environmental condition faced by alternatives in the *External Interfaces* decision.
Resource	What will be consumed/used?	From the externally-supplied resources identified through the *External Interfaces* decision.
Physical	Physical properties of the system as a whole	From the footprint constraints identified in the *External Interfaces* and *Lifecycle* decisions.
Other Qualities	General attributes	The *Lifecycle* decisions are the primary source, but given the breadth of "ilities", almost any decision can result in derived "Other Qualities" requirements.
Design	Directed design	Directed design requirements are, by definition, those that specify internal characteristics of a system or system element. These stakeholder-imposed requirements take away decision-making freedom from the solution designer.

Table 2 – Requirements Derivation by Type

The content of this article lays down the conceptual foundation for using a decision pattern (in general) and the solution design kernel (in particular) as the starting point for next-level requirements derivation. PPI SyEN readers are encouraged to look for the follow-on article that will provide a detailed example of these principles in action.

References

[1] Fitch, J.A. 2006. "Decision Driven® Design – Achieving Product and Process Breakthroughs". Workshop participant guide, delivered in multiple workshops during 2006.

[2] Mendonza, P. and Fitch, J.A. 2012. "Decision Management (DM) as the engine for scalable, crossdomain Systems Engineering". Paper presented at 22nd Annual International Symposium of the International Council on Systems Engineering, Rome, Italy, 9-12 July.

[3] Fitch, J.A. 2016. "Product Scoping Decisions", https://decisiondriven.wordpress.com/2016/08/30/product-scoping-decisions/, 30 August.

About the Author

John Fitch is a Principal Consultant and Course Presenter with Project Performance International. John brings over four decades of systems engineering, engineering management, consulting and training experience to PPI's clients. 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: Systems Engineering in Early-stage Research and Development (ESR&D)

The September 2023 edition (Volume 26, Issue 3) of INSIGHT, INCOSE's Practitioner Magazine published by Wiley, has been released. Electronic subscriptions to INSIGHT are available as a member benefit to INCOSE members. Hard-copy subscriptions to INSIGHT are available for purchase by INCOSE members for one membership year, and to the public.

The focus of this issue is *Systems Engineering in Early-Stage Research and Development: Bridging the Gap*. Contents of this 68-page document includes:

Systems Engineering Management in Research and Development Valley of Death
by Michael DiMario and Ann Hodges

A failure of a great many early research and development programs is the result of encountering the traditional valley of death that shadows early research and technology development. The elements that create the valley of death leads to research and technology development high risk and poor return on investment for a great many research and development organizations. This leads eventually to avoiding research and technology development all together because the organizations cannot viably manage the outcome of their early-stage research and development (ESR&D) efforts. Unfortunately, there are few established frameworks and processes for enabling smooth transitions to avoid failure and manage risk across fundamental research, applied research, development, and productization. Many leaders, program managers, and scientists are unwilling to involve systems engineering because of the perception that systems engineering is heavily process oriented, adds unnecessary costs, and should be applied only to mature technologies. The value of systems engineering as applied to ESR&D is unclear to these key individuals. The unfortunate result is that systems engineering is not applied to ESR&D. This article discusses the potential of application of systems engineering to ESR&D to improve return on investment and decrease risk.

A Bridge Blueprint to Span the Chasm Between Research and Engineering - A Framework for Systems Engineering in Early-Stage Research and Development
by Ann Hodges and Arno Granados

Researchers and funding organizations often do not understand the value of systems engineering in early-stage projects (technology readiness levels TRL 1-5), during which systems engineering may be viewed as an unnecessary cost, and as a process heavy effort applicable only for mature technologies. This may result in a relative lack of engineering rigor and lack of understanding of innovation context which often contributes to failures in the "valley of death" between fundamental research and applied development.

We argue there is more than one pathway for crossing the valley of death, and that relevant application of systems engineering implemented at an appropriate level of rigor provides a foundation for transition and use of technical innovation. This article discusses the principles and foundational elements necessary for development and use of a framework for systems engineering applicable in early-stage research and development (ESR&D), including tailoring considerations associated with TRL and stakeholder roles. Associated framework metrics are suggested to enable evaluation and practical implementation of the framework for systems engineering innovation management at this phase of technology development.

Systems Engineering in Technology Development
by Jaime Sly and David Crowne

Technology development is the crucial first step in designing new products and systems. It is a unique phase of product development in that it incorporates both scientific exploration and reduction to an engineered result. Too often, systems thinking and systems engineering principles aren't applied at this stage, leading to technologies that solve the wrong problems, inability to progress to higher maturity levels, and unworkable implementation architectures. In practice, this means higher development costs, extended timelines, and failed technology development projects. This article presents a framework for and provides guidance on systems engineering activities that add value and improve outcomes if applied during early stages of product development.

An Approach to Bridging the Gap Between the Attainment of Research Objectives and System Application
by Susan Ruth

The aerospace industry has widely adopted the use of technology readiness levels (TRLs), (NASA) which describe the maturity of a technology from earliest stages of research through the operational system. In using TRLs, it has been observed that bridging the gap between research on a technology and its incorporation by engineers into a system is challenging. Nominally, the transition from TRL 4, defined as a component and/or breadboard validation in a laboratory environment, to TRL 7, defined as a system prototype demonstration in an operational environment, is a programmatic gap known as the "valley of death." The valley of death is a schism whereby the component that incorporates the new technology fails to meet the eventual system requirements.

The goal of this paper is to provide a methodology and "language" that enables the researchers and engineers to communicate more effectively to traverse this gap. The basis for this methodology is the combination of established methods for communicating progress for a program combined with the development and application of domain assessments. Domain readiness levels (DRLs), analogs of the TRLs, are specific to the domains relevant to the system of interest. Specifically, the methodology is intended to enable two-way communication between the domain experts and the systems engineer, with the goal of effective incorporation of a technology. This paper will use an example of the approach to bridge the "valley of death" targeted on the development of a satellite composites optical support structure that must stay in focus across the temperature range of 77-323 degrees Kelvin. In this example, the communication will use two relevant domains, materials and processes, to illustrate the methodology.

Enhancing Early Systems R&D Capabilities with Systems - Theoretic Process Analysis
by Adam D. Williams

Systems engineering today faces a wide array of challenges, ranging from new operational environments to disruptive technological - necessitating approaches to improve research and development (R&D) efforts. Yet, emphasizing the Aristotelian argument that the "whole is greater than the sum of its parts" seems to offer a conceptual foundation creating new R&D solutions. Invoking systems theoretic concepts of emergence and hierarchy and analytic characteristics of traceability, rigor, and comprehensiveness is potentially beneficial for guiding R&D strategy and development to bridge the gap between theoretical problem spaces and engineering-based solutions. In response, this article describes systems–theoretic process analysis (STPA) as an example of one such approach to aid in early-systems R&D discussions. STPA - a 'top-down' process that abstracts real complex system operations into hierarchical control structures, functional control loops, and control actions - uses control loop logic to analyze how control actions (designed for desired system behaviors) may become violated and drive the complex system toward states of higher risk. By analyzing how needed controls are not provided (or out of sequence or stopped too soon) and unneeded controls are provided (or engaged too long), STPA can help early-system R&D discussions by exploring how requirements and desired actions interact to either mitigate or potentially increase states of risk that can lead to unacceptable losses. This article will demonstrate STPA's benefit for early-system R&D strategy and development discussion by describing such diverse use cases as cyber security, nuclear fuel transportation, and US electric grid performance. Together, the traceability, rigor, and comprehensiveness of STPA serve as useful tools for improving R&D strategy and development discussions. Leveraging STPA as well as related systems engineering techniques can be helpful in early R&D planning and strategy development to better triangulate deeper theoretical meaning or evaluate empirical results to better inform systems engineering solutions.

Digital Engineering Enablers for Systems Engineering in Early-Stage Research and Development
by Arno Granados and Celia Tseng

Robust systems engineering is perceived as an unnecessary cost and schedule burden when the goal is proof of concept in an early-stage project (TRL 1-5). In reality the majority of industry, as opposed to academic, early-stage research and development (ESR&D) efforts are generally not "pure research", but instead focus on technology development for the purpose of technology transition to applied development and technology insertion into new or existing products. To overcome the barriers, an early and active end-user focused system engineering approach is needed to build the use cases to support the transition from fundamental research to applied development. Digital engineering (DE) enablers can lower the transition investment cost through the use of agile methodologies, reference architectures, and model-based design and manufacturing capabilities. End-to-end digital continuity from ESR&D to manufacturing and sustainment facilitates early discoveries of transition risks, which enable informed decision-making to mitigate pitfalls leading to the "valley of death."

This article leverages efforts associated with Industry 4.0, digital engineering transformation and INCOSE working group efforts to illustrate how a systems engineering approach based on DE concepts facilitates rapid instantiation of key systems engineering process and elements in ESR&D projects. This approach is both enabling to foundational ESR&D efforts, and transformational in building a bridge across the valley of death to foster success in technology transition to product. An agnostic tool, standards-based framework is presented, and specific tools are used to illustrate ESR&D transformation.

Incorporating Digital Twins In Early Research and Development of Megaprojects To Reduce Cost and Schedule Risk
by Christopher Ritter and Mark Rhoades

Early-stage research and development (ESR&D) plays a vital role in the product development lifecycle, necessitating innovative approaches to address the complex challenges faced during this phase. This article quantifies how the incorporation of digital twin (DT) technology can reduce cost and schedule risk during ESR&D and later lifecycle stages in megaprojects. The Idaho National Laboratory demonstrated the application of DT in the Microreactor AGile Non-Nuclear Experimental Testbed (MAGNET) operations phase, showcasing the transformative potential of DT in both design and operation. These advances allowed real-time assessment of construction changes and their impact on project requirements. By focusing on the benefits of digital twinning, this article aims to promote a more positive attitude toward the incorporation of digital twin technologies in the early stages of R&D projects.

Join INCOSE here to access this rich systems engineering resource.
Download the entire issue of INSIGHT Volume 26, No. 3.

Waters Center: Systems Thinking Courses

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 offers a rich set of systems thinking courses, available at no cost. PPI SyEN readers are encouraged to peruse the available courses listed below and consider how these "bite-sized" (generally one-hour) sessions could accelerate your mastery of systems thinking.

Habits of a Systems Thinker Courses:
The Habits of a Systems Thinker courses help learners understand how systems work and how actions taken can impact results seen over time. The Habits encompass a spectrum of strategies that foster problem-solving and thoughtful reflection about systems of interest.

- #1: Beginning Your Systems Thinking Journey - Are you ready to begin your journey to becoming a systems thinker? This course helps prepare you for the learning that will take place in the Thinking Tools Studio by providing important definitions and reflection opportunities.
- #2: Makes Meaningful Connections Within and Between Systems - This course will help you identify important connections in systems, allowing you to deepen your understanding of systems as a whole and the parts within them. You will also learn how different systems connect to one another and practical ways to use this knowledge to produce new ideas and thoughts. This includes creating visual representations of causal connections.
- #3: A Systems Thinker Seeks to Understand the Big Picture - Learn what it means to see the "big picture" of a system. You will begin to understand how this view, in conjunction with attention to detail, can bring about a broader perspective and understanding of systems as a whole, goals, actions, boundaries of influence and more.
- #4: A Systems Thinker Changes Perspectives to Increase Understanding - Learn how systems thinkers aim to see situations, experiences, viewpoints, and more, through the eyes of others. By doing so, we can see beyond our own deeply-held viewpoints and increase our understanding.
- #5: A Systems Thinker Considers How Mental Models Affect Current Reality and the Future - Where do our viewpoints come from? Why do we place more or less value on certain things compared to others? In this course, you will learn about mental models and how they shape our views and actions, in addition to how surfacing our own mental models and those of others can deepen our understanding of system structure.
- #6: A Systems Thinker Observes How Elements Within Systems Change Over Time, Generating Patterns and Trends - Systems thinkers pay close attention to patterns and trends - even when they may not be immediately obvious. In this course, you will learn how to measure change and identify patterns and trends. By doing so, you can better understand your system of interest and get closer to your goals and desired outcomes.
- #7: A Systems Thinker Surfaces and Tests Assumptions - We all have beliefs and opinions - but what do we do when those beliefs are met with conflicting evidence? In this course, you will learn how to use listening strategies and visual tools to test your assumptions and weigh them against other viewpoints.

- #8: A Systems Thinker Recognizes that a System's Structure Generates its Behavior - Take an in-depth look at the design of systems and learn to recognize structures within your own systems of interest. Through examples and practice exercises, you will learn how to alter the design of systems to produce desirable outcomes and get you closer to reaching your goals.
- #9: A System Thinker Identifies the Circular Nature of Complex Cause and Effect Relationships - Take a deep-dive into the causal nature of systems. You will learn the role of feedback in cause and effect relationships, and how this can create either a balancing or reinforcing scenario. You will also learn how to use causal loop diagrams to identify relationships within systems.
- #10: A Systems Thinker Recognizes the Impact of Time Delays When Exploring Cause and Effect Relationships - Have you ever made a quick decision based on wanting instant gratification, only to experience unwanted consequences at a later time? In this course, you will come to understand why and how systems thinkers explore cause and effect relationships while recognizing the impact time can have on their decisions and actions.
- #11: A Systems Thinker Considers Short-term, Long-term and Unintended Consequences of Actions - How do you handle decision-making? Do you consider the short and long-term consequences of decisions? What happens when you make a decision for an immediate pay-off, but there are unintended consequences? In this course, you will learn the strategies systems thinkers use to ensure decisions and actions are carefully thought through to produce desired results.
- #12: A Systems Thinker Considers an Issue Fully and Resists the Urge to Come to a Quick Conclusion - Learn the process systems thinkers integrate for fully considering an issue. By taking the time to think things through, the more likely a high-quality outcome will be achieved.
- #13: A Systems Thinker Pays Attention to Accumulations and Their Rates of Change - Become familiar with elements in systems that change over time and how you can affect these elements by taking (or avoiding) certain actions.
- #14: A Systems Thinker Uses Understanding of System Structure to Identify Possible Leverage Actions - In previous courses, you learned how a system's structure generates its behavior. In this course, go one step further by using knowledge of system structure to identify points of leverage. You will practice drawing casual loop maps as a way to identify areas of leverage.
- #15: A Systems Thinker Checks Results and Changes Actions If Needed: "Successive Approximation" - We're all on a journey of continuous improvement - whether it's for our work, personal life, or the pursuit of acquiring a new skill, the act of improvement is a process. In this course, you will learn about successive approximation and the steps systems thinkers take when establishing a goal.

Tools of Systems Thinking Courses

Systems thinking utilizes a variety of tools that help make thinking visual. By using methods to take our thinking and reasoning outside of our minds and into a form that we can see and easily share with others, we can better understand current behaviors of a system and ways to operate within a system to create desired change.

- #1: Behavior-Over-Time Graphs (BOTGs) - Learn to draw behavior-over-time graphs to show patterns and trends, in addition to telling the story of a graph as a way to explain your assumptions about a system of interest.
- #2: The Ladder of Inference - Learn about mental models and their impact on systems. You

will also learn how to use the Ladder of Inference to recognize the reinforcing nature of our beliefs/actions, and how to use this tool to come to sound conclusions.

- #3: Stock-Flow Mapping - Learn to recognize and map key accumulations that change over time in a system. Through practice exercises, you will become comfortable with drawing a simple stock-flow map to help you analyze a system of interest.
- #4: The Iceberg - Use the systems thinking iceberg to deepen your understanding of how system structure generates patterns, trends and outcomes.
- #5: Causal Links - Learn about the importance of causal connections and their influence on systems. You will be able to tell the story of causal relationships and apply this to elements within your own system of interest.
- #6: Causal Connection Circle Mapping - Apply your knowledge of causal links from the previous course to learn and create connection circles and causal connections maps as a way to identify interdependencies in systems.
- #7: Causal Loop Diagrams Part 1: Reinforcing Feedback - Causal loop diagrams show feedback relationships that make up systems. Learn about reinforcing feedback and how to draw it as one of the two types of causal loops.
- #8: Causal Loop Diagrams Part 2: Balancing Feedback - As you learned in the previous course, causal loops are visual diagrams that show feedback relationships within systems. In this course, you will learn about balancing feedback, which is one of two types of causal loops.
- #9: Causal Loop Diagrams Part 3: Bringing Reinforcing and Balancing Loops Together - Explore various ways to use both reinforcing and balancing feedback loops to map a system of interest. It is highly recommended that you begin this course with a basic understanding of both reinforcing and balancing feedback. We encourage you to first take these two courses as prerequisites (Tools courses #7 and #8).

Systems Archetypes Courses
An archetype, as defined by dictionary, is a pattern or model of a person or thing that serves as a recurring example. In these courses, you will learn about systems archetypes - multi-loop, causal loop diagrams that represent behavior seen commonly in complex systems.

- #1: Fixes that Backfire - Learn about the Fixes that Backfire archetype. You will identify ways to recognize this pattern in your own system of interest and strategies to avoid unintended consequences that may arise as a result.
- #2: Success to the Successful - Learn to recognize and tell the Success to the Successful story. Through practice exercises, you will become comfortable with drawing a Success to the Successful archetype connected to a system of interest.
- #3: Limits to Growth/Success - This archetype is referred to as both Limits to Growth and Limits to Success, depending on the story you're telling. For brevity's sake in writing, we'll use the title Limits to Success, but may refer to both success and growth in examples. This course will help you identify the Limits to Success archetype and how to avoid constraints that hinder desired outcomes.
- #4: Escalation - Learn to identify escalation scenarios in your own systems of interest and explore strategies to break and prohibit the cycle from occurring.
- #5: Shifting the Burden - Learn to identify the Shifting the Burden archetype and the important difference between symptomatic and fundamental solutions and how they can impact a problem symptom.
- #6: Drifting Goals - Learn to identify ways to prevent giving in to pressure to lower a goal rather than wait to see if actions that have been taken would have eventually gotten you to

your original goal.

- #7: Tragedy of the Commons - Learn to recognize and apply The Tragedy of the Commons archetype. Through practice exercises, you will become comfortable with drawing the Tragedy of the Commons archetype and identify ways to avoid succumbing to the pattern.
- #8: Accidental Adversaries - Learn to recognize the accidental adversary dynamic when two people or groups are amicably working together toward a common goal and then, the actions of one person or group challenges and undercuts the success of another.
- #9: Repression and Revolution - Learn to identify, apply and prevent the Repression and Revolution archetype. This archetype occurs when official policies are perceived as repressive and members of an oppressed group join together to act defiantly.

Join WCST (create a free account) here.

Republished System Dynamics Classics

The System Dynamics Society (SDS) has republished two classic books, originally published by MIT Press in the 1960's, and instrumental to the study of industrial dynamics, business, and management. The SDS has updated *Growth of a New Product* by Ole C. Nord and *Resource Acquisition in Corporate Growth* by David W. Packer. In addition to digitizing the books, expert modelers Len Malczynski, Donald DeLand, Georgios Papachristos and Robert Ward have updated the original DYNAMO models into modern software (Stella, Vensim, and Studio). The updated models may be purchased independently from the books.

Growth of a New Product: Effects of Capacity-Acquisition Policies
by Ole C. Nord,
This book is the first in a series of publications on industrial dynamics research, originally published by The MIT Press in 1963. This illuminating monograph delves into the dynamic interplay between a firm's capacity acquisition policies and the growth of its market. Serving as an exemplar of the industrial dynamics approach to managerial challenges, this book provides profound insights into the management of companies, unveiling how managerial policies can significantly impact growth behavior. Growth of a New Product dissects the interactions between information flow, finance, orders, materials, inventory, personnel, and capital equipment within an organization, industry, or national economy, turning abstract theories into tangible strategies. This book is an essential companion for those studying industrial dynamics formally or informally, executives in business, or anyone keen on understanding the intricate machinery that propels business growth.

Resource Acquisition in Corporate Growth
by David W. Packer
This book is the second industrial dynamics study published by The MIT Press, originally published in 1964. What sets Resource Acquisition in Corporate Growth apart is its focus not only on the 'what' and 'why' of resource acquisition, but also the 'how.' David Packer demystifies the dynamics of resource acquisition, highlighting the significance of successful resource management in an expanding business context. The book offers in-depth insights into managerial delays and efficiencies, the absorption of professional effort, and the role of recruitment in augmenting professional capabilities. It also underscores the role of simulation modeling, offering practical tools to forecast resource needs accurately. Packer makes a compelling case for why businesses must understand these critical dynamics to avoid inefficiencies and maximize growth potential.

Learn more and purchase these resources here.

Smart Cities Council Resources

The Smart Cities Council (SCC) hosts a variety of podcasts relevant to smart cities strategies, technology and application experience. PPI SyEN readers are encouraged to check periodically for new topics addressed by these events.

Urban Futurism for Smarter Cities

In this podcast series host Alby Bocanegra, SCC Futurist in Residence, talks with individuals who are shaping the future of global cities, advancing the application of science, data, technology, and engineering to enable a safer, more activated, beautiful, and sustainable world now for the future, for everyone. Guests and their individual podcasts include:

- Josh Breitbart (Director of the Division of Broadband Access for the state of New York)
- Sean Audain (Strategic Planning Manager, Wellington, New Zealand)
- Umair Surani (Siradel)

Cyber Security Snapshot

This podcast series features a monthly roundtable with cyber security and data privacy experts from across the SCC ecosystem. Topics addressed include:

- What is a smart city?
- Who is responsible for data?

Prior podcasts in the Everyone series include:

- Introduction: Who is everyone?
- The complex, fragile, messy and beautiful pieces of smart places
- The Cost of Compliance
- Adopting and leveraging AI and IoT to gain visibility and control over assets
- Successful Partnerships

In additional to news items highlighting events and development in the SCC ecosystem, the SCC News feed provides a diverse set of articles on smart cities topics, often with accompanying resources. Examples include:

- Siradel releases new whitepaper: “Accelerate Climate Action with Digital Twins”
- Demystifying Smart Cities: Enhancing Livability through Technology and Data
- Kicking Off Task Forces for Smarter Cities: Unleashing Collaborative Power
- Data Exchange, Trust, and the Challenges to Smart City Implementation
- Landscape Based Digital Twin Case Study
- The “ABC” Approach for the Development of Smart & Sustainable Cities

Learn more about the Smart Cities Council here.

Splitting Requirements at Scale

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

In a recent edition, Gareth Rogers, member of the RE@Agile working group, authored an article titled "*Splitting Requirements at Scale - Strategies for building manageable requirements hierarchies in complex problem domains*.

Abstract:
Analysis means breaking down large problems into smaller, more manageable ones. We, as BAs, understand intuitively that this is what we do and that how well we do this will likely be a major factor in achieving a successful implementation. As problem areas become more complex, however, our intuitions may at times let us down: the parts we have chosen for our breakdown can become tangled in a mesh of interdependencies, and the delivered pieces do not quite assemble to form the solution we were expecting. What strategies, then, can we apply to the splitting of requirements that will ensure that even a large set of requirements remains manageable and that the resulting deliverables meet our original goals?

In this article I will explore the topic of requirements splitting and the resulting hierarchies of requirements that emerge within complex problem domains. I will consider in particular cases where business events trigger lengthy processes, involving multiple steps to deliver business value. I will attempt to show how different dimensions can often be found within the problem domain and that these dimensions present alternative strategies when it comes to splitting requirements. Finally, I will present a worked example that illustrates how multiple splitting strategies may be combined within a single requirements hierarchy.

Rogers addresses this topic with the following outline:

- Online Ordering Portal Example
- Bottom Up or Top Down
- Agile Requirement Splitting
- Requirements Hierarchies
- Requirements within Hierarchies
- Dependencies among Requirements
- Dependencies in the Hierarchy
- Splitting Requirements
- Order of Splitting
- Putting it all together
- Conclusion

View other RE Magazine articles.
Sign up to be notified about new issues of the Requirements Engineering Magazine.

See guidelines for contributing to the RE Magazine as an author.

SERCTALKS: How Can Model Governance Aid Digital Engineering Execution?

On 6 September, the USA Systems Engineering Research Center (SERC) continued its virtual *Celebrating Systems Engineering Digitalization* Talk series. Dr. Heidi Davidz, an Engineering Fellow in the Intelligent Systems Engineering team at ManTech International Corporation, explored the question: How Can Model Governance Aid Digital Engineering Execution?

ABSTRACT:
As Digital Engineering employs a digital thread with a broad range of interconnected models, it can be

difficult to govern linked models across disciplines and contractual boundaries. After an introduction to model governance in this context, the importance of governance is discussed and the relationship to solution debt described. Contributing standards are reviewed, and characteristics of a solution provided.

As an example, the ManTech Elastic Model Governance Guide for the digital thread is shown. Key features include: (1) model-based guidance with in-model work instructions; (2) integration of the overall Model Governance System, Digital Engineering Environment infrastructure, individual models, and composite models; (3) scoping of model purpose and resolution of solution debt; (4) automated validation for insight on compliance; (5) customization for flexibility and tailoring.

Excerpts from this governance guide are provided and discussed, and next steps are given. Potential model governance research topics are suggested. Integrating model governance practices with additional mechanisms for flexibility, scalability, and automated validation provides robust control over the Digital Engineering ecosystem to enhance the value delivered to customers.

Download slides here.
Watch on YouTube.

View the previous talk in the this series, "What are the Myths and Facts About Implementation of Digital Engineering in DoD Acquisition?"

See previous SERCTALKS series and topics here.
Subscribe to the SERCTALKS YouTube channel.

SPEC Innovations Resources

SPEC Innovations, a leading provider of systems engineering services and the Innoslate and Sopatra software solutions, maintains a community blog that provides a diverse range of useful information for systems engineering practitioners (beyond their immediate customers). A sampling of posts from 2023 include:

- A Digital Engineering Platform Approach for Missile Defense
- NASA Moon to Mars Reference Architecture Exploration
- Generations of Systems Engineers: Unpacking Working Styles
- How to get Started with System Modeling
- What is SysML: A Powerful Language for Complex Systems
- How to Build FMECA and Fault Tree Analysis with MBSE
- Adopting MBSE Successfully
- Creating a Data Management Plan
- Agile Systems Engineering Using the Middle-Out Process
- 7 Systems Engineering Lessons from the Titanic

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

- Webinars
- User Stories
- eBooks
- Whitepapers
- Datasheets

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

Intercax Blog: Critical Metrics for Digital Threads

Intercax, the creator of the Syndeia digital thread platform for model-based engineering, has completed publication of a 9-part blog series on Critical Metrics for Digital Threads. After the initial introduction, the series addresses the following topics:

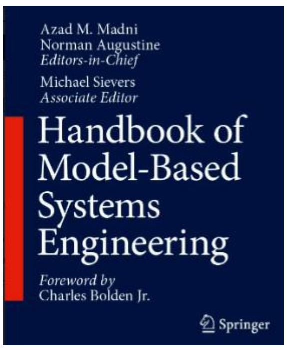
- Tools
- Complexity
- Activity
- Completion
- Consistency
- Verification
- Automation
- Implementation in Syndeia

Other recent series within the intercax blog include:

- RESTful API Integration Demos (4 parts, in-progress)
- Data Science and the Digital Thread (5 parts)
- Syndeia API for Open Digital Thread (8 parts)

Subscribe to the intercax newsletter and blogs.

Handbook of Model-Based Systems Engineering



In July 2023, Springer published the first edition of the *Handbook of Model-Based Systems Engineering, edited by Dr. Azad M. Madni, Hon. Norman Augustine and Dr. Michael Sievers. This 2320 page hard-copy document (202 MB in Kindle electronic format) brings together diverse domains and technical competences of Model Based Systems Engineering (MBSE) into a single, comprehensive publication. It is intended for researchers, practitioners, and students/educators who require a wide-ranging and authoritative reference on MBSE with a multidisciplinary, global perspective. It is also meant for those who want to develop a sound understanding of the practice of systems engineering and MBSE, and/or who wish to teach both introductory and advanced graduate courses in systems engineering.*

The book is specifically focused on individuals who want to understand what MBSE is, the deficiencies in current practice that MBSE overcomes, where and how it has been successfully applied, its benefits and payoffs, and how it is being deployed in different industries and across multiple applications. MBSE engineering practitioners and educators with expertise in different domains have contributed chapters that address various uses of MBSE and related technologies such as simulation and digital twin in the systems lifecycle.

The introductory chapter reviews the current state of practice, discusses the genesis of MBSE and makes the business case. Subsequent chapters present:

- *the role of ontologies and meta-models in capturing system interdependencies*
- *reasoning about system behavior with design and operational constraints*
- *the use of formal modeling in system (model) verification and validation*
- *ontology-enabled integration of systems and system-of-systems*
- *digital twin-enabled model-based testing; system model design synthesis*
- *model-based tradespace exploration*
- *design for reuse*
- *human-system integration*
- *role of simulation and Internet-of-Things (IoT) within MBSE.*

ISBN-13: 978-3030935818

Available on Amazon, SpringerLink, and eBooks.com

ISE&PPOA Model-Based Systems Engineering (MBSE) methodology

In PPI SyEN Edition 103 (August, 2021), we published a feature article by José L. Fernández and Juan A. Martínez titled "*Applying Heuristics to Model the System Physical Architecture*". The article addressed the application of the MBSE methodology, ISE&PPOA (Integrated Systems Engineering & Pipelines of Processes in Object Oriented Architectures) to model the physical architecture of an intravascular medical device. It highlighted the use of three engineering best practices:

- Allocation of functional and performance requirements
- Tradeoff assessment
- Use of heuristics for non-functional requirements

A private LinkedIn group was formed in September 2023 to connect the community of users and those interested in the ISE&PPOA Model-Based Systems Engineering (MBSE) methodology.

To participate in this community, systems engineering practitioners may request membership in the ISE&PPOA group via LinkedIn.

"

The qualities of an item that make an item a "good" item should never be included in the definition of the item.

Robert Halligan

FINAL THOUGHTS FROM SYENNA

You can't get blood out of a turnip!

No sooner than this teaching point left my lips, one of the fifteen students in my systems engineering class retorted, "Yes, I can - if I throw it at your head!". Mildly annoyed at his cleverness, I muttered something about his creativity and went on with my lesson plan.

Upon later reflection, I realized the brilliance of that insight and have used this story as an example of numerous innovation and engineering principles over the last few decades.

Today, let's think about that example from the perspective of creating a functional model of a physical solution concept. If I start with the top-level functional requirement for such a system, it might be named "Transform turnips into blood". I prefer to name system functions with the strongest possible verb and *transform* also highlights the fact that this function involves turning inputs into a very different form of outputs. Forget about the wimpy "provide", "support" or "manage" verbs and let's get something that is almost violent.

Starting with a functional requirement, I ponder the process needed to decompose that requirement further. But I realize that my goal isn't decomposition, it's satisfaction. I want to conceive, evaluate, select and develop a solution that fully satisfies that requirement, i.e., delivers the required functionality at the required level of performance, within other constraints like cost, time, interface compatibility and physical and resource constraints. This calls for a decision, perhaps framed as,

"How will we transform turnips into blood? Which technology, method, algorithm, or solution concept will we use to get blood from turnips?"

Once the decision is framed, my creative juices kick in and ideas (solution alternatives) flow like water.

- Turnips as projectiles.
- Turnips as payment to donors in a blood drive.
- Boobie trap the turnip patch.
- and many, many more …

The flow of ideas eventually dwindles, and a few are ruled out as unethical (or simply evil, but fun to brainstorm).

However, I need to understand the surviving alternatives at a much deeper level than brief titles to choose between them, so I turn to my systems engineering toolkit and pick a functional modeling technique to elaborate the definition of the top few (projectiles and blood drive).

What immediately stands out is the fact that these two solution concepts will have very different functional decompositions. Although a few next-level functions might be similarly named such as "Acquire turnips", the real transformation processes associated with each solution will be very different. Perhaps multi-layered functional decomposition is a myth and next-level functional requirements are always derived from the physical solution concept! That sounds a bit like the "Decisions create requirements" stuff that some fellow is peddling in this month's feature article.

Lacking a sophisticated MBSE tool, I choose to represent the functional model using a Functional N-Squared Diagram. The N-Squared does a great job with clarifying the item flow (information, energy, or matter) between the functions, but lacks the control flow constructs (e.g., ANDs, ORs, Loops, Iteration, Replication). However, if I generally arrange the functions on the diagonal in an intuitive time-oriented sequence, that level of rigor may suffice for this simple story.

Here are my initial set of functions for the *Turnips as projectiles* alternative:

- Acquire turnips.
- Choose target(s).
- Achieve proximity to target(s).
- Hide evil intentions.
- Load turnip in throwing hand
- Aim at target (orient body for launch?)
- Accelerate turnip to target.
- Impact target.
- Achieve proximity to wounded target.
- Collect (sop up) blood.

I note the absence of the “Advertise blood drive” function in this alternative.

I’ll leave the rest to you, i.e., to add appropriately named item flow to represent inputs/outputs passing between the functions.

Extra credit is available if you tackle the “blood drive” alternative (or your own novel solution) from scratch.

Submit your contributions to ppisyen@ppi-int.com and we will be happy to publish the best of the best!

Regards,

Syenna