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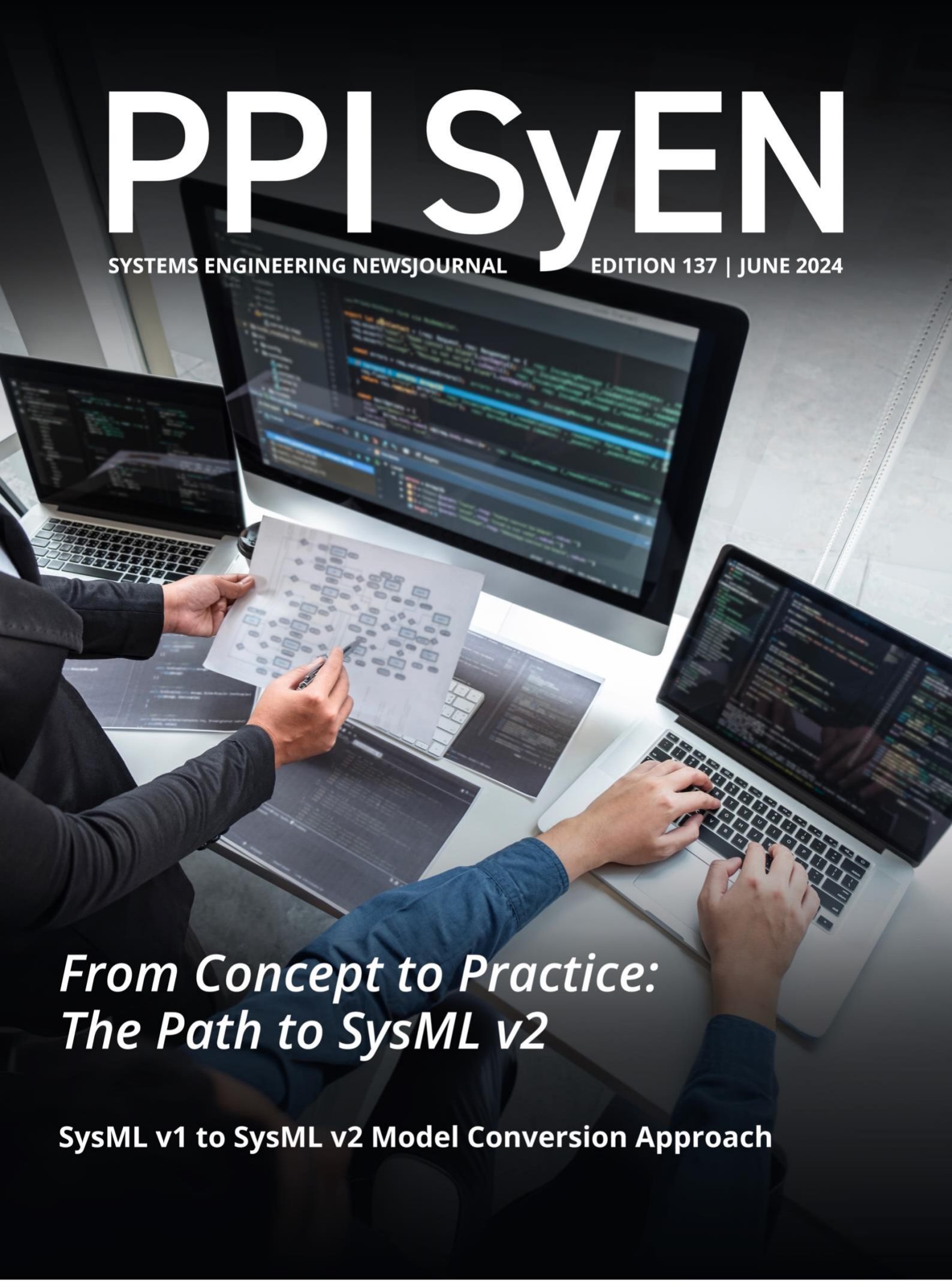

From Concept to Practice: The Path to SysML v2

SysML v1 to SysML v2 Model Conversion Approach

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WELCOME

Dear PPI SyEN Readers,

Welcome to another edition of PPI SyEN. I am excited to present to you the 137th edition, themed "From Concept to Practice: The Path to SysML v2." This edition explores the practical steps and innovative approaches our community is taking to transition from the modeling language SysML v1 to SysML v2, marking a significant milestone in the evolution of systems engineering practice.

We begin with essential SE news items. One of the highlights is the NIST Global AI Initiatives and their ARIA program. The ARIA (Assessing Risks and Impacts of AI) program focuses on evaluating the societal risks and impacts of AI systems in real-world settings. Additionally, we bring you updates on the latest developments in SEBoK Version 2.10, which continues to be a valuable resource for systems engineering professionals.

Our conferences, meetings, and webinars section is packed with opportunities for professional development. From the PDMA Webinar on Estimating and Forecasting. to the 2024 International System Dynamics Conference, each event promises to enhance your understanding and application of systems engineering principles.

This edition also features a much-anticipated article by Friedenthal, Salvatore, Bak, and Abreu titled "SysML v1 to SysML v2 Model Conversion Approach." This article highlights the journey and efforts involved in adopting the new standard, offering a positive yet realistic view of the potential and challenges associated with SysML v2 deployment.

Supporting your professional journey, we've included resources such as the PDMA Recommended Resources and updates to the Systems Engineering Tools Database (SETDB). We conclude with Syenna's witty reflections in "From ROM to Reality or SWAG to Sorrow?" capturing the trials and triumphs of systems engineering with humor and insight.

Happy reading and thank you for your continued support.

Warm regards,

René

Managing Editor (on behalf of the PPI SyEN team)

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

PPI Systems Engineering Newsjournal (PPI SyEN) seeks:

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

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

SYSTEMS ENGINEERING NEWS

Recent events and updates in the field of systems engineering

NIST Global AI Initiatives

The U.S. National Instititute for Standards and Technology (NIST) has announced two new initiatives to push the boundaries of AI best practices and to influence the progress of this critical set of technologies.

Strategic Vision: U.S. Artificial Intelligence Safety Institute (AISI)
NIST has released its strategic vision for the recently formed U.S. Artificial Intelligence Safety Institute (AISI). The AISA strategic vision document outlines the steps that the AISI plans to take to advance the science of AI safety and facilitate safe and responsible AI innovation. The vision may be summarized as *a future where safe AI innovation enables a thriving world*. Operationally, this vision may be realized through pursuit of three goals:

- Advancing the science of AI safety
- Articulating, demonstrating, and disseminating the practices of AI safety
- Supporting institutions, communities, and coordination around AI safety

In support of the third goal, AISI plans to work with a global scientific network for AI safety through meaningful engagement with AI Safety Institutes and other government-backed scientific offices.

Assessing Risks and Impacts of AI (ARIA)
NIST is launching a new testing, evaluation, validation and verification (TEVV) program intended to help improve understanding of artificial intelligence's capabilities and impacts. ARIA aims to help organizations and individuals determine whether a given AI technology will be valid, reliable, safe, secure, private and fair once deployed.

ARIA expands on the AI Risk Management Framework, which NIST released in January 2023, and helps to operationalize the framework's risk measurement function, which recommends that quantitative and qualitative techniques be used to analyze and monitor AI risk and societal impacts. ARIA will help assess those risks and impacts by developing a new set of methodologies and metrics for quantifying how well a system maintains safe functionality within societal contexts.

View an ARIA overview video here.

SEBoK Version 2.10 Update Released

The Version 2.10 update to the Systems Engineering Body of Knowledge (SEBoK) was released on 6 May 2024. The SEBoK provides a guide to the key knowledge sources and references of systems engineering.

Version 2.10 includes a wide range of improvements:

- A new Get Involved invitation page including a new SEBoK content review form
- Significant Part 3 Systems Engineering and Management updates to reflect current practice
- Renaming of System Life Cycle Models articles to simplify the titles
- A new Requirements Management article
- "Business and Mission Analysis" knowledge area renamed to System Concept Definition
- "Stakeholder Needs and Requirements" is now Stakeholder Needs Definition
- "Stakeholder Requirements Definition" is now System Requirements Definition
- A new System Architecture Design Definition knowledge area article
- The System Maintenance knowledge area has been reorganized

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

Access SEBoK here.

INCOSE Thailand Chapter Announces Interim Leadership

The process of launching the INCOSE Thailand chapter reached a significant milestone in the selection of its slate of interim officers. Named to these leadership positions were:

- Vithaya Suharitdamrong, PhD (Interim President)
- Chaiwat Klampol, PhD (Interim Vice President)
- Vorachet Jaroensawas (Interim Secretary & Acting Interim Treasurer)
- Arnon Phuekfhon, PhD (Interim Director of Marketing and Communication)
- Pongsatorn Sukhum (Interim Director of Professional Programs)
- Thanaphon Chearanai (Interim Director of Academic Programs)

In addition to the business of organizing the chapter and building national awareness and momentum among the engineering community, this team is preparing for the first INCOSE Thailand System Engineering Conference, TSEC2024. See details in the Conferences section of this edition of PPI SyEN.

Updates to SE Tools Database (SETDB)

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

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

Vendor: Ansys Inc.

- Ansys ModelCenter: A vendor neutral software platform for creating and automating multi-tool workflows, optimizing product designs, and enabling Model Based Systems Engineering (MBSE).

- Ansys Systems Architecture Modeler (SAM): A cloud native general-purpose system architecture modeling tool based on SysML v2 (in development).
- Ansys SCADE One Essential: Develop safe and reliable embedded software, reduce development time and costs, and secure your certification journey.
- Ansys Systems Tool Kit (STK): Enables you to model complex systems with realistic & time-dynamic three-dimensional simulation. Simulate the entire system-of-systems, at any location & at any time, & across multiple domains, to gain a clear understanding of mission performance.

Vendor: Palisade (Lumivero)

- The DecisionTools Suite: An integrated set of programs for risk analysis and decision making under uncertainty. The DTS integrates seamlessly with Microsoft Excel, and includes: Monte Carlo simulation, predictive neural networks, decision trees and sensitivity and statistical analysis.
- @RISK: An add-in to Microsoft Excel that lets you analyze risk using Monte Carlo simulation. @RISK shows you all possible outcomes for any situation - and tells you how likely they are to occur enabling to decided which risks to take on and which ones to avoid.
- NVivo: A market leading qualitative data analysis software with an AI solution. A highly cited qualitative data analysis software (QDA software) that employs AI powered auto-coding to automatically detect and code themes that apply advanced visualization tools that clearly articulate defensible findings.

Vendor: SEMP

- SEMPx: Platform that offers a cloud-based solution that unites commercial, engineering, design, project delivery, and supply chain teams within a single platform. This ensures adherence to project contractual requirements and specifications throughout the entire project delivery lifecycle.

Vendor: Siemens Digital Industries Software

- Simcenter: A flexible, open, and scalable portfolio of the best predictive simulation and test applications that support every stage of a system lifecycle. The heart of a digital twin is simulation and test that provide insight into the performance of your system.
- Simcenter Systems Simulation: A family of simulation tools that reach across mechanic, electronic, electric, software and control systems to optimize system performance during any stage of the system lifecycle. Users can evaluate performance attributes such as thermal management, operability and fuel efficiency.
- Simcenter Amesim: Integrated, scalable system simulation platform that enables system simulation engineers to virtually assess and optimize the performance of mechatronic systems. This is an open environment that can be easily coupled with CAE, CAD and controls software packages.
- Simcenter Flomaster: Simulation tool for fluids engineering and offers reliable and accurate solvers and best-in-class in-built correlations. Users can effectively size gas, liquid and two-phase systems and components to achieve maximum efficiency and evaluate dynamic system failures.

Vendor: Siemens Polarion

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

Vendor: Siemens Teamcenter

- Teamcenter PLM process management: Enables teams to control and coordinate complex change across disciplines, enabling visibility to data, people and processes impacted by a change using manual and automatic workflows. Users can take control of planning, schedules, resources and lifecycle processes.
- Teamcenter Bill of Materials Management: An integrated, multi-domain enterprise BOM solution enables the management of software, electrical, electronic and mechanical parts with automated reconciliation between domains. Coordinate new products and upgrades with digital threads that connect functional domains and span the product lifecycle.

Vendor: SPEC Innovations

- Innoslate: The first web-based MBSE tool, was developed by SPEC Innovations to support the entire system or product lifecycle. This cloud or on-premise application simplifies system or product development while reducing time-to-market, cost, and risk.

Vendor: Stanford University School of Medicine

- Protégé: A free, open-source ontology development environment for the Web that makes it easy to create, upload, modify, and share ontologies for collaborative viewing and editing. It is available for downloading or using via the Web from Stanford University.

Vendor: VisibleThread

- VisibleThread: An AI-Driven language analysis platform intended for managers and business writers to improve the efficiency, quality, clarity and compliance of RFPs, contracts and mission-critical business writing with quantifiable metrics throughout the lifecycle.

Vendor: Visual Paradigm

- Business Process Design Tool: Creates and animates business process diagrams. Supports operational procedure development, As-IS and To-Be process models, RACI and CRUD charts, animation and simulation of processes and other business process support features to meet your needs.
- Agile Project Tools: A suite of agile and scrum tools intended for agile teams to manage development projects. They include Project Management, Agile Process, Scrum Process, User Story mapping, quality improvement and roadmap visulization.

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

Access the SETDB website.

CONFERENCES, MEETINGS & WEBINARS

PDMA Webinar: Estimating & Forecasting: Sorcery or Science?

The St. Louis (Missouri, USA) chapter of the Product Development Management Association (PDMA) will host a webinar on 18 July 2024 titled "*Estimating & Forecasting: Sorcery or Science?*", presented by Product Management leader, Kristina Glynn.

Description
Many struggle with the mystery of how to confidently set a feature, epic, MVP, or other target date with the many known unknowns of agile software development. Sometimes, any sort of estimation or date "commitment" feels like a gamble, and failure undermines trust and confidence in your product delivery. Yet, working with your team and others to scope, estimate, and forecast with varying degrees of fidelity doesn't have to be an impossible task accessible only to Product Wizards of the Dark Arts.

In this session, I'll propose some methods for estimating and forecasting work, long- and short-term, share an Excel template you can start using immediately, and we'll open up discussion to help break down the barriers you face in your work so you can demonstrate your Product Wizardry and deliver with higher degrees of success and confidence.

This is a free event for both PDMA members and non-members alike. Learn more and register here.

International System Dynamics Conference (ISDC 2024) – More Details

Details are being finalized for the 2024 International System Dynamics Conference (ISDC 2024) hosted by the System Dynamics Society (SDS). The in-person portion of this hybrid conference will take place on 4-8 August 2024 in Bergen, Norway The theme of ISDC 2024 is "*Bridging Perspectives for New Insights*".

In support of this theme, newly announced conference speakers include:

- Billy Schoenberg, lead developer at isee Systems inc, researcher at the University of Bergen, and "dad" of the FRIDA whole-earth climate model.
- Juan Ríos-Ocampo, Lecturer in the Department of Management Science at the University of Strathclyde in Glasgow, Scotland. His research focuses on how policymakers' mental models and decision-making in urban planning impact societal well-being in cities.
- Jeroen Struben, Associate Professor of Strategy and System Dynamics at Emlyon Business School, whose research focuses on market formation processes and sustainable consumption and production.
- Anna Pagani, postdoctoral researcher in the fields of people-environment studies, housing

studies, and systems thinking. Her work aims at disentangling the complex interrelations that hinder the provision of healthy and sustainable housing for all.

View the conference schedule.

Register for ISDC 2024.

NAFEMS Verification & Validation Learning Opportunities

NAFEMS, the international modeling and simulation association, is offering a series of learning opportunities during 2024 to highlight the role of simulation in supporting system verification and validation. A free NAFEMS webinar, recorded in August 2023, will introduce two online courses to be delivered in October.

An Introduction to Verification, Validation and Uncertainty Quantification in Scientific Computing (August 2023 recording)
Discover the concepts of verification, validation, and uncertainty quantification in this special 45-minute taster webinar with William Oberkampf and Christopher Roy. These experts will introduce you to simulation-based decision-making, verification and validation, non-deterministic simulation, predictive capability, and uncertainty quantification. Topics include:

- Simulation-Informed Decision Making: Concept Introduction
- Understanding Verification, Validation, and their Distinction from Systems Engineering
- Non-deterministic Simulation and Predictive Capability and Exploration of Uncertainties and their Implications
- Verification, Validation, and Uncertainty Quantification in Scientific Computing: Course Overview Discussion

A free NAFEMS user login is required to access this webinar.

Verification and Validation in Engineering Simulation (7-11 October)
Engineering simulation plays an increasing role in industry's search for competitiveness and technology-based innovation at any stage of the design, qualification, and certification of their products. Key decisions and product qualification/certification increasingly rely on virtual tests and computational simulations, creating a major paradigm shift in which the objective of physical tests is progressively moving from a demonstration of compliance to a reference for simulation validation. This trend in industry is shown through adoption of new terms such as "realistic simulation" and "virtual testing". This situation creates new responsibility for the engineer to guarantee the required confidence level.

This Master Class is especially dedicated to V&V and credibility assurance methodologies for numerical simulation in Engineering. Participants will:

- Develop their knowledge in V&V including fundamental concepts, most recent methodologies, and contents of existing standards.
- Understand essential links between the product validation/certification and simulation V&V.
- Learn how to plan and prioritize simulation V&V including physical tests programs.
- Understand validation test issues and improve synergy between virtual and physical tests in

the context of validation.
- Learn how to build business cases allowing for justification of V&V plans.
- Understand simulation V&V organization and management issues and best practices.
- Learn how to implement reporting to bring visibility and confidence to all managers concerned with simulation outcomes.
- Be able to adapt or tailor the course methodologies to their specific industrial context, and further improve their V&V processes and plans.

Learn more and register here.

Verification, Validation and Uncertainty Quantification in Scientific Computing (21-24 October)
Engineering systems must increasingly rely on computational simulation for predicted performance, reliability, and safety. Computational analysts, designers, decision makers, and project managers who rely on simulation must have practical techniques and methods for assessing simulation credibility. This short course presents modern terminology and effective procedures for verification of numerical simulations, validation of mathematical models, and uncertainty quantification of nondeterministic simulations.

The techniques presented in this course are applicable to a wide range of engineering and science applications, including fluid dynamics, heat transfer, solid mechanics, and structural dynamics.

Upon completion of this course, attendees will be able to:

- Define the objectives of verification, validation, and uncertainty quantification.
- Implement procedures for code verification and software quality assurance.
- Implement procedures for solution verification, i.e., numerical error estimation.
- Plan and design validation experiments
- Understand procedures for model accuracy assessment.
- Comprehend the concepts and procedures for non-deterministic simulation.
- Identify sources of uncertainty, such as aleatory and epistemic uncertainties
- Recognize the goals of model parameter calibration/updating.
- Interpret local and global sensitivity analyses.
- Recognize the practical difficulties in implementing VVUQ technologies.

Learn more and register here.

Investigate membership in NAFEMS.

INCOSE Thailand Systems Engineering Conference (TSEC2024)

The emerging INCOSE Thailand chapter is hosting its first Systems Engineering Conference (TSEC2024) on 6-9 August 2024. This in-person event will take place in Bangkok at Pathumwan Institute of Technology. The TSEC2024 theme "*Building Thailand's SE Future - Step One*" invites participants to explore the current stage of systems engineering progress in Thailand, real world experiences, viewpoints and case studies from practitioners and academics.

Keynote speakers for TSEC2024 include:

- Asst Prof. Dr. Vithaya Suharitdamrong, Interim President of INCOSE Thailand and Vice-Chairman of Computer Engineering at Engineering Institute of Technology
- Ralf Hartmann, INCOSE President
- Dr. Quoc Do, INCOSE Director for Asia-Oceania Sector
- Serge Landry, INCOSE immediate past Director for Asia-Oceania Sector
- Dr. Chaiwat Klampol, Interim Vice President of INCOSE Thailand, Lecturer and Researcher at Department of Aerospace Engineering, Kasetsart University

Multiple panel discussions will highlight the progress being made by Thailand's systems engineering community with topics such as:

- The Ever-Evolving Landscape of Systems Engineering
- Pioneering SE in Thailand: The INCOSE Thailand First Officers
- Bridging the Gap: Goals, Reality, and How Systems Engineering Drives Innovation in Thailand's Key Industries: Aerospace, Defense, Energy/EPC
- SE Education and Professional Development in Thailand

Case studies will address the application of systems engineering in multiple domains:

- MBSE Initiative in Defense
- MBSE Initiative in Aerospace
- MBSE Initiative in Energy: Transforming Energy/EPC Project

View the full event program.

Learn more about TSEC2024.

INCOSE International Conference on Human Systems Integration (HSI2024)

The Third INCOSE International Conference on Human Systems Integration (HSI2024) will be held on 27-29 August, with the in-person portion of this hybrid event taking place in Jeju, Korea. HSI2024 will be held jointly with the International Ergonomics Association (IEA) 22nd Triennial World Congress. Topics to be addressed include:

- HSI principles, methods, and tools
- Organizational/societal issues and solutions
- Humans, autonomy, and complexity
- HSI, safety, and infrastructure
- Legal and Regulatory

Keynotes talks for HSI2024 include:

Taking measure of Human Systems Integration: A view from NASA (Dr. Cynthia H. Null, Technical Fellow for Human Factors for the NASA Engineering and Safety Center)

Building on work from recent NASA studies, Dr. Null will discuss challenges and successes of implementing Human System Integration approaches across mission life cycle. Topics will include the

implications of focusing on human resilient performance for mission and system design; the use of quantitative analyses of human performance in development of a mission architecture; and the need to expand HSI metrics.

Human Systems Integration Across the Health Care Continuum: Examples, Opportunities, and the Future (Ayse P. Gurses, PhD, Director, Center for Health Care Human Factors, Armstrong Institute, Johns Hopkins Medicine, and Professor at Johns Hopkins University)

There is an increasing and urgent need for infusing Human Systems Integration (HSI) and Human Factors Engineering (HFE) principles and methods to improve safety and quality of operations in complex, adaptive sociotechnical work systems such as in health care. In this presentation, Dr. Gurses will describe how HSI and HFE can be used to improve care across the entire care continuum (i) by systematically identifying hazards to patient safety, health care worker safety, and equity; and (ii) by developing effective and sustainable human-centered interventions with the purpose of eliminating and/or mitigating these hazards and improving adaptive capacity and resilience of the frontline care work and public health. Examples from a variety of health care settings (i.e., emergency department, operating rooms, patient home), and focus areas (e.g., infection prevention and control, pandemic preparedness, care transitions/ handoffs, healthcare information technology) will be provided. Lessons learned across the different projects and implications for future HSI efforts will also be discussed.

Learn more here.
Register for HSI2024.

International Conference on Mathematical Modelling, Computational Techniques and Simulation for Engineering (MMCTSE)

The 2024 edition of the International Conference on Mathematical Modelling, Computational Techniques and Simulation for Engineering (MMCTSE) will take place in Istanbul, Turkey on 30 August – 1 September. The conference will highlight recent advances in computational and mathematical techniques for physics, chemistry, biology, engineering, geoscience, economics, and medicine.

Plenary speakers for MMCTSE 2024 include:

- Prof. Gerya Taras, Swiss Federal Institute of Technology (ETH-Zurich), Switzerland)
- Prof. Gretar Tryggvason, Johns Hopkins University, USA
- Prof. Jean-Pierre Burg, Swiss Federal Institute of Technology, (ETH-Zurich), Switzerland
- Prof. Joaquim Peiro, Department of Aeronautics, Imperial College, London, UK
- Prof. Siddhartha Mishra, Swiss Federal Institute of Technology (ETH-Zurich), Switzerland

A special session on Advancements in Artificial Intelligence and Its Applications: Driving Optimization, Decision-Making and Sustainable Development will explore the latest advancements at the intersection of artificial intelligence (AI), mathematics, and optimization techniques, with a specific focus on their applications in engineering and Decision Support Systems.

OMG Business Architecture Master Series and Primer

The Object Management Group (OMG), in conjunction with its Q3 Technical Meeting, is hosting a two-day Business Architecture Master Series in Chicago, Illinois, USA on 10-11 September. This in-person "*Mastering the Practice*" event will feature hands-on workshops focused on building out a business architecture baseline and applying that baseline to priority business scenarios. Teams will engage in mentored exercises, share their results, and exchange real-time feedback.

Topics will include:

- Master Series Overview & Goal Setting
- A Formal Point of Reference: Seeding the Baseline
- Business Architecture Baseline Building Sessions
- Business Architecture Usage Scenario Working Sessions
- Key Takeaways & Follow-up Action Items

Novice practitioners are asked to attend a half-day, complimentary Business Architecture Primer on the afternoon of 9 September. The Primer will be delivered by Business Architecture Associates (BAA) cofounders and industry experts Whynde Kuehn and William Ulrich.

Register here.

Registration Open for PDMA Inspire Innovation Conference

The Product Development Management Association (PDMA) has opened registration for its Inspire Innovation Conference that will take place on 14-17 September 2024 in St. Louis, Missouri, USA. Held in conjunction with the Journal of Product Innovation Management (JPIM) Research Forum, this four-day in-person event will focus on:

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

The top-level schedule for this combined event is shown below:

14 September	8:00 am – 5:00 pm	JPIM Research Forum
15 September	8:00 am – 12:00 pm	JPIM Research Forum
15 September	1:00 pm – 5:00 pm	JPIM Research Forum and PDMA's 2024 Inspire Innovation Conference Bridge Session

16 September	8:00 am – 5:30 pm	PDMA's 2024 Inspire Innovation Conference
17 September	8:00 am – 5:00 pm	PDMA's 2024 Inspire Innovation Conference

The Bridge Session on Sunday, 15 September will include presentations by the finalists for PDMA's Global Student Innovation Challenge.

Unique to this year's event is the availability of "tailored journeys", a customizable model that enables attendees to curate their own experience at the conference. Three such journeys have been defined:

Ideation & Discovery
Explore the Ideation & Discovery track focusing on the early stages of the product life cycle & the front-end of innovation. Delve into idea generation, market analysis, and strategy design. Learn from thought leaders about navigating uncertainties in early product development, fostering creativity, and aligning concepts with customer needs.

Development & Delivery
Jump into the execution and delivery phases of your product development journey. From advanced product development techniques to efficient market launch strategies, this track addresses challenges in production, and measurement, and scaling.

Innovation Governance & Tools
Become an expert at managing and sustaining innovation within your organization. Tailored for senior managers and decision-makers, the Innovation Governance & tools track offers insights into establishing frameworks, processes, and governance structures to bolster innovation at all levels.

Register here.

Registration Open for Zuken Innovation World and Integrate24

Registration is open for the Zuken Innovation World (ZIW) and Integrate24 conference to be held in Cleveland, Ohio, USA on 17-19 September. The conference is designed to help systems engineering practitioners find resources to support a variety of engineering roles:

- Thinkers: Solve complex problems that impact timelines and budgets regardless of lifecycle stage. Learn from industry thought leaders.
- Innovators: Break boundaries and meet the mavericks that pave the way for digital engineering.
- Designers: Drive intentional outcomes by weaving stakeholder needs into engineering requirements for early-lifecycle product professionals.
- Makers: Realize ideas by connecting upstream and downstream engineering processes for design, verification, and operations.

Featured speakers include:

- Brian Selvy, Chief Innovation Officer, Zuken Vitech
- Paul Harvell, Product Director, E3.series, Zuken USA

- Laura Mirto, Technical Marketing Manager, Zuken USA

A sample of presentation topics includes:

- A Methodology for Model Federation Applied Across Defense Systems Development Programs
- Digital Engineering Hub - Model Governance and Consistency Analysis over the Digital Thread
- Digital Transformation Principles for Program Execution
- Enterprise Architecture & Systems Engineering: Same Coin, Different Sides
- MBSE-Driven Next-Generation Simulation Using Digital Twin
- Model-Based Lifecycle Performance Management of Industrial Assets
- Multi-Dimensional Systems Architecture Modeling
- Neutralize Patient Zero: Avoid a Digital Engineering Zombie Apocalypse
- Systems Engineering Technical Review (SETR) Template Modeling
- Transforming Systems Engineering with Generative Artificial Intelligence
- Using GENESYS to Support Creation of the INCOSE SE Handbook

Check back here for details on the evolving agenda.

Register for ZIW + Integrate24.

Call for Presentations: NAFEMS Engineering Simulation in Electronics Conference

NAFEMS has issued a Call for Presentations for its online Engineering Simulation in Electronics Conference 2024 that will take place on 9-10 December. Submissions are sought that highlight the pivotal role of simulation in electronic design, development, and innovation. The entire spectrum of electronic simulation technologies is of interest, including:

- RF Electronic Simulations
- EMC Simulations
- Power Integrity Simulations
- Signal Integrity Simulations

View the conference overview and Call for Presentations here.

Presentation abstracts are due by 10 September. Submit abstracts here.

FEATURE ARTICLE

SysML v1 to SysML v2 Model Conversion Approach

By

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Authored for PPI SyEN

Abstract

The Systems Modeling Language (SysML) v1 was adopted by the Object Management Group (OMG) in 2007. SysML v2 is the next generation systems modeling language. The SysML v2 beta specification was approved by the OMG in June 2023, and the updated specification is expected to be submitted for final adoption in 2024. There is a critical need for organizations to maintain their investment in SysML v1 models as they transition to modeling with SysML v2.

The SysML v2 specification includes a transformation specification that defines how a conformant SysML v1 model can be automatically transformed to a SysML v2 model. However, additional steps may need to be taken to convert a SysML v1 model to a SysML v2 model and fully benefit from the features of SysML v2. A proposed SysML v1 to SysML v2 conversion approach is summarized in this paper.

The conversion approach was defined as part of a project hosted by the DoD Department of Digital Engineering, Modeling and Simulation. The project is developing guidance for organizations, projects, and practitioners to support their efforts to transition from modeling with SysML v1 to modeling with SysML v2. This project will enable the department of defense to properly plan for and understand the implications of converting a SysMLv1 model to a SysML v2 model.

Keywords

SysML v2, SysML Model Conversion, SysML Model Transformation, SysML v2 Transition, OMG, MBSE

Introduction - SysML v2 Motivation and Background

The Systems Modeling Language (SysML) v2 is the next generation Systems Modeling Language to support the evolving practice of model-based systems engineering (MBSE) and address the challenges of increasing system complexity and technology changes. The objectives for SysML v2 are to increase MBSE effectiveness and MBSE adoption over SysML v1 by making significant improvements in language precision, expressiveness, regularity, interoperability, usability, and extensibility. SysML v2 is

intended to enable program MBSE efforts to realize improved system quality through early verification and error detection, and improvements in agility and productivity through broad-based reuse, while reducing development cost, schedule, and risk by providing a shared and precise understanding of the system as it evolves across its lifecycle.

SysML v2 incorporates a new metamodel that was architected to address the needs of systems modeling while leveraging the capabilities of the Unified Modeling Language (UML) metamodel that SysML v1 was based on. It also includes a textual notation in addition to a graphical notation that facilitates increased precision of the language. SysML v2 includes a standard application program interface (API) to enable interoperability between the system model in SysML v2 and other models and tools that are part of the digital engineering ecosystem. The differences between SysML v2 and SysML v1 are further highlighted in reference 1.

The SysML v2 beta specifications, available on the Object Management Group (OMG) website, were approved by the Object Management Group (OMG) on June 30, 2023. The beta specifications are now in their finalization phase to obtain feedback from tool vendors based on their implementation of the specifications. The final specifications are expected to be submitted for adoption in 2024. It is anticipated there will be commercial tools available shortly after adoption.

SysML v1 to SysML v2 Transition

To realize the benefits of SysML v2 highlighted above, organizations and projects should develop a strategy and plan to transition from modeling with SysML v1 to modeling with SysML v2. A transition team should be formed that is part of an organization's existing improvement efforts, such as digital engineering and model-based systems engineering with the responsibility for developing and implementing the SysML v1 to SysML v2 transition strategy and plan. The transition strategy and plan should focus on establishing the organization's modeling practices, tools, and training that can be used by projects as they make the transition to SysML v2. The transition plan should include pilot projects to assess the impact and proposed updates to the MBSE practices, tools, and training. Careful consideration should be given to assess which programs should transition and when they should transition to SysML v2. These considerations should be based on the potential near, intermediate, and long-term benefits of transitioning versus the costs and risks of transitioning. The strategic approach should include support for both SysML v1 models and SysML v2 models which will co-exist for some years to come.

The organization should provide the needed support to assist the programs in their MBSE transition planning, facilitate tool acquisition, and help train the program team members in the language, methods, and tools. The organization should also provide their programs with the reference models, patterns, and reuse libraries that were established during the pilot phase. The organization should also provide on-going subject matter expertise to guide the program through the transition.

A program will need to develop and execute their plan to implement an MBSE approach with SysML v2 and leverage the organization's modeling capabilities described above. The program should begin their transition planning to SysML v2 prior to the start of a new program or prior to a major system upgrade. A smooth transition requires considerable preparation to ensure the program's systems engineering team is properly trained in SysML v2 and has access to the appropriate tools and resources.

SysML v1 to SysML v2 Model Conversion Process

The conversion from a SysML v1 model to a SysML v2 model is highlighted in Figure 1 and includes pre-processing the SysML v1 model to prepare it for the transformation, transforming the SysML v1 model to a SysML v2 model, post-processing the SysML v2 model to better leverage the SysML v2 capabilities, and validating that the SysML v2 model accurately reflects the intent of the SysML v1 model. In addition, further steps may be required to assess the impact of the SysML v2 model on existing artifacts that were derived from the SysML v1 model. The derived artifacts may need to be updated for the SysML v2 effort, but this may be considered outside of the scope of the SysML v1 to SysML v2 model conversion. Each of these steps is summarized below.

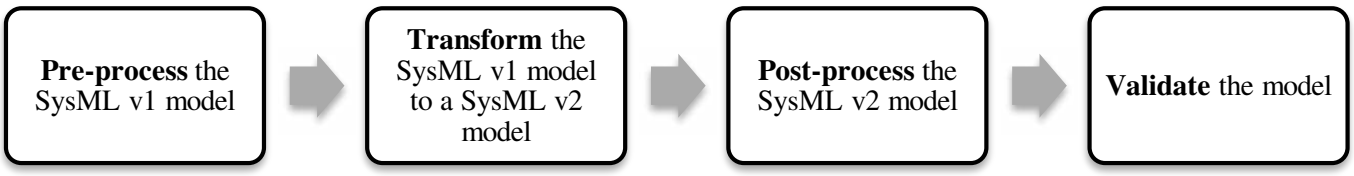

Figure 1 Model Conversion Process

Pre-process

This step involves pre-processing the SysML v1 model to prepare the model for transformation. The required pre-processing will depend on the transformation capability that the modeling tool provides so it is important to understand the tool capability and limitations. Performing the standard SysML v1 to SysML v2 model transformation requires that the SysML v1 model conform to the SysML v1 specification, so the pre-processing of the model should ensure such conformance. Any tool-specific extensions along with other tool customizations to the model may need to be removed. However, the use of stereotypes and profiles should be supported by the transformation.

There are certain features of SysML v1 such as adjunct properties that have no explicit mapping to SysML v2. Part of the pre-processing could be to remove these elements or assess the impact of the transformation on these features and note that they may need to be addressed in the post-processing.

Circular dependencies should be identified to determine if and how they may impact the transformation and addressed accordingly. The SysML v1 model may also need to be reorganized to enable an incremental conversion process.

Creating a well-formed SysML v1 model that conforms to good practice will facilitate the conversion process. Model validation errors should be resolved to ensure the model is well-formed. Standard modeling conventions should be applied such as consistent naming conventions and minimizing ambiguities and redundancies. The amount of effort to pre-process can be compared to the additional effort to transform and post-process. The value of converting the SysML v1 model should be weighed against the level of effort to create the SysML v2 model from scratch.

Transform

This step involves transforming the SysML v1 model to a SysML v2 model. A SysML v1 model can be transformed to a SysML v2 model using a tool that can execute the standard SysML v1 to SysML v2 transformation specification. The standard transformation requires that the SysML v1 model be conformant to the SysML v1 specification in order to be transformed to a conformant SysML v2 model. It is important to understand the tool capabilities and limitations relative to the standard SysML v1 to v2 transformation specification.

The SysML v1 to v2 transformation specification defines the rules for transforming each kind of element in SysML v1 to a corresponding element in SysML v2. The transformation also includes rules for cases where there is no corresponding SysML v2 element. For example, a block in SysML v1 includes a meta property called 'isEncapsulated'. There is no equivalent concept in SysML v2 since the SysML v2 language designers did not see a need for this. However, there is a rule for how to address this in the transformation.

The tool should generate validation errors and warnings to indicate what aspects of the transformation were not successful. In addition, a manual inspection should be performed to compare the SysML v2 model with the SysML v1 model.

Post-process
This step involves post-processing the SysML v2 model to leverage the SysML v2 capabilities. The transformed SysML v2 model may need to be reorganized and refactored to fully leverage the SysML v2 capabilities. The reorganizing and refactoring should apply the usage-focused modeling paradigm to more fully leverage the SysML v2 capabilities. This paradigm is briefly discussed in the section entitled “Post-process the SysML v2 Skyzer model.”

Validate
It is imperative to validate that the SysML v2 model accurately reflects the intent of the SysML v1 model. This can be done by comparing the two models. This may include reproducing selected views of the SysML v2 model such as a system hierarchy and carefully comparing it with the system hierarchy in the SysML v1 model. It is anticipated that tool vendors may be able to generate automated comparison reports to assist in the inspection. Comparing execution and analysis results from the SysML v2 model with the corresponding execution and analysis results of the SysML v1 model may also assist in the validation.

A tool is expected to support the SysML v2 standard views which can render similar information that is contained in the nine standard SysML v1 diagrams. However, the layout information is not preserved and would need to be adjusted manually to align with the original SysML v1 diagram.

Additional Steps Outside of the Model Conversion Process

The following are additional steps outside of the scope of the SysML v1 to SysML v2 model conversion but may be critical to the program’s success.

Assess impact on SysML v1 derived artifacts
This step involves identifying artifacts that were generated or derived from the SysML v1 model and assessing the potential changes to these artifacts that result from the SysML v2 model. The artifacts can include specifications, architecture description documentation, requirements traceability reports, related analysis, test plans, and others.

Update derived artifacts
This step involves updating the derived artifacts as needed. This step may be dependent on integrations between the SysML v2 modeling tool and other modeling tools and repositories.

Other Considerations in the Model Conversion Process

There are other considerations that can impact the model conversion process that are discussed below.

Incremental model conversion

The conversion process should be performed incrementally rather than converting the entire model in a one-time batch process. As part of the pre-processing, the SysML v1 model can be partitioned to minimize coupling and enable incremental transformation. For example, the model can be partitioned into packages that contain the structure, behavior, and requirements and further partitioned into mission, system, and subsystem levels. The incremental conversion process can first transform the structure, then transform the behavior, and then transform the requirements.

One-way transformation

It should be noted that the transformation is currently one-way from SysML v1 to SysML v2, and that there is no standard transformation specification to transform a SysML v2 model to a SysML v1 model. This is because many of the capabilities in SysML v2 are not supported in SysML v1. For example, SysML v1 supports a block decomposition but does not support a SysML v2 part decomposition.

Security classification considerations

The transformation of a classified SysML v1 model should preserve all classification markings in the SysML v2 model. A standard security extension should be applied that leverages the metadata capability in SysML v2. A well-defined process should be established to ensure all markings are properly applied. This should include manual inspection of the model. The same classification procedures that apply to the SysML v1 model should apply to the SysML v2 model and must be adhered to.

Configuration management considerations

The SysML v2 API configuration management services can be leveraged to manage the configuration of the SysML v2 models beginning with the initial transformation. Typical branch and merge concepts can be used to manage updates to the model. The configuration management of the SysML v2 model should be managed in the broader context of the overall engineering ecosystem that typically involves a product lifecycle management environment and workflow/issue management applications such as Jira.

Example SysML v1 to SysML v2 Conversion

An initial investigation was conducted to perform a conversion of an existing SysML v1 model to a SysML v2 model. The objective of this investigation was to gain insights that would assist in future SysML v1 to SysML v2 model conversions. The example SysML v1 model is the Skyzer Mission Model that was developed by the Systems Engineering Research Center (SERC) under contract to the Naval Air (NAVAIR) Systems Command. The original SysML v1 Skyzer Mission Model is available publicly at the following link. The tool used to create this model was MagicDraw version 19.0 sp4. Instructions to open the model are in the figure 2 below.

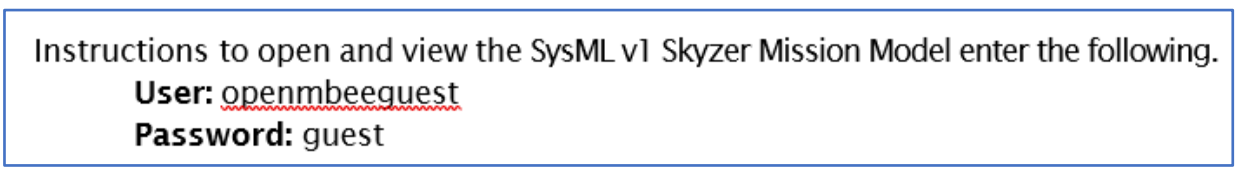

Figure 2 Instructions to open the SysML v1 Skyzer Mission Model

The Skyzer Mission Model is a model of a UAV that is launched from a ship and performs a search and rescue mission. The Skyzer Mission Model is one of several models used to represent the mission and

system design. The SERC developed the federation of models to demonstrate the application of typical modeling practices and methods using SysML v1. The mission model consists of approximately 5300 model elements and includes 6 of the 9 standard SysML v1 diagrams, and requirements tables, but does not include any state machine, parametric, or requirements diagrams as shown in Figure 3.

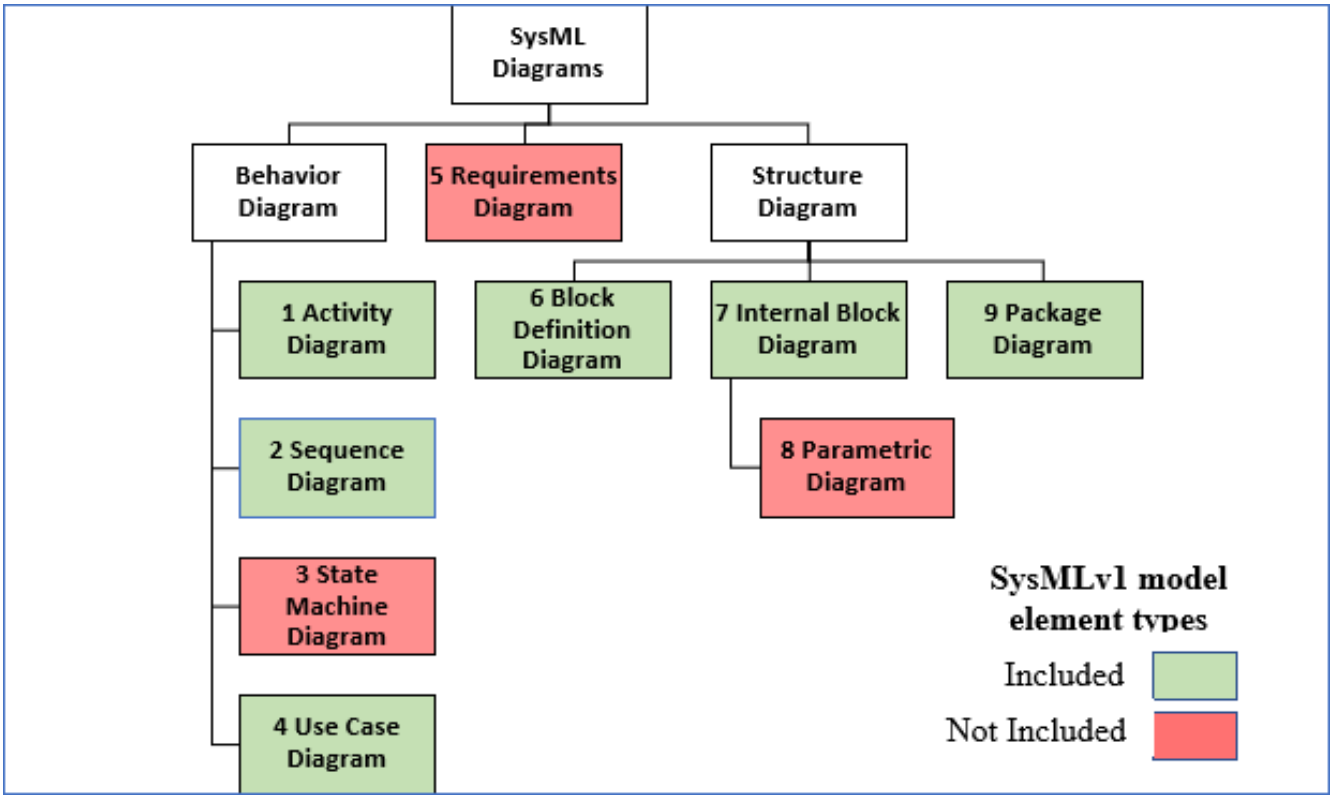

Figure 2 SysML v1 Diagram Types Used in the Skyzer Mission Model

The model includes many kinds of SysML v1 model elements including packages, dependencies, blocks, attributes, parts, ports, connections, associations, use cases, actors, activities, actions, swim lanes, control flows, object flows, lifelines, messages, requirements, constraints, and trace and satisfy relationships. Some of the more common elements that are not included in this model are proxy and full ports, interface blocks, states, transitions, test cases, derive and verify relationships, constraint blocks, constraint properties, binding connections, views, and viewpoints. The model also includes some stereotypes to create language extensions and some customizations that are unique to the tool such as a glossary, acronym list, a legend, and some custom images.

The SysML v2 modeling environment is the pilot implementation that was developed as part of the SysML v2 Submission Team (SST) to validate the SysML v2 language (Seidewitz & Bajaj). This implementation is integrated into the Jupyter Lab environment to provide support for creating SysML v2 models using the textual notation. The graphical visualization environment is adapted from the open-source PlantUML application that also was integrated into the Jupyter environment. The modified PlantUML visualization capability is limited and is not entirely conformant to the SysML v2 specifications. It is anticipated that the visualization capability will be substantially improved when commercial tools become available.

The SysML v2 model was created using the Jupyter environment and is available in two formats using the Jupyter extension. jpynb, and a SysML extension that can be opened in most text editors. (https://www.omgwiki.org/MBSE/doku.php?id=mbse:sysml_v2_transition:sysml_v1_model_samples)

Since the objective for converting this example was to illustrate the model conversion approach, only representative parts of the model were converted and not the entire model. The conversion process was performed manually since automation was not available for this effort. The focus for this example was on the transformation and post-processing steps. The manual transformation precluded the need to pre-process the model. The transformation and post processing steps are described below. The Skyzer Mission Model took approximately 80 hours over a 3-month period to perform the manual conversion and review the converted SysML v2 model to ensure its consistency with the source SysML v1 model. Over the 3-month period, the conversion effort was reviewed with the project team to help train them in the conversion approach so they could apply this approach to other models.

Transform the SysML v1 Skyzer Model into SysML v2

An implementation of the transformation specification is not currently available. The transformation was performed by manually creating SysML v2 elements in the Jupyter environment that corresponded to elements in the SysML v1 model. Significant portions of the SysML v1 model were transformed to demonstrate the approach.

The mapping from SysML v1 elements to SysML v2 elements was based on the modelers' experience with SysML v2 rather than following the strict rules defined in the SysML v1 to SysML v2 transformation specification. Much of the mapping is straightforward, such as a block in SysML v1 is transformed to a part def in SysML v2 and a requirement in SysML v1 is transformed to a requirement def in SysML v2. There will be differences between the results of the manual transformation and the results of an automated transformation. However, the manual transformation should be a reasonable approximation of the expected results from an automated transformation after some level of pre-processing.

The transformation steps were performed incrementally as follows:

Transform SysML v1 model to SysML v2 model

- Transform Package Structure
- Transform Blocks and their Parts
- Transform Ports and Connectors
- Transform Value Properties and Value Types
- Transform Requirements and their Hierarchy
- Transform Use Cases
- Transform Activities
- Transform Interactions (e.g., sequence diagrams)
- Transform State-Based Behavior
- Transform Parametrics
- Transform Requirements Relationships
- Transform Other Elements
- Transform Stereotypes
- Transform Customizations

Post-process the SysML v2 Skyzer model

This step involved post-processing the transformed SysML v2 model to take advantage of some of the SysML v2 modeling capabilities. The SysML v2 model was significantly reorganized and the model was refactored to align with the usage focused modeling paradigm.

The usage focused modeling paradigm leverages the SysML v2 definition and usage pattern that supports decomposition and specialization of parts, actions, requirements, and many other kinds of SysML v2 elements. A decomposition with usage focused modeling results in a hierarchy of parts, actions, requirements, etc. This contrasts with the block decomposition in SysML v1 which decomposes blocks into parts that are typed by blocks, and those blocks are further decomposed into parts that are typed by blocks. The more direct part decomposition in SysML v2 results in a straightforward parts tree. In the usage focused paradigm, the parts can be defined by part definitions, but each part definition represents a black box that does not contain parts of its own. This enables multiple parts to be defined by the same black box but have their own part decomposition. This approach facilitates reuse of the black box specifications and can be applied at each level of design.

Similarly, a SysML v1 activity decomposes into call behavior actions that call activities that further decompose into call behavior actions. This again contrasts with a more direct-action decomposition in SysML v2 resulting in an action tree. The actions can be defined by action definitions which specify their inputs and outputs. This same usage focused decomposition pattern applies to virtually all SysML v2 concepts.

The model organization for a usage focused paradigm separates the packages that contain definition elements from the packages that use the definition elements. The packages that use the definition elements contain the usage hierarchies such as a parts tree and action tree, and cross connections between parts and actions.

The post-processing steps were performed incrementally as follows:

Post-process the SysML v2 model

- Reorganize the SysML v2 model
- Refactor parts hierarchy
- Refactor parts interconnection
- Capture action definitions in action definitions package
- Refactor action hierarchy
- Integrate behavior
- Refactor the requirements
- Refactor requirements traceability
- Additional refactoring

Example artifacts

The details of each of the above transformation and post-processing steps are provided as an appendix in an expanded version of this paper which is available in the OMG WIKI SysML v2 Transition Project page https://www.de-bok.org/asset/5bd90f82fab101bdf093103f76ce74ec5411300e Some selected artifacts resulting from the conversion process are included below as examples.

Figure 4 shows the package structure for the SysML v1 model, the transformed SysML v2 model, and the post-processed SysML v2 model. The SysML v1 model organization is a typical organization that includes packages for Mission Requirements, Mission Structure, Mission Use Cases, Mission Behavior, and others. The transformed SysML v2 model organization mirrors the SysML v1 package structure since a corresponding SysML v2 package was created for each SysML v1 package. The correspondence

applies to the nested packages and their content. The post-processed SysML v2 model is organized based on the usage focused paradigm. The definition elements for part definitions, item definitions, attribute definitions, etc. are in one set of packages and the hierarchy of usage elements for parts, actions, and requirements are contained in the Mission Domain Level and SysML Level packages. Another package contains allocation relationships between requirements and other elements.

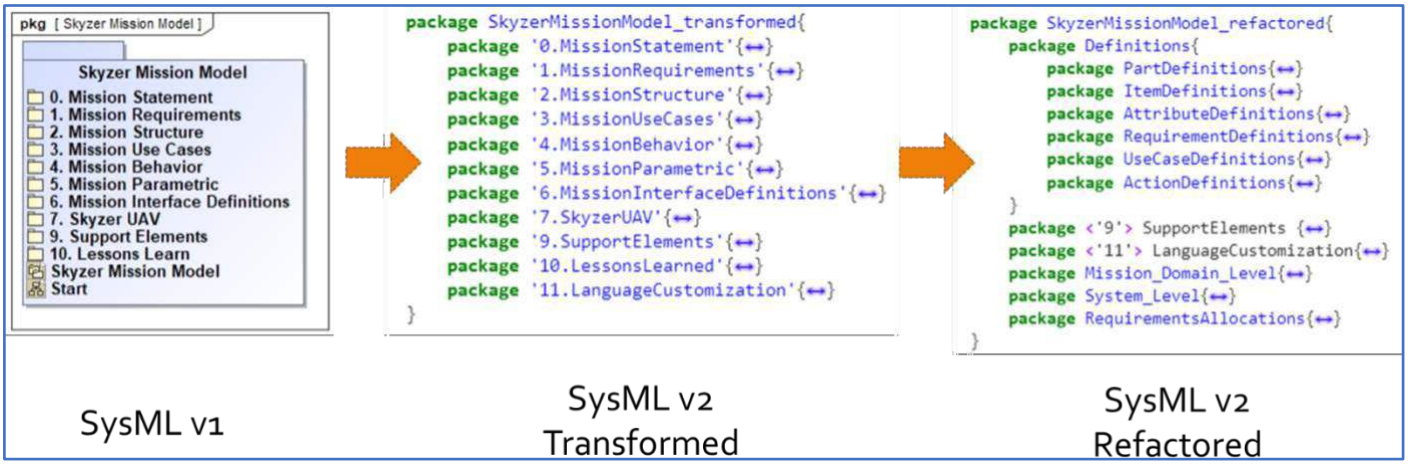

Figure 4 Package structure for SysML v1 model, Transformed SysML v2 model, and Post-processed SysML v2 model

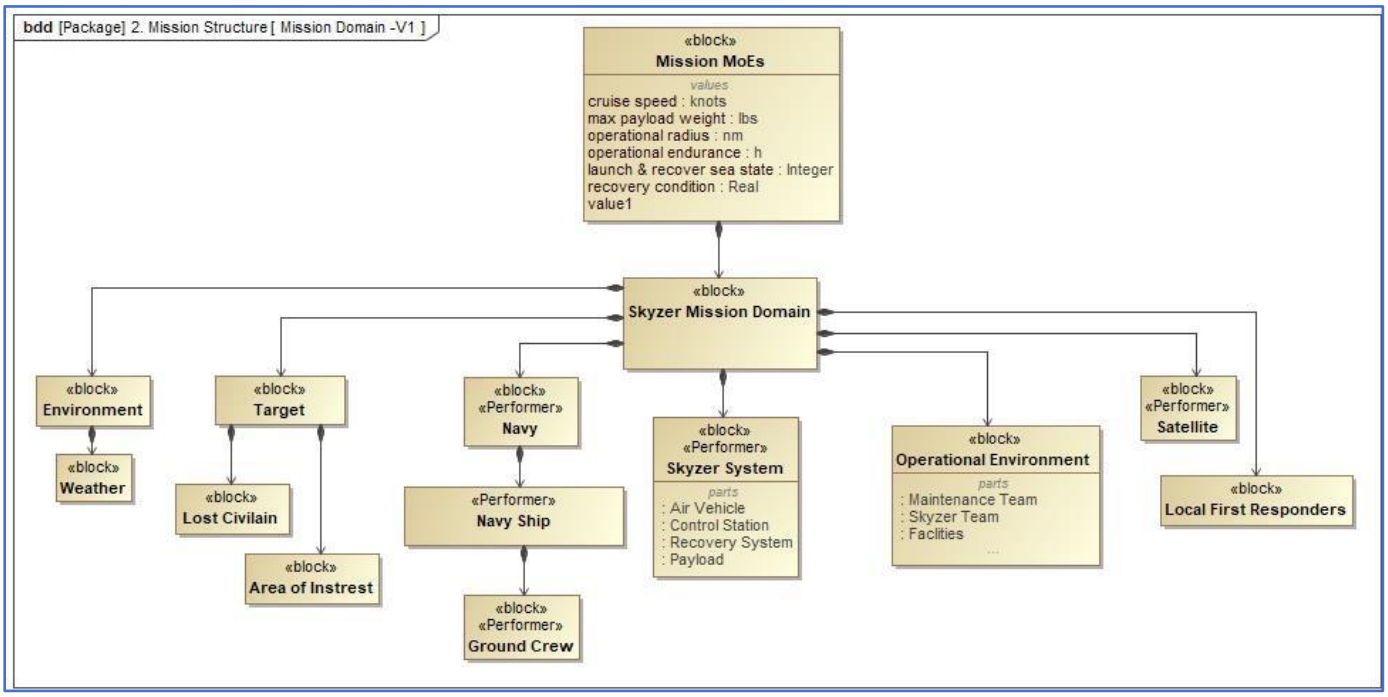

Figure 3 Block decomposition showing structure of the SysML v1 Skyzer Mission Model (some elements not shown)

Figure 5 shows a portion of the structure for the SysML v1 model and Figure 6 shows a corresponding portion of the structure for the post-processed SysML v2 model. The SysML v1 model includes a top-level block called Mission Measures of Effectiveness (MOE) that contains the measures of effectiveness for the Skyzer Mission. The Mission MOE's block is composed of a part typed by the SkyzerMissionDomain which provides the overall context for the systems and other entities that participate in the mission. The Skyzer Mission Domain block is further decomposed into parts that are

typed by the Environment, Target, Navy, Skyzer System, and others. The Skyzer System is further decomposed into parts that are typed by the Air Vehicle, Control Station, Recovery System, and Payload. All the parts are unnamed.

The corresponding SysML v2 structure for the refactored model is a parts hierarchy. The top-level part is called the skyzerMissionDomain_1. It is composed of parts that include the elements participating in the mission including the navy, the target, the environment, and the satellite. A new part was introduced called the Skyzer Enterprise that contains the measures of effectiveness. This part is further decomposed into the uav_Operator, the skzyerSystem, the maintenance team, etc. The skyzerSystem is decomposed into the airVehicle, payload, controlStation, and the recoverySystem. The airVehicle, payload, and controlStation are defined by their part definitions which serve as a black box specification for these elements. As noted above, the decomposition is a part hierarchy versus a more complex block decomposition structure. This approach is more straightforward and reduces ambiguity for nested structures that are more than one level deep as is the case here.

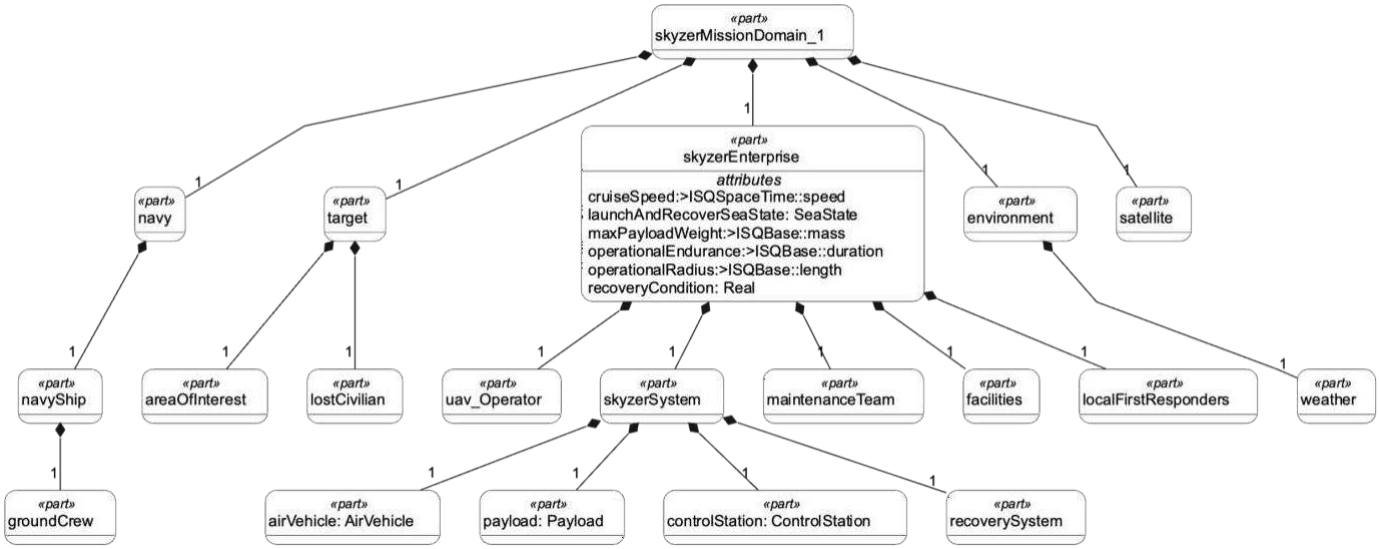

Figure 6. Corresponding part hierarchy for post-processed SysML v2 model of the skyzerMissionDomain (some elements not shown to fit on the page)

Figure 7 shows the mission requirement for an imaging capability in the SysML v1 model that contains two nested requirements. The requirements are visualized in a requirements table.

10	1.1.2	R 1.1.2 Imaging Capability	The system shall perform various imaging capabilities for search and rescue
11	1.1.2.1	R 1.1.2.1 Image Processing	Ground Control to have image-processing capabilities to support identifying locations, lost personnel, and drop locations for search and rescue
12	1.1.2.2	R 1.1.2.2 Image-Exploitation	Ground Control to have image-exploitation capabilities to support imagery mapping and seeking capabilities

Figure 7. The requirement for imaging capability with two nested requirements in a SysML v1 requirements table.

The corresponding SysML v2 requirements are shown in Figure 8 using the textual notation. SysML v2 tools are also expected to provide the ability to represent requirements and many other elements in a tabular and matrix format.

```
requirement def <'1.1.2'> ImagingCapability{
    doc /* The system shall perform various imaging capabilities for search and rescue*/
    requirement def <'1.1.2.1'> ImageProcessing{
        doc /* Ground Control to have image-processing capabilities to support identifying
        locations, lost personnel, and drop locations for search and rescue */
    }
    requirement def <'1.1.2.2'> ImageExploitation{
        doc /* Ground Control to have image-exploitation capabilities to support imagery
        mapping and seeking capabilities */
    }
}
```

Figure 8. The corresponding requirement for imaging capability in SysML v2 using the textual notation

Figure 9 shows another mission requirement in the post-processed SysML v2 model for the operational radius. This requirement has been elaborated to include formal constraints in terms of both required constraints and assumed constraints. The assumed constraints must be valid for the requirement to apply. A SysML v2 solver can evaluate the constraints based on the results of an analysis, test, or other verification method to determine whether the requirement is satisfied or not.

```
requirement operational_Radius{
    doc /*The Skyzer UAV shall have an operational radius of 200nm while sustaining cruise speed,
    carrying at least 100 lb of payload and hovering 15 minutes at the turn around point.*/
    attribute operationalRadius :> ISQ::length;
    attribute payloadWeight :> ISQ::mass;
    attribute hoveringTime :> ISQ::time;
    require constraint {operationalRadius >= 200 [nmi]}
    assume constraint {payloadWeight >= 100 [lb]}
    assume constraint {hoveringTime >= 15 [minute]}
}
```

Figure 9. The requirement for operational radius in SysML v2 with formal constraints using the textual notation

The more detailed writeup in the appendix to this paper is included in the references and provides additional elaboration and examples that contrast the SysML v1 model with the transformed and post-processed SysML v2 model.

Observations & Recommendations

This early effort to manually convert a SysML v1 model to a SysML v2 model is being done prior to the availability of commercial SysML v2 modeling tools which will automate part of this process. These results should help set expectations for the effort required, the approach, and the potential benefits of model conversion. However, it should be recognized that these are early observations and are likely to significantly evolve as commercial tools become available and the industry gains experience with model conversion. The observations include the following:

- The conversion steps for transformation post-processing, and validation should be performed incrementally. Performing a batch conversion will make it more difficult to validate the model and will limit the opportunities to significantly improve the model quality and leverage SysML v2 modeling capabilities.
- The post-processing step should apply the usage-focused paradigm to more fully leverage the SysML v2 modeling capabilities. This will require significant reorganization and

refactoring of the model. The model reorganization establishes packages that contain the reusable definition elements that serve as black box specifications with no decomposition. Separate packages are created to contain the mission and system hierarchy that typically include a parts hierarchy, an action hierarchy, and a requirements hierarchy. The usage elements in the hierarchies may be defined by the definition elements as needed to facilitate reuse.

- Establish a consistent parts hierarchy. The core structure of the SysML v1 model is based on the block decomposition generally starting with a top-level block that serves as a mission context. There may be other implicit structure associated with the OV-1, the swim lanes in activities, the lifelines in sequence diagrams, and the actors in use case diagrams. These implicit structures may not be entirely consistent with the block decomposition. The SysML v2 model provides an opportunity to provide a consistent parts hierarchy from the top-level mission context part down to the lowest level of design.
- Integrate the behavior with the structure including states, actions, message sequence, anduse cases. The initial focus for establishing the integrated behavior is to establish a consistent action decomposition based on the SysML v1 model. There may also be opportunities to create action specializations that share common sets of actions. This has been difficult to do in SysML v1 but is straightforward to do in SysML v2. After the action tree is clearly established, the parts that perform the actions can be established. Although there were no states in the Skyzer model, it is anticipated that the states can then be integrated by identifying which states enable which actions. There were considerable sequence diagrams in the SysML v1 model which were transformed to messages in the SysML v2 model. The messages had to be carefully integrated to ensure they were sent across the correct connections. It is also critical that they be integrated with the action flow, but this may depend on the selected methodology.
- The post processing may yield significant changes to the system structure and behavior,particularly as it is identified will resolve redundancies, inconsistencies, and other gaps. This, in turn, may impact the requirements allocation/satisfaction and other requirements relationships. In the Skyzer SysML v1 model, there were several requirements that were satisfied by the in the Mission MOE's block. However, this block was not included in the SysML v2 model, and a skyzerEnterprise part was introduced that contained the MOE's. This change impacted the requirements allocations.
- There are many opportunities to leverage SysML v2 capabilities to further refine the model and add both precision and expressiveness. An example is the ability to formalize selected requirements with formal constraint expressions that can be evaluated as pass or fail. The standard quantities and units library is much improved over SysML v1 in both precision, expressiveness, and usability. The language adds new concepts to model variability, trade studies, metadata, and many other concepts. SysML v2 also provides the ability to define an alias for any name and can leverage annotations to establish a glossary of terms. There will be new opportunities to integrate with many other applications through the standard API including analysis, configuration management, visualization, and other electrical, mechanical, software, and verification tools.

Summary

The transition from SysML v1 to SysML v2 should be carefully planned to include updates to an organization's methods, tools, and training. A particular project should determine when to transition to SysML v2 based on near-term, mid-term, and long-term considerations of the benefits, costs, and risks of transition. The timing of the transition on a program should typically be at the start of a new

program or system upgrade, with the goal to minimize disruption and maximize the benefit. The program should ensure the proper expertise and resources are available to support their transition to SysML v2 in accordance with the program plan. A program may choose to convert an existing SysML v1 model or start with a new SysML v2 model depending on the state of the SysML v1 model and how well it will support the SysML v2 modeling objectives.

Converting a SysML v1 model to a SysML v2 model includes pre-processing the SysML v1 model, transforming and post-processing the SysML v2 model, and validating the SysML v2 model adequately reflects the original intent of the SysML v1 model. In addition, an assessment should be made of the impact to artifacts that were derived or generated from the SysML v1 model and update those artifacts as required. The conversion process should be done systematically and incrementally, and the results should be validated as part of each increment.

The transformation from a SysML v1 model to a SysML v2 model is anticipated to be enabled by tool automation that implements the SysML v1 to SysML v2 transformation specification. It is also anticipated that pre-processing of the SysML v1 model will be required to remove customizations that are not supported by the standard transformation.

To maximize the advantages of the conversion, it is advisable to reorganize and refactor the transformed SysML v2 model in accordance with the usage focused paradigm to benefit from the SysML more fully v2 modeling capabilities. If done properly, the additional effort can yield a much more integrated SysML v2 model that is more precise, expressive, regular, interoperable, extensible, and usable than the original SysML v1 model.

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About the Authors

Sanford Friedenthal is an industry leader and independent consultant in model-based systems engineering (MBSE). He has over 30 years of experience as a system engineering practitioner, department manager, and leader of organizational initiatives for Lockheed Martin. Mr. Friedenthal also has been a leader of the industry standards effort through the Object Management Group (OMG) and INCOSE to develop the Systems Modeling Language (OMG SysML®) that was adopted in 2006 and more recently co-led the effort to develop the next generation of SysML (v2). He is co-author of "A Practical Guide to SysML" and "Architecting Spacecraft with SysML".

Mr. Daniel Hettema is the Director of Digital Engineering, Modeling and Simulation (DEM&S) within the Office of the Under Secretary of Defense for Research and Engineering. In this role he oversees DoD strategy, policy, and coordination for DEM&S topics. He brings experience in model-based systems engineering and digital engineering in both government and industry and has held leadership roles in the International Council on Systems Engineering. He holds a B.S. in Systems Engineering from George Mason University and an M.S. in Space Systems from Johns Hopkins.

SYSTEMS ENGINEERING RESOURCES

Useful artifacts to improve your SE effectiveness

Recommended PDMA Resources

kHUB PDMA Knowledge Hub

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

Note that kHUB sections have recently been re-organized to align with the PDMA's new Body of Knowledge V3.0.

General Recommendations

Recent PDMA resource recommendations include the following articles, webinars, podcasts, blogs, newsletters, etc.:

Breaking Boundaries: Harnessing AI to Fuel Insights for Innovation
(Webcast)
Explore how Gen AI is propelling brands' ability to obtain robust, actionable VOC insights for innovation. Learning Objectives include:

- Understand the benefits of needs-based innovation versus technology-led innovation.
- Discover how generative AI can unearth customer needs necessary for product development, even in complex, highly technical, or nuanced categories.
- Explore examples of how AI gathers comprehensive and detailed lists of customer needs for product development.
- Learn about the future of Gen AI for VOC and what this could mean for the product development community.

Community Driven Product Development
(PDMA New Zealand chapter webinar)

How to 10x Your Product Management with Generative AI
(PDMA Carolinas chapter webinar)
In this cutting-edge webinar, we delve into the untapped potential of Generative AI to revolutionize your approach to product management. As an experienced product leader, you're well-versed in the challenges and opportunities of the digital era. This session aims to arm you with advanced AI tools and strategies, transforming your product management practice into a powerhouse of innovation and efficiency. We'll explore how Generative AI can be your ace in navigating complex market landscapes, driving product innovation, and crafting compelling customer experiences.

Including Sustainability in Innovation Governance and Portfolio Management
(Webcast)

Paul Heller will present how leading companies are including sustainability in their new product decision-making processes and how they are evaluating the impact of such decisions on their innovation portfolios.

Paradigm Shift: Dramatic Operational Improvement with a Change in Mindset
(PDMA Minnesota chapter webinar)
Promoting and managing change in an organization is of great value but presents many challenges. Even without direction, change occurs so management is critical to achieve the types of changes that are desirable. Mindset drives and affects change. Mindset, Methods, and Measures interact, and all must be in harmony to effect and preserve the planned changes. Significant improvements are accomplished through a paradigm shift that requires challenging current assumptions and changing mindsets. This session will provide tools and methods that can be used to manage and sustain changes and improvements and will also address some of the challenges that are likely to be encountered. Attendees will leave with a framework for managing change and improvement projects in their organization.

Simplicity in Design – TEDTALKS with Practitioner Insights
This blog post summarizes key learning from and provides links to three talks on design simplicity:

- Towards a science of simplicity by George Whitesides
- Design for simplicity by John Maeda
- What can we learn from shortcuts? by Tom Hulme

Together We Create: The Power of Integrating Customers in Your Product Development
(PDMA St. Louis chapter webinar)
Exceptional products and services are born from valuable insights. The most profound insights aren't based solely on formal research. They come from Community Voice, a relational engagement with community members and customers. Community Voice is a powerful combination of customer insights and emotional engagement with the customers and community members who have personal investment in both the products you build and the communities they are used in. This speech explores the concept of Community Driven Product Development (CDPD), a methodology that goes beyond traditional design and development by embracing the wisdom and input of the user community.

Journal Papers
kHUB includes links to a mix of open access and subscription-only papers published in the Journal of Product Innovation Management (JPIM). Recommendations among these papers include:

Addressing the grand challenges of poverty with data-driven creative service offerings
Big data-driven innovation gains momentum in the developing world by tackling grand challenges and making a pronounced and lasting impact. However, research has still not answered the key question regarding the dimensions of big poverty data analytics (BPDA) capabilities for creative service offerings nor their effects on economic and social outcomes. This study fills this gap by conducting a two-phase Delphi study and two rounds of surveys focusing on a globally leading microcredit institute in a developing country. The study conceptualizes management (analytics climate, cross-functional integration), platform (technology and data), and talent (pattern spotting and market ambidexterity) capabilities as the dimensions of BPDA capability. It further investigates creative service offerings (meaningfulness and novelty) as the mediator between BPDA - new service performance (economic outcome from the firm's end) as well as BPDA - quality of life (social outcome from consumer's end).

Read the full open access article on Wiley.

A good neighbor, a found treasure: Do local neighbors affect corporate innovation?
This study examines whether local neighbors operating in different industries affect corporate innovation engagement. Based on mimetic isomorphism theory, we find that innovative local neighbors can serve as a social reference group for corporations to build legitimacy and guide corporations' mimetic innovation behavior. Our results remain robust after controlling for endogeneity by employing various methods. More importantly, our mechanism analysis indicates that local government activism is crucial to promote mimetic innovation behavior in a region. Our study provides a valid mechanism to explain the emergence of highly innovative cities that agglomerate across industry boundaries.

Collective turnover and firm innovation: Knowledge-sharing system as a contingency
Is high employee turnover harmful to innovation? To answer this question, we draw on the knowledge-based view of innovation. Specifically, we theorize that the collective turnover of a firm engenders complex changes in knowledge insourcing needed for generating innovation, which may lead to the attenuating negative effect of turnover on innovation. This study also aims to investigate a contingency that modifies the detrimental effect of collective turnover on innovation. Specifically, we identify knowledge-sharing system (KSS) as a positive knowledge-related contingency that engenders a U-shaped curvilinear relationship between collective turnover and firm innovation.

Converting inventions into innovations to address cancer grand challenges: The role of scientific and digital search intensity
The present study seeks to shed further light on what favors the conversion of inventions into innovations in for-profit firms and to advance our understanding of how to tackle cancer grand challenges (CGCs). Specifically, following the literature on knowledge search and recombination, we analyze whether and how cancer-related inventions developed through an intense adoption of scientific knowledge (scientific search intensity) result in (i) a higher number of approved drugs and (ii) a shorter approval time for new drugs.

Read the full open access article on Wiley.

Grand challenges and emerging market small and medium enterprises: The role of strategic agility and gender diversity
This paper examines the role played by strategic agility and gender diversity in enabling the creation of value for grand challenges (VCGCs) by small and medium-sized enterprises originating from emerging markets (ESMEs). ESMEs face significant challenges due to the dynamic environments in which they operate and the limited support they receive from formal institutions. In such contexts, strategic agility enables ESMEs to drive VCGCs through responsible collaborative innovation. We further argue that gender diversity is an important boundary condition that influences the effect of strategic agility on VCGCs via responsible collaborative innovation.

Read the full open access article on Wiley.

Grand challenges and platform ecosystems: Scaling solutions for wicked ecological and societal problems
The persistence of grand societal and environmental challenges demands attention from innovation management scholars and practitioners to find effective resolutions. In this catalyst article, I argue that platform ecosystems - communities and groups of actors in different markets orchestrated

through a digital platform and driven by combinations of economic and prosocial incentives - are an organizing form that can help effectively scale solutions for grand societal and environmental problems.

Read the full open access article on Wiley.

How do grand challenges determine, drive, and influence the innovation efforts of for-profit firms? A multidimensional analysis

While raising concerns, the recent proliferation of grand challenges has sparked interest in the role played by innovation in causing them, and in how the attempts made to fix them may cause even greater challenges that present themselves down the line. This article provides an analysis of the bibliographic metadata, published between 2002 and 2020, focusing explicitly on the private-for-profit sector. By identifying common themes from 66 documents, a framework highlighting the shared concerns and research trajectories was derived. Our results are illustrated and discussed along 11 research themes.

How firms realign to tackle the grand challenge of climate change: An innovation ecosystems perspective

This study investigates how, why, and under which conditions incumbents and new entrants realign in innovation ecosystems to collectively tackle the grand challenge (GC) of climate change. The discussion on innovation and GCs is still lacking sufficient theoretical underpinnings and empirical insights to make sense of the role of for-profit firms and their collaborative innovation efforts to address the GCs of our times. We introduce innovation ecosystems as a theoretical lens for understanding the combinations of technological interfaces and strategic relations that firms can employ to craft value propositions with high potential for tackling GCs. Empirically, this study focuses on the GC of climate change that requires a transformation of the electricity sector.

Read the full open access article on Wiley.

Setting contextual conditions to resolve grand challenges through responsible innovation: A comparative patent analysis in the circular economy

This article draws on responsible innovation (RI) undertaken by hybrid organizations, institutional rigidity, and national innovation systems (NISs) to assess and contextualize the innovation performance of for-profit firms seeking to resolve grand challenges (GCs). The extant research on RI lacks the theoretical underpinnings to profile the unique characteristics of RI firms and the contextual conditions behind the resolution of GCs through RI. This study aims to fill this important gap by focusing on a specific type of RI firm—a firm seeking to reduce climate change through implementation of a circular economy model.

Read the full open access article on Wiley.

Tackling exigent grand challenges through corporate social innovation: Evidence from the COVID-19 pandemic

While the body of research on grand challenges (GCs) has grown, our understanding of the role of corporate social innovation (CSI) in tackling exigent GCs, such as the COVID-19 pandemic, is limited. Based on in-depth analyses of four cases of CSI in the services sector during the COVID-19 pandemic, this paper contributes to the GC literature by developing a 3Es framework of the CSI process (i.e., embeddedness, engagement, and enhancement) to illustrate the mechanisms through which exigent GCs can be effectively addressed by firms in the services sector.

Tackling grand societal challenges: Understanding when and how reverse engineering fosters frugal product innovation in an emerging market

Societies are confronted with grand challenges that require the efforts and coordination of diverse stakeholders. In this context, the role of for-profit organizations has become vital in addressing such challenges. Drawing on the strategy tripod perspective, this study investigated the influence of reverse engineering on frugal product-innovation performance (PIP) through the mediating effect of frugal innovation (i.e., cost innovation, and affordable value innovation). In addition, we examined the moderating impact of the industry environment (i.e., technological turbulence) and institutional context (i.e., legal inefficiency) on this relationship.

Read the full open access article on Wiley.

Tackling pandemic-related health grand challenges: The role of organizational ambidexterity, social equality, and innovation performance

The outbreak of COVID-19 has brought the world to a standstill, with severe consequences on economic and health systems, requiring the identification and implementation of innovative solutions. This study's aims are threefold: first, to examine the impact of balanced and combined dimensions of ambidexterity on for-profit organizations' innovation performance related to pandemics; second, to uncover whether and to what extent such innovation performance contributes to tackling global health grand challenges (i.e., mortality rate, risk of infection, and life expectancy) associated with pandemics; and, third, to investigate the moderating role of social equalities in health in the relationships between innovation performance and health-related outcomes associated with pandemics.

Read the full open access article on Wiley.

The uncertainty-handling function of project leaders' political behavior in breakthrough innovation

Innovation management research demonstrates that political behavior is necessary for project leaders to conduct breakthrough innovation (BI) projects successfully. We investigate six BI projects in five mature Japanese companies through the lens of the meaning management perspective. The analysis reveals that (1) project leaders use political behavior to address a specific situation in which two uncertainties are intertwined; (2) project leaders use different political behavior depending on the type of intertwined uncertainties; and (3) project leaders resolve intertwined uncertainties with political behavior and then address each uncertainty in their BI projects.

Read the full open access article on Wiley.

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System Dynamics Review

The System Dynamics Review (SDR), published quarterly by Wiley on behalf of the System Dynamics Society (SDS), typically provides non-member access to a select set of journal articles. The recently released SDR Volume 40, Issue 2 contains four open access articles that address both the history and future directions of the system dynamics community.

A comparison of loop dominance methods: measures and meaning
Authors: John Hayward and Paul A. Roach

Abstract: The behavior of a system dynamics model is determined by its structure expressed in its stocks, flows, and feedback loops. The latter are especially important as they represent endogeneity in the system and provide intuitive explanations of behavior. Further, knowing which loops are influential can help determine suitable interventions for system change.

Several methods have been developed to quantify the relationship between feedback loops and behavior. (For a review, see Kampmann and Oliva [2020].) Despite promising results, the methods are not used widely in the system dynamics community. One potential reason for their slow uptake is that the conceptual interpretation provided by the methods can lack transparency, especially to modelers not versed in mathematics. Our purpose in this article is to address the conceptual hurdles by examining a well-known model and comparing the interpretations provided by each method.

Ethical considerations of using system dynamics in participatory settings: a social-ecological-systems perspective
Authors: Henry Amorocho-Daza, Pieter van der Zaag, and Janez Sušnik

Abstract: The social-ecological systems (SES) approach elicits a broad understanding of some of the most pressing socionatural challenges (e.g. resource scarcity, biodiversity loss, and climate change) and the responsibility that humans have in addressing them. System dynamics has proven a powerful paradigm for dealing with complex SES-related issues. Here we discuss some ethical considerations of using system dynamics (SD) to model SES, something that is often either overlooked or discussed as an isolated issue. Sustainable development and human rights are used as ethical standpoints across the modelling cycle, opening the discussion around guiding principles that need to be considered when modelling SES. Based on these, a set of guiding ethical questions are identified and classified across a participatory SD modelling cycle. This structured approach is a simple yet potentially useful tool for SD practitioners to examine the ethical implications of their modelling endeavors in the context of grand societal challenges.

History of the Beer Game
Author: Ignacio J. Martinez-Moyano

Abstract: This article describes the history of the Beer Game. By triangulating information from literature, archival analysis, and interviews with experts in the field, the main changes in the game over its almost 70-year history are identified. The article discusses three aspects of the game: 1) its structure (phases of its history, stocks and flows, parameters, etc.); 2) the process for playing the game; and 3) the game debrief.

What is (quantitative) system dynamics modeling? Defining characteristics and the opportunities they create
Authors: Asmeret Naugle, Saeed Langarudi, and Timothy Clancy

Abstract: A clear definition of system dynamics modeling can provide shared understanding and clarify the impact of the field. We introduce a set of characteristics that define quantitative system dynamics, selected to capture core philosophy, describe theoretical and practical principles, and apply to historical work but be flexible enough to remain relevant as the field progresses. The defining characteristics are: (1) models are based on causal feedback structure, (2) accumulations and delays

are foundational, (3) models are equation-based, (4) concept of time is continuous, and (5) analysis focuses on feedback dynamics. We discuss the implications of these principles and use them to identify research opportunities in which the system dynamics field can advance. These research opportunities include causality, disaggregation, data science and AI, and contributing to scientific advancement. Progress in these areas has the potential to improve both the science and practice of system dynamics.

This issue of the SDR includes members-only content that captures an ongoing community conversation in response to a previous article, Never the strongest: reconciling the four schools of thought in system dynamics in the debate on quality.

- Luis F. Luna-Reyes highlights how acknowledging differences can make the System Dynamics community stronger and make the field more attractive to new practitioners and the general audience.
- Mohammad S. Jalali and Hesam Mahmoudi emphasize quality aspects and transparency in both qualitative and quantitative modeling.

Learn more about the System Dynamics Review here.
Join the SDS to gain full access to the System Dynamics Review.

System Dynamics Society Recognizes Sponsors and Supporters

In preparation for the 2024 International System Dynamics Conference (ISDC2024), scheduled for 4-8 August, the System Dynamics Society has been recognizing the contributions of its many sponsoring organizations through their partnershp in advancing the practice and global reach of system dynamics. Because the global system dynamics and systems engineering communities are not tightly integrated, PPI SyEN encourages our readers to check out these organizations and their capabilities, knowledge and resources in this field and to look for opportunities to leverage systems dynamics know-how in their projects.

The following organizations (presented alphabetically) represent a mix of 2024 Society sponsors, Conference sponsors, benefactors and other champions of system dynamics.

- California State University – Chico, System Dynamics Group
- Case Western Reserve University
- Change Agent, Inc.
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- Consideo
- Copernicos
- Creative Learning Exchange
- Credit Human
- DESTA Research LLP
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- DynamicVu
- Forio
- Georgia Health Policy Center, Georgia State University
- isee systems

- Jack B. Homer Giving Fund
- Journal of Open Innovation: Technology, Market, and Complexity
- KU Leuven
- Markus Schwaninger
- MIT Sloan School of Management, System Dynamics Group
- PathFwd: Dynamic Simulation Modeling Tool
- Powersim Software AS
- Sage Analysis Group
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- University of Bergen, System Dynamics Group
- Ventana Systems, Inc.

See more details on the various sponsors and their contributions here.

The importance of active listening in the role of a Business Analyst

Requirements Engineering Magazine
The Magazine for RE Professionals from IREB

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

In the May 2024 edition, Karolina Zmitrowicz, Polish business analysis and requirements engineering consultant and a member of the IREB Executive Board, authored an article titled "*The importance of active listening in the role of a Business Analyst – How to improve the quality of communication*.

Abstract:
The International Institute of Business Analysis (IIBA) defines business analysis as "the practice of enabling change in the context of an enterprise by defining needs and recommending solutions that deliver value to stakeholders" [1]. This process relies heavily on effective communication and understanding of stakeholder needs, with particular emphasis on active listening. In this article, we will explore why these skills are essential for business analysts and how they can overcome some typical barriers to active listening. We will also highlight the benefits of these practices in fostering better relationships and creating a positive work environment.

Topics addressed include:

- What is active listening?
- The significance of active listening
- Barriers to active listening and their impact on Business Analysis activities
- How to improve active listening
- Benefits of active listening

Read the full article here.

View other RE Magazine articles (105 in total).

Sign up to be notified about new issues of the Requirements Engineering Magazine.

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

The Role of Visual Modeling in Centaur Applications

On 24 April 2024, Tom Sawyer Software hosted a webinar by Joshua Feingold, CTO at Occam Systems, to discuss the role of visual modeling in "centaur" applications. "Centaur" applications elevate the capabilities of both humans and machines to achieve outcomes beyond what either humans or machines could achieve independently. The video recording of this 40-minute presentation may be viewed here.

Topics addressed include:

- What are centaur applications and the challenges and considerations when designing such an application?
- What is the role of visual modeling and how to achieve productive synergy between humans and machines?
- How to prioritize human versus computer interactions, exploring when to harness the raw computational power of machines and when to leverage the nuanced understanding and flexibility of human intelligence.
- When to use text and keyboard interfaces versus mouse and diagram interactions, uncovering how these choices impact the effectiveness of applications in real-world scenarios.
- Gain a deeper understanding of how visual modeling can act as a bridge between human intuition and machine precision, unlocking new possibilities in the development of applications.

How Did En-ROADS Get 755,000 users? Lessons on Modeling, Interface Design, and Facilitation

On 15 May 2024, the System Dynamics Society (SDS) hosted a webcast concerning En-ROADS, the global climate solutions simulator that has attracted hundreds of thousands of users worldwide. Led by Andrew Jones (Climate Interactive), John Sterman (MIT), and Florian Kapmeier (ESB Business School), the webcast shared lessons learned on how systems dynamics modelers can increase their impact.

Principles driving the success of En-ROADS include:

- Modeling: Build Trust and Ensure Accuracy
- Interface Design: Guide Users to Key Insights
- Facilitation: Create a Safe Space for Learning

Read the SDS summary of the webcast. Watch the recording on YouTube.

FINAL THOUGHTS FROM SYENNA

From ROM to Reality or SWAG to Sorrow?

Having observed, contributed to, or taken (or *made* if you're a Yank) many design decisions across my illustrious career, I marvel at the process involved in transforming an initial set of crude estimates into sufficient confidence to pull the trigger and commit to a novel design solution to a complex problem. I'm reminded that the road to (someplace very hot and nasty) is paved with good intentions. Experience shows that a process that begins with Rough-order-of-Magnitude (ROM) estimates can occasionally lead to real, working solutions that satisfy our stakeholders – well most of them anyway. But statistics show (can't find those darn references that we all quote so freely) that 70.473% of all new product launches fail, so the more likely destination derived from our Simple-Wild-Assed Guesses (SWAGs) is place of sorrow, not success.

To help my readers avoid the trauma of their Nth product failure, I've developed some anti-heuristics (rules of the thumbless?) in the form of beliefs and practices to avoid when navigating data usage from the front-end of a new design to successful delivery and happy customers. These are shared in no particular order:

1. Present all estimates in Excel spreadsheets to at least *six decimal places*. That will increase the team's confidence in the precision of your thinking.
2. Define *significant figures* as Newton (Sir Isaac), Einstein (Albert) and Churchill (Winston).
3. Variety is the spice of life. *Mix units* from different systems (Imperial vs SI/metric) in your specifications and trade studies. Mars will move, if needed.
4. Even better, throw in a few *archaic units* for fun. Cubits, stones, and hands work well for nanoscale products.
5. Even better, mix unit systems in *a single parameter*, e.g. fuel economy as gallons/km or torque as Newton-feet to appeal to the global audience. We don't want to offend anyone.
6. Never do *dimensional analysis* on your equations; you copied them well.
7. Pick your *favorite equations*; those that yield the answers that you prefer.
8. Use *imaginary numbers* whenever possible; they are hard to challenge (or explain).
9. Use lots of *large exponents*; everyone intuitively understands $10^{-17.}$ And we all grasp the real-world meaning of Avogadro's number.
10. Make all estimates assuming the most *benign* environmental, loading and threat conditions. Pessimists don't get invited to the best parties.
11. *Ignore uncertainty* in all estimates; it will make you look weak and waffling. Single point values always imply deterministic results.
12. Estimating performance against 100 parameters instead of just 10 will yield *10X better decisions*.
13. Keep all your calculations on the *back of an envelope*; solar flares may wipe out your data center.
14. Documented *assumptions* – who needs them?

FINAL THOUGHTS FROM SYENNA

15. Don't estimate at all; build the real deal and *physically test it 100 times*. They will give you more budget when you ask.
16. Have your engineers *vote* on the expected value of each parameter. Use a secret ballot; we wouldn't want them conspiring together to come up with a consensus answer or learning from each other in the process.
17. Never ask for a *second opinion*. You're the expert.
18. Ignore all *minority reports*; they come from troubled souls who need to get with the program.
19. Never *check* your calculations; you're not an undergraduate.
20. Give the program manager *full edit rights* to your parametric data.
21. *Extrapolate* freely from your experience; interpolate seldom. Your one project shares so much in common with every other one.
22. Replace all quantitative estimates with *qualitative* ones; good, better, best is good enough.
23. Throw your design decisions into an *optimization engine with an AI front-end*. What could go wrong?

Best wishes for your impending success as you heed these words of wisdom,
Syenna
