PPI SyEN

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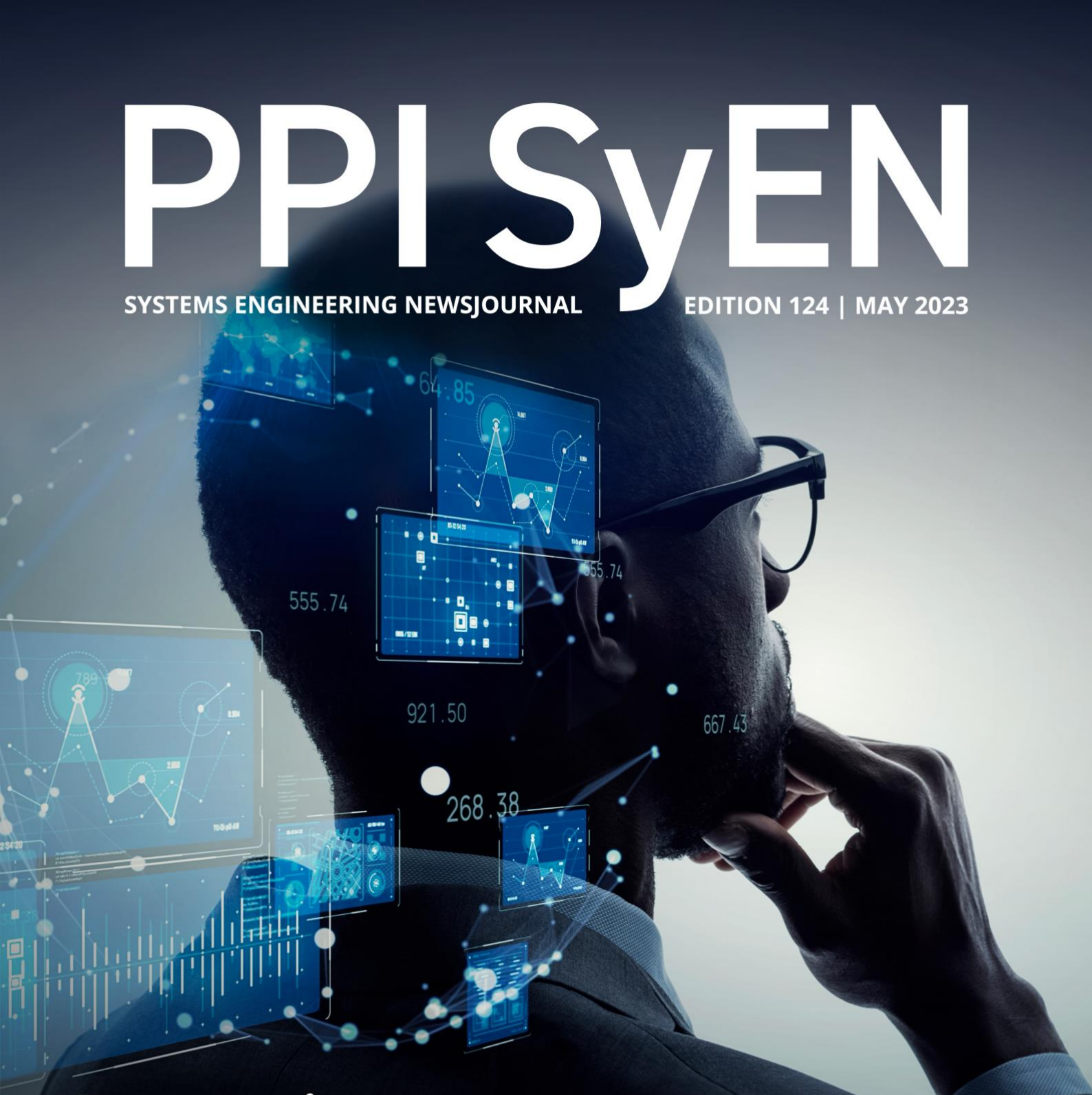

Perspectives on Models and Metrics

TRANSFORMING MODEL-BASED ENGINEERING
Improving access to system models

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PPI SyEN

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WELCOME

A warm welcome to the May edition of PPI SyEN! It's crazy to contemplate we're almost halfway through 2023; what a year it has been so far in the world of systems engineering. Exciting things have been taking place, including major happenings in MBSE language development and advancement of modeling tools. In addition, multiple collaborations between societies committed to a systems engineering approach, as well as the burgeoning of new societies and conferences across various specialty areas definitely shine a positive light on the future of SE. However, along with the wins, we are seeing a rise in urgency to address challenges such as the need for effective tool integration, managing the cultural and technical challenges of adopting new practices in engineering organizations and of course the elephant in the room that we can't ignore anymore – climate change. To this end, it is so motivating to witness the rise in awareness and application of systems engineering to solve global problems and be used as a reliable approach to solving problems within systems engineering practice itself – engineering the engineering system.

Whether you are a picking up PPI SyEN for the first time or are an avid subscriber, whether you scan through this edition or read the edition from cover to cover, I want to honor you for your commitment to the discipline of engineering through your reading of this newsjournal. Continuous improvement via reflection and further learning is fundamental to making this world a better place with engineering solutions that solve problems ethically and effectively. On that note, one important aspect of our work as systems engineering practitioners is to take responsibility for carrying the message of the work we do in a way that is understandable by practitioners in other fields. To explore this topic, Liana Kiff unpacks how graph visualization can be used to increase shared understanding amongst key stakeholders, in her feature article in this edition titled, 'Transforming Model-Based Engineering with Data-Driven Graphs'. This is a worthwhile read that inspired me to think of creative ways to use software to communicate more effectively with people on my team who will almost always be viewing the same system from different perspectives.

As always, we also offer in PPI SyEN a healthy helping of SE news items; a list of significant conferences, meetings and webinars; as well as systems engineering resources that you may like to be aware of for future reference. I believe that this month's edition captures the essence of what is possible when great minds come together to solve problems. I hope you enjoy the read ☺

Regards,

René

Managing Editor, PPI SyEN

PPI Systems Engineering Newsjournal (PPI SyEN) seeks:

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

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

NIST Workshop: Standards and Performance Metrics for On-Road Automated Vehicles

The U.S. National Institute for Standards and Technology (NIST) will host a virtual workshop on 5-8 September 2023 to further explore the development of standards and performance metrics for on-road automated vehicles. The purpose of this workshop is to bring together the Automated Vehichle (AV) community to update them on NIST's recent work in the area, provide a forum to provide feedback, and set a path forward to ensure that NIST's efforts in developing standards and performance metrics provide the greatest value to the community.

Keynote speakers and their topics include:

- Perception: Rajeev Thakur (Director, Ouster)
- Communications: Jim Misener (Global V2X Ecosystem Lead, Qualcomm)
- AI: Aleksander Madry (Director of the Center for Deployable Machine Learning, MIT)
- Cybersecurity: Anuja Sonalkar (CEO and co-founder of STEER)
- Infrastructure: Ed Straub (VP and Director of Automation Office at SAE)

The workshop builds on the results of a previous event held in March 2022. Download the report from the March 2022 workshop.

Learn more about the 5-8 September workshop. Register here.

Learn more about NIST Transportation research.

Discussion Draft of the NIST Cybersecurity Framework 2.0 Core

In late April, NIST released a preliminary draft of the NIST Cybersecurity Framework (CSF) 2.0 Core to support the development of the complete NIST CSF 2.0 Draft. This 26-page document is intended to increase transparency of the update process and promote discussion to generate concrete suggestions for improving the Framework.

NIST seeks feedback as to whether the cybersecurity outcomes address current cybersecurity challenges faced by organizations, are aligned with existing practices and resources, and are responsive to the comments.

The Discussion Core reflects extensive feedback received thus far through a series of events:

- The 92 written responses to the January 2023 CSF 2.0 Concept Paper;
- The February 2023 In-Person Working Sessions (attended by approximately 250 participants in Rockville, MD);
- The "Journey to the NIST Cybersecurity Framework 2.0" February 2023 Workshop #2 (attended virtually by more than 2,000 participants from 69 countries);
- The "Journey to the NIST Cybersecurity Framework 2.0" August 2022 Workshop #1 (attended virtually by approximately 4,000 participants from 100 countries);
- The 134 written responses to the February 2022 NIST Cybersecurity RFI;
- Feedback from organizations that have leveraged the CSF over the years; and

- NIST participation at conferences, webinars, roundtables, and meetings around the world.

Download the CSF 2.0 Discussion Draft.

Call for Papers: Resilience Engineering Special Issue

The Resilience Engineering Association (REA) has issued a Call for Papers for a special issue of the REA Newsletter titled: *Digital technologies supportive of resilient performance in socio-technical systems: a human factors and ergonomics perspective*.

Rationale:

The growing use of digital technologies (DTs) has been a major driver of the increasing complexity of socio-technical systems (STSs). This complexity plays out, for instance, in terms of more tightly-coupled systems in which variability propagates at the speed of electronic signals, often in unexpected and undesired ways. Complexity driven by DTs has also made STSs opaque as users do not really understand how the system functions and why it occasionally fails unexpectedly (Dekker, 2011).

The notion of cyber-socio-technical systems (CSTSs) has been used to emphasize the cyber dimension of such systems, which require a dedicated integration with human and social factors (Patriarca et al., 2021). Indeed, the core purpose of any technological advancement is to expand human capabilities, physical and cognitive, although this amplification has worked less well for cognitive capabilities (Hollnagel, 2021).

Topics of interest include:

- Impacts of DTs on the human and economic costs of resilient performance
- Contributions of DTs to safety-II management
- Role of DTs for training and development of resilience skills
- Unmanned vehicles and resilient performance
- Resilience assessment and modelling tools that account for the role of DTs
- New products that enhance the resilient performance of users and systems
- Cyber-resilience and human factors
- Implications of the industry 4.0 and 5.0 movements to resilient performance
- Lean digital and resilient performance
- Artificial intelligence and resilient performance
- Data analytics and resilient performance
- Implications of collaborative robots´ to resilient performance
- Contributions of digital information systems to resilient performance
- Roadmaps and methods for designing and operating resilient and smart socio-technical systems
- Accident investigations that highlight the role of DTs in the deterioration of resilience capabilities

It is anticipated that 10-15 papers will be published.

Key dates are:

- Full paper submissions due: 31 October 2023
- Reviewer comments returned: 31 January 2024

- Revised papers returned: 30 April 2024
- Submission of final issue to journal: 31 May 2024.

Download the Call for Papers.
View past editions of the REA Newsletter.
Join the Resilience Engineering Association here.

System Dynamics Mentorship Milestone

The System Dynamics Society (SDS) offers a mentorship program that connects students, early-career professionals, and others interested in System Dynamics with experienced mentors from around the world. SDS recently announced that the program had reach a significant milestone having reached ***100 mentees*** since the program launch in December 2019.

Multiple types of mentorship are available:

- Peer Mentoring
- One-on-one mentoring
- Short-Term Modeling Assistance

Learn more about SDS Mentorship programs.

Join the System Dynamics Society here to take advantage of the One-on-One Mentoring and Short-Term Modeling Assistance programs.

Feature Update: Stella 3.3 System Modeling Software

iseesystems has announced the release of Stella 3.3 system modeling software that support system dynamics (SD) modeling, discrete event simulation (DES) and agent-based modeling. Originally introduced in 1989, the subsequent versions of Stella have delivered increasing modeling functionality and ease of use. Features added in Stella 3.3 include:

- Optimization on the Interface
- Optimization and Sensitivity Status Display
- Selectors Active During Optimization
- Tracing Optimization Overflows
- Improved Zoom
- Connector Setting Added to Model Styles
- Allow Updating of Multiple Formats in Tables and Graphs
- Group Inputs Now Work with Placeholders and Wildcards
- Better Array Editing Messages

For details, investigate isee systems products, i.e., the Stella family of solutions:

- Stella Architect
- Stella Professional
- Stella Online
- iThink
- Stella Designer

- Stella Simulator

View a product family overview video.

System Dynamics Society (SDS) Hackathon

In conjunction with the International System Dynamics Conference (ISDC 2023), the System Dynamics Society (SDS) will host the SDS Hackathon, a two day hybrid event that that brings together practitioners, researchers, and students to collaborate and develop solutions to complex problems using the System Dynamics methodology. The 2023 version of this event, the ***PwC Mark Paich Hackathon,*** will start on Friday 21 July, with judging taking place on Sunday 23 July.

Teams (recommended size = 4 or 5 individuals) will compete to consider the potential of new technologies applied to one of two challenges:

- Artificial Intelligence
- Health

At least one member of each team must be registered for the ISDC 2023 conference.

Teams will compete for recognition and three prize levels of $3000, $1500 and $500. Each member of the first-place team will also receive a free 1-year subscription of AnyLogic™ Professional.

Although teams may use any simulation software that they desire, three vendors have offered free access to their software:

- isee systems: Time-limited version of Stella ® Architect Workshop
- AnyLogic: Time-limited subscription of AnyLogic™ Professional
- Powersim: Participants can download a free 30-day demo of Powersim Studio 10 from their website

Important Hackathon dates include:

- Registrations close: 18 July
- Kickoff (9 AM CDT): 21 July
- Submission deadline & presentations: 23 July
- Award ceremony: 25 July

Learn more about the Hackathon. Register here.

The PwC Mark Paich Hackathon is a tribute to the exceptional contributions that Mark Paich made to the field of System Dynamics. Mark was a gifted modeler and a generous mentor. He helped establish the simulation and modeling practice at PwC US when he joined the company in 2010 as Director of Analytics. Mark earned his Ph.D. in System Dynamics from MIT, taught for many years at Colorado College, and returned frequently to MIT Sloan as a visiting lecturer. A recipient of the System Dynamics Society's Forrester Award and Applications Award, Mark was widely recognized as a leading expert in System Dynamics.

PDMA Carolina's Student Innovation Competition

The Carolinas chapter of the Product Development Management Association (PDMA) hosted their 14th annual local conference, Innovate Carolina, on 22 April 2023. A highlight of this conference was the PDMA Carolina's Student Innovation Competition which showcased the innovation skills of 56 students and 10 faculty advisors on teams from Clemson University, North Carolina State University and Duke University.

Awards were given as follows:

Graduate – First Place: Durabloom from Duke University
Idea: A surgical tool to more effectively repair cerebrospinal fluid leaks in the mastoid of the skull posterior, that affects ~ 16,000 people every year.
See presentation here.

Undergraduate – First Place: The Nairo/CS Medical from Clemson University
Idea: A heated respiratory humidifier ventilator attachment for use during burn victim surgery. This product provides a more effective way of preventing hypothermia of the patient during surgery, while also enabling the operating room to be controlled to an optimum temperature for OR staff.
See presentation here.

Undergraduate – Second Place: EnteroFlux from North Carolina State University
Idea: An optical sensing system that notifies physicians and healthcare providers of an anastomotic leak, a common and potentially life-threatening complication associated with the colectomy procedure to treat colon cancer. This detection reduces the lag between diagnosis and repair, leading to better patient outcomes.
See presentation here.

Undergraduate – Third Place: ProbeMate from Duke University
Idea: An ultrasonic device that improves the ergonomics associated with sonography, thereby reducing work-related musculoskeletal disorders (WRMDs). Probemate has been designed to address WRMDs specific to perinatal sonographers and OB/GYNs.

These teams have the opportunity to participate in PDMA's Global Student Innovation Challenge. The finalists from that challenge are invited to share their innovation ideas at PDMA's Inspire Innovation Conference and JPIM Research Forum in New Orleans in September.

Learn more about the PDMA Carolinas chapter.

CONFERENCES, MEETINGS & WEBINARS

Upcoming PDMA Webinars

The Carolinas chapter of the Product Development Management Association (PDMA) will host two product development and innovation webinars this summer.

Building Resilience as We Navigate Change (13 June).

Overview: Organizations strive to foster sustainability, and we often think that we will be able to adapt thanks to careful planning. Speakers Rodney E. Gaddy and Emily S. Lancucki have learned that riding the wave of catalysts like the pandemic, stakeholder changes, and consumer feedback can ultimately lead to personal and product resilience. Sharing lessons learned from careers in law, nonprofits, and community health, Rodney and Emily will discuss navigating change in order to achieve a sustainable future.

Learn more and register.

Mission Driven Innovation (15 August)

Overview: Mark Adkins, former chair of the PDMA and the CEO of the medical technology startup LeanMed, will explore this hypothesis through the lens of the development of the O2 Cube. A solar powered medical innovation that brings vital medical oxygen to the one billion people around the world that lack access. Just addressing the scourge of pediatric pneumonia, which kills 800,000 children every year, is one way innovation is making the world a better place to live.

Learn more and register.

PPI SyEN readers are encouraged to take advantage of these learning opportunities from the innovation and product management community.

Join PDMA.

Kongsberg Systems Engineering Event 2023 (KSEE 2023)

The University of South-Eastern Norway (USN) will host the Kongsberg Systems Engineering Event 2023 (KSEE 2023) on 14-15 June at the USN Kongsberg campus. The theme of this free in-person event is *The difficult relationship between software (and data) and systems*.

Background: Software and data play an integrating role within and between systems, determining functionality and performance of the system (of systems) capabilities. Despite this crucial role of software for system behavior and performance, most organizations experience a troublesome relation between systems and software. During this KSEE we will explore this relation, the causes of the difficult relation, and opportunities for improvement.

Planned presentations on this challenging topic include:

- Keynote: *Better together: how system- and software engineers can cooperate to innovate faster.* (Dirk-Jan Swagerman, Chief on demand Innovation & Systems at Buffadoo)
- *Understanding the interface between systems engineering and software engineering*. (Richard Doornbos, Senior Research Fellow at Embedded Systems Innovation by TNO)
- *The Digital Twin and the need of open, public available and international standards*. (Kjell Bengtsson, Vice President – Jotne)
- *The challenges of software for process systems engineering.* (David Cameron, Head of External Engagements, University of Oslo)
- *Future trends and innovations in software for E&P and the challenges in software and data integration during system development*. (Karen V. Czachorowski, Digital/Data Product Manager at Aker BP)
- *A case study on emission analysis and accounting in the waste management industry*. (Tobias Hylleseth, Student speaker, USN-SE)
- *Keynote: Towards an era of smart life cycle connected cyber-physical systems - What are the implications for SE, or … when is an Automated Vehicle ready to go?* (Martin Törngren, Professor in Embedded Control Systems at KTH)

Learn more about KSEE 2023 here.
Learn more about USN's Norwegian Industrial Systems Engineering (NISE) Research Group.
Register for KSEE 2023.

Call for Papers - System Analysis and Modelling (SAM2023) Conference

A Call for Papers has been issued for the 15th System Analysis and Modelling conference (SAM2023) The theme of this conference is *System Modeling and Analysis in State-of-Practice Technologies*. SAM2023 will be held on 2-3 October 2023 in Västerås, Sweden and will be co-located with the Models 2023 conference. SAM2023 provides an arena for participants from academia and industry to present and discuss the most recent innovations, trends, experiences and concerns in modeling, specification, analysis, implementation, and monitoring of complex systems using ITU-T's Specification and Description Language (SDL 2010) and Message Sequence Chart (MSC) notations, as well as related system design languages — including but not limited to UML, ASN.1, TTCN, SysML and the User Requirements Notation (URN).

SAM 2023 seeks academic and industrial submissions in the following categories:

- Full papers describing original, unpublished results (max 10 pages, including figures, appendices and references in IEEE format).
- Short papers, describing work in progress (max 6 pages, including figures, appendices and references in IEEE format).

Topics of interest include:

- Evolution of languages
- Model-driven development
- System engineering models
- Industrial application and tools

Important dates:

- Paper submission deadline: 3 July 2023
- Notification of acceptance: 7 August 2023
- Camera-ready version deadline: 21 August 2023

Learn more about SAM2023 Conference and paper submission guidelines.
Learn more about the SDL Forum Society, sponsors of SAM2023.

International Congress on Modelling and Simulation (MODSIM2023)

The Modelling and Simulation Society of Australia and New Zealand Inc. (MSSANZ) will host the 25th International Congress on Modelling and Simulation (MODSIM2023) in Darwin, Northern Territory, Australia on 9-14 July 2023. The theme of this in-person event is *Modelling to support planning for resilience in a changing world*.

Additional organizations that participate in the Congress include:

- Australian Society for Operations Research (ASOR)
- International Environmental Modelling and Software Society (iEMSs)
- Open Modeling Foundation (OMF)

Plenary speakers have been identified, including:

- Sondoss Elsawah (University of New South Wales, Canberra) - *The critical systems thinking capability gap: Reflections for future research and education?*
- Dr. Simon Barry (CSIRO, Canberra)
- Professor Daniel P. Ames (Brigham Young University, Provo, Utah, USA) - *Forecasting flow in every river everywhere all at once: Advances in continental scale hydrologic modeling and simulation*
- Professor Anne Poelina (Nyikina Warrwa Indigenous woman, Kimberley region, Western Australia)

The MODSIM2023 program is built around a diverse set of content streams, each comprised of multiple sessions, including:

Applied and computational mathematics
Focuses on mathematical contributions to modelling and simulation (e.g. based on statistical, stochastic and PDE modelling). This includes development, application and testing of algorithms used in data analysis, model formulation (including component integration), sensitivity analysis and uncertainty quantification. Examples of areas of interest include inverse problems, machine learning, and industrial applications.

Biological systems
Welcomes submissions from a wide range of modelling styles: mathematical, mechanistic process-based, agent-based, systems dynamics, and/or data science approaches as applied to biological and agricultural systems. Topics can be inclusive of models and simulation: from descriptions, to development, to applications. Examples of areas of interest include: uncertainty and sensitivity analysis; image analysis; machine learning and artificial intelligence; advances in agent-based modelling of wildlife and pests; livestock, rangelands, pasture and cropping systems; drought resilience, terrestrial and aquatic food webs, and value chain modelling.

Computer science and engineering

Methods for sharing data and computational resources, integrating models, and building simulation systems integrating various disciplines in the open web environment are rapidly changing with the continual development of new information and communications technologies (ICT) including cloud computing, edge computing, blockchain computing, high-performance computing, and high-speed Internet. We encourage the submission of papers that provide further insights in novel, emerging and advanced ICT, other software technologies and computational methods; and that support decision making to solve comprehensive complex issues in the era of 'big science'. This stream is supported and co-led by the International Environmental Modelling and Software and The Open Modeling Foundation.

Economics and finance

Welcomes proposals from a wide range of issues pertaining to Innovation and Trade, Risk Management, and impacts of Climate variability/change on financial markets and economies more generally. Examples of topics include any original research and comprehensive review papers at the intersection of economics and finance with commodity markets, international trade, financial risk modelling, and computational finance, and financial markets and climate impact modelling.

Energy, integrated infrastructure and urban planning

Australia is in the midst of an energy transition. The move to Electrify Everything is underway. This revolution requires a myriad of activities in various areas. This stream focuses on multiple ways infrastructure networks, systems and services contribute to urban renewal, regional development, better livability and enhanced productivity. Smart data analytics, resource assessment and forecasting, digital twins, real-time modelling and complex network optimization are becoming essential instruments for planning, managing, protecting and upgrading these systems. The stream can include submissions covering forecasting of renewables, energy efficient building design, microgrid design, precinct infrastructure, and related topics.

Environment and ecology

Focus on the development of generic frameworks and integration of models across issues, scales, disciplines and stakeholders. The stream will accommodate sessions spanning a scope from advances in modelling, software and simulation, the development and use of advanced software tools, interdisciplinary and transdisciplinary environmental modelling, the integration of models and software tools across issues, scales, disciplines, and stakeholders, to the application of novel data science concepts in decision support.

Global change and natural hazards

All aspects of global change and natural hazards and their interactions within the earth system. Topical streams may include modelling of natural hazards such as drought, heatwaves, hail, fires, tropical cyclones, earthquakes, and tsunamis. It also covers modelling of global change issues such as climate change, land degradation (including desertification and plant migration), and the relevance for United Nations sustainable development goals. New model developments and modelling of the phenomena, their impacts on human and natural systems, potential techniques for adaptation, and the use of remote sensing data to address these, are all of interest.

Health and biosecurity

Focus on latest developments, applications and challenges for epidemiological and biosecurity modelling, data science and machine learning. Health applications include but are not limited to disease surveillance, communicable diseases, chronic diseases, health services and systems, human behavior and health, climate change and environmental exposures and health risks.

Social systems and modelling processes
All aspects of the human and cultural dimensions of modelling. This includes modelling socio-ecological systems (human-environment interactions), applications or approaches which bring a social-systems lens to modelling, and the process of modelling and associated challenges and best practice. Suitable content for this stream includes model development, data and knowledge management, pedagogical culture, application, case-studies, theory, practice, challenges, opportunities and insights into integration for modelling socio-ecological systems, and for a life-cycle approach to modelling which incorporates input from decision-makers and diverse knowledge sources from model conceptualization through to application. Submissions that include Indigenous perspectives on modelling are particularly encouraged.

Water resources
Focuses on research into hydrological processes and hydrological modelling tools (landscape and river system) that advance our understanding and management of surface water and groundwater at catchment, regional and continental scales over time scales from hours to decades.

Hydroclimate
focuses on the research fields between climate and hydrology. With continuous climate change in the past several decades and the foreseeable future, our understanding of the hydroclimate continues to evolve, and the complexity in forecasting, predicting, simulating, or attributing change, means many processes, and their interactions, remain not completely understood. However, new data sets, statistical tools, modelling techniques, and advances in computing are all providing us opportunities to improve the understanding of hydroclimate. We invite proposals from a wide variety of disciplines that analyze and model all aspects of the hydroclimate, from rainfall, to streamflow, evapotranspiration, groundwater, temperature, and their related hazards. We encourage proposals aiming to improve our process understanding, untangle uncertainties, and attribute changes across all time and spatial scales in the hydroclimate.

Water quality
Proposals that focus on monitoring, modelling and analyses of all aspects of water quality across all environments including natural, agricultural, urban, peri-urban catchments, as well as rivers, groundwater, lakes, estuaries and other receiving waters.

ASOR
High-quality contributions from across the broad spectrum of OR methods, techniques and applications in academia, defense, and industry. Techniques may include (but are not limited to) mixed integer-linear programming, constraint programming, metaheuristics, and modelling and simulation through to more recent approaches in matheuristics, artificial intelligence (AI), machine learning (ML) and data sciences (DS). Applications areas may include (but are not limited to) emergency management and natural hazards, defense, transport, logistics, mining, agriculture and healthcare. We encourage collaboration between academia and industry in both session proposals and paper submissions.

General
Placeholder for papers that don't fit easily into other sessions, either because they describe a new modelling paradigm or are so general that they transcend all other streams.

On Friday 14 July there will be an opportunity for participation in a variety of workshops and other learning experiences:

- Bayesian ideas in pictures
- How to build a spatial causal network

- The En-ROADS Interactive Climate Simulation Game
- Modular Assessment of Rainfall-Runoff Models Toolbox (MARRMoT) tutorial
- Navigating a Career in Science: A professional development workshop for Early Career Researchers and Young Professionals
- Simulation-based Optimization: A tutorial with Python
- Savanna SuperSite and Waterfall Tour, Litchfield National Park

Learn more about MODSIM2023.
Register for MODSIM2023.

INCOSE SySTEAM Mini-conference

The INCOSE SySTEAM (Systems, Science, Technology, Engineering, Arts, and Mathematics) initiative seeks to improve the quality of STEAM education worldwide. To further these goals, the initiative is hosting an inaugural SySTEAM mini-conference on 27-28 July 2023.

This free, two-day online event is intended to provide individuals from around the globe with the opportunity to convene, discuss, and exchange ideas relating to the intersection between systems STEM/STEAM education and systems thinking/systems engineering competencies. The event will feature talks & posters showcasing SySTEAM-relevant projects, efforts, and ideas from the SySTEAM community members and other members of the public, as well as opportunities for roundtable discussion and small-group discourse with other attendees.

Learn more about the SySTEAM initiative.
Register for the SySTEAM mini-conference.

Human and Organizational Performance (HOP) Summit 2023

The National Safety Council (U.S. based) is hosting the 2023 Human and Organizational Performance (HOP) Summit in Indianapolis, Indiana, USA on 12-14 September. HOP is a risk-based operating philosophy that recognizes error is part of the human condition, and an organization's processes, systems and culture greatly influence employees' decisions, actions, and consequently, their likelihood of success. HOP is used by leading companies to advance their safety & health processes, build resilient systems, and achieve operational excellence.

The theme of this event is *Integrating HOP into Your Organizational Systems & Management Practices*. The focus of the summit is moving organizations from principles to practice.

See details on HOP Summit 2023 here.
Register for HOP Summit 2023.

Energy and Mobility Conference and Expo

Registration is open for the 2023 edition of the Energy & Mobility Technology, Systems and Value Chain Conference & Expo that will take place in Cleveland, Ohio, USA on 12-15 September 2023. This multi-industry international conference is

focused on energy and modern mobility, with an emphasis on advanced technologies, the challenges of systems integration, autonomy, and related product value chains and business models that enable the transition to a robust, decentralized and resilient energy sector, the security of critical infrastructure, and the evolution of mobility towards energy-efficient, cost-effective and sustainable solutions.

The organizer of the conference, Telepath Systems, Inc., has partnered with NASA Glenn Research Center, SAE International, and INCOSE to create a forum for sharing research, concepts, and ideas for a "sustainable future".

The technical program includes forty-five presentation sessions on topics such as Electric Propulsion, Advanced Nuclear Technology, Critical Infrastructure, Microgrids, Energy Storage, Autonomy, Human Factors, Systems Safety, Systems Engineering, MBSE & Digital Transformation, System Integration and more.

Sixteen keynote speakers will share insights based on their work with government agencies and industry-leading technology providers and service organizations.

Eight workshops will address key enabling technologies. A workshop on Digital Engineering from SysML and Beyond may be of particular interest to systems engineering practitioners.

Learn more about the conference here.
Register for the Energy & Mobility Conference & Expo.

The INCOSE EMEA Workshop and Conference, Sevilla, Spain, 24 – 26 April 2023
(EMEA is the Europe, Middle East, and Africa sector of INCOSE.)

PPI was proud to be Gold Sponsor of this event and was represented by Trudy King, Kim Taylor, and Michael Gainford.

René King and Michael Gainford co-authored a short presentation that was well-received – see later. The event took place in the city of Sevilla, Spain, and we were fortunate that it coincided with the annual festival known as Feria de Abril. There were some wonderful national costumes in evidence! Around the World, many such traditions have been kept up for centuries. Perhaps we should ask how many will survive another century given the global warming threat? It was ironic that the conference week coincided with the hottest April on record in Spain.

The main theme of the conference was that systems approaches should play a key role in achieving the seventeen United Nations Sustainable Development Goals (UN SDGs):
THE 17 GOALS | Sustainable Development (un.org)
These goals are becoming more and more talked about as a way of driving our decisions. They demonstrate the aligned thinking of our World leaders as they "recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests".

Some of the key topics included:

- INCOSE Vision 2035
- Digital Threads for the engineering of sustainable products
- Empowering women leaders, and awareness of diversity, equity and inclusion
- The Future of Systems Engineering (FuSE) initiative
- UAE's Green House Gas reduction pathways
- Interoperable smart and sustainable urban energy systems
- Impact of the forthcoming update to the INCOSE Systems Engineering Handbook
- Smart cities and the UN SDGs
- Natural systems
- Explainable artificial intelligence
- Generating a collaborative Systems Thinking culture
- Leading for a sustainable future
- Transformation challenges in transportation
- Extending SE to address climate change
- Human System Integration for sustainability
- Architecting sustainable systems

PPI's short presentation
René King and Michael Gainford co-authored a short presentation entitled "A demonstration of the power of Systems Engineering and Systems Thinking to frame and solve important human challenges".

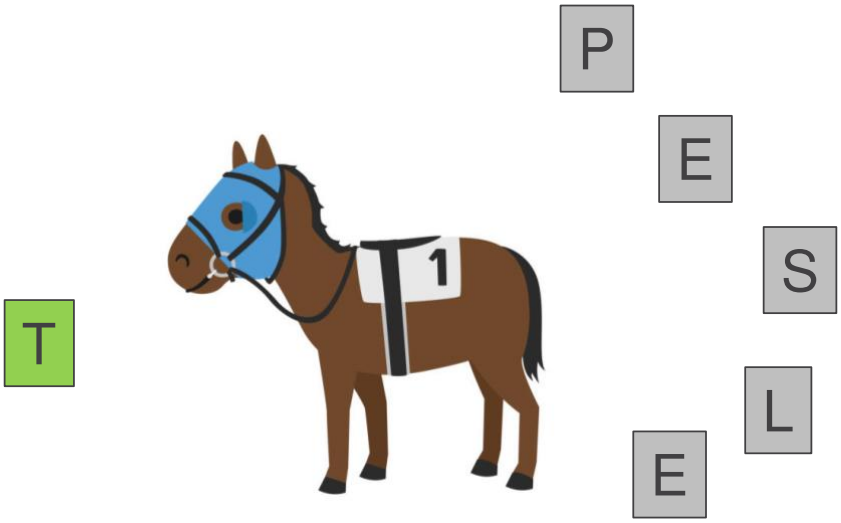
This presentation used as a case study the ongoing crisis with electrical power supply in South Africa. The problem is not so much the problem itself, but more to do with how we can solve such problems!

Three main challenges with this issue were identified:

- Inappropriate goals
- Aversion to change
- Technology blinkers.

Regarding the inappropriate goals, we now have the UN SDGs to steer us towards a more sustainable World, which gives us 

To help with the natural human aversion to change, we can turn to authors like William Bridges and John Kotter.
This leaves us to discuss the 3rd challenge, "technology blinkers". National infrastructure problems are often understood through the 6 PESTLE dimensions (Political, Economic, Social, Technical, Legal and Environmental). Very often, the "T" dimension is the easiest to deal with (or close to irrelevant), whilst many in the engineering professions shy away from the other five. The presentation illustrated this tendency with the following image.



Systems Thinking and Systems Engineering are complementary schools of thought, and the presentation concluded with a plea for a more connected application of these techniques in pursuing the United Nation SDGs.

The presentation is available to download via the PPI website here.

FEATURE ARTICLE

Transforming model-based engineering with data-driven graphs

by

Liana Kiff, Senior Consultant (Tom Sawyer Software)

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Authored for PPI SyEN

Abstract

Graph technology is poised and ready to be a vehicle for model-based engineering to serve more stakeholders than ever before and deliver more value through improved access to system models. SysML v2 is positioned to take advantage of the growing availability of graph-based solutions to improve the tooling available to system engineers; in particular, enabling dynamic, context-preserving navigation through model visualizations that represent different levels of abstraction and serve a wide range of stakeholders.

Growing Pains for System Engineering

Engineering drawings are a vital tool for design, documentation, and communication. When we develop complex, critical systems that have the potential to go wrong in spectacular ways, we need to do an exceptional amount of visual communication. However, the weight of maintaining a complex model by maintaining the diagrams that describe it has always been fraught with challenges and is limited by the hours that must go into the deliberate maintenance and review of these artifacts for all the stakeholders that demand them.

From INCOSE Vision35:

"A digital representation of a system is at the heart of a model-based systems engineering approach. This approach leverages automation and computation to support simulation of the system dynamic behavior, multi-disciplinary analysis, visualization, and management of the system design across its lifecycle. The digital representation enables a shared understanding of the system among its stakeholders." [1]

Tooling for Model-Based Systems Engineering (MBSE) is gaining ground, but most tools continue to use diagrams as the main mechanism for input, rather than expression of what is already in the model. These diagrams may lack consistency and coherence at best or may be entirely missing unless explicitly required or requested, since the volume of drawings required to fully represent large systems is difficult to produce and manage.

From INCOSE Vision35:

"The future of systems engineering is model-based, leveraging next generation modeling, simulation, and visualization environments powered by the global digital transformation, to specify, analyze, design, and verify systems. High fidelity models, advanced visualization, and highly integrated, multi-disciplinary

simulations will allow systems engineers to evaluate and assess an order of magnitude more alternative designs more quickly and thoroughly than can be done on a single design today." [2]

Coherence at the intersection of all the domains that comprise these vital systems requires a common abstraction that is meaningful across the system and to all stakeholders. [3] In digital engineering (DE) practice today, the availability of a consistent abstraction layer across disciplines is often missing or functionally unavailable because of the state of tooling. Additionally, if all the details related to every discipline were captured in a single drawing, it would likely be undigestible. And if they were in separate drawings, they may be incoherent, or worse, completely inconsistent. While artificially limiting the contents of a drawing can provide consistency, this approach does not support the wide range of engineering needs. Moving freely between low-fidelity and high-fidelity abstractions in the system can be challenging or impossible.

"The transformative aspect of DE/MBSE will succeed based on how technology enables automation of SE tasks and human collaboration across all disciplines across a full model-centric engineering process. The DoD should fund research and incentivize tool vendors to introduce more automation into the DE/MBSE processes."

Summary Report Task Order WRT-1001: Digital Engineering Metrics Supporting Technical Report SERC-2020-SR-003 June 8, 2020

MBSE practice and tooling has continued to improve over the last 10 years, but it hasn't come far enough. One significant limiting factor today is not whether technology exists to address the fundamental problems, but rather how to apply the current technology in a meaningful way. Graph-based technology and new analytic techniques can transform engineering, analysis, and visualization practices [4], but we are still working toward applying it in all the ways that will make model-based system engineering practical and effective for more projects, more of the time.

Systems as Graphs

In 20+ years as a research scientist and software developer in an industrial lab, the author has encountered many technical barriers impeding innovation for the operations side in a variety of domains. The most significant of these barriers is the lack of cross-cutting system documentation and incoherence across boundaries between technical practices. Third-party contractors produce system schematics (PDFs), but these are not readily translatable. Control systems and sensors are wired on top of the physical layer and labeled but are constrained by the legacy nature of those systems and contain no real digital model of the system outside the control loop. Visual control panels for operators were manually constructed, hard-wired to data, and rarely maintained. Often, the only source of truth about the system is the system itself because all other sources are considered suspect or untrustworthy. Engineers all over the world have a variety of tools to help them design, simulate, build, operate, and diagnose system issues, but rarely do all these tools share a common model of the system. Practitioners often distrust models produced by others or find them lacking in other respects.

In data modeling, a canonical model is a trusted point of integration and translation across these data divides in an enterprise. In engineering, MBSE is positioned to provide the trusted canonical model that will allow more seamless interaction across domains and practices.

This is a short list of publications by MBSE leaders and practitioners who have turned to graph technology to address endemic issues with collating, managing, analyzing, and communicating engineering data for a variety of purposes, applying graph technology along with various other modeling frameworks, languages, and tools:

- Bajaj, et al. [5] make the case for a graph-based approach for the Total System Model, where the TSM and each participating subsystem is described as a graph using SysML.
- Plum [6] discusses the application of a graph layer (implemented with Neo4j) to maintain consistent views across a model where different modeling languages have been employed.
- Mordcai et al. [4] propose a new way to work with system models by employing graph structures to enable a "Concept→Model→Graph→View Cycle" (CMGVC) pattern for describing, storing, and accessing canonical system models to improve access to and utilization of system engineering data.
- Dunbar et al. [3] propose "…the digital engineering framework for integration and interoperability (DEFII)" where graph technology and semantic ontology provide the foundation for the digital engineering authoritative source of truth.

Those mentioned above, and many other contributors to MBSE and other engineering practices describe graph-specific use cases largely related to the design, simulation, and validation of system models:

- Integration of multiple sources of ground truth from different disciplines
- Translation of concepts from one modeling language to another
- Insertion of domain-specific concepts (ontologies) to further inform models
- Validation of system properties based on graph-based techniques (e.g., redundancy, the presence or lack of cycles - closed loops between entities, complete testing of paths through a network or process)
- Traceability of connections through the system
- Separating the specification of views from the specification of the model

Topological analysis of systems is a valuable, but less-discussed aspect of applying graph technology. Distribution systems, which make up a significant number of engineered systems in buildings and industry, are best described as directed graphs [7], and make it possible to use graph-based techniques to describe and analyze the functions of that network. Industrial batch processing standards described by ISA 88 also require topological analyses to ensure that procedural operations process and terminate successfully and do not fall into cyclic traps.

A widely trending use case adjacent to engineering is the digital thread, which may span IT systems and business systems that an engineering product or process depends upon, in addition to the historical record of engineering changes.

The Next Generation of Engineering Visualization

Aside from the ability to store or organize system data in the form of a graph, many of the use cases cited by MBSE practitioners share a common requirement—*to visualize some subset of concepts and their relationships to some user*—generally with the intent that a well-informed decision or choice will be enabled.

"SysML v1 has the notion of "views" and "viewpoints." These capture the idea of presenting pieces of systems to categories of stakeholders. However, the standard suggests no meaningful implementation approach. Instead, SysML v1 offers nine normative diagram types that are assumed to be the primary authoring mechanism for the model. Because they are the authoring mechanism, it is assumed that diagrams will be constructed and maintained by hand. This paradigm has downstream effects that constrict engineers' ability to both create and interrogate the model."

Josh Feingold, Tom Sawyer Software

As K. Trase and E. Fink noted [8], “Simply viewing tables of data or countless SysML diagrams will not always enable the reviewer to understand the system’s complexity or status of the design effort.”

MBSE is on a path to reverse the practice of using drawings as the primary form of input, but most tools available today still require drawings to be maintained manually. As noted by Simpson et al. [9],

“Diagram from SysML tool modeling is not inherently informative” and in their experience, it is labor-intensive to modify raw Block Definition Diagrams (BDDs) to make them visually effective for all stakeholders. Creating new drawings on demand is time-intensive and can lead to inconsistencies as the system continually changes and these drawings are not maintained.

By making the diagram the canonical form of the model, engineers are burdened with the requirement to manage change control on the drawings rather than the data, which then imposes controls on drawings that are impractical and constrain the utility of drawings as a communication mechanism. Engineers only create drawings that are absolutely necessary, and these are likely not the drawings that might be most useful for another stakeholder.

Consequently, one of the most widely recognized use cases for using graph technology in system engineering is to automate the generation of some of the drawings that are required to satisfy the system engineering discipline and the stakeholders (i.e., other decision-makers), thereby reducing the number of hours that engineers spend arranging drawings rather than contributing to the model.

In 2017, Tom Sawyer Software introduced an advanced visualization integration for MagicDraw and Cameo by Dassault, as well as a stand-alone web application that integrates with Teamwork Cloud. These integrations support systems engineers by automatically creating interactive and customizable visualizations for SysML 1.X diagrams, as well as the ability to generate new diagrams through direct interaction with SysML models. While these solutions were specifically built for No Magic products using the Perspectives graph platform, we also have used Perspectives to support users of SysML 2.0, PTC Windchill, OpenMBEE, and IBM Rhapsody.

The resulting data-driven drawings can be navigated dynamically, supporting easy exploration of the model without needing to change context to a different drawing. Interactive diagrams can be more widely used in more situations and adjusted on demand to support specific investigations and discussions. Diagrams become a real tool for communication instead of a time sink for the system engineering team.

This is the sort of abstraction through different layers of fidelity that facilitates users and use cases inside and outside of engineering. With interactive diagrams, you can drill down into your model to navigate each of the abstraction layers without losing orientation to the context of your exploration and without having to create each intermediate diagram manually. Interactive drawings are flexible, and always up to date with the underlying model.

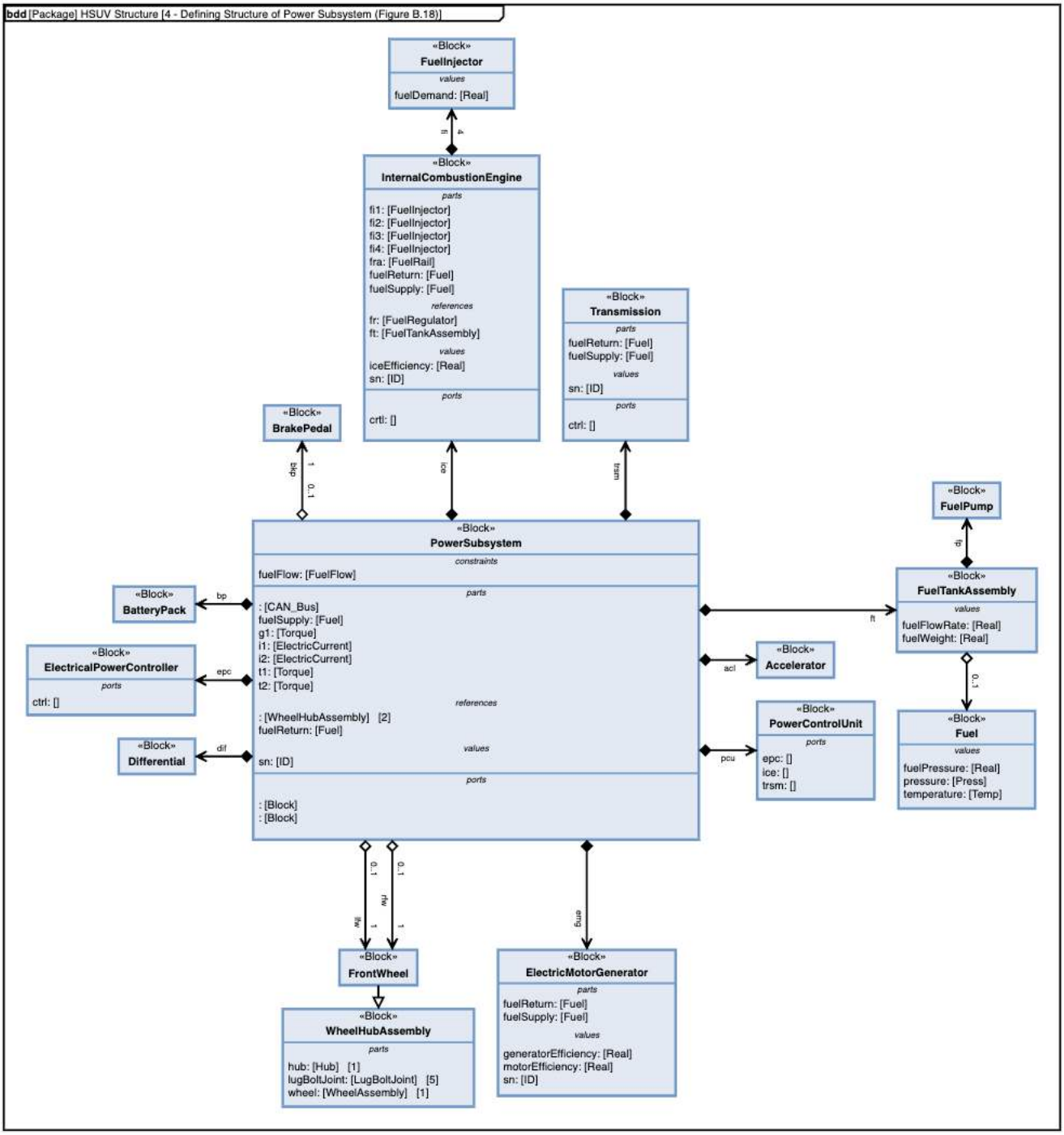

Figure 1. Example of detailed BDD generated with Tom Sawyer Model-Based Engineering for MagicDraw

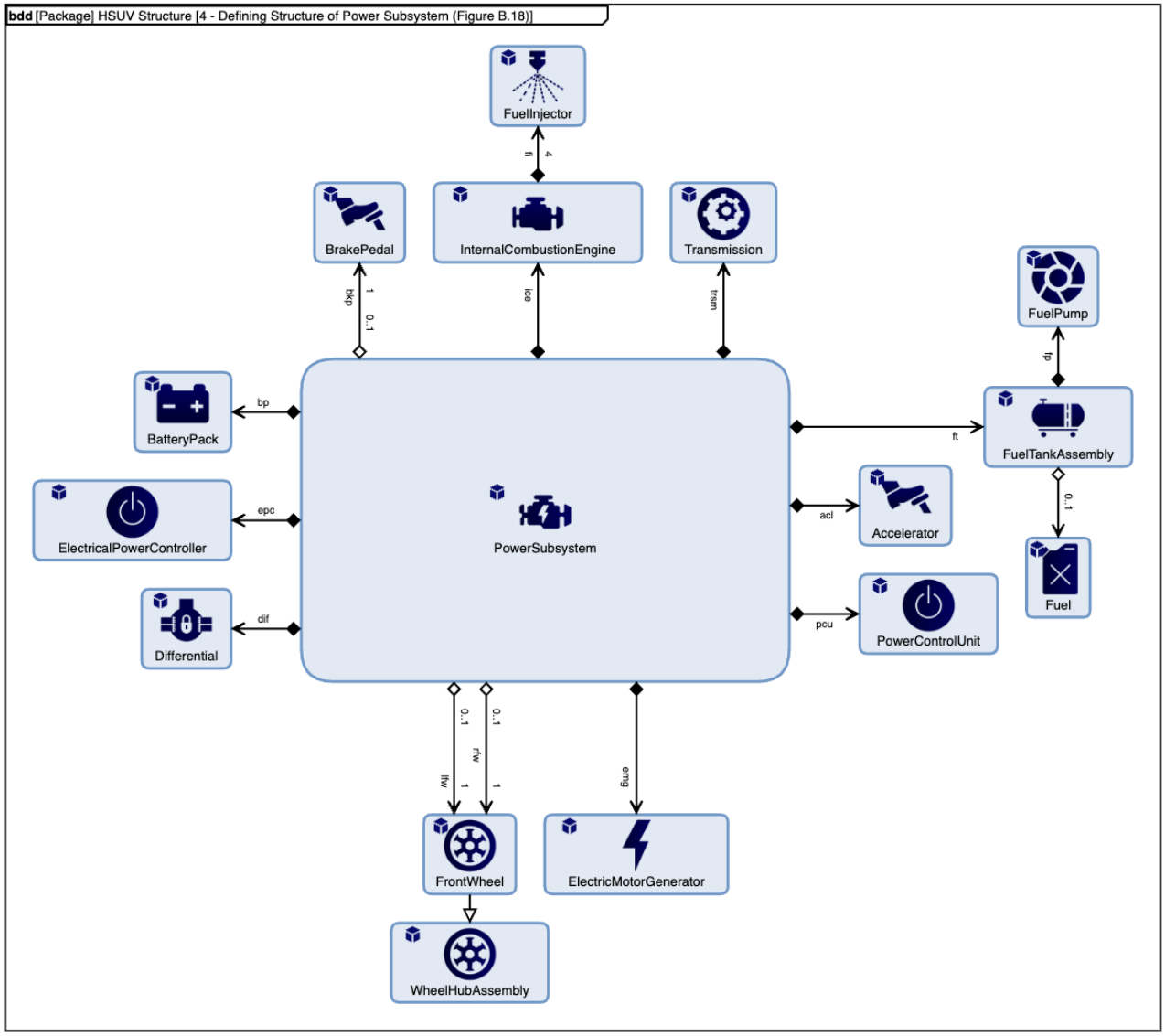

Figure 2. Example of a Simplified BDD using images assigned to MagicDraw elements

Through experience with Model-Based Engineering customers in several industries, we frequently saw a need to provide these benefits for systems engineers:

- simplified visualizations without the need for manual authoring through replacement of text details with icons, hiding of elements, or collapsing of nested drawings
- automatic coloring of element per stereotype or meta class
- generation of new diagrams created directly from the model
- loading related elements into a current diagram without disorienting the user from their context

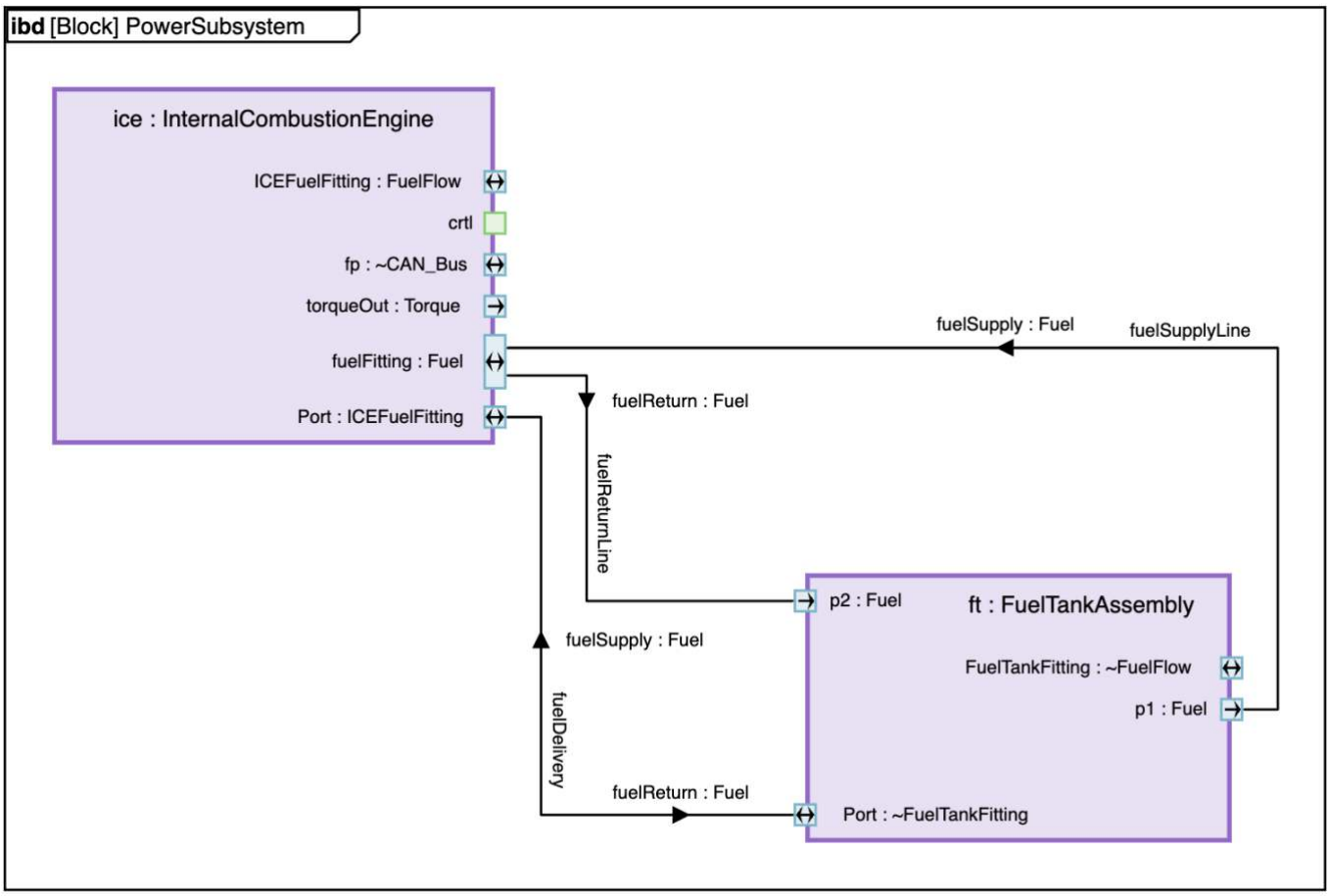

Figure 3. Example IBD generated with Tom Sawyer MBSE plugin for MagicDraw

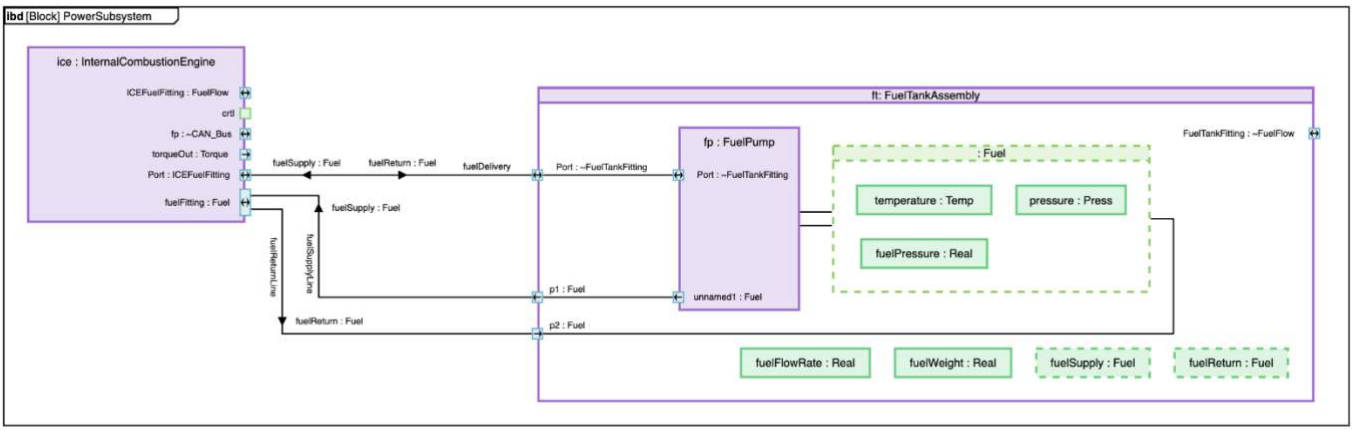

Figure 4. Example of dynamic expansion into a more detailed layer of abstraction while preserving context

SysML v2 and the Future of System Engineering

Freidenthal and Seidewitz describe the improvements that SysML v2 will bring: [10]

"SysML v2 was rearchitected and redesigned to meet the requirements in the SysML v2 RFP. It includes a new metamodel that is not based on UML, the introduction of a textual syntax in addition to the graphical syntax and a more flexible view and viewpoint mechanism for presenting the model information to stakeholders. SysML v2 also includes a new standard API that enables interoperability

with other engineering models and tools."

Tom Sawyer Software is grateful for the opportunity to contribute to the future of system engineering through engagement with the SysML v2 Submission Team (SST), which submitted the specification in March 2023 at the OMG Technical Meeting in Florida. Through interaction with the other members, and through the development of the SysML v2 prototype visualization tool, Tom Sawyer Software has helped to explore the requirements for the language and APIs to satisfy both the engineers using the tools, and the software engineers building the tools, so that the full power of the improved methodology can be realized.

As Sandy Friedenthal describes [11]:

"SysML v2 will define standard diagram kinds similar to SysML v1 to facilitate the transition from SysML v1 to SysML v2. However, unlike SysML v1 diagrams, SysML v2 will not constrain what can be presented on a particular diagram, as long the model conforms to the SysML v2 metamodel. For example, a SysML v2 parts interconnection diagram is similar to a SysML v1 internal block diagram (IBD). However, the modeler is free to add requirements with satisfy links on a SysML v2 parts interconnection diagram, where-as a requirement graphical symbol cannot be shown on a SysML v1 IBD."

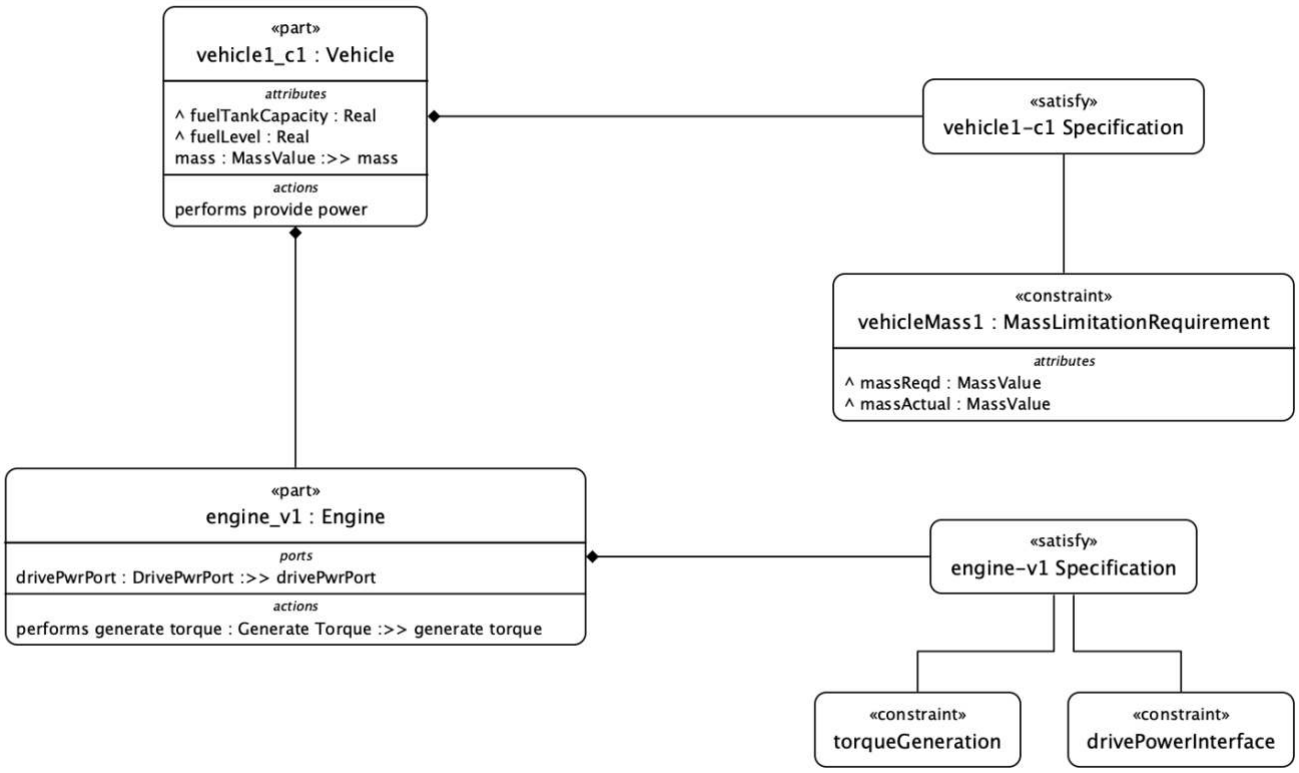

Figure 5. Valid SysML v2 diagram showing parts and the requirements they satisfy

The preceding diagram is an example produced with Tom Sawyer Software's prototype visualization tool for SysML v2. This web-based prototype is available to evaluators using the SysML v2 public review environment, to view all published examples contributed by the community.

With SysML v2, the model comes first, in the form of a graph [12], and diagrams are a product of the modeling exercise. As the Resource Description Framework (RDF) [13] did for semantic engineering, SysML v2 makes it possible to "code" the model instead of diagramming it by providing an

interpretable textual syntax. This approach has many advantages. The trend in this direction is happening across a variety of system domains and is described more generally as “diagrams as code” [14]:

- Code follows rules that can be tested at compilation, making it easy to enforce the principles that result in the integrity of the whole.
- Code is more compact for efficient storage.
- Technology to track and identify changes in code is mature and readily available, but changes in diagrams can be difficult to identify and track.
- Visualizations are often not an efficient mechanism for data entry, but they are vital to visualize and validate the result and communicate with others.

Though there are no tools today that provide round-trip accuracy from text to drawing and back again, SysML v2 makes it possible for the open-source community or commercial vendors to build graphical editors for SysML v2 for those who prefer to draw rather than code.

There are significant technical advantages to maintaining a system model as a set of statements that describe relationships in a graph, in addition to those already discussed:

- Composability: Graphs provide the flexibility to grow a model through composition of parts, without limitations imposed by the storage of the model and without interfering with other existing elements of the model.
- Element-Centricity: Because every element is connected to all related concepts in the model, any required viewpoint for that element can be made available from any place that item is presented.

These are highly practical considerations for shifting to a code-first, graph-based paradigm for system engineering. However, even more compelling are the emergent properties of this approach—the ability to leverage the underlying graph to deliver more value.

More Use Cases for Data-Driven System Views

In SysML v2, views can be defined and adjusted on the fly or saved for future reference by others. Some views may still be standardized, but the standard views are no longer the limiting factor in the practice of system engineering. Furthermore, having a well-structured, canonical graph model of the system makes it possible to satisfy use cases that deliver value throughout the product lifecycle, for a variety of stakeholders.

- SysML v2 promises to make a comprehensive view of the lifecycle of a system available through 4D modelling as Occurrences & Snapshots [15], supporting high-resolution digital twins.
- Macro-level abstractions have utility later in the lifecycle as the framework for operator interfaces of complex systems of systems, such as those provided to facility engineers and control-room operators in industrial operations. These are still, to a large extent, manually developed and maintained in proprietary tooling and at significant expense.
- A key operations issue is troubleshooting problems in installed systems. Tracing the root cause of a problem can be time consuming and subject to error or false assumptions because the information that is available to someone who is troubleshooting might be limited. For example, in a large commercial facility, there are several cooperating systems that deliver environmental services. With a properly formed graph representation it is possible to code the question “Why is this space too cold?” and receive a comprehensive answer describing all the components in the chain that are involved in the delivery of that service, how they are configured, and whether they are functioning correctly.

- A systems engineer studying a large model can use a view to focus attention on the parts of the architecture that are relevant to a specific function or service and follow a dependency chain that might normally cross several diagrams cluttered with information that isn't meaningful to their immediate investigative task.

Tools like Tom Sawyer Perspectives can facilitate these use cases by providing easy and flexible interrogation of the model via embedded meta-data. Through the use of advanced visualization features, Tom Sawyer's graph visualization tools can help manage the resulting complexity by providing an initial view of the most abstract layer and supporting drill-down within the same drawing to understand details.

With SysML v2 still awaiting final acceptance, it will be a few years before we know if the collective community of engineers and tool vendors will be able to provide the advantages, and avoid the pitfalls surveyed by James Towers in 2020. [16] We can aspire that through a combination of both open source and commercial contributors, and with strong demand from both public and private sector customers, SysML v2 will be positioned to move past the issues that limited adoption of SysML v1 and improve the tooling available to make the practice of MBSE more accessible to practitioners in different fields and for problems of varying complexity, building on and contributing to the foundation established by OpenMBEE.

In Closing

Tom Sawyer Software has been producing graph-based solutions since 1992. If you are interested in more information about the engineering solutions mentioned above, you may visit its website for more information and a free evaluation of Tom Sawyer Perspectives or Tom Sawyer Model-Based Engineering. Or try Tom Sawyer Software's prototype SysML v2 demo.

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About the Author

Liana Kiff is the former Director of Solutions at Tom Sawyer Software. Liana joined Tom Sawyer in January 2019 to grow the team of Solution Architects that served its expanding Services business. Liana brought more than 20 years of global and distributed software innovation, design, and development experience to Tom Sawyer Software. In her role at Tom Sawyer Software, she supported the efforts of the OMG STT to develop and demonstrate the SysML V2 standard.

Prior to Tom Sawyer Software, Liana held several lead roles with Honeywell’s corporate labs, where she worked on innovative graph-based approaches to industrial information management and acquired deep domain knowledge related to Honeywell's federal, commercial, and industrial offerings and customers. As a champion of information standards and model-driven approaches, she led the development of an ontology for use across all of Honeywell’s building automation solutions and managed the innovation of cloud-based services and model-based APIs for enterprise software development.

Liana holds a Master of Software Engineering degree from the University of Minnesota.

SYSTEMS ENGINEERING RESOURCES

Useful artifacts to improve your SE effectiveness

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- Improv to Improve Your Team's Creativity (blog) (podcast)
- Lessons for Product Managers From PDMA's Outstanding Corporate Innovators Award (blog) (podcast)
- Lean Product Management (blog) (podcast)
- Reimagining Engagement in Product Development and Management (blog) (podcast)
- The Key to Successful VOC in Agile Teams (blog) (podcast)
- Three Ways to Escape Gut-Feeling and Rapidly Boost Innovation to Markets (blog) (podcast)
- Transforming Products into Experiences (blog) (podcast)

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- The Back End of Innovation: The Neglected Stepchild of NPD (webcast)
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The St. Louis chapter of the Product Development Management Association (PDMA) maintains a rich repository of presentations and other open-access resources associated with past events. Content added thus far in 2023 includes:

- A Product Owner's Journey from Scribe to Entrepreneur (7 Feb video)
- PDMA Body of Knowledge 2nd Edition Review (21 March video)
- User Footsteps Method (11 April video)
- 2023 Chapter Conference – Design Thinking Workshop (6 May video)
- 2023 Chapter Conference – Mission Driven Innovation (6 May video)

Learn more about the PDMA St. Louis chapter.

NAFEMS E-Learning Courses for July - August

NAFEMS offers a diverse range of code-independent, in-depth online training courses on engineering analysis and simulation. Upcoming courses beginning in July - August 2023 include:

Metals Material Modelling: Creep (3 sessions; 5 – 19 July)
This course is aimed at engineers and designers who want to learn about how metal creep is modelled using FE software. The course will cover creep theories and approximations that are widely used to analyze practical high-temperature engineering applications. Mathematical formulations and equations are intentionally kept to a minimum. Emphasis will be placed on how engineering design incorporates these theories and how the FE method models metal creep.

Advanced Dynamic FEA (4 sessions; 11 July – 1 August)
This course covers a broad range of solution types, beyond the usual natural frequency and dynamic response methods. This allows more physical phenomena to be investigated and simulated using dynamics in FEA. Topics covered include Random Vibration, Shock and Response Spectra, Nonlinear Dynamic Response, Explicit Dynamic Analysis and Complex Eigenvalue Analysis.

10 Steps to Successful Explicit Dynamic Analysis (3 sessions; 20 July – 3 August)
This course provides a basic overview of explicit dynamics simulation methods, briefly describing the theoretical nature together with its software implementation and its advantages and disadvantages. It should help engineers carry out explicit dynamics simulations, ensuring accurate and robust solutions with correct analysis choices avoiding possible pitfalls. It should also help engineers distinguish problems that should be solved explicitly or implicitly, thereby providing the least time to obtain a solution.

Metals Material Modelling: Welding Simulation and Residual Stresses (3 sessions; 26 July – 9 August)
This course is aimed at engineers and designers who want to become familiar with how the Finite

Element method can be used to simulate the welding process in metals and the residual stresses arising from welding. The course will cover the finite element modelling of the welding of metallic structures using filler material where the high temperatures experienced by the materials during welding generate thermo-mechanical stresses and microstructural changes. Finite element solutions for the post-weld residual stresses will be discussed and compared to experimental measurements.

Non-Linear FEA (6 sessions; 27 July – 31 August)
This live, online course addresses the important features of non-linear FEA - independent of any specific software – Focus on key background and practical hints and tips, covering topics including:

- Background to non-linear FEA
- Nonlinear analysis strategy
- Geometric nonlinearity
- Material nonlinearity
- Contact nonlinearity
- Explicit analysis background.

How to Implement a Modelling & Simulation Strategy (5 sessions; 1 – 29 August)
This high-level training course focuses on modelling and simulation tools from a C-level perspective, identifying business goals, product requirements and organization needs before introducing a framework that will become the foundation of your comprehensive Modelling and Simulation strategy. It also addresses the challenges you'll face when deploying the strategy and shows you how to tackle them head-on to ensure successful implementation.

Fatigue & Fracture Mechanics in FEA (5 sessions; 14 August – 12 September)
The objective of this course is to break down the fatigue analysis process into clearly defined steps, give an overview of the physics involved and show how to successfully implement practical solutions using Finite Element Analysis. Topics covered include High Cycle Fatigue Methods, Notch Effects and Low Cycle Fatigue, Multi Axial Fatigue, Fracture Mechanics and more.

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INCOSE INSIGHT Practitioners Magazine - Model-Based Test and Evaluation

The March 2023 edition (Volume 26, Issue 1) of INSIGHT, INCOSE's Practitioner Magazine published by Wiley, has been released. Electronic subscriptions to INSIGHT are available as a member benefit to INCOSE members. Hard-copy subscriptions to INSIGHT are available for purchase by INCOSE members for one membership year, and to the public.

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The focus of this issue is *Model-Based Test and Evaluation*. Contents of this 104-page document includes:

The Challenge of Enabling Dynamic Innovation with Rigor
by John Frederick, Columb Higgins and Angela Moore

How do we incubate and accelerate innovation? This article examines lessons learned from recent Verification and Validation (V&V) summits and Technical Interchange Meetings (TIMs) held by the Federal Aviation Administration (FAA) V&V Strategies and Practices Branch, which explored the

challenges of being agile and dynamic (in step with the pace of technology) while being effectively systematic and rigorous.

Determining Reliability Requirements and Testing Costs in the Early Stages of Single Use Medical Product Design
by Fritz Eubanks

The production of single use medical devices, particularly for home use by patients, continues to grow, and the reliability of these devices is a primary concern for manufacturers and end-users. The systems engineer tasked with the device development needs methods and tools to establish reliability requirements and provide cost estimates for the testing necessary to show compliance with those requirements. This paper examines methods for determining reliability requirements, the cost of reliability testing for single use medical devices in the design input phase of product development, and how the costs of testing and potential errors can be used to perform trade-off analysis between reliability tolerance and confidence level.

A Concept for Set-based Design of Verification Strategies
by Pen Xu and Alejandro Salado

In current practice, a verification strategy is defined at the beginning of an acquisition program and is agreed upon by customer and contractor at contract signature. Hence, the resources necessary to execute verification activities at various stages of the system development are allocated and committed at the beginning, when a small amount of knowledge about the system is available. However, contractually committing to a fixed verification strategy at the beginning of an acquisition program fundamentally leads to suboptimal acquisition performance. Essentially, the uncertain nature of system development will make verification activities that were not previously planned necessary and will make some of the planned ones unnecessary. To cope with these challenges, this paper presents an approach to apply set-based design to the design of verification activities to enable the execution of dynamic contracts for verification strategies, ultimately resulting in more valuable verification strategies than current practice.

Formalizing the Representativeness of Verification Models using Morphisms
by Paul Wach, Peter Beling and Alejandro Salado

With the increasing complexity that is being introduced to engineered systems, the literature suggests that verification may benefit from theoretical foundations. In practice and in teaching of system engineering (SE), we typically define a verification model (simulation, test article, etc.) under the assumption that the model is a valid representation of the system design. Is this assumption always true? In this article, we explore the use of system theoretic morphisms to mathematically characterize the validity of representativeness between verification models and corresponding system design.

Verification and Validation of SysML Models
by Myron Hecht and Jaron Chen

Model-based systems engineering depends on correct models. However, thus far, relatively little attention has been paid to ensuring their correctness. This paper describes a methodology for performing verification and validation on models written in SysML. The methodology relies on a catalog of candidate requirements that can be tailored for a specific project. Both manual and automated methods are used to verify and validate these requirements. Manual methods are necessary where knowledge of the domain and other extrinsic characteristics are necessary.

Automated methods can be used where the requirements cover the use of SysML. Examples from a public domain SysML model of a satellite are presented to demonstrate application of automated

requirements verification.

From Model-based to Model and Simulation-based Systems Architectures — Achieving Quality Engineering through Descriptive and Analytical Models
by Pierre Nowodzienski and Juan Navas

Systems architecture design is a key activity that affects the overall systems engineering cost. Hence it is fundamental to ensure that the system architecture reaches a proper quality. In this paper, we leverage model-based systems engineering (MBSE) approaches and complement them with simulation techniques, as a promising way to improve the quality of the system architecture definition, and to come up with innovative solutions while securing the systems engineering process.

System Verification and Validation Approach Using the MagicGrid Framework
by Aurelijus Morkevicius, Aiste Aleksandraviciene and Zilvinas Strolia

The ongoing transformation in the industry from a document-based systems engineering to a model-based systems engineering approach reveals a need for new methods of verifying and validating systems. Traditional methods of testing the actual system are getting more and more expensive. A model-based environment could significantly reduce testing and, most importantly, verification and validation processes costs. It allows testing on the system model by applying various techniques, such as simulation, analysis, review, mock-ups, etc. There are, however, very few approaches today detailing how verification and validation of the entire system (taking into count its components and subsystems) could be performed. This paper proposes an approach to perform verification and validation of a system using system models developed with Systems Modeling Language (SysML) and in accordance with the MagicGrid (formerly known as MBSE Grid) framework. The approach covers system testing activities beginning with verification of the lowest modeled system elements against system requirements and finishing with validation of the system as a whole, against stakeholder needs.

Configuration Management for Model Based Systems Engineering — An Example from the Aerospace Industry
by Adriana D'Souza and Phanikrishna Thota

Model-based systems engineering approach is increasingly used to manage the complexity of modern systems and to reduce costs of their development. In the aerospace industry, modelling and simulation is not only a cost-effective verification and validation strategy where test rigs and flight tests are far more expensive but also is increasingly used in the certification process. Nevertheless, as with any digital artifact, if the models aren't configured and traceability isn't assured, then the models are not of much use. Configuration management comes into play as a key discipline to enable the use and maintenance of the models. This paper explores the use of configuration management for modelling and simulation in an aerospace setting, with a specific example involving landing gear and its surrounding systems.

You Don't Save Money by Doing Less Testing – You Save Money by Doing More of the Right Testing!
by Andrew C Pickard, Richard Beasley and Andy J Nolan

Like so many aspects of life, we are looking for value-for-money. But we need to consider the value in terms of both short and long-term gains. Although certification standards require verification that requirements have been met, we need to recognize that verification is also there to bring value to a project and to the business as a whole. However, prioritizing the value to the project over the value to the business can result in sub-optimization and an overall higher cost to the business. This paper examines a specific case, the prediction of the fatigue lives of critical parts in gas turbine engines, to

illustrate the more general case of performing tests to calibrate models that then have general applicability across multiple projects, rather than focusing testing on the needs of a specific project. In some circumstances, testing may not even be the best approach to take; if some level of error escape into service is acceptable (unlike the life prediction example given in this paper) then more focus on requirements validation and design review may provide a more cost-effective approach. This is where the linkage in a systems engineering model between requirements, functions, failure modes and effects analysis, verification test cases, and available calibrated models can help with identifying opportunities and risks.

Inconsistent and Incomplete Datasheet: The Case for Systematic Use of Requirement Engineering
by Lorraine Brisacier-Porchon and Omar Hammami

The lifecycle of a system is extended from its early conception to its retirement of service. The lifespan of unmanned ground vehicles (UGVs) can be expected to last over 50 years in the defense market. In this context, the rising complexity of UGV systems imposes engineering steps that would ensure both capabilities of the system and resilience to its future inclusion in a system-of system context. During its operational usage, the UGV is supposed to be maneuvered for specifically designed purposes following user manual datasheet of the components off-the-shelf (COTS) that were integrated. This paper exposes the public user datasheet relevance compared to the system engineering requirements that are the artifacts of system design architecture. The use of connecting COTS user manual to system requirements is discussed, all the more if the systems are to be re-used in a system production line. This article is intended to explore system of system conception methods for future robotized battlefields.

Exploring the Test and Evaluation Space using Model Based Conceptual Design (MBCD) Techniques
by David Flanigan and Kevin Robinson

During the initial concept development phase, systems engineers focus on defining the problem space and system functions to explore candidate concepts that may address the systems engineers' problems. Model-based conceptual design (MBCD) techniques may be used to assist the customer and other stakeholders develop a greater understanding of the system concept, as well as identifying areas in the system that are affected by changes in requirements. This approach has generally been documented for describing the system concept in the early stages in the lifecycle, without significant focus on the test and evaluation (T&E) space that would be needed to evaluate these concepts or identifying where the T&E space would be affected with a change in requirements. Our hypothesis is that decision makers would equally gain insight into the T&E considerations as well as system space considerations using MBCD techniques. An approach is offered to extend the previously published MBCD methodology to better consider the T&E space.

Framework for Formal Verification of Machine Learning Based Complex System-of-Systems
by Ramakrishnan Raman, Nikhil Gupta and Yogananda Jeppu

A complex system is characterized by emergence of global properties which are very difficult, if not impossible, to anticipate just from complete knowledge of component behaviors. Emergence, hierarchical organization, and numerosity are some of the characteristics of complex systems. Recently, there has been an exponential increase in the adoption of various neural network-based machine learning models to govern the functionality and behavior of systems. With this increasing system complexity, achieving confidence in systems becomes even more difficult. Further, ease of interconnectivity among systems is permeating numerous system-of-systems, wherein multiple

independent systems are expected to interact and collaborate to achieve unparalleled levels of functionality. Traditional verification and validation approaches are often inadequate to bring in the

nuances of potential emergent behavior in a system-of-systems, which may be positive or negative. This paper describes a novel approach towards application of machine learning based classifiers and formal methods for analyzing and evaluating emergent behavior of complex system-of-systems that comprise a hybrid of constituent systems governed by conventional models and machine learning models. The proposed approach involves developing a machine learning classifier model that learns on potential negative and positive emergent behaviors, and predicts the behavior exhibited. A formal verification model is then developed to assert negative emergent behavior. The approach is illustrated through the case of a swarm of autonomous UAVs flying in a formation, and dynamically changing the shape of the formation, to support varying mission scenarios. The effectiveness and performance of the approach are quantified.

View the entire issue of INSIGHT Volume 26, No. 1 in the INCOSE Connect Library INSIGHT Practitioners Magazine.

Webinar: The Genesis of Holistic Digital Engineering

On 4 April 2023, IncQuery and Zuken Vitech collaborated to present a webinar titled "*The Genesis of Holistic Digital Engineering - Automated Consistency of System Architecture and Detailed Physical Design*".

During the webinar, István Ráth, CEO of IncQuery, and Enrique Krajmalnik, CEO of Zuken Vitech:

- Shared their insights on the current challenges of the existing tooling landscape for digital engineering in handling present and future levels of system complexity.
- Proposed innovative toolchains focused on both domain diversity and toolchain interoperability to cope with the ever-growing demand in systems engineering for multi-domain modeling analysis.
- Demonstrated how a connected toolchain for a multi-domain engineering scenario can improve the complex electrical harness design process.
- Highlighted the importance of consistency analysis covering all the design domains and phases, providing automated quality checks and in-depth analytics over the entire digital thread.

Key learnings:

- Understand a connected toolchain for a multi-domain engineering scenario of a complex electrical harness design process.
- Learn about consistency analysis covering all the design domains and phases.
- Overview a complex case study involving GENESYS, E3, E3.GENESYS.Connector, and the IncQuery Suite.

View the webinar at Zuken Vitech.

INCOSE Canada Webinar Series

The Canada chapter of INCOSE has been hosting a series of webinars since late 2022. The webinars are available for viewing (for INCOSE members after portal login) at the chapter events page. Five webinars have been delivered, including:
MBSE in the Railway Industry (11 April 2023)

SYSTEMS ENGINEERING RESOURCES

This is the Fifth session of the technical program offered by the INCOSE Canada Chapter. In this session, the webinar will explore the potential benefits of Model-Based Systems Engineering (MBSE) in the railway industry. Speakers, Qifang Wang and Sergio Guindas García, will discuss the challenges faced by the industry and how MBSE can provide solutions.

Conceptual models for Agent Based Modeling (20 March 2023)
This is the fourth session of the technical program offered by the INCOSE Canada Chapter. In this session, the webinar explores the topic of "Conceptual models for Agent Based Modeling" with Terry Fitzgerald, Vice-President of INCOSE Canada Chapter.

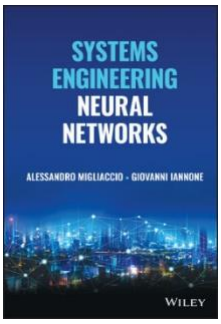
Generating a Robust System Architecture Using ARCADIA Capella (13 February 2023)
This is the third session of the technical program offered by the INCOSE Canada Chapter. In this session, the webinar explores the topic of "Generating a Robust System Architecture Using ARCADIA Capella" with Eric Dano, Associate Professor of Practice at the George Washington University.

Requirements Engineering for Software Engineering Projects (9 January 2023)
This is the second session of the technical program offered by the INCOSE Canada Chapter. In this session, the webinar explores the topic of "Requirements Engineering for Software Engineering Projects" with Majd Karam, Ph.D. Candidate and director, National Capital FreeNet.

Cybersecurity Modeling and Simulation (28 November 2022)
This is the first session of the technical program offered by the INCOSE Canada Chapter. In this session, the webinar explores the topic of "Cybersecurity modeling and simulation" with Dr. Ivan Taylor, President of Policy Dynamics Inc.

Learn more about INCOSE Canada.

Book and Course: Systems Engineering Neural Networks



Wiley has published a new AI-related book, Systems Engineering Neural Networks, by Alessandro Migliaccio (INCOSE CSEP and member of the Artificial Intelligence Working Group) and Giovanni Iannone (INCOSE member with a Masters in Systems Engineering).

Description:
A complete and authoritative discussion of systems engineering and neural networks. 240 pages. ISBN: 978-1-119-90201-0

In *Systems Engineering Neural Networks*, a team of distinguished researchers deliver a thorough exploration of the fundamental concepts underpinning the creation and improvement of neural networks with a systems engineering mindset. In the book, you'll find a general theoretical discussion of both systems engineering and neural networks accompanied by coverage of relevant and specific topics, from deep learning fundamentals to sport business applications. Topics include:

- A thorough introduction to neural networks, introduced as key element of complex systems.
- Practical discussions of systems engineering and forecasting, complexity theory and optimization and how these techniques can be used to support applications outside of the traditional AI domains.
- Comprehensive explorations of input and output, hidden layers, and bias in neural networks, as well as activation functions, cost functions, and back-propagation.
- Guidelines for software development incorporating neural networks with a systems

engineering methodology.

The authors have produced a companion training course on udemy, Systems Engineering Neural Networks – Machine learning with a "system" approach. The online course includes 31 minutes of on-demand video, homework assignments and 10 downloadable resources. Learning objectives include:

- Understand the basic of machine learning
- Understand the basics of systems engineering
- Set up a simple neural network
- Put machine learning in a system context

New System Dynamics Resources

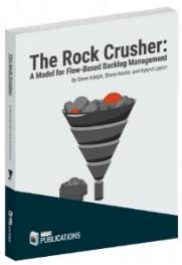
The System Dynamics Society (SDS) continues to curate and/or recommend a variety of system dynamics resources in the form of blogs, videos and papers. Here are some of the latest open-access resources to check out:

- Five Core Competency Areas for Participatory Modeling (article)
- The United Nations Sustainable Development Goals and System Dynamics Simulation (video)
- Barriers and potentials of city hubs – a system dynamics approach (TSIG) (video)
- Systems Thinking Tools: Archetypes (video)
- An Overview on En-Roads and a Discussion on its Ability to Move People to Act - Envt SIG (video)

Join the SDS to gain access to additional content.

Business Analysis Resources

The International Institute of Business Analysis (IIBA) is a non-profit professional association that helps business analysts develop their skills and further their careers by providing access to relevant content.



IIBA recently published a new book, The Rock Crusher by Steve Adolph, Shane Hastie and Ryland Leyton, that offers an agile approach to backlog management, highlighting the power and simplicity of this essential tool in modern agile organizations. This new publication emphasizes the importance of the backlog as a single repository from which a team pulls its next most valuable work item, enabling agility through the ability to add, remove, reprioritize, and visualize potential work for a product.

You may order *The Rock Crusher* at the IIBA Bookstore.

The IIBA offers public webinars for non-members. Upcoming open access events in the Business Analytics series include:

- Choosing a Representative Group of People for a Survey (8 June)
- Introduction to Python (6 July)

Each webinar will be delivered in three different time zones to support convenient global access.

Register here.

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Upcoming PPI Live-Online ™ Systems Engineering Five Day Courses

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

P006-916	Eindhoven, the Netherlands CEST 8:30 (UTC +2:00) In-Person	12 Jun - 16 Jun 2023
P006-917	Las Vegas, United States of America PDT 8:00 (UTC -7:00) In-Person	19 Jun - 23 Jun 2023
P006-918-1	Asia SGT 6:00 (UTC +8:00) PPI Live-Online	26 Jun - 30 Jun 2023
P006-918-2	Oceania AEST 8:00 (UTC +10:00) PPI Live-Online	26 Jun - 30 Jun 2023
P006-920	London, United Kingdom BST 8:30 (UTC +1:00) In-Person	31 Jul - 04 Aug 2023
P006-921-1	North America MDT 8:00 (UTC -6:00) PPI Live-Online	31 Jul - 04 Aug 2023
P006-921-2	South America BRT 11:00 (UTC -3:00) PPI Live-Online *(Exclusive to South America)*	31 Jul - 04 Aug 2023
P006-922	Las Vegas, United States of America PDT 8:00 (UTC -7:00) In-Person	07 Aug - 11 Aug 2023
P006-923-1	Asia SGT 6:00 (UTC +8:00) PPI Live-Online	14 Aug - 18 Aug 2023
P006-923-2	Oceania AEST 8:00 (UTC +10:00) PPI Live-Online	14 Aug - 18 Aug 2023
P006-924-1	North America EDT 8:00 (UTC -4:00) PPI Live-Online	18 Sep - 22 Sep 2023
P006-924-2	South America BRT 9:00 (UTC -3:00) PPI Live-Online *(Exclusive to South America)*	18 Sep - 22 Sep 2023
P006-925-1	Europe CEST 9:00 (UTC +2:00) PPI Live-Online	18 Sep - 22 Sep 2023
P006-925-2	United Kingdom BST 8:00 (UTC +1:00) PPI Live-Online	18 Sep - 22 Sep 2023
P006-925-3	South Africa SAST 9:00 (UTC +2:00) PPI Live-Online *(Exclusive to South Africa)*	18 Sep - 22 Sep 2023
P006-925-4	Turkey TRT 10:00 (UTC +3:00) PPI Live-Online	18 Sep - 22 Sep 2023
P006-925-5	Saudi Arabia AST 10:00 (UTC +3:00) PPI Live-Online	18 Sep - 22 Sep 2023

FINAL THOUGHTS FROM SYENNA

The law of unexpected consequences

You may have detected in earlier ramblings that I am keen to reduce my carbon footprint. Even if I were fanatical about this, my annual CO2 reduction would be wiped out in about 13 hours by the flare from a single oilwell. But if millions of us take small steps, then collectively we can make a difference.

As part of this, I have had the gas supply to our house disconnected, and we choose to buy "green" electricity. To be more accurate, we pay for green energy, but we have no control over what is sent to our property. To my knowledge, there is no filter on our electricity fuse-board that can reject electrons generated by a fossil-fuelled power station. Nevertheless, I reason that we should commit to as much green energy as possible, and encourage others to do so, because that will incentivize the markets to invest in green energy, reducing the cost per KWh, and creating a virtuous circle in systems thinking terms. [Or it would do if government policy didn't get in the way; I provocatively ask whether the energy market is a huge system of systems that evolved to support the incumbents and those who influence our politicians].

Getting back to my narrative, our electrical heat costs us quite a bit more than gas-fuelled heat. Fortunately for us, we can use our electrical system in a much smarter way, so our energy consumption has noticeably reduced, although our total bill is still higher (with or without the recent surge in energy prices).

I accept this because fossil fuel has been far too cheap for a century. As a race, we plundered the planet for short-term development without accounting for the life cycle costs. I suggest that it is only systems-aware people who care about that. Now our generation has to find a way of paying the debt back, and I'm happy to be in the van, even if my English is archaic.

In the unlikely event that you are still reading it, I'd like to explain the title of this article. We have quite a number of thermostats dotted around our house. If any measured temperature falls below 4 Celsius, the relevant heaters switch on automatically, in order to avoid frozen pipes and destruction of grand pianos.

In order to reduce the cost and disruption of installation, we opted for wireless devices, each of which is powered by 3 AA batteries.

When the batteries get low, the measurement defaults to outside temperature, which is obtained from Unsocial Media or something along those lines. The unexpected consequence? If we are on holiday when the batteries run down, the heating system will stay on until the outside temperature goes above 4 Celsius. Our little hotspot of a house will be doing its best
to warm up the planet, which of course is the inverse of our mission statement.
But at least I will only be paying for "green" energy to achieve this own goal.

[1] The global number of flares being tracked is 136,000:
https://www.worldbank.org/en/programs/gasflaringreduction/global-flaring-data
The estimated total CO2 output from flares is 350 MTonnes:
https://www.bing.com/search?q=annual+CO2+from+flaring&PC=C441&FORM=C441DF
Hence the average annual CO2 output from one flare is 2,574 Tonnes.

FINAL THOUGHTS FROM SYENNA

My typical household annual gas usage was equivalent to 3.8 Tonnes.

Regards,
Syenna

PPI RESOURCES

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

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

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

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

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

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

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