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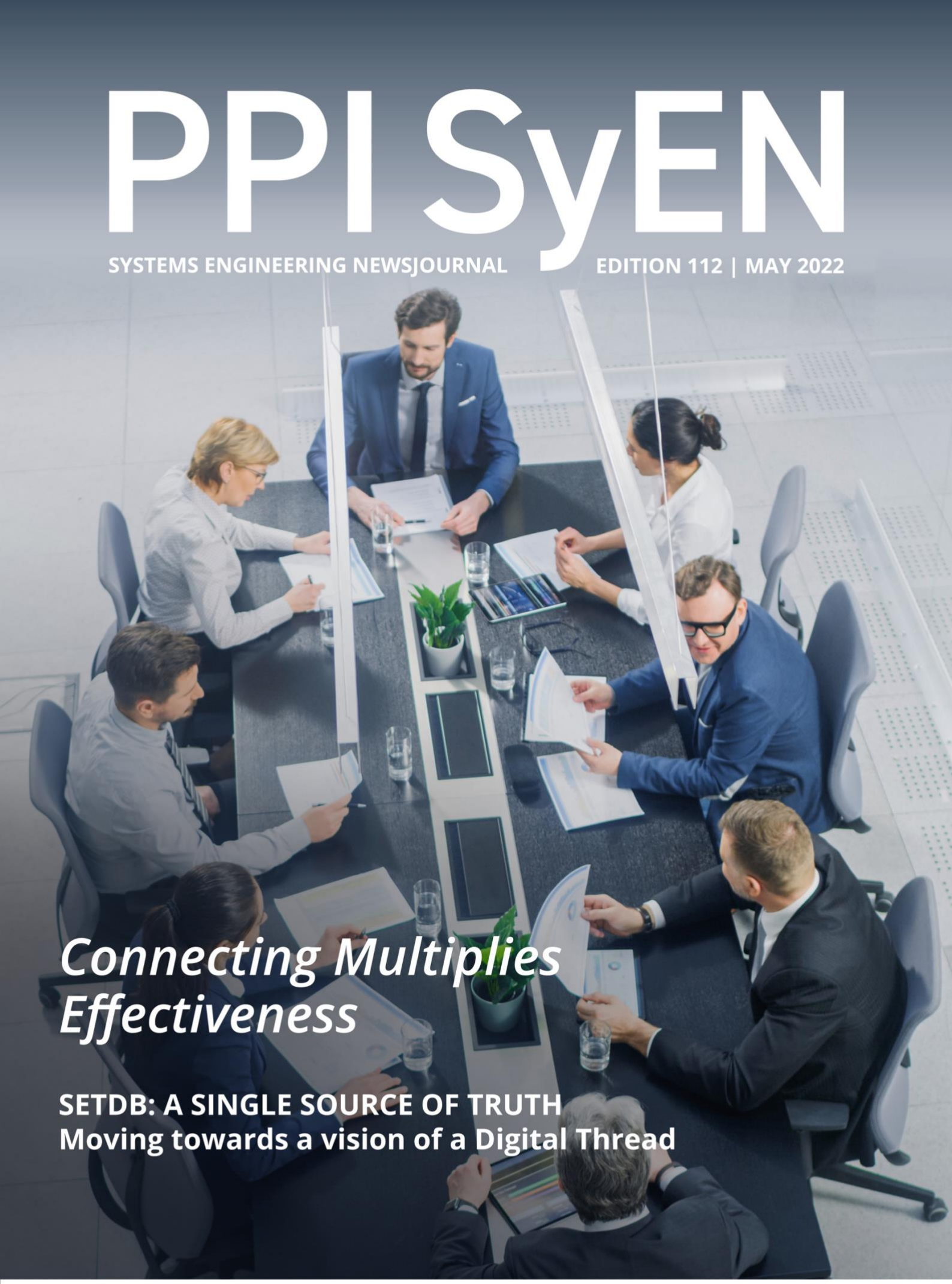

Connecting Multiplies Effectiveness

SETDB: A SINGLE SOURCE OF TRUTH
Moving towards a vision of a Digital Thread

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PPI SyEN

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WELCOME

SyEN readers,

Welcome to the May edition of PPI SyEN. Much of systems engineering revolves around making value-creating connections – between system elements, lifecycle information (the Digital Thread) and human beings. This SyEN May edition echoes that theme, better stated as "Connections Multiply Effectiveness".

Lots of technical and professional conferences are spinning up, with engineering practitioners looking forward to more face-to-face interaction. This month's PPI SyEN highlights quite a few such events, including an overview of the amazing technical program that awaits in June at INCOSE's International Symposium, IS2022, and a recognition of the contributions of various sponsors to the International System Dynamics Conference in July. You are encouraged to check out additional networking and professional growth opportunities such as the prostep ivip Symposium 2022, SiriusCon 2022, Swiss Systems Engineering Day, Forum on specification & Design Languages (FDL 2022) and the International Conference of Modern SE Solutions. Let's not overlook the exciting news of the INCOSE International Symposium 2023 being hosted in Honolulu, Hawaii. Sun … waves … ocean breezes.

Other articles continue the "Connections" theme; the launch of the IEEE Open Journal for Systems Engineering (OJSE) creates a new channel for sharing insights. The Functional Mockup Interface (FMI) is a standard for exchanging system simulation models. The New Horizons in Systems Science article highlights a meet & greet session and the potential for future collaborations between the System Dynamics Society (SDS) and INCOSE. INCOSE Systems Exchange Cafés are informal knowledge sharing sessions among SE community members. Blockchain is an enabling technology for connecting the dots for supply chain traceability.

The lone (and lengthy) feature article showcases the Systems Engineering Tools Database (SETDB). I had the privilege of a front-row seat during the development of the SETDB and appreciate the opportunity to tell its story. The SETDB provides a platform through which organizations seeking to build out their systems engineering "tool chains" toward a vision of a Digital Thread can identify the software building blocks that will move them forward. The SETDB story has additional value in illustrating the power of systems engineering done well-disciplined methods that populate a single source of truth, from which emanate a chain of connected and aligned views that engage stakeholders and contributors across the entire systems lifecycle. Dive in and get connected!

John

Editor, PPI SyEN

PPI Systems Engineering Newsjournal (PPI SyEN) seeks:

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

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

SYSTEMS ENGINEERING NEWS

Recent events and updates in the field of systems engineering

NCOSE IS2023 Set for Honolulu Hawaii

The physical location for the 33rd Annual INCOSE International Symposium, IS2023, has been set as Honolulu, Hawaii, USA. INCOSE's premier annual event will be conducted in hybrid format on 15-20 July 2023.

Details, as they become available, may be found at the conference website.

PPI News: PPI Participation at INCOSE IS 2022

Will we see you at the hybrid 32nd Annual INCOSE International Symposium (INCOSE IS)? This leading conference, the world's largest annual gathering of people working in the field of systems engineering, will take place physically and virtually in Detroit, Michigan, over June 25 to June 30, 2022.

For six days, attendees will be enlightened by presentations, case studies, tutorials, panel discussions, and the opportunity to engage in workshops.

Our team will be delivering a number of insightful presentations this year:

- What Force is More Powerful Than Profit? - *by PPI's Randall Iliff, Principal Consultant and Course Presenter*
- MBSE in the Problem Domain - even More Valuable than Model-Based Design? - *by PPI's Robert Halligan, PPI Managing Director, Principal Consultant and Course Presenter (20 min. virtual)*
- PPI Promotional Video - *PPI's René King, Business Development Manager and Senior Engineer, will give you a short overview of PPI, our services and the free PPI SE products available to you (3 min. virtual)*
- A Framework of Knowledge, Skills and Attitudes for High Performance Engineering - *by Robert Halligan (30 min. virtual)*
- Six More Myths of Systems Engineering - *by Robert Halligan (15 min. virtual).*

Click here for full details of PPI's participation in the INCOSE IS 2022.

Register for the INCOSE IS

IEEE Launches Open Journal for Systems Engineering (OJSE)

The Institute for Electrical and Electronic Engineers (IEEE) has launched a new publication, the Open Journal for Systems Engineering (OJSE). This new open access technical journal is devoted to the multidisciplinary aspects of systems engineering.

OJSE is sponsored by the consortium of IEEE Aerospace and Electronic Systems Society, IEEE Systems, Man, and Cybernetics Society, and the IEEE Systems Council. The publication provides a forum for practitioners, scientists, academics, and researchers engaged in the discipline of Systems Engineering.

Systems engineering involves elements of model-based systems engineering; digital thread; requirements generation, flow-down, tracking, needs analysis, and validation/verification; integration and test; and full life cycle support of the target system. OJSE deals primarily with the science, methodology, and tools of systems engineering, rather than the results of the application of systems engineering that is the focus of other IEEE journals.

OJSE seeks scholarly papers that report original research on the methodologies, tools, principles, and applied engineering aspects of the process of systems engineering for complex systems. OJSE also seeks proposals for special issues. OJSE is an Open Access journal for which authors pay the publication costs. Publication costs for a ten-page manuscript in 2023 are projected to be $975 (USD). Articles are provided free to the public and available on IEEE Xplore.

See additional details on OJSE here. Download the OJSE flyer.

While the official launch date for OJSE is January 2023, manuscript submissions are accepted beginning 1 April 2022. Manuscripts for OJSE are submitted here.

OJSE has issued its first Call for Papers for a special issue targeting Front-end Need Analysis. This special issue seeks papers that contribute to establishing references that:

- Formalize the activities, concepts, and techniques around front-end need analysis.
- Share good examples of the use of such techniques.
- Address the gaps in need analysis approaches.
- Provide a vision for the evolution of need analysis in the context of model-based and digital environments.

Both theoretical and applied papers are welcome. Note that applied papers must be constructed based on argumentation, ideally underpinned by established theoretical frameworks (those in peer-reviewed publications or validated otherwise). Papers that only report practices without such support are discouraged.

In this special issue 'needs' refer to the outcomes that stakeholders want to achieve by interacting with the system of interest. Topics related to formulation, derivation, decomposition, and/or management of requirements are outside of the scope of this issue.

Key Topic Areas:

- Stakeholder identification and management
- Need elicitation, formulation, identification, and resolution of conflicts
- Formal methodologies of transitioning from need analysis to requirement derivation
- Metrics and measurements for assessment of elicited needs
- Results of empirical studies

The deadline for manuscript submission is 15 July 2022. Final manuscripts are due on 1 January 2023.

Functional Mockup Interface (FMI) 3.0 Released

The Modelica Association and the FMI Project announce the release of version 3.0 of the Functional Mockup Interface (FMI). The FMI has proven itself as the most widely adopted format for system simulation model exchange and the de facto industry standard for model exchange and co-simulation.

FMI version 3.0, now released by the Modelica Association, is a major milestone for the standard with new features that enable the use of FMI in important new use cases:

- Advanced co-simulation
- Virtual Electronic Control Units (vECUs)
- Next generation of Digital Twins
- Artificial intelligence applications.

Overview over the most important new features: FMI 3.0 Highlights
Complete Press release: FMI 3.0 - a major milestone for interoperability in system modeling and simulation

Modelica Business Simulation Library 2.0 Released

The Business Simulation Library (BSL) is a free library for creating system dynamics models, written in the Modelica non-proprietary, object-oriented, standardized modeling language. BSL Version 2.0 was released in December 2021 and includes a CausalLoop package that introduces high-level classes to quickly generate a quantitative simulation from a causal loop diagram. Version 2.0 also now supports agile system dynamics modeling.

The Business Simulation library makes use of Modelica's acausal connectors to better distinguish material/mass flows from instantaneous information signal flows (causal connections). The approach has the additional benefit of allowing the modeler to build more compact models in a fast and reliable fashion.

Features of BSL 2.0 include:

- Hierarchical and acausal modeling with increased reusability of components and enforcement of mass balance
- Modeling of mass and information flows
- Use of the system dynamics metaphor
- Inclusion of many pre-built components ("molecules of structure")
- Ability to combine components from the Modelica Standard Library
- Support for convenient parametric lookup functions—including typical fuzzy membership functions

Download BSL 2.0 from GitHub or Wolfram.

Reference Erik Aberg's excellent overview of Modelica and the benefits of acausal modeling in SyEN Edition #110 (March 2022) in the feature article titled "*Technology and trends in systems modeling and simulation*".

Request for Comments: NIST Guide to Operational Technology Security

The U.S. National Institute of Standards and Technology (NIST) has released the initial public draft of NIST Special Publication (SP) 800-82r3, Guide to Operational Technology (OT) Security, which provides guidance on how to improve the security of OT systems while addressing their unique performance, reliability, and safety requirements.

OT includes a broad range of programmable systems and devices that interact with the physical environment (or manage devices that interact with the physical environment). These systems and devices detect or cause a direct change through monitoring and/or control of devices, processes, and events. Examples include industrial control systems (ICS), building automation systems, transportation systems, physical access control systems, physical environment monitoring systems, and physical environment measurement systems.

The document provides an overview of OT and typical system topologies, identifies typical threats and vulnerabilities to these systems, and provides recommended security countermeasures to mitigate the associated risks.

This revision of the guide addresses the expansion of its scope from ICS to OT, while covering updated threats, practices and security capabiliities.

Email comments to sp800-82rev3@nist.gov no later than 1 July 2022. Use the comment template for your submission.

Software Engineering MBSE tool positions at CEA LIST

CEA-LIST: Laboratory for Integration of Systems and Technology
Institute

The CEA LIST Institute in Paris, France is seeking to add two software engineering experts to a R&D team of twenty people who are working on the development of software environments for Model-Based System Engineering (MBSE), based on the Papyrus open-source modeling platform. In the near term, this opportunity focuses on the development of modeling, simulation and optimization functionalities, and the exploitation of these functionalities for the design and deployment of functional digital twins in multiple fields of application (manufacturing, logistics, rail, building, health, etc.). Longer term, the opportunity will grow into participation in a major upgrade of the platform, including the webization of Papyrus and its modules, which will involve making and sharing global architectural choices.

Tasks include:

- Contributing to architecture choices and implementation technologies
- Development and implementation of new models and new functionalities
- Migration of existing functionalities into new architectural frameworks for the modernization of the platform
- Testing and validating these developments
- Writing technical reports, project deliverables and scientific articles
- Technological monitoring in the areas concerned
- Piloting and setting up projects

Qualifications include:

- PhD in Computer Science or equivalent experience
- Excellent knowledge of the Java language
- Expertise in Eclipse development, in particular EMF, GMF, XTEXT, CDO and/or UML frameworks
- Experience/knowledge in UML/SysML modeling, Python, web development (REST, JAX-RS, etc.) and JavaScript, HTML, CSS
- Experience in writing technical reports/deliverables and project management
- Good level of English to support international project participation.

To apply, contact Arnaud Cuccuru, head of the Executable Language Engineering and Optimization Laboratory (LIDEO): arnaud.cuccuru@cea.fr

GfSE Celebrates 25 Years and Plans TdSE(r) 2022

GfSE

INCOSE's German chapter, GfSE (Gesellschaft für Systems Engineering e.V) is celebrating its 25th year. Founded in Munich in June 1997 with 15 members, GfSE has grown to be one of the largest, most active and influential global contributors to the advancement of Systems Engineering.

GfSE is preparing to resume its annual conference, Day of Systems Engineering (TdSE®), in face-to-face format in Paderborn, Germany from 16-18 November with its motto celebrating "25 years of GfSE".

Contributions are sought in the following topic areas:

- Stakeholder-friendly (model-based) systems engineering methods & tools
- Systems Engineering Best Practices
- Organizational design and compatibility systems engineering
- Acceptance of stakeholders / human-technology integration
- Networked Systems & Systems of Systems (SoS)
- Agility, Artificial Intelligence (AI) & Digital Twins in Engineering
- Sustainability and Model-Based Product Line Engineering

The deadline for submissions is 17 June. See the Call for Papers & Call for Tutorials for details.

Find more GfSE facts and resources here.

"

Engineering is not merely knowing and being knowledgeable, like a walking encyclopedia; engineering is not merely analysis; engineering is not merely the possession of the capacity to get elegant solutions to non-existent engineering problems; engineering is practicing the art of the organized forcing of technological change... Engineers operate at the interface between science and society...

Dean Gordon Brown

CONFERENCES, MEETINGS & WEBINARS

Technical Program is online for INCOSE International Symposium IS2022

The full technical program for the INCOSE International Symposium (IS2022) is now available online, enabling registrants to create their own custom agenda.

IS2022, with a theme of "The Power of Connection", is being offered as a hybrid conference to be held from 25-30 June 2022. The in-person venue is Huntington Place in downtown Detroit, Michigan, USA.

Tutorials to be presented on 25-26 June, include:

Tutorial	Delivered by:
Back to Basics: Fundamentals for Systems Engineering Success	David Long
Systems Security Engineering: A Loss-Driven Focus	Mark Winstead, Michael Mcevilley, Daryl Hild
Systems Engineering an Off-Grid Utility System – A MBSE Tutorial	Steve Cash
Behavior control: methodology and framework for integrating socio-technical systems	Avi Harel
Artificial Intelligence for Systems Engineers: Going Deep With Machine Learning and Deep Neural Networks	Barclay Brown; Ramakrishnan Raman; Ali Raz
Modelling Systems of Systems Without Drowning: Using ISO 24641-Compliant ARCADIA Methodology	Anthony Komar
Systems 101 - An Introductory Tutorial on Systems Thinking and Systems Engineering	Jawahar Bhalla
Systems Engineering by the Book	Paul Martin
Negotiation, Persuasion and Conflict Management for the Systems Engineer	Zane Scott
Complex System Governance: Practical Implications for Improving Complex System Performance	Joseph Bradley; Richard Hodge
Building Really Big Systems with Lean-Agile Practices	Harry Koehnemann; Robin Yeman, Jeff Shupack
Trustworthy Secure Design	Mark Winstead, Michael Mcevilley

Note: Tutorials are subject to a $50 admission fee each ($30 if remote) and must be selected individually during registration. See the event track schedule for timing.

During the heart of the conference, from 27-30 June, the IS2022 will deliver the option of attending any of six concurrent technical tracks including 130+ papers and 7 panel discussions. Additionally, are variety of presentations by vendors/sponsors will be available.

Four keynote talks will shine the light on key conference themes:

Architecting the Future: The Role of SE and DE at the NRO
Monday, June 27: Dr. Christopher Scolese (NRO)

Since its inception more than 60 years ago, the National Reconnaissance Office has worked to secure and expand the U.S. intelligence advantage by developing, acquiring, launching, and operating the world's best space-based intelligence, surveillance, and reconnaissance, or ISR, capabilities. That mission is unwavering. But the world in which we operate has changed. Over the past two years, we learned we could no longer take anything for granted. Some of the processes and systems we relied on proved unreliable. The pandemic showed that the global supply chain is fragile, and Russia's assault on Ukraine made it harder to access raw materials. Rather than bemoaning the fact that what worked in the past may not work in the future, we can embrace this changing world as an opportunity. This presentation will explore how the NRO aims to take advantage of new capabilities to be faster and more efficient, relying on systems engineers and their digital engineering tool box to mitigate risks and architect the future.

Mobility and System Engineering Integration
Tuesday, June 28: Carla Bailo (Center for Automotive Research)

The automotive and mobility industries have been experiencing undergoing dramatic shifts in the last decades. Emerging modern methodologies such as electrification, digitalization, artificial intelligence (AI), connectivity, automation, and shared mobility have collided with new ways to move people and goods. This technology is driving innovations such as mobility charging solutions, ride-hailing and sharing, and robotics. This is totally disrupting the mobility ecosystem of today and creating a much more equitable future.

This presentation will review the industry and technology updates its systems engineering impact on product development, infrastructure, and more.

The Power of connection: The power of influencing and how to do it
Wednesday, June 29: Laura Doughty (Peakfield Consultancy Ltd & Sellafield Ltd)

It can be frustrating, even demoralising, to develop technically excellent and highly useful ideas to then have them disregarded without due consideration – sometimes without any consideration. In her talk, Laura will explain why what you develop is only part of the solution. Knowing who you need and how to connect them to your ideas is key to achieving them. She will go on to share tips and techniques for how to achieve this in a range of situations with a range of personalities. Spoiler alert, the key to influencing starts with you doing the listening. Knowing who to listen to, how to engage them and what to do with what they tell you can help you create better solutions and foster the commitment to ensure their delivery.

CONFERENCES, MEETINGS & WEBINARS

Ford's Connected-Agile, Model Based Systems Engineering and Simulation Journey….so far.
Thursday, June 30: Christopher Davey (Ford Motor Company)

Ford Motor Company is committed to helping build a better world, where every person is free to move and pursue their dreams. This will be advanced through the delivery of outstanding Electric Vehicles (EVs) with compelling connected vehicle services, Advanced Driver Assistance Systems (ADAS) and mobility solutions including self-driving Autonomous Vehicle (AV) technologies. These System-of-System (SoS) solutions will require that we leverage a diverse, global, agile Systems Engineering team that can extract actionable information from, and respond to, real-time connected customer experience data. This presentation will describe the Ford Model Based Systems Engineering (MBSE) journey. It will describe how our MBSE solutions have evolved and adapted to different system, software and technology complexity challenges, resulting in a Connected and Integrated, Agile, Model Based Systems Engineering & Simulation solution. The presentation will provide examples of how this Systems Engineering approach has been successfully applied to EV, ADAS and AV systems analysis and design. It will discuss some lessons learned on the trade-offs encountered when balancing "just enough" formalism (ontologies and standards) with scaled agility and risk. It will conclude by discussing the power of a harmonized systems engineering-enterprise-wide, AI/ML powered, digital-twin/digital thread solution. It is a fantastic time to be a system engineer. It is also an important time for us all to contribute where-ever and how-ever we can to help solve the many significant societal challenges.

Register here.
See more details at the event web site.
See the full event schedule here.
Download a printable schedule.
Download the Book of Abstracts for the planned sessions.

PDMA Webcast: Combining Jobs-To-Be-Done and Journey Mapping: An Innovative Approach to Innovation

The Product Development Management Association (PDMA) is offering a webinar on 2 June that will demonstrate how to build a comprehensive and effective innovation strategy by combining the popular Jobs-To-Be-Done and Journey Mapping frameworks. Steve Hansen, partner at Phase 5 and chair of the firm's Data Analytics practice, will explain his conviction that Customer Centricity is the new competitive battlefield for businesses.

Participants will gain:

- A better understanding of both frameworks applied to innovation and product development
- How to practically design research using the hybrid approach
- Do's and don'ts to maximize success

See details and register here.

Prostep ivip Symposium 2022

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

The prostep ivip Symposium 2022 will take place in Stuttgart, Germany on 8-9 June 2022. The theme of the symposium is "Innovations for Systems Creation". Topics addressed during this 25th anniversary vendor-neutral meeting of the Product Lifecycle Management (PLM) community will include digital transformation, autonomous driving, Internet of Things, systems engineering, Industry 4.0 and digital twin.

Keynote addresses include:

- How to shape a sustainable future with PLM & IOT: Karl Heinz Zachries - CEO - Contact Software GmbH
- Smart integration of production in the value chain: Stefan Knauf - Division Manager Factory Automation -Mitsubishi Electric Europe BV
- Strategic options for industrial transformation: Board of the prostep ivip Association

Beyond the keynotes, over forty additional presentations will be offered in multiple tracks. The range of topics covered may be seen in the sample below:

- Integrated PLM and ALM: Prerequisite for Innovative Interdisciplinary Products and Systems
- Leveraging Circular Economy through Federated Data Exchange in CATENA-X Automotive Network
- DevOps for MBSE: Manage Models with Pipelines
- Software Defined Vehicle, How to Transform the Established Hardware Centric Development Process
- Streamlining Design Workflows with User-centric, Adaptive and Collaborative 3D Spaces
- Elimination of Cost Drivers by Implementation of AI-Based Methods for Vehicle Testing.
- Machine Learning Based Simulation in Vehicle and Service Engineering
- Seamless Collaborative Engineering in the Cloud across Enterprise Boundaries

Three workshops will also be available:

- Rethink Digital Collaboration – Objectives for Sustainability
- Workshop for Comprehensive & Model-Based Knowledge Management via Ontologies
- Create Live Traceability from Product Definition to Product Implementation through Connected Data

See conference details here.
Register for prostep ivip 2022.
Learn more about prostep here.

CONFERENCES, MEETINGS & WEBINARS

To better understand where prostep ivip fits into the broader Product Data Management and Data Exchange Landscape, check out the same-named article in SyEN edition #106 (November, 2021), pp. 32-36.

SiriusCon 2022 – Online Conference on Graphical Modeling

Eclipse Sirius is an Open Source framework used to create a graphical modeling workbench dedicated to domain specific languages (DSLs). Eclipse Sirius allows users to graphically design complex systems (IT software, business activities, physics, etc.) while keeping the corresponding data consistent (architecture, component properties, etc.). A modeling workbench created with Sirius comprises a set of Eclipse editors (diagrams, tables and trees) that allow you to create, edit and visualize Eclipse Modeling Framework (EMF) models.

Sponsored by OBEO and the Eclipse Foundation, SiriusCon 2022 is scheduled for 14-15 June 2022 as a virtual conference, free to all participants. The goal of the conference is to enable the Eclipse Sirius community to get the opportunity to meet the team behind the tool and to learn from adopters' experiences.

Planned presentations include:

- Visualizing, Analyzing and Optimizing Automotive Architecture Models using Sirius
- SimfiaNeo - Workbench for Safety Analysis powered by Sirius
- Development of DSL for Context-Aware Mobile Applications
- Defining Viewpoints for Ontology-Based DSLs
- Sirius Project, Now and In the Future
- Sirius Web 101: Create a Modeler With No Code
- Sirius Web Advanced: Customize and Extend the Platform

Register here.

Forum on specifications and Design Languages – FDL 2022

The 25th Forum on specification and Design Languages (FDL 2022) is scheduled for 14-16 September 2022 in Linz, Austria. FDL is an international event where academics and industrial experts exchange their experiences, advances and the new trends in the languages and techniques used along any phase of the development process of hardware and platform based Cyber Physical Systems (CPS). The targeted systems include, but are not limited to, distributed, real time, embedded systems, mechatronics, IoT and reactive systems.

The FDL 2022 program is designed to stimulate scientific and controversial discussions within and in between scientific topics at different maturity levels. The forum focuses on the cross-fertilization between systems engineering, language (particularly Domain Specific Languages – DSLs), semantics, simulation and verification/analysis.

At present, planned keynote and tutorial topics for FDL 2022 include:

- Incremental Solvers for Formal Reasoning
- Virtual Prototypes in Automotive Radar Applications
- Design of Asynchronous Circuits: from Principles to Tools

For details see the conference website.

Register here.

Swiss Systems Engineering Day 2022 - SWISSED22

The Swiss Society of Systems Engineering (SSSE), an INCOSE chapter chartered in 2011, is hosting the annual Swiss Systems Engineering Day 2022 (SWISSED22) in Zurich on 12 September. The conference theme is *From Design to Reality - Walking up the "V"*.

The window for submissions (presentations) to SWISSED22 is open through 18 June. Topics are welcomed that bring the classical aspects of Systems Engineering into the spotlight and investigate their impact on our Engineering projects, e.g., Architecture, modeling, system optimization, RAMS, decision making, managing complexity, verification, validation, etc.

Submit your presentation for consideration here. Look for additional conference details here.

Upcoming Capella Online Training

Obeo is offering an online Capella training course, consisting of 6 sessions of 3.5 hours each, conducted from 27 June to July 5. The course will be delivered in English by a Thales MBSE expert, teaching Capella beginners how to effectively use the open-source tool Capella and the Arcadia MBSE method.

The OBEO team is also offering online "M2Doc for Capella Training" on 20-24 June (as five, 3.5-hour sessions), taught by a member of the M2Doc development team.

This session will enable participants to:

- Understand the principles of document generation;
- Query a Capella model to automatically retrieve structured data;
- Implement M2Doc templates to generate MS Word documents.

Please contact sales@obeosoft.ca for more details on either course.

CONFERENCES, MEETINGS & WEBINARS

International Conference of Modern Systems Engineering Solutions - MODERN SYSTEMS 2022

The Modern Systems 2022 conference is planned for 24-28 July 2022 as a hybrid event, with a physical site of Nice, France. Sponsored by the International Academy, Research, and Industry Association (IARIA), this inaugural conference is colocated with the following events as part of SocSys 2022 Congress:

- PANDEMICS ANALYTICS 2022, International Conference on Pandemics Analytics
- PREDICTION SOLUTIONS 2022, International Conference on Prediction Solutions for Technical and Societal Systems
- SOCIETY TRENDS 2022, International Conference on Technical Advances and Human Consequences

Modern Systems 2022 conference themes include:

- Specifying the requirements of modern systems engineering
- Emerging requirements for advanced technologies
- System-wide type requirements
- Systems engineering solutions for (non-functional) requirements
- Analytics for complex systems and with cost-intensive maintenance
- Deployment/Maintenance Challenges

Conference proceedings will be published in the ThinkMind Digital Library.

Find additional information on Modern Systems 2022 here.

Webinar: New Horizons of Systems Science

On 20 April, the System Dynamics Society (SDS) hosted a webinar, delivered by three members of the INCOSE *New Horizons of System Science Panel*. The webinar was designed as a "meet and greet" session between members of the SDS and INCOSE communities to foster inclusive dialog around the topic of Systems Science.

Presenters included:

- **Erika Palmer** (Cornell University), co-chair of the INCOSE Social Systems Working Group and co-chair of the SDS Psychology and Human Behavior thread.
- **Michael Watson** (NASA), Chair of INCOSE Systems Engineering Principles Action Team and Chair of INCOSE Complex Systems Working Group.
- **Javier Calvo-Amodio** (Oregon State University), Associate Professor of Industrial and Manufacturing Engineering, Deputy Editor of the Systems Research and Behavioral Science Journal, and Chair of INCOSE Systems Science Working Group.

After welcoming both communities to this joint session, Erika Palmer provided an overview of INCOSE to the SDS audience before summarizing the purpose of the Social Systems Working Group (SocWG):

- To evaluate evolving changes to systems engineering processes and practices.
- To develop measures to integrate social and sociotechnical systems understanding at theoretical, applied and technical levels, in collaboration through outreach initiatives with the social sciences and interested stakeholder groups.

She emphasized that the SocWG approaches Systems Thinking through the lens of "methodological pluralism", always being open to learning from diverse sources and lines of inquiry. In that context, the advancement of Systems Science as a discipline depends on the ability to blend ideas from different perspectives to create shared practices.

Michael Watson placed System Dynamics within the context of other types of modeling approaches (physics, state, statistical, relational/MBSE, value) that support the successful engineering of systems. He shared fifteen Systems Engineering principles and highlighted the relevance of System Dynamics in supporting each principle. For example:

- SE Principle 13: Systems Engineering integrates engineering and science disciplines in an effective manner.
- SD Relevance: System Dynamics provides a fabric to model the data exchange between engineering and science disciplines.

Watson also addressed:

- The benefits of system architecture in managing complexity.
- The importance of understanding the socio-political complexity associated with an engineered system because of its interactions with its natural and social environment.
- The potential for Category Theory to provide a common mathematical foundation for both Systems Engineering and System Dynamics.

In the final presentation, Javier Calvo-Amodio shared the purpose of the INCOSE Systems Science Working Group, namely to promote the advancement and understanding of Systems Science and its application to Systems Engineering. The hypothesis of the working group is that Systems Science can provide a more rigorous basis for the empirically-derived practices of Systems Engineering that have evolved over time.

To elaborate on the purpose of the Systems Science Working Group, he modeled the relationships between Systems Science and its scientific cousins (analytical science, statistical science, systems research and complexity science), followed by modeling the dynamic relationships between Systems Science, Systems Thinking and Systems Engineering to show how each discipline, done well, reinforces the others. Finally, an architectural framework for evolving the Systems Engineering discipline was shared as a possible way-ahead to guide further SDS-INCOSE collaboration around the topic of Systems Science.

Read the overview of this webinar in the System Dynamics blog.
Watch the video.
Learn more about INCOSE Working Groups here.
Learn more abou the SDS Seminar Series.
Join the System Dynamics Society here.

FEATURED ARTICLE

The Systems Engineering Tools Database – From Concept to Delivery

by Robert Halligan (PPI), John Nallon (INCOSE),

René King (PPI) and Stephane LaCrampe (INCOSE)

Email: setdb@ppi-int.com

Adapted from an INCOSE IS 2020 presentation. Authored for PPI SyEN

Introduction

INCOSE once had a systems engineering tools database, which was very popular, but unfortunately, the site was lost during a site migration. Over the years, PPI has received many questions from clients about the whereabouts of the previous INCOSE systems engineering tools database. Acknowledging the value of the systems engineering tools database, PPI made the business decision to develop its own systems engineering tools database, to complement our existing Systems Engineering Goldmine (if you do not have access to PPI's popular Systems Engineering Goldmine, you may apply for access on the SEG home page). It soon became apparent, however, that a joint development was attractive to both PPI and INCOSE. In 2018, a Memorandum of Understanding and later a Technical Project Plan was signed off to kick off the partnership between PPI and INCOSE. This afforded joint development on the PPI-INCOSE Systems Engineering Tools Database (SETDB). As of May 2022, the SETDB is weeks away from the launch of V1; V0.98 was launched at the INCOSE IW in 2022. This paper will overview the SETDB Project Team's approach to development, project kick-off, system-level work done, and the development of the information system at the heart of the SETDB (what we refer to as the SETDBIS). The paper will conclude with how the project has been managed.

SETDB Overview

Key to the development of the SETDB has been recognition that the aim of systems engineering is to deliver value to stakeholders; stakeholders here being PPI clients, INCOSE members, leadership from both parties, and the engineering community in general. This immediately led the development team to the concept of a capability or enterprise system which is the system that delivers sustained value to stakeholders over a period of time - for the SETDB, this is anticipated to span a period of a few decades. SETDB problem definition and solution development have therefore been on this lifecycle basis, ensuring that a complete SETDB solution is developed, i.e. not only the IT component of a solution (the main element of which is the SETDB website, the home page of which is shown in Figure 1).

Capability engineering in one sense is like any other engineering, in that a system is being engineered. That system has stakeholders with needs, some of which become requirements. Some of the stakeholders are users; others are not. The system solution comprises solution elements, the interoperation of which gives rise to emergent properties of the capability system.

One thing that differs between a regular system and a capability system is that you cannot pick up a capability system as you can with a cellphone or a car. Capability solution elements are invariably diverse in nature, and often geographically distributed. Some solution elements may be pure technology; others are often human organizations or individual humans. More on the enterprise system elements later.

Figure 1. A snapshot of The Systems Engineering Tools Database home page

Conducting Engineering Management – The Planning

The Memorandum of Understanding signed by PPI and INCOSE in 2018 was generated to define the responsibilities that PPI and INCOSE would operate under, and how both parties would do business together on other projects of mutual benefit. The SETDB, as the first project of collaboration, was assigned to the Tool Integration and Modeling Lifecycle Management (TIMLM) Working Group. After approval of the Technical Project Plan by the INCOSE Technical Operations unit, the next action was to elaborate and expand on the SETDB Project Plan.

This documented the project overview including the objectives and scope; the Work Breakdown Structure, the project stage gates, the master schedule, and other plans such as a Risk Management Plan and Communication Plan. The SETDB Project Plan also contained an outline and definition of the SETDB Project. These are working plans used to define the management of the development of the SETDB project.

The TPP and Project Plan (see a snapshot shown in Figure 2), as well as all the project artifacts described in this presentation, are all available via Yammer, MS Teams, and INCOSE Connect, to members of the INCOSE SETDB Working Group. If you are a member of INCOSE, the SETDB Project Team encourages you to become a SETDB WG member and access the documents at your discretion.

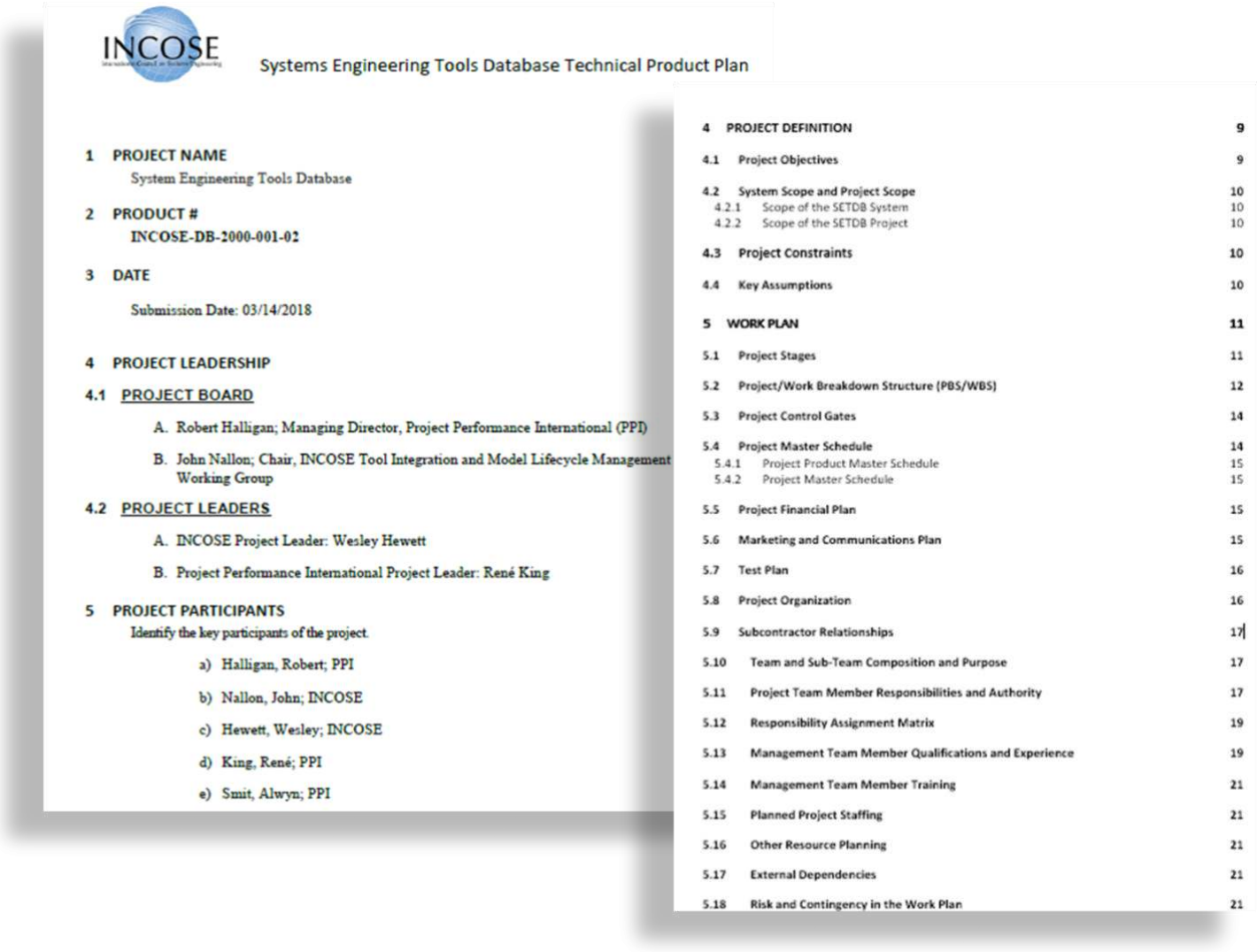


Figure 2. Snapshots from the SETDB TPP and Project Plan

SETDB Project Organization and Stakeholders

Figure 3 captures the Project Organization Model. As shown in the Organization Chart, the Project organization begins with the Corporate Advisory Board (CAB) and the project direction and support roles continue down to the SETDB Working Group. The project is overseen by a two-person Project Board comprising Robert Halligan (PPI Managing Director) and John Nallon (the TIMLM and SETDB WG chair for IINCOSE). The project development team is led jointly by project managers, René King (PPI) and Stephane LaCrampe (INCOSE).

In addition to the Development Team, INCOSE Office Holders have contributed and continue to contribute to this project, including INCOSE IT developer, Nico Castan who has been instrumental in coding the SETDB website. Although, the SETDB project was initiated as a project under the TIMLM WG, the SETDB Working Group was chartered in February of 2020 to support further development and operation of the SETDB.

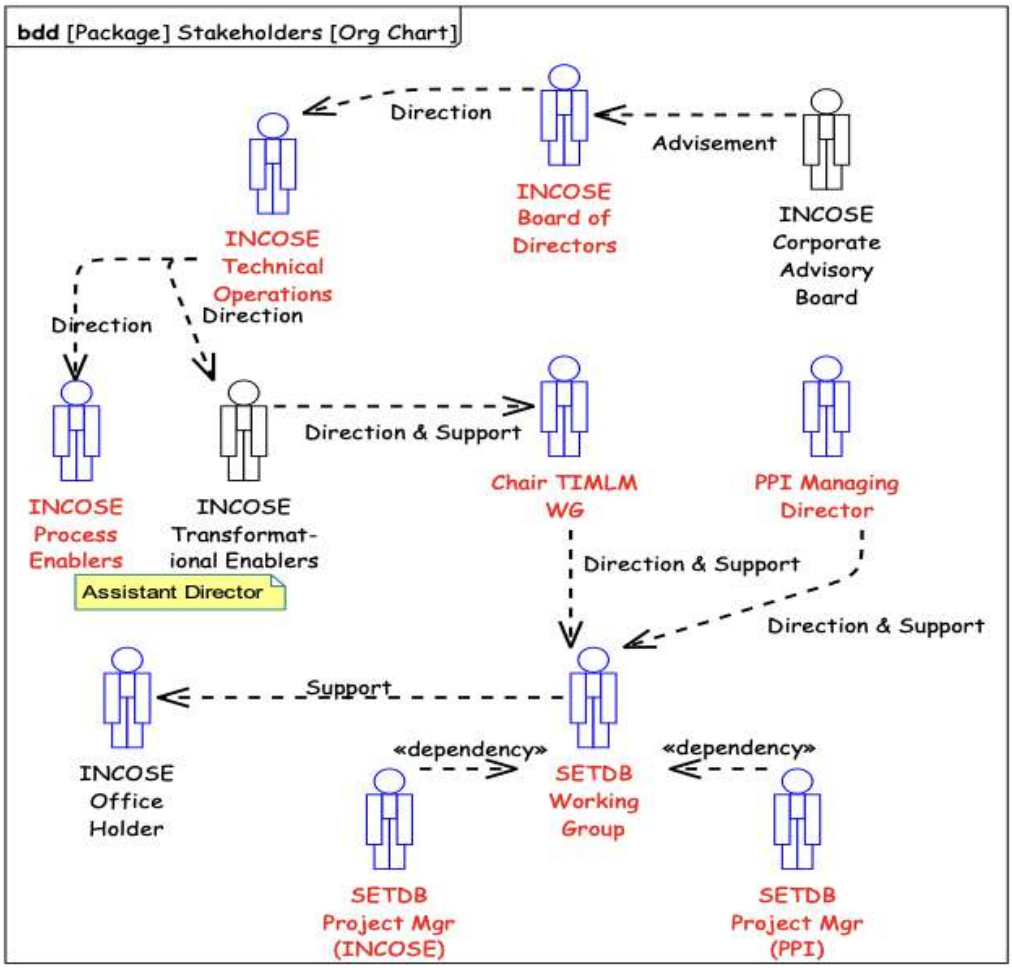


Figure 3. The SETDB Organization Chart.

Overall Engineering Approach

The SETDB development approach has been consistent with PPI's engineering development model (see Figure 4) and the INCOSE Systems Engineering Handbook V4. Our assessment was that the SETDB could, and should, be developed against a good and stable set of requirements, thereby avoiding much of the rework that would otherwise occur as is common in many projects. This has been borne out in practice, with requirements growth during development of less than 3% so far, and with project completion in sight.

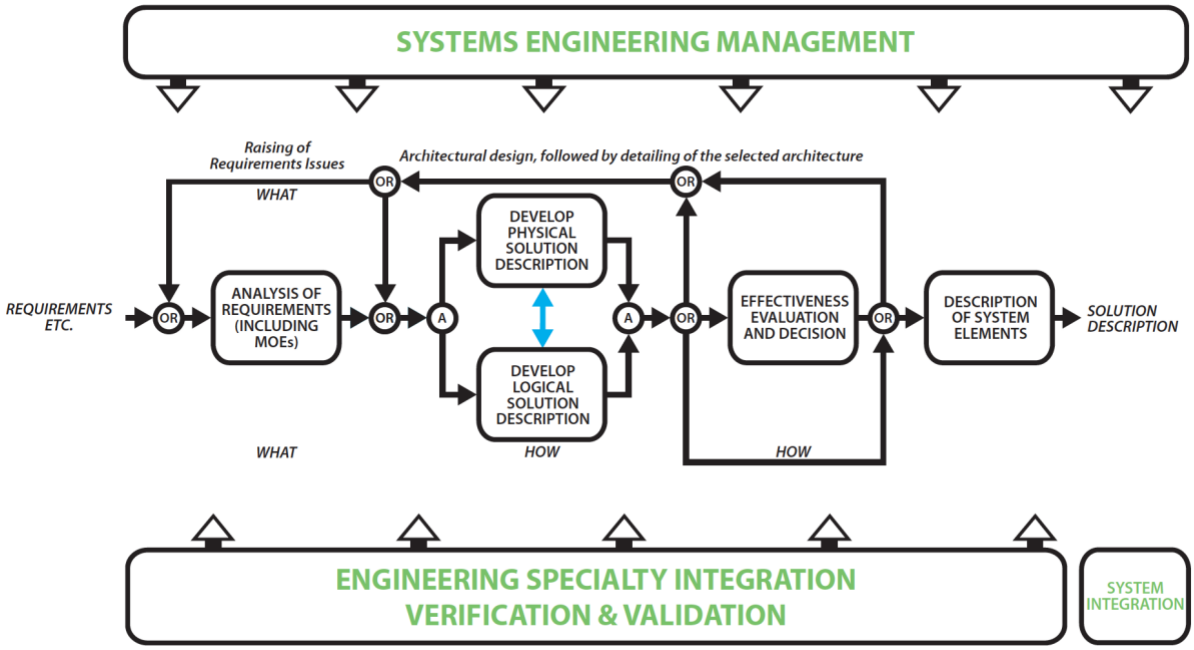


Figure 4. PPI's Systems engineering process overview model

A two-build incremental development strategy was chosen, the first build being a prototype and a second build that comprises the Initial Operational Capability (IOC). The IOC of SETDB is intended, and expected, to meet all specified requirements, the IOC is the website component of SETDB 1.0. Some evolution of features beyond IOC is anticipated and is explicitly provided for in growth capability requirements. From time to time, we have agreed to decline the addition of requirements to the V1.0 set but consider updated requirements for future enhancements. These requirements are captured as an annex to our SETDB Capability Systems Requirements Specification (SETDB CapSyRS). Our SETDB CapSyRS is presently sitting at just under 700 requirements and goals (excluding verification requirements) for SETDB V1.0. More on the CapSyRS later.

Referring to the process elements, most of the project effort has been in requirements analysis, physical design, verification and validation, together with the application of the specialty disciplines of cyber-security and user interface design. Regarding cyber-security, European GDPR compliance has been necessary as human factors are always an issue with systems such as the SETDB that involve substantial human interaction. Little need has been identified during development for formalized logical design, or for formal trade-off studies. The next section will describe the requirements analysis process adopted during the project.

Requirements Analysis Overview

Requirements Analysis had the primary objective of producing a problem definition adequate to drive successful design and development of the SETDB, together with providing references for SETDB verification against requirements, and validation against need. Input to this activity included requirements of the previously existing systems engineering tools database, parts of a few previous tools surveys, and email communication between former stakeholders.

The emphasis, however, has been on current needs and opportunities, reflected in the goals of the SETDB, which include:

- serving the community of members of INCOSE, PPI clients and other engineering professionals, so that they may access, via the INCOSE and PPI Goldmine websites, comprehensive systems engineering tools knowledge and data
- increasing the attractiveness of INCOSE membership to existing and potential members (an INCOSE objective, which PPI also totally embraces)
- increasing the value delivered by PPI to its clients, which is a PPI objective.

  PPI professionals are members of INCOSE, and PPI has five past INCOSE Chapter Presidents amongst our professional team, so the alignment of INCOSE values and objectives and PPI values and objectives for the SETDB has been high.

The Requirements Analysis Process

Our approach to problem definition is illustrated by the process diagram shown here (see Figure 5), the three major work products being a description of intended use of the SETDB, under the name of Operational Concept Description - OCD, also called an OpsCon, a SETDB requirements specification under the name Capability System Requirements Specification CapSyRS, and associated SETDB verification requirements incorporated in the CapSyRS. These will be unpacked in the subsequent sections.

Most of the activities shown here were used to some degree in capturing, validating and specifying SETDB requirements. Some of the larger activities were context analysis, functional analysis, the development of verification requirements, and populating the OCD with information on intended use.

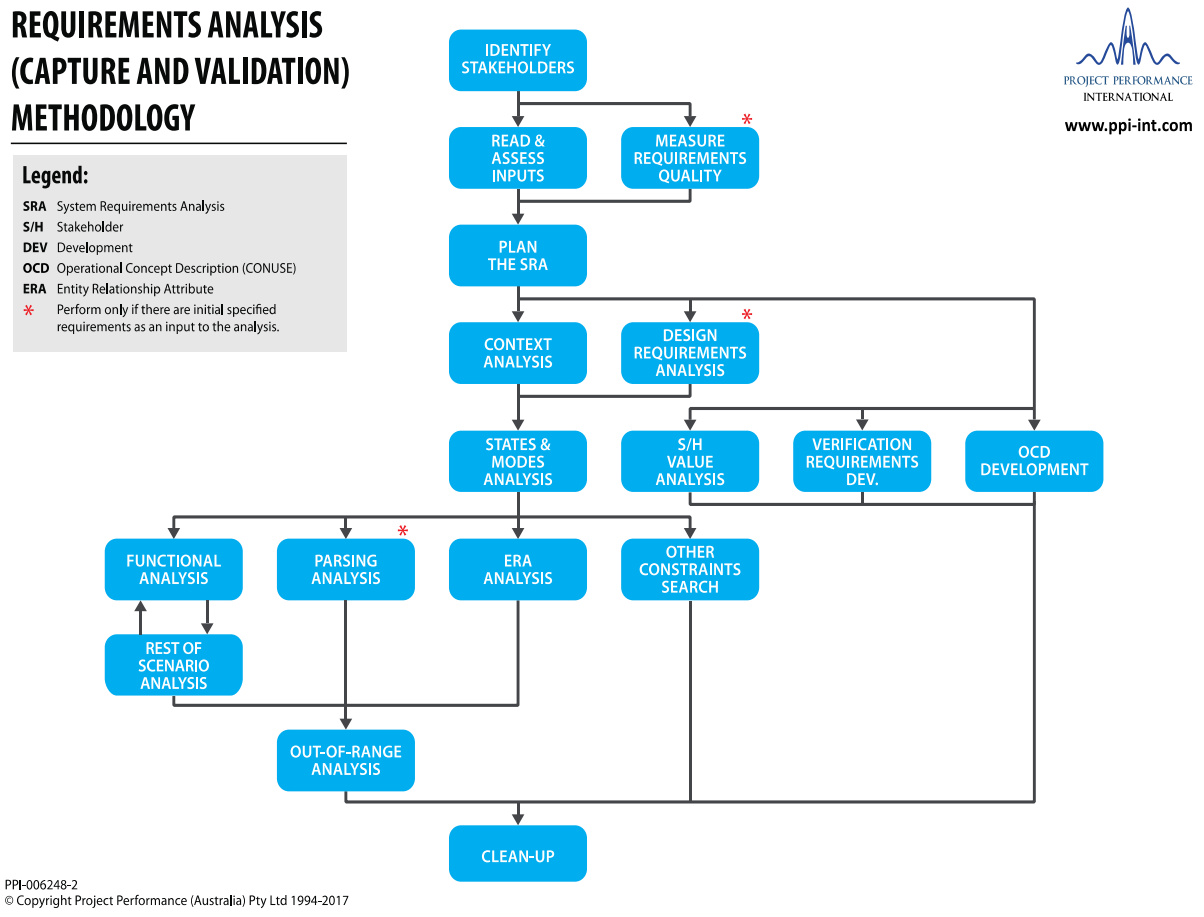


Figure 5. PPI's Requirements Analysis process model

Uses, Users and the Environment – Operational Concept Description

On the far-right hand side of the PPI requirements analysis process model in Figure 5, there is an activity titled "develop OCD". This description of intended use identifies and describes intended users of the SETDB and their relevant characteristics, intended uses, how the SETDB is intended to be used, and under what conditions, for example, in office or mobile environments. If anything about the SETDB requirements, design, system elements or system is inconsistent with this content of the OCD, that item is not entirely valid. That is, the OCD provides a direct reference for validation of requirements, design, system elements and SETDB system. The SETDB OCD (see the Table of Contents in Figure 6) has been invaluable so far for this purpose. The OCD was populated from the various individual analyses as part of the requirements analysis process, especially from functional analysis in the form of use cases (see later in this paper).

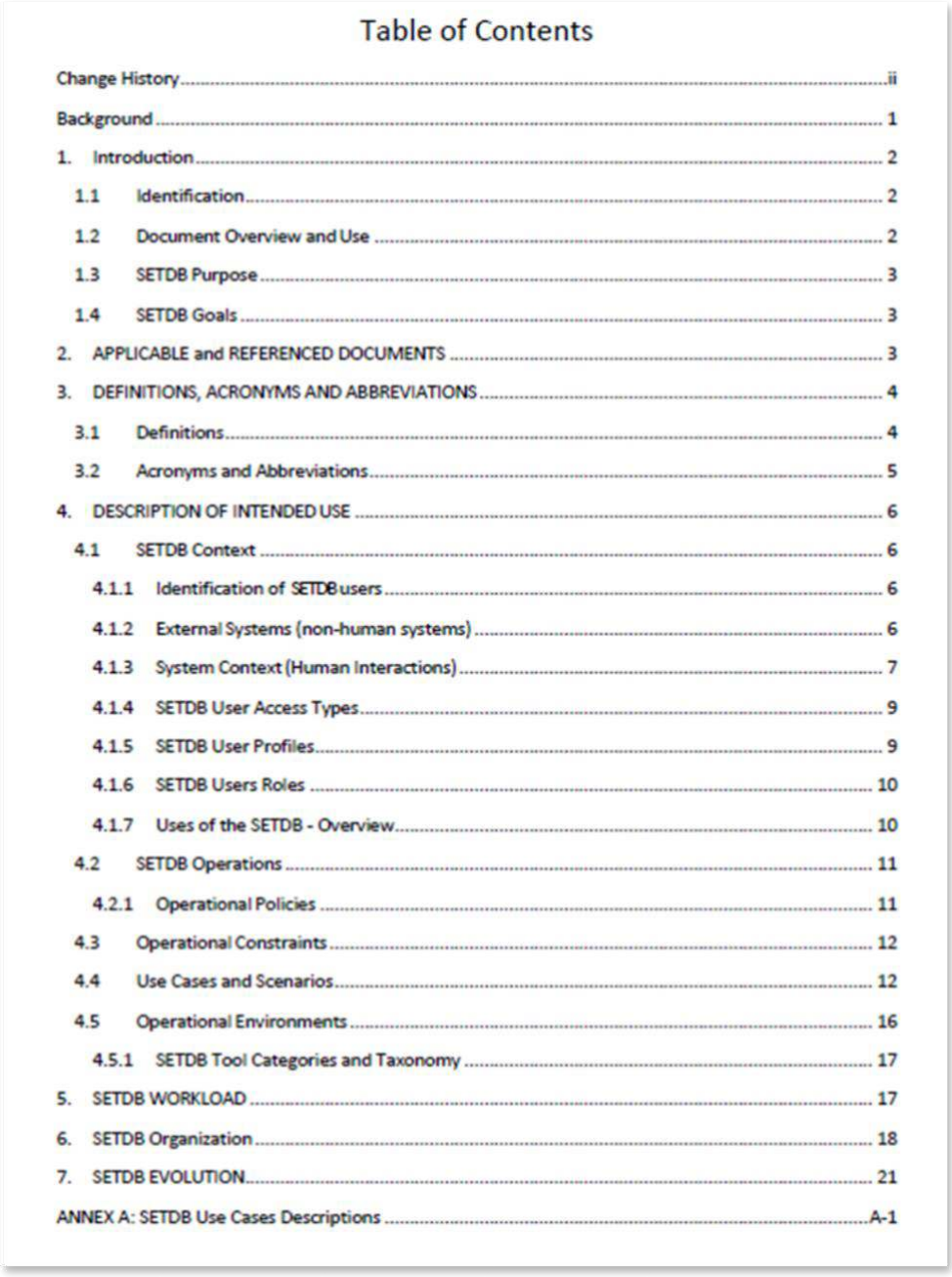


Table of Contents

Figure 6. A snapshot of the Table of Contents from the OCD

Context Analysis

The foundation of any requirements analysis is the placement of the system into the context of things with which it will interact, purposefully or otherwise, throughout the relevant part of its lifecycle. Context analysis gives rise to mainly external interface requirements, and to a small degree for the SETDB, environmental requirements. Figures 7 and 8 show the non-human and human interfaces to the SETDB identified as being significant to requirements, together with a corresponding external interface requirement. Here is an example emerging from the recognition of the Casual User interface, (here a Casual User is characterized by *a* person who accesses the SETDB Home page via the internet without any login).

"The Casual User Interface, for each Casual User, shall be located at a Casual User-selected fixed, portable or mobile location (at the discretion of the user) worldwide, unless access to the SETDB is unavailable through lack of internet connectivity, or is blocked by government action, government direction or employer direction."

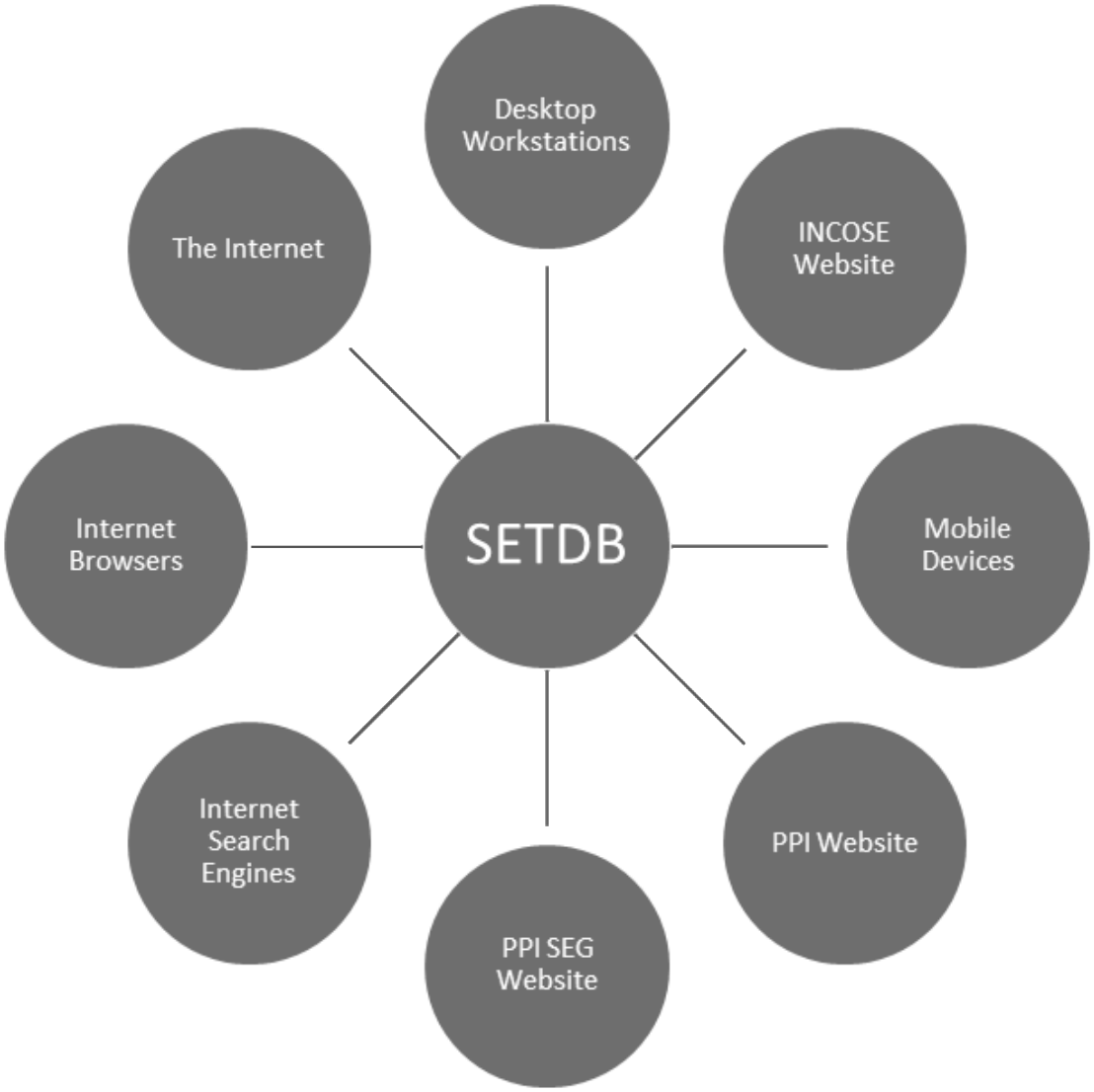


Figure 7. Non-Human Interfaces with the SETDB

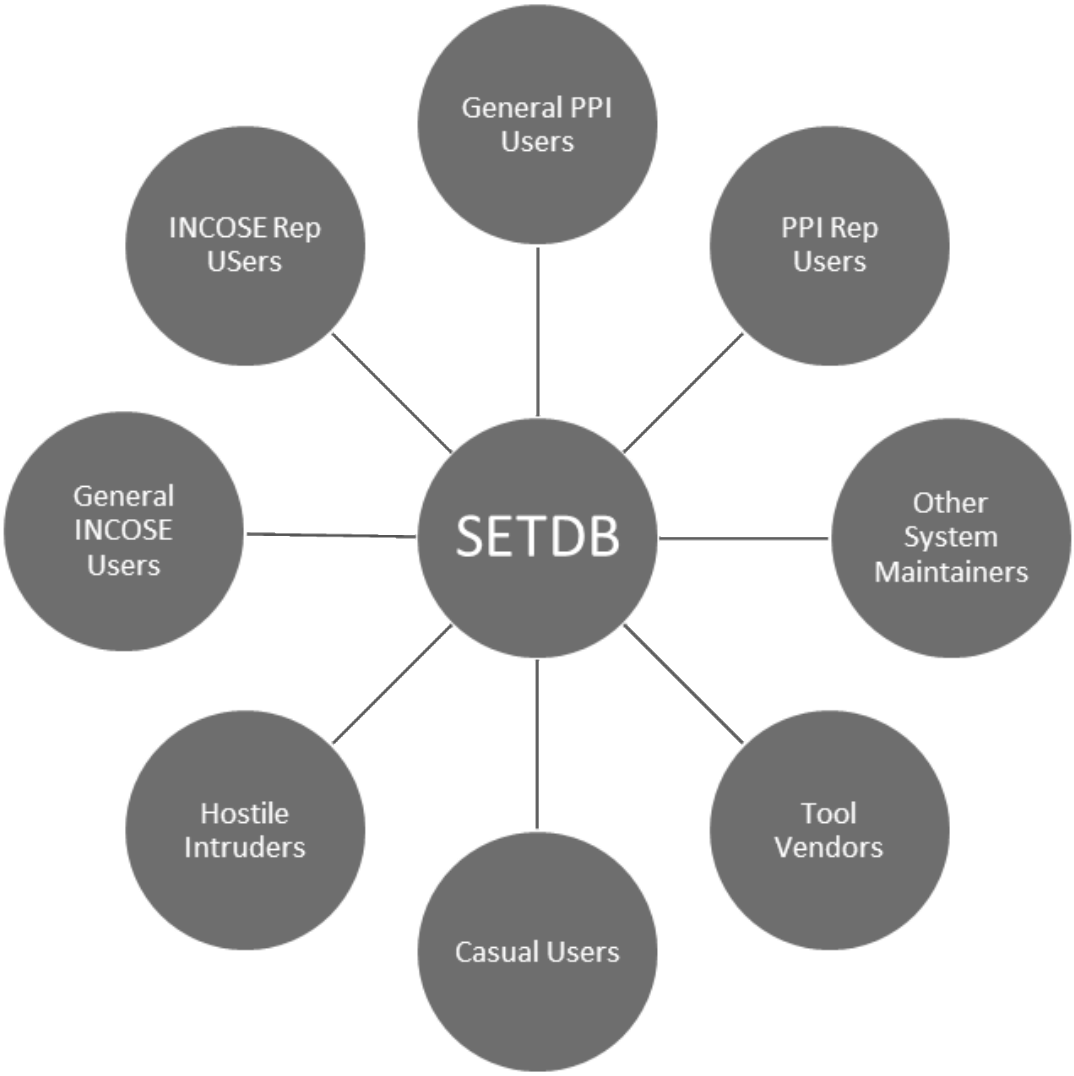


Figure 8. Human Interfaces with the SETDB

States and modes analysis

The team then looked at states and modes for the SETDB. The potential states were defined very simply as: Developmental State, Online (Live) state and Offline State. No useful modes were identified. Nevertheless, a few necessary requirements were identified as a result of this analysis for example:

"The SETDB, in Developmental State with all specified functionality for Online State available online, shall by definition transition to Online State when representatives of INCOSE and PPI nominated by INCOSE and PPI respectively have both declared in writing the SETDB to be operational."

Functional Analysis – Example Use Cases

A use case captures the time-sequential interactions between the system and actors outside of the system, such as users and external interoperating systems. The use case includes both conditions before the use case is executed – preconditions, and conditions after the use case is executed – post-conditions. System functional requirements are embedded within the use case. Use cases were particularly valuable for grouping functional requirements for test design.

The Table 1 shows five SETDB use case summaries on the left. Note that a full use case contains the whole sequence of action and reaction, unlike the summaries shown here. An example SETDB functional requirement may be found below:

"*The SETDB, having added a new draft definition, shall forward that definition by email to both the INCOSE Rep User and the PPI Rep User having authority to approve definitions for publication.*"

A high proportion of SETDB requirements are functional requirements as is expected from an online database project hence creation of the use cases was a pivotal part of development.

Table 1. Excerpt from the SETDB Use Case table from in the OCD

Use Case Name	Actor or Stakeholder	Additional Information	Pre-Condition	Post-Condition
UC. 03a Add vendor information	Tool Vendor User, INCOSE Rep User, PPI Rep User	Information about the tool vendor provided by an person with authority by the company to do so, or an rep user.	Tool Vendor User and Rep Users already have approved access to the SETDB for the activity to add vendor information.	SETDB prompts to user check for correctness of information/prompt for specific corrections based on inputs given. SETDB confirms to the user that information has been added and will be reviewed prior to publishing.
UC. 03b Edit vendor information	Tool Vendor User, INCOSE Rep User, PPI Rep User	Edit information on the vendor	Tool Vendor User and Rep Users already have approved access to the SETDB for the activity of contributing vendor information.	SETDB prompts user check to for correctness of information/prompt for specific corrections based on inputs given. SETDB confirms that information has been marked for review prior to publishing.
UC. 03c Publish vendor information	INCOSE Rep User, PPI Rep User	Information must be screened by authorized INCOSE and PPI user prior to going live	Have authorized Rep User Access for the activity of publishing data on the tool vendor.	Notification to contributor of information that vendor information has been published. Updated vendor information visible to SETDB users.
UC. 03d Delete vendor information	Tool Vendor User, INCOSE Rep User, PPI Rep User	Includes part or all information. Will data be deleted permanently from the site or just from visibility? There is research value in keeping the data.	Tool Vendor User and Rep Users already have approved access to the SETDB for the activity of contributing vendor information.	SETDB prompts user to verify deletion of content. SETDB confirms that information on the tool vendor will be deleted. Information is no longer viewable on the SETDB by users.
UC. 03e View vendor information	General User, Rep User	Show information about tool vendor	User elects to see all the information on the tool vendor.	SETDB displays all vendor information that has been contributed and approved for publishing.

The CapSyRS

The CapSyRS is a substantial document populated with approximately 650 validated, solution-free requirements and 40 or so goals of varying importance, most of which are devised to ensure growth capacity.

The CapSyRS has driven development and verification of the SETDB. The requirements, together with assessment of risk, have also driven the development of corresponding verification requirements.

Requirements for the CapSyRS have been written using PPI's Requirements Parsing Template, illustrated in Table 2. The use of this template has ensured consistently well-written requirements that are economical to write, easy to review, and easy to change where necessary.

The requirements have been organized in the CapSyRS into a structure that meets all of eight criteria for organizing requirements into an easily usable, able-to-be-navigated structure.

Each requirement has a unique requirement identifier, REQID, enabling traceability and easy search-based location of any requirement within the set. Associated with each requirement in the CapSyRS is a corresponding verification requirement to be explained next. The SETDB requirements and verification requirements have been managed using Vitech's MBSE tool CORE.

Table 2. Example requirement written using PPI's parsing template for excellent requirements

Each verification requirement, located in an Annex to the CapSyRS, states the characteristics of evidence required to demonstrate that the corresponding system requirement has been met. This evidence may be in the form of a directed verification method such as test, demonstration, analysis, inspection, simulation, analogy or certification, the usual possibilities. For many requirements, about 20% in this CapSyRS, the verification requirement is more than that. For example, as shown in Table 3, VR058 specifies demonstration, but also defines the number of different entry defects for which rejection of the entry is to be demonstrated.

The verification requirements were created with the aim of maximizing the difference between the risk reduction benefit of verification and the cost of achieving that benefit. Verification requirements are being used to drive the development of test cases to objective criteria, which is always a good practice.

Table 3. Snapshot of the CapSyRS Verification Requirements Trace Table

R056	Creation of Tool Vendor Account Functions	Design analysis	VR056
R057	Creation of Tool Vendor Account Functions	Demonstration for at least 10 different types of defective entry, including each of those referred to explicitly in the requirement	VR057
R058	Creation of Tool Vendor Account Functions	Demonstration for at least 10 different types of defective entry, including each of those referred to explicitly in the requirement	VR058
R059	Creation of Tool Vendor Account Functions	Demonstration for at least 10 different types of defective entry, including each of those referred to explicitly in the requirement	VR059
R060	Creation of Tool Vendor Account Functions	Demonstration	VR060
R061	Creation of Tool Vendor Account Functions	Demonstration	VR061
R062	Creation of Tool Vendor Account Functions	Demonstration for a single registration	VR062
R063	Creation of Tool Vendor Account Functions	Demonstration for a single registration containing special characters in the tool vendor name, from Turkish	VR063
R064	"Access SETDB by Tool Vendor User" Function	Demonstration of logged-in Tool Vendor User access to tools taxonomy, survey questions, definitions, Tool Vendor FAQ, browse screens and their own data.	VR064

SETDB Enterprise-Level Architecture

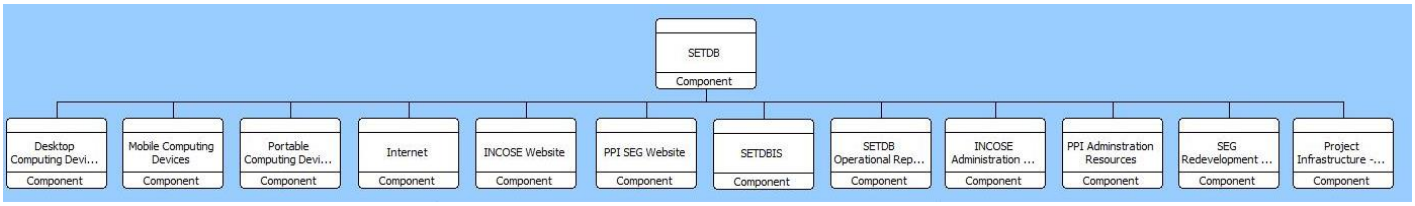


Figure 9. The SETDB system breakdown structure

In Figure 9, the SETDB is expressed as a system breakdown structure, using CORE. The system elements are:

- The SETDB Information System, the heart of the SETDB
- The INCOSE website, which provides INCOSE member access to the SETDB functionality
- The PPI Systems Engineering Goldmine website, which provides PPI client access to the SETDB functionality
- User Desktop, Portable and Mobile Computing Devices, which accept user input, and deliver tools data output
- The Internet, which provides worldwide comms to user terminal devices
- INCOSE Administration Resources, which provide system administration, and a range of other administrative functions
- PPI Administration Resources, which also provide administrative functions
- SETDB Project Infrastructure, including John and I and other team members, and related MBSE software
- PPI Goldmine Re-engineering resources
- And a set of Operational Procedures.

  All of these elements play a role in the solution to delivering tools information to SETDB users. Note also the life cycle orientation of the set of solution elements, since the requirements are themselves life cycle-based.

SETDB Operational Procedures

Pivotal to the successful operation of the SETDB is development and execution of effective operational procedures. The SETDB comprises of 14 operational procedures, listed below.

1. INCOSE SETDB Access Management Procedure
2. INCOSE SETDB Publicity Procedure
3. Mapping Tool Categories to PPI Process Elements
4. Mapping Tool Categories to/from SEH Processes
5. PPI SETDB Publicity Procedure
6. PPI's SETDB Access Management Procedure
7. SETDB Enhancement and Configuration Management Procedure
8. SETDB IT Infrastructure Admin Procedure
9. SETDB Lifecycle Management Procedure

10. SETDB Operational Reporting Procedure
11. SETDB Problem Handling Procedure
12. SETDB Stakeholder Operational Communication and Response Procedure
13. SETDB Tool Information Management Procedure
14. SETDB Vendor Registration Procedure

SETDB System Block Diagram – Enterprise Level

This system block diagram view, again from the tool CORE, shows the interfaces between the system elements in typical System Block Diagram representation. The ovals represent contact points with users. Identification of items passing across the interfaces has been hidden for clarity.

Next the Systems Engineering Tools Database Information System (SETDBIS), the heart of the SETDB, will be unpacked.

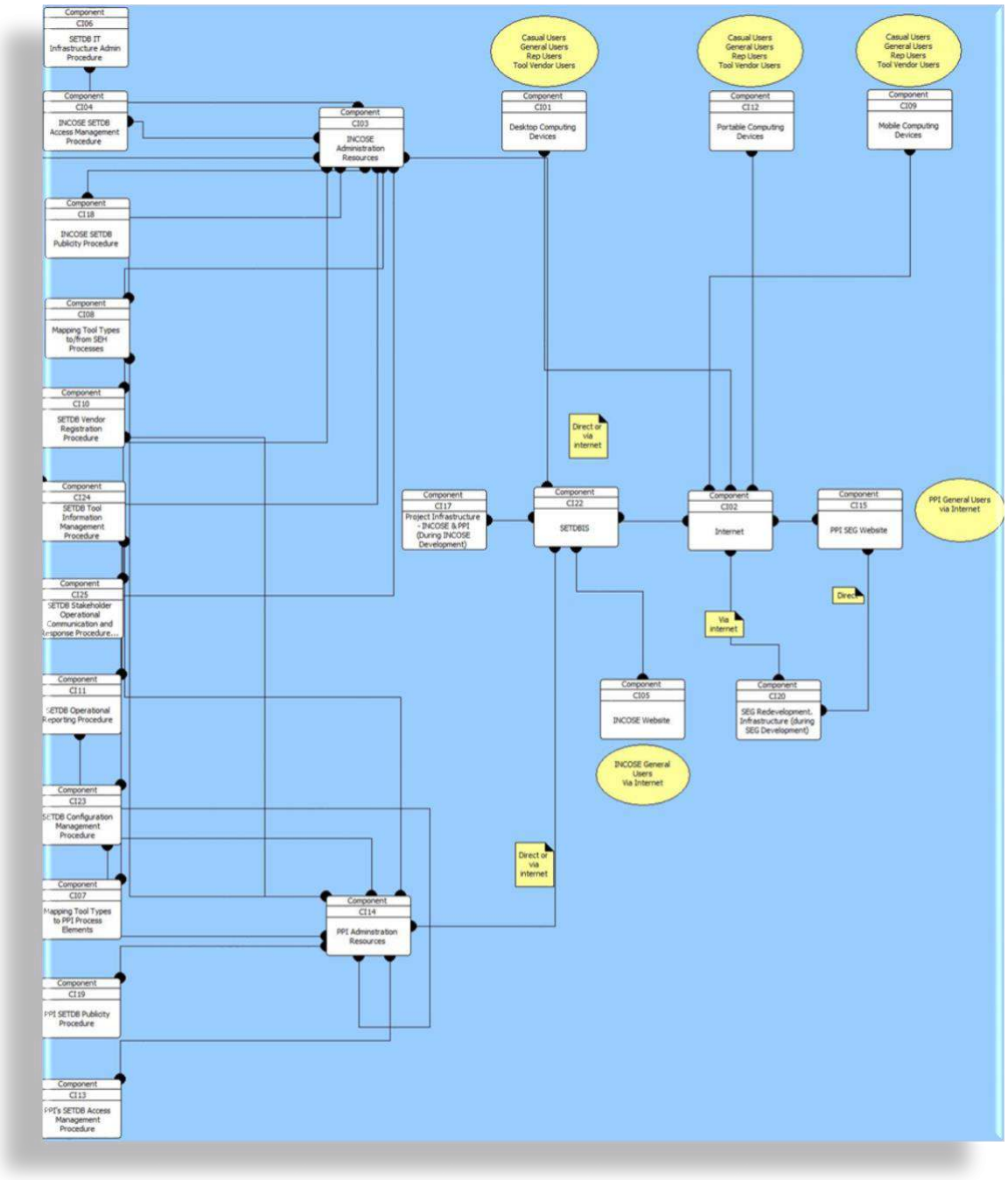


Figure 10. SETDB system block diagram

SETDBIS Context, Domain and Data Model

In parallel with the Operational Concept development and Requirements Analysis, the SETDB System Models were being developed to capture numerous viewpoints of the system. The SETDB Development Team is widely dispersed around the globe and the models have helped us visualize the system elements, functions, use cases and requirements and communicate through them with developers, other working groups and stakeholders.

The Operational Concept Description (OCD) also contains other models that enabled us to achieve clarity and consensus with our users and stakeholders on the intended use(s) of the SETDB.

For traceability, the Use Cases are linked to activity diagram swim lanes that are allocated to system blocks. The Use Cases and the Activity Diagrams are also linked to the System Test Cases that are executed and analyzed to verify the system requirements are being met.

The following models are displayed in Figures 11, 12 and 13.

The SETDB Domain Model (Figure 11) : defines the operational domain of the SETDBIS. The SETDBIS interacts with the INCOSE Domain, PPI Domain, the Government Domain, and mobile applications. The model also shows the Actors (people or other systems) that are expected to support or use the SETDB and their relationships.

The SETDB Context Diagram (Figure 12): defines our system context, the boundary between systems, the entities and the environment that will interact with the SETDB and the relationship of the SETDB with the SETDB Information System (SETDBIS). The SETDBIS is comprised of the system elements and IS services that enable the SETDB.

The SETDB Data Model (Figure 13) defines the data model elements and data stored in the repository. The Use Cases indicated in this model represent the user interactions with the data in the repository as they would execute a system function.

The Use Cases, System Models, OCD and CapSyRS are the source documents for the design stage.

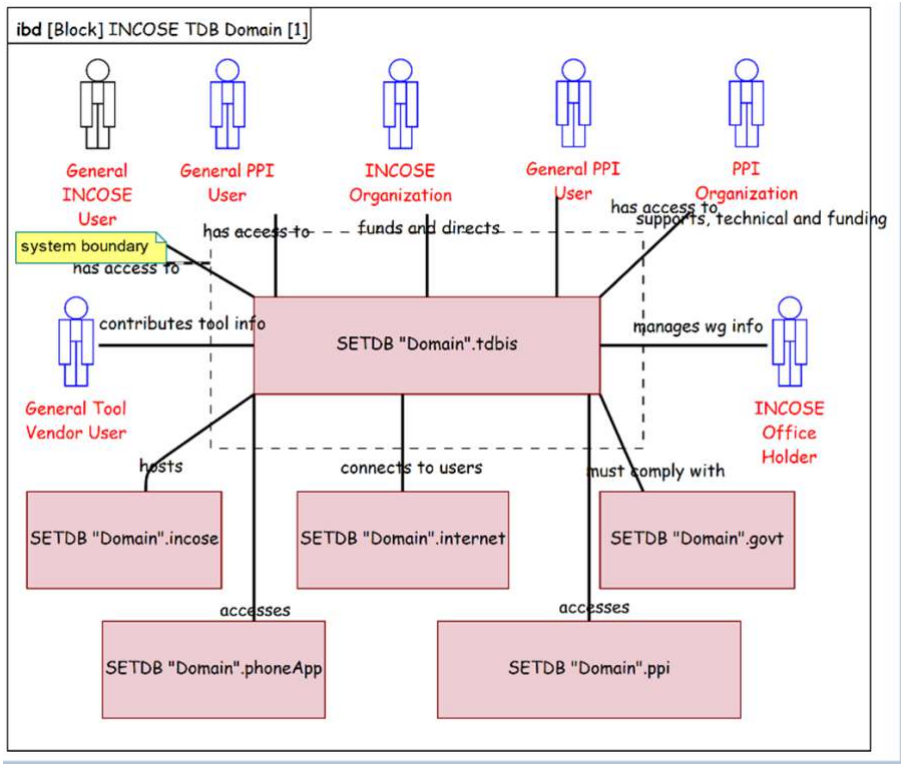


Figure 11. The SETDB Domain Model

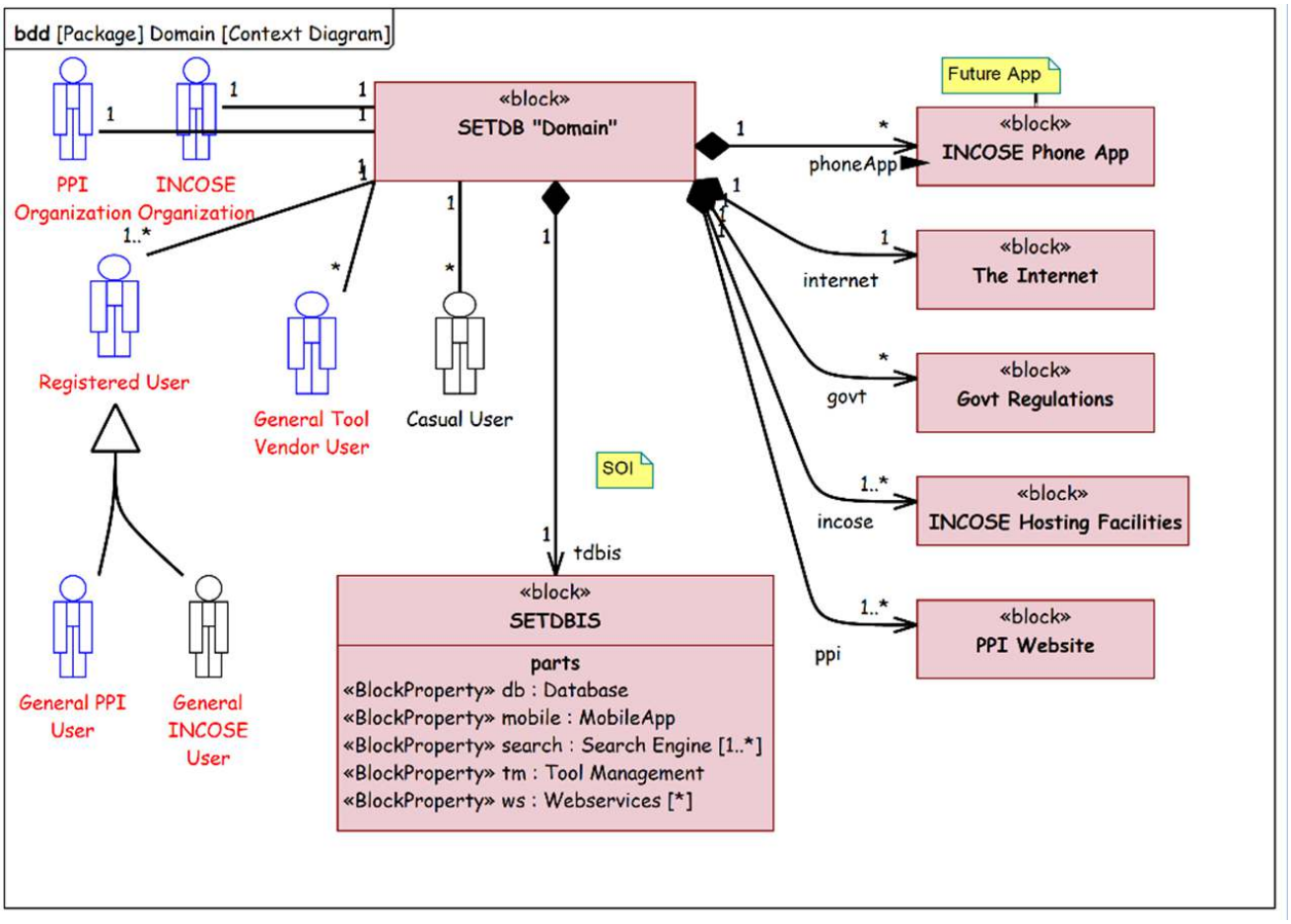


Figure 12. The SETDB Context Diagram

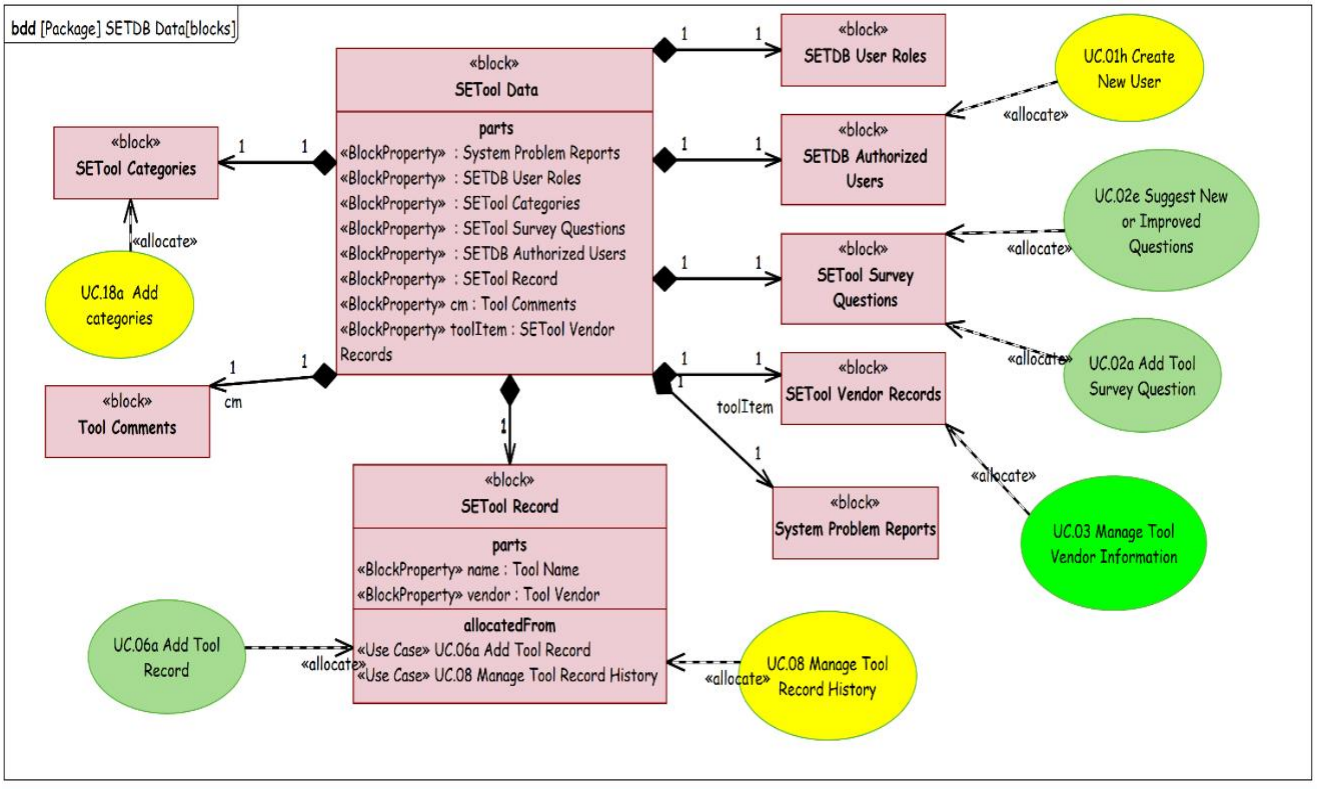


Figure 13. The SETDB Data Model

SETDBIS Development

With the System Models and Architecture Models, OCD, CapSyRS and Use Cases completed, the system design was initiated during the fall of 2019.

The Balsamiq Wireframes Tool was selected to design mock-ups of the User Interface and system functions. Over 40 wireframes were built and used to validate requirements, and to design web page content and appearance. The mock-ups enabled us to visualize the user interfaces and different solutions to meet the system requirements. The applicable system requirements were annotated on each mockup for traceability. Some of the results are depicted by the examples shown on this slide.

The Balsamiq browser (Figure 14) shows several mockups in a sequential list. This is like an index of the mockups that visualize different ways to make selections, navigate and design the web page graphics and linkages.

The SETDB mockups were initially presented to the INCOSE community at INCOSE International Symposium in 2019 and as mentioned were used to develop the first operational prototype presented at International Workshop 2020. The SETDB implementation has proceeded using the knowledge learned from the mockups and prototypes (see Figure 15).

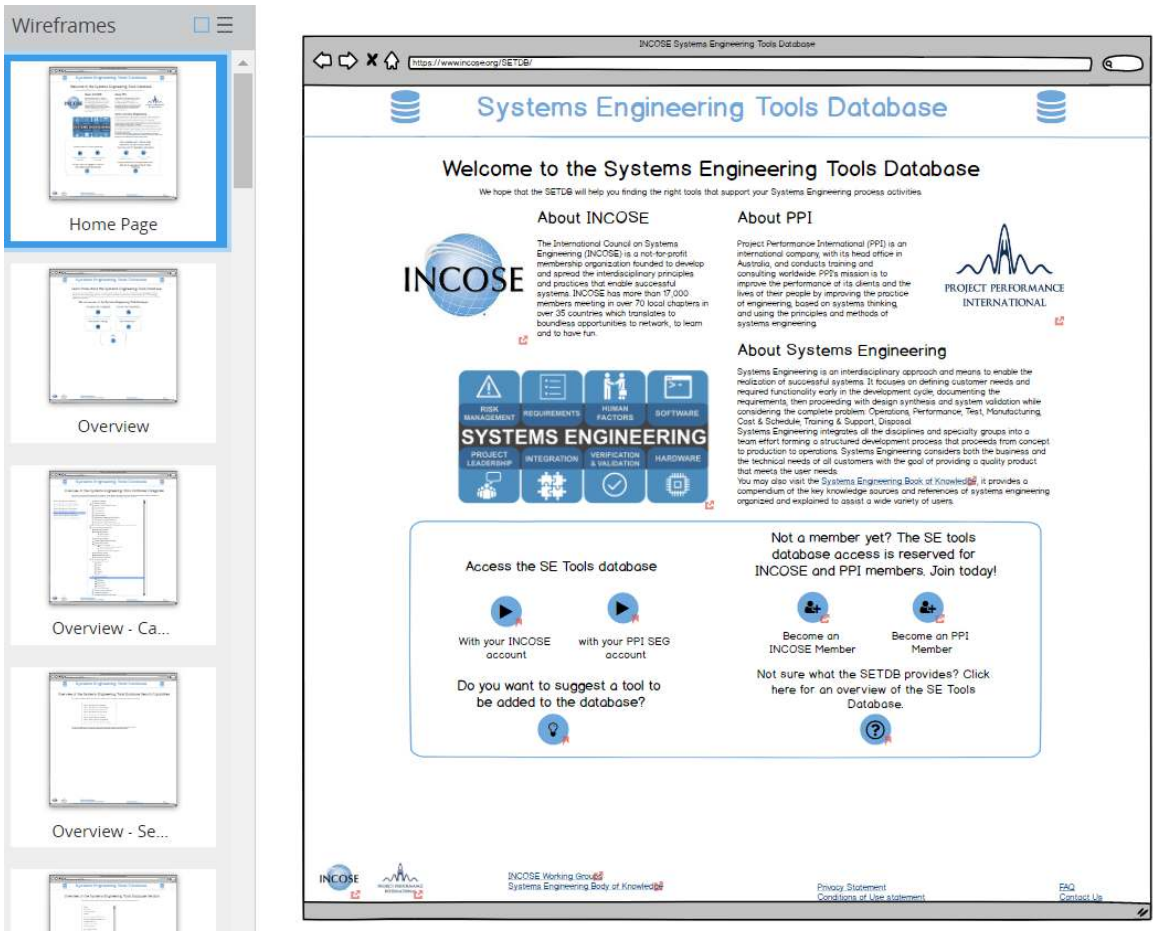


Figure 14. Balsamiq Mockup of the SETDB Home Page

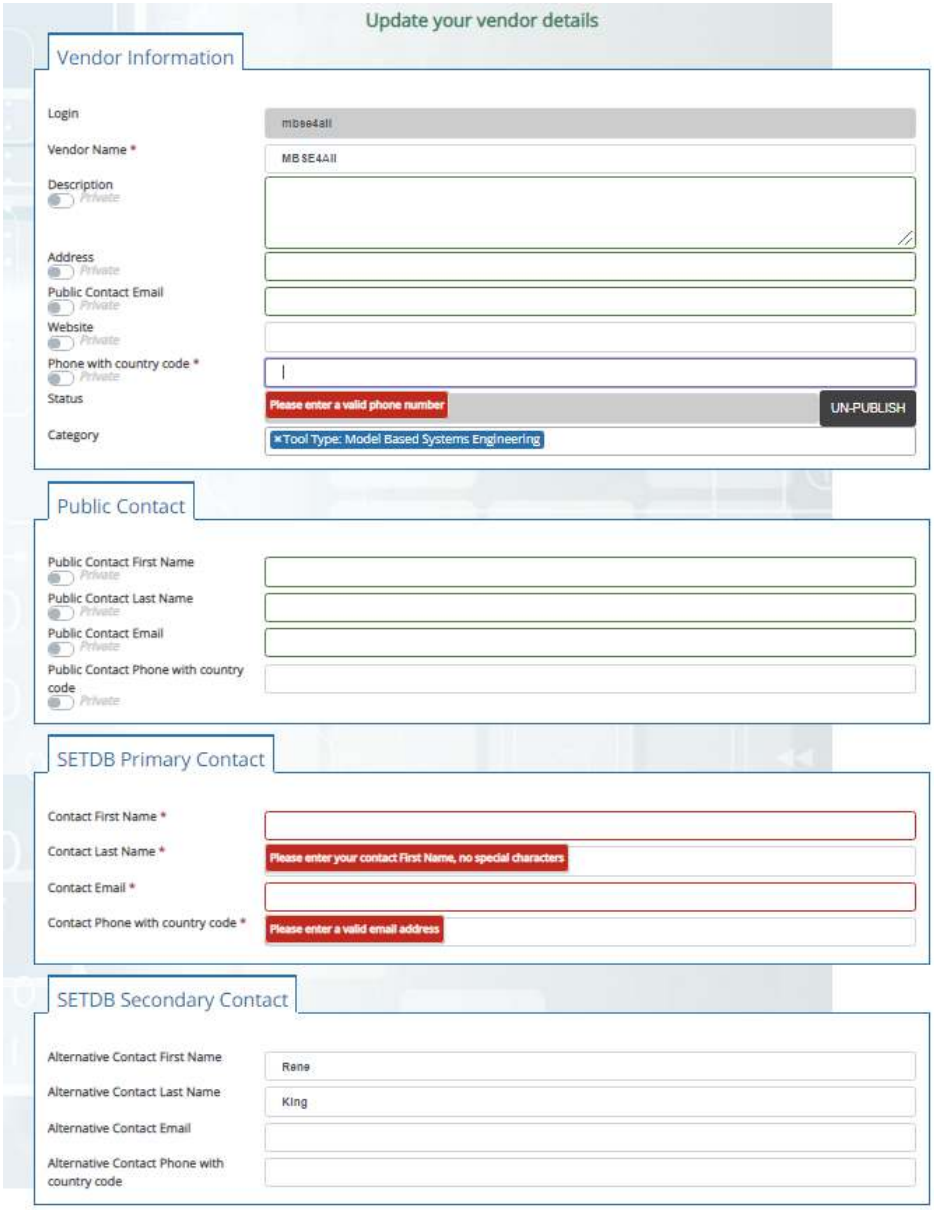


Figure 15. Snapshot of Tool Vendor User creation page as seen in the SETDB prototype

Engineering Management – Verification and Validation

1. The SETDB software development planning, status tracking and management activities are being performed using a software product from Altassian called JIRA.
2. In addition to software development planning, JIRA is being used in heavily our Validation and Verification Management stage to develop, manage and execute Test Cases to verify compliance with the system requirements.
3. Test Cases are developed from the System Use Cases (an example use case in shown in Figure 16). The applicable Verification Requirements are copied from the Verification Requirements Table in the CapSyRS and copied into each Test Case Description.
4. The verification methods are identified in the Verification table and the Test Steps are written to describe how to execute that method to verify satisfaction of the verification requirement(s).

5. Each Test Case also provides descriptive areas to capture the Expected and the Actual Test Results for test analysis, to determine a test pass or failure.
6. Issues that arise during testing result in an issue or bug being generated and assigned for resolution (see Figure 17).

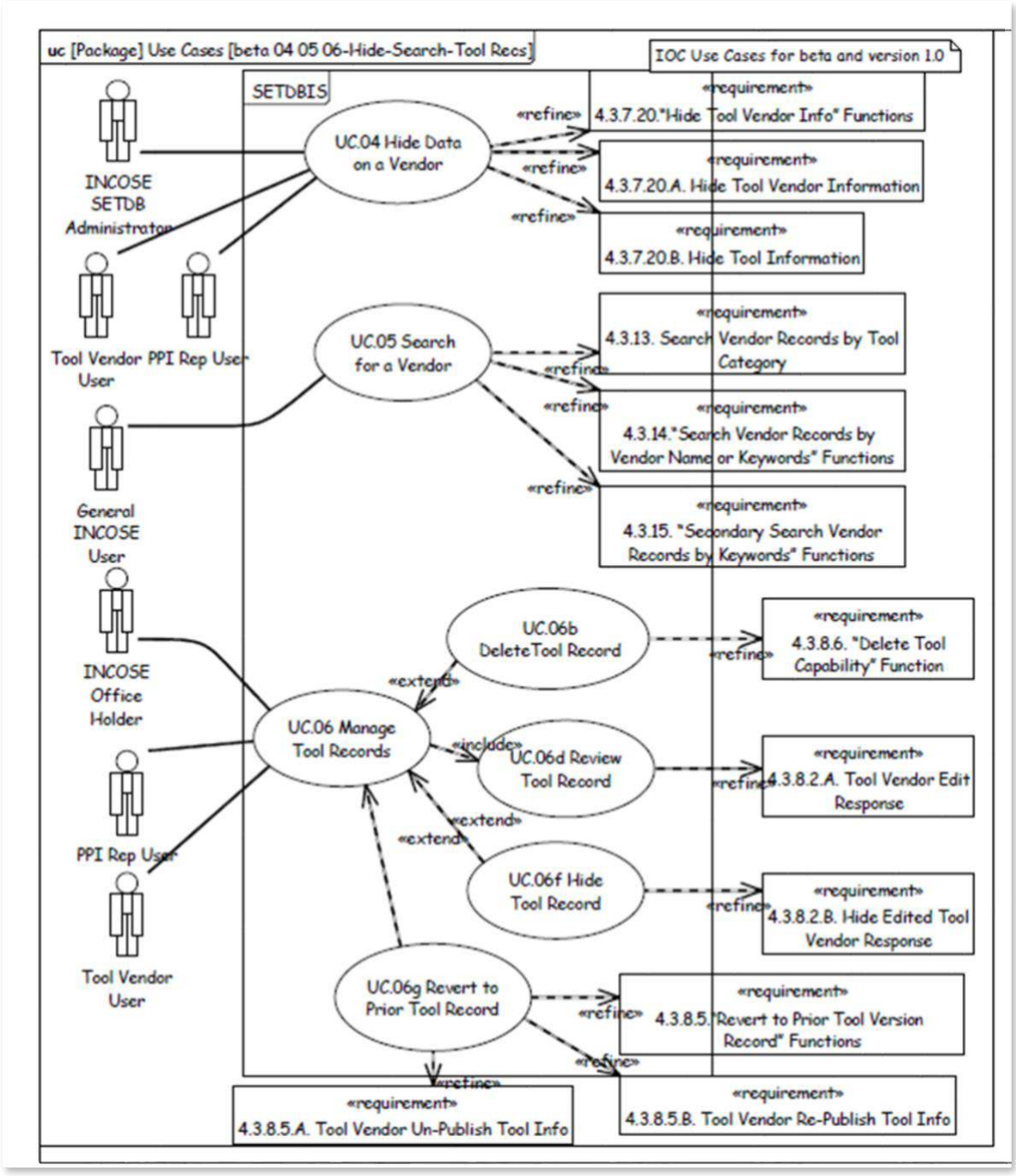


Figure 16. Linking of use cases to requirements in preparation for verification in JIRA

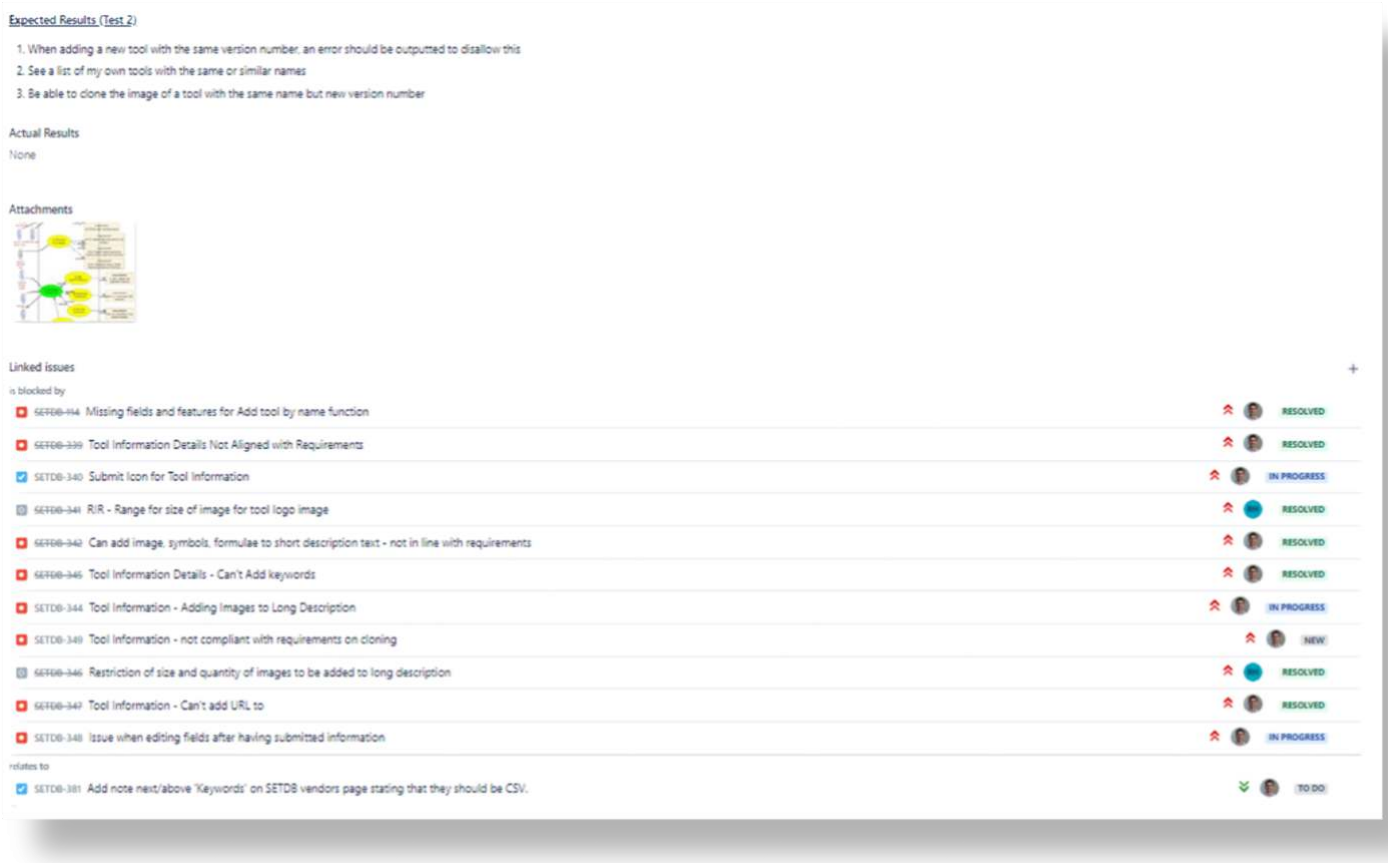


Figure 17. Verification and validation management: test cases developed and executed in JIRA, based on use cases

Conclusion

The SETDB team has conducted its development on the SETDB almost exclusively virtually although the team's work was enhanced by some face-to-face development time at INCOSE workshops and symposiums in the earlier stages of the project (pre-pandemic). Based on sound systems engineering principles, and with the use of a curated selection of digital tools, the SETDB development team and working group have applied a systems engineering approach to developing the SETDB with satisfactory results.

The SETDB Development Team strives to deliver the objectives of the Technical Project Plan to a high level of quality. A good systems engineering approach has enabled us to transition the SETDB from needs and objectives to a valuable product that is already available to the INCOSE and PPI membership on their websites.

The SETDB project has well demonstrated the benefits of a systems engineering approach – starting with the actual problem of delivering value to humans; objectively adequate, life-cycle based problem definition; using sound design processes to create requirements on solution elements; an ever-present emphasis on verification and validation of work products, teamwork, and tight management. The development process was infused, of course, with the essential ingredients of technology knowledge and creativity.

Read more about the Systems Engineering Tools Database Taxonomy in PPI SyEN 105 published in October 2021.

SYSTEMS ENGINEERING RESOURCES

Useful artifacts to improve your SE effectiveness

INCOSE Webinar: How to be Successful in the Absence of Requirements

On 20 April, Dr. Ron Carson, INCOSE ESEP, Boeing Technical Fellow and Adjunct Professor of Systems Engineering at multiple universities, delivered an INCOSE-sponsored webinar #157 on *How to be Successful in the Absence of Requirements*. As a member of the INCOSE Requirements and Measurement Working Groups, Dr. Carson has published definitive papers on requirements completeness, structured requirements, requirements verification and validation, and measuring requirements quality.

In this webinar, Dr. Carson defined the problem as:

1. Clients and customers often believe they know the solution they prefer but may not understand the problem they need solved.
2. As a result of problem #1, their requirements may be non-existent, incomplete, or incorrect.
3. Requirements elicitation may be inadequate to realize a correct and complete set of requirements.

As a solution, Dr. Carson shared practical insights concerning how to generate requirements when there aren't any or they are not complete, consistent or correct. Guidance included:

1. Methods for addressing ambiguity
2. Defining good requirements
3. Finding all the requirements
4. Validating requirements

Checklists were provided for engaging clients/ customers and validating requirements.

INCOSE members may download the presentation and access the video through INCOSE Connect.

View additional requirements-related presentations by Dr. Carson here.

OMG BPMN Overview

The Object Management Group (OMG), during its Q1 Technical Meeting in March 2022, hosted a demonstration concerning the current capabilities addressed in the Business Process Model and Notation™ (BPMN) standard. The BPMN™ in Action! presentation was led by Denis Gagne, CEO & CTO of Trisotech. Leading software vendors demonstrated live the iterative elaboration and interchange of a BPMN model using their respective tools that implement the BPMN standard.

View the presentation slides.

Watch the 61-minute webinar.
Learn more about BPMN™.
View a related Trisotech presentation, Overview of BPMN, CMMN and DMN, that compares BPMN with the related standards, Case Model and Notation (CMMN™) and Decision Model and Notation (DMN™).

PDMA kHUB Portfolio Management Resources

Engineers focused on the development of successful products often lack insight into the role that their organization's Portfolio Management process plays in shaping the requirements for the solutions that they design.

The Knowledge Hub (kHUB) of the Product Development Management Association (PDMA) maintains a rich set of information resources that address a wide range of product development and innovation topics. Relevant to Portfolio Management, the following kHUB resources may help systems engineers to gain a deeper understanding of this critical upstream process:

- Aligning Product Portfolios with Strategic Plans (Iain King)
- A Fresh Look at R&D Decisions: Learning from the Best (Jason LeBoeuf and Marc Drucker)
- Integrated Product Portfolio and Project Management: The Art of New Product Demand Planning (Oliver Wight – White Paper Series)
- Portfolio Mixology! How to Manage Successful Portfolios (Mark Bouchea and Corey Fiedler)
- Portfolio Simulation (David Matheson)

Learn more about PDMA. Become a member.

NIST Study on Blockchain and Related Technologies for Manufacturing Supply Chain Traceability

The U.S. National Institute of Standards and Technology (NIST) has published a study that explains how tamper-evident and tamper-resistant information sharing technologies, like blockchain, can help create a supply chain ecosystem that assures traceability of products.

NIST Internal Report 8419, Blockchain and Related Technologies to Support Manufacturing Supply Chain Traceability: Needs and Industry Perspectives is intended help industry protect manufacturing supply chains from disruptions, IP theft and product sabotage. The report provides an overview of manufacturing supply chains – web-like connected sets of manufacturing resources, products, and processes.

SYSTEMS ENGINEERING RESOURCES

To ensure a supply chain's integrity, manufacturing enterprises must track "provenance of products," defined as the chronology of the origin, development, ownership, location, and changes to a system or system component and associated data. Enterprises must also validate – or ensure the "pedigree" – of this supply chain flow.

The 118-page report addresses the data sharing and storage technologies which could be used to meet supply chain traceability requirements. Blockchain, a distributed ledger that stores all network activity, is highlighted because of its ability to create a digital thread for a product, moving through the supply chain. Blockchain's two-step validation process has promise for ensuring supply chain pedigrees. Once published, blockchain cannot be altered and it becomes an open record that users in a supply chain can access and verify the authenticity of all products' data.

The publication includes a variety of case studies on blockchain and related technologies.

Download the paper here.

INCOSE Systems Exchange Cafés

INCOSE hosts three regularly scheduled Systems Exchange Cafés, informal virtual get-togethers that operate on a "book club" model. Attendees freely discuss a previously agreed topic such as a book chapter, news items or journal article that is relevant to systems and systems engineering.

Systems Exchange Cafés are open to INCOSE members and non-members alike. No recordings are captured or meeting minutes produced to encourage free interchange of ideas. Separate follow-on discussions among attendees are encouraged, perhaps initiated by use of the Zoom chat feature.

Each Café meets every two weeks, with days and times as shown below:

Fir Tree Café: Wednesday 9:00 am Japan. Register
Oak Tree Café: Wednesday 8:00 am UK. Register
Maple Tree Café: Friday 8:00 am US Pacific. Register

> "
>
> *The principles of systems engineering apply almost identically to non-systems.*
>
> *But their importance differs.*
>
> **Robert John Halligan**

System Dynamics Society Recognizes 2022 Conference Sponsors

In the run up to the 2022 International System Dynamics Conference (ISDC2022), scheduled for 18-22 July, the System Dynamics Society has been recognizing the contributions of its many sponsoring organizations through their partnershp in advancing the practice and global reach of system dynamics. SyEN echoes that recognition and encourages our readers to check out these organizations and their capabilities, knowledge and resources in this field.

University of Bergen

UNIVERSITY OF BERGEN

University of Bergen has sponsored the International System Dynamics Conference for over 16 years and is a 2022 Conference Exhibitor**,** Society Sponsor and University Partner. University of Bergen's System Dynamics Group has been training students for decades in System Dynamics and systems thinking and is well recognized in the System Dynamics community. UiB's Masters in System Dynamics programs offered by the Department of Geography and the PhD in System Dynamics are among the leading System Dynamics programs in the world. As previously noted in SyEN edition #109 (February 2022), this year University of Bergen has released two new free online courses (MOOCs), open to people around the world who are interested in learning more about System Dynamics Modelling and Analysis and Natural Resources Management.

Learn more about the University of Bergen in Norway and the UiB System Dynamics Group.

Frankfurt School of Finance & Management

Frankfurt School of Finance & Management
German Excellence. Global Relevance.

The Frankfurt School of Finance & Management is the #ISDC2022 Conference Host and the Society's Dynamic Partner. Frankfurt School has been instrumental in planning this year's hybrid conference.

Frankfurt School is one of Europe's leading business schools delivering excellence in management and finance education. In addition, Frankfurt School's commitment to sustainability in their infrastructure is demonstrated by the campus's Platinum Seal certification by the German Sustainable Building Council, meeting the highest standards in terms of its environmental footprint and responsible use of resources, as well as indoor air quality, barrier-free access and comfortable climate.

Find out more about Frankfurt School of Finance & Management here.

DGSD

The mission of the **German Chapter**, **Deutsche Gesellschaft für System Dynamics e. V.** (**DGSD**), co-host for this year's conference, is to promote the spread of systems thinking and System Dynamics in science, research, teaching and practice as well as the exchange between people and institutions interested in these topics in German-speaking countries.

Founded in December 2006, the German Chapter organizes an annual conference, awards a scientific prize (Gert von Kortzfleisch Prize for outstanding work in the field of System Dynamics), supports students and doctoral candidates, for example, by granting travel scholarships to attend system dynamics conferences. The implementation of the DGSD's mission is carried out according to generally accepted criteria of sustainability.

Learn more about **Deutsche Gesellschaft für System Dynamics e. V.** here.

isee systems

isee systems is dedicated to increasing understanding of our world through user-friendly, intuitive modeling and simulation software. Their software includes Stella Online, Stella Architect, Stella Professional, Stella Designer, Stella Simulator, and iThink.

Coming soon: Version 3.0 of isee systems' software, featuring built-in user interface designs.

Also, check out the isee Exchange, a repository of content created by Stella® users around the world. Learn more about isee systems and what they have to offer here.

Change Agent Inc.

Change Agent, located in Japan, offers training programs, seminars, facilitation, and consulting in order to create organizations and communities that can learn why and how changes occur, adapt to environmental changes, and continue to evolve resiliently through systems thinking and learning organization methodologies. They support nurturing change agents who intend to create changes that are desirable for societies and organizations.

In addition, Change Agent is involved in projects, such as building and supporting a network of aspirations, facilitating multi-stakeholder dialogues, advancing Sustainable Development Goals (SDGs), and nurturing leaders in developing countries.

To learn more about Change Agent Inc.'s organization and work, visit their website here.

California State University – Chico (Chico State)

A System Dynamics approach has been incorporated into several of the undergraduate course offerings at Chico State, such as courses offered for Business Administration majors, among others.

Learn more about Chico State here.

Copernicos

Copernicos is consultancy firm based in the Netherlands that specializes in effectively optimizing **Asset Management and Asset Innovations** to produce better asset performance, risk reduction and better financial results. Copernicos helps organizations to deal with their assets, like ships, trains, factories or general infrastructure, in a more **innovative and cost-effective** way.

Asset Dynamics
Asset Dynamics focuses on the functioning of physical capital goods in the dynamic context in which they operate. Changing circumstances can have a major impact on the entire system. Copernicos uses Asset Dynamics: a modeling and simulation environment for scenario analyses. Asset Dynamics provides insight into future performance, including functional, safety, environmental, and financial performance.

Innovation Management
Copernicos systemically maps societal and environmental challenges in order to gain insight into measures and innovations that will lead to better performance (of assets) in the future. Many of the problems we now face – such as climate change, climate adaptation, mobility, safety and sustainable living environments – are complex: many parties are involved and often there are many innovative ideas for improvement. But it is by no means always clear whether these various innovations contribute to the set objectives and under which preconditions. Copernicos has co-developed the STORM method to better understand such challenges and to clarify which innovations and measures will lead to better future performance.

DESTA Research LLP

DESTA, which stands for Developing Ecosystems for Systemic Transformation and Adaptation, is a consulting firm based in India that provides research and consulting services for sustainable development using System Dynamics and systems thinking. DESTA's modelling approach is rooted in participatory modelling and stakeholder engagement because DESTA believes in the co-creation of models, policies, and programs which are fit for purpose. DESTA has worked in the areas of climate change adaptation, energy transitions, organizational theory of change, ecosystems restoration, livelihood development, and social issues.

Over the past year, DESTA has launched several online certificate courses on systems thinking and system dynamics modelling. These three-week immersive courses are instructor-led and synchronous. The courses are taught by the Founder Directors of DESTA, Mihir Mathur and Kabir Sharma, both seasoned practitioners and researchers with vast experience in applying simulation modelling and systems thinking across various industries and community contexts.

Learn more about DESTA and its offerings here.

Simlin

Simlin is a new web-based tool for visual simulation modeling, built around the system dynamics method. Simlin works with open source tools like PySD and Stella for more advanced features.

Basic features include:

- Create models with stocks, flows, and auxiliary variables.
- Import models from Vensim (*.mdl) and Stella (*.stmx), and export a model as XMILE at any time.
- Basic unit checking of equations.

Check out additional Simlin features here.

System Dynamics Approaches to Complex Social and Health-Related Issues

The System Dynamics Society recommends system dynamics as a great tool for analyzing complex social and environmental problems and testing policy solutions and implementations. Four book are recommended as particularly relevant to the general application of system dynamics to social issues:

Readings in Urban Dynamics – Volume 1

Edited by Nathaniel J. Mass.
The urban dynamics approach centers on analyzing mutual interactions among various subsystems of an urban area. This book discusses the value of models in analyzing social systems and summarizes several broad policy implications derived from the original urban model and subsequent work.

Readings in Urban Dynamics – Volume 2

Edited by Walter W Schroeder; Robert E Sweeney; Louis Edward Alfeld.
This book is a record of urban dynamics research through 1974. It responds to many initial criticisms of Jay Forrester's book Urban Dynamics, presents further results of applying the methodology in Lowell, Massachusetts, and describes model extensions to account for land rezoning, housing abandonment, and city-suburb interactions.

Feedback Thought in Social Science and Systems Theory

By George Richardson.
Feedback Thought is an original investigation into the history of an idea and a way of thinking in the social sciences – the notions of feedback and circular causality. Richardson argues that feedback thinking is one of the most penetrating patterns of thought in all social science.

Social Dynamics: A Curated Collection of Works by Jay W. Forrester

By Jay W. Forrester.
This collection was assembled by Jay W. Forrester in the two years before he died in November 2016 at the age of 98. It contains papers he considered his most important statements about the dynamics of social systems, ranging from corporations and cities to global issues and K-12 education, from the methods of System Dynamics to some of its historically important applications.

Additional resources dive deeper into the application of system dynamics to health-related social issues:

Application of Systems Thinking to Health Policy & Public Health Ethics: Public Health and Private Illness

By Michele Battle-Fisher.
This book looks at health policy through the systems thinking lens of public versus private: population health versus the somatic, social, or emotional experiences of a patient. Rather than presenting policy/ethics as overly technical, this book takes a novel approach of framing public and private health in terms of political philosophy, ethics, and popular examples.

Systems Thinking For Social Change

By David Stroh.
Systems thinking leader David Stroh walks readers through techniques he has used to help people improve their efforts to end homelessness, improve public health, strengthen education, early childhood development, and more.

The book gives concrete guidance on how to incorporate systems thinking in problem solving, decision making, and strategic planning without becoming a technical expert.

Community Based System Dynamics

By Dr. Peter Hovmand
This book covers the design and application of participatory systems modeling with diverse communities. It bridges community-based participatory research methods and rigorous computational modeling approaches to understanding communities as complex systems.

Group Model Building: Facilitating Team Learning Using System Dynamics

By Jac Vennix.
This book focuses on building System Dynamics models when tackling a mix of interrelated strategic problems to enhance team learning, foster consensus, and create commitment.

Additional Resources

The Society's online store is the source for these publications and numerous other system dynamics resources.

The Society's simulations and model repositories pages provide access to a variety of third-party simulations and system models relevant to such complex social and health-related problems:

- En-Roads simulator – Create and evaluate scenarios to limit global warming.
- PRISM (PRevention Impacts Simulation Model) estimates potential health impacts of community-level interventions.
- COVID-19 Simulator - choose from four scenarios to deepen understanding of policy implementation.
- ReThink Health simulation models - support local solutions to a national problem. For more information, visit ReThink Health's website.

The Society's 15 Special Interest Groups (SIGs) focus attention on complex social problems in a variety of domains. New SIGs may be formed as member interests dictate to address different aspects of complex social systems.

The Social Impact SIG attempts to connect system dynamics to social impact, i.e., to drive breakthrough social impact by capturing and sharing the knowledge of social science in system dynamics models.

The Health Policy SIG promotes and supports the wider adoption of System Dynamics methodology and best practices to inform health policy and provides communication channels for collaboration as well as for recognizing achievements of System Dynamics practitioners in health.

Join the System Dynamics Society here.

Systems Thinking for Infrastructure Projects

In a recent edition of the *New Civil Engineer*, the Andrew McNaughton shares "*Why systems thinking is critical to project delivery*." In the article, McNaughton summarizes a December 2020 Institution of Civil Engineers (ICE) report, A Systems Approach to Infrastructure Delivery (SAID), and its hypothesis that system thinking provides an excellent methodology for managing the complexity of technology-driven infrastructure projects. In a related article, McNaughton has defined system thinking as:

> *"considering all the interdependent elements and influences that must be successfully combined and managed to achieve the desired result".*

The initial ICE SAID report identified eight principles believed to be essential to improving infrastructure delivery:

- **Think outcomes, not edifices:** Owners must clearly define the user outcome, so that engineers and technology developers can deliver for that use.
- **Close the gap:** Close the gap between infrastructure and sectors adapting better to technological change. Cherry-pick best practices to improve delivery efficiency.
- **Owners must own projects:** Owners should give direction on everything, from functional requirements for the operational system to data requirements and acceptable technology and innovation risks.
- **Future-proof projects:** Use the V-cycle process to establish systems architecture, manage technology development and upgrade it with minimal disruption.
- **Think shovel worthy, not shovel ready:** Front-end project development gives clearer project definition, creates a more stable delivery environment and improves stakeholder engagement and management.
- **Bake in systems thinking:** Bake systems thinking and risk management into the project DNA. Design an organisation and structure that mirrors how you're going to manage risk.
- **Agile leadership:** Agile leadership adapts to multiple risks in complex systems. Spread authority through empowerment models that listen to the right voices at critical moments, enable skilled front-line people to make decisions and support baton handovers.
- **Data oils your project:** Owners should define the vital data for delivering the service, the appropriate collaboration model and share it through the supply chain. Collaborating around shared data increases productivity, enables integration and improves operational performance.

McNaugton describes follow-on activities to the first SAID report to translate these principles into effective implementation. These efforts have yielded a second report, published in April 2022, titled A Systems Approach to Infrastructure Delivery – putting the principles into practice. This report includes six case studies that were used to test the systems thinking principles defined in the first report. Cross-cutting themes identified from these practical examples included:

- Keep the end in mind throughout the entire project.
- Ensure we are all in this together.
- Think hard about leadership.
- Do you have to deliver it all at once?

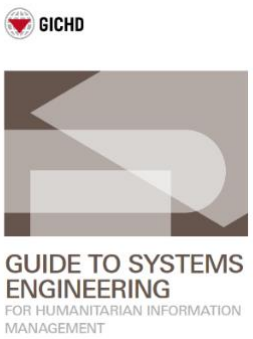
Learn more about Institution of Civil Engineers (ICE).

SYSTEMS ENGINEERING IN SOCIETY

View the SAID report #1 briefing sheet and view the embedded ICE video.
View the SAID report #2 briefing sheet.
View the *New Civil Engineer* website and subscribe.

PPI SyEN applauds ICE's effort to apply systems thinking principles to infrastructure projects and points out that PPI offers a five-day course to deliver the concepts and skills to realize the vision set out in the ICE SAID reports. The Engineering Successful Infrastructure Systems course is an immersion in the successful engineering of infrastructure that delivers maximum value to stakeholders. The course is based on systems thinking, here applied to projects and engineering. And so, the course has a strong systems engineering foundation. Systems engineering as a discipline has been proven to substantially reduce costs, reduce project durations and increase client satisfaction. Download the course brochure here.

Guide to Systems Engineering for Humanitarian Information Management



In April 2022, the Geneva International Centre for Humanitarian Demining (GICHD) issued a Guide to Systems Engineering for Humanitarian Information Management. The guide provides theoretical and practical methods for using systems engineering to deploy information management systems in support of a variety of humanitarian missions such as mine action, peace monitoring and disaster risk reduction.

GICHD sees systems engineering as relevant to their humanitarian mission because SE:

- Is a structured and all-encompassing design and management process, which considers both the business and the technical interests of stakeholders throughout the life cycle of any proposed system.
- Improves the likelihood of success of technologically risky projects.
- Seeks to understand the big picture, and to identify the cause-and-effect relationships between the various elements of any overall system.
- Recognizes the importance of understanding the short- and long-term consequences of any action, as well as the associated risks and costs.

This 142-page guide provides examples of how systems engineering has been employed by GICHD and its partners around the world.

Chapters include:

- Rudiments of Systems Engineering & Information Management
- Systems Engineering-based Design Process
- Implementation Strategies
- Case Studies

Learn more about the GICHD.
Download the full guide.

An 11-page Quick Reference to the full guide is also available. SyEN applauds the application of systems engineering principles to such important and difficult humanitarian challenges.

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.

FINAL THOUGHTS FROM SYENNA

Dear Reader,

In a previous article - see SyEN 110 PPI SyEN 110 - PPI (ppi-int.com) - I shared some thoughts about a Systems Engineering viewpoint onto music, which I would now like to develop further.
I use for illustration a classical orchestra, which is familiar ground for me, but I'm sure the ideas would translate to other spheres of music.

The orchestral system includes musician subsystems (each including player, instrument, chair, music desk, and instrumental part.) The instrumental part is a functional specification for the musician. It is written using open source musical notation, which is a model-based problem definition using a relatively small number of symbols.

Professional players can very reliably produce notes to meet the specification, whatever is going on off-stage (divorce, bereavement, bankruptcy proceedings, affairs, job offers…). Amateurs practice until they can play the right notes, whereas professionals practice until they can't play any wrong ones. [For those in the know, French Horn players seem to be the exception to this rule.]

Even so, the players are so much more than robots (after all you can easily buy software that plays from music scores through sound generators). Each player sounds different even though respecting the specification, and each plays differently on each performance. There is so much that can't be encoded in a score….

The Conductor acts as the live system integrator, reading from the full score, which is the integration plan.

Then the magic happens. Use the same orchestra on a different day or with a different conductor, and you will get a very different result.

As a shortlist, the conductor:

- determines tempo and dynamics;
- directs subtle stretching and compression of the tempo ("rubato");
- signals "fresh air" at the end of phrasing;
- creates empathy with the players and between players;
- communicates the type of tone required and the balance between players;
- builds up a particular emotion and then releases it.

The conductor and players adapt to the acoustics of the concert hall, which are influenced by the audience and any unoccupied seats. More than that, they are influenced by the mood of the audience in a bidirectional relationship, even if they can't see them. In SyEN 108 PPI SyEN 108 - PPI (ppi-int.com) I suggested that "as human beings, we aren't just units meandering inconsequentially through the Universe; the interaction with our environment is bidirectional". So now we have a higher-level system that includes the concert hall, the audience, and the orchestral system.

FINAL THOUGHTS FROM SYENNA

Feed the same sound waves into our homes as a series of digits (or on vinyl if you can remember that), and a lot of that magic is lost, even with a so-called "live recording" (something to be added to the oxymoronic dictionary).

How is it that a particular sequence of sound waves in a concert setting can provoke such a wide range of emotions in the audience? This is the magic of emergent properties; inexplicable when you look at the contributions of the individual elements. The scientific method has achieved some impressive things even though hampered by its reductionist approach that destroys the appreciation of emergence. Some people put such trust in science that it becomes a benchmark of truth for them; if something can't be scientifically proven, it can't be true. For decades, politicians dithered on climate change, demanding scientific proof that our greed was destroying the planet. Few of those politicians would deny the truth of the emotional experience to be found in a concert hall (or equivalent).

So now let's face up to our greed. Immediately after birth, we have the perspective that everything in the universe is put there to support our needs. Then we discover that particular clusters of molecules have meaning (e.g., parents, milk, rusks, and unpleasant things). That we interact with others, and that they have their own needs. Depending on the triple-whammy accident of geography, culture, and genetic code, we learn how to modify our World view and behavior. Societal rules of the road and legal frameworks are generally there to coax us away from "ego" (the personal greed of I am) to "sumus" (We are). If all else fails, we can always have a climate catastrophe or a war.

A cross-section of amateur musicians would be well-represented by doctors, teachers, mathematicians, scientists, and engineers. We need some systems engineers in the mix to talk about the magic of emergent properties. Or, like members of the Magic Circle, perhaps they should keep the secret to themselves?

If you are still with me, dear Reader, I invite you to think about how you can use your understanding of emergent properties to influence our World leaders.

Syenna