A.1. Electrification

Electrification across the energy lifecycle. This stream will explore lifecycle issues around all aspects of electrification, from generation, to storage, to distribution and charging, to end use (EVs and heating/cooling). Contributions to this stream are invited to share insights on the system as a whole across the energy lifecycle, including sustainability issues.

Lead: Thomas Manley
Domains: Energy & Nuclear Technologies, Sustainability and the Environment, Transport & Cities

A.2. Energy futures

Engineering Solutions for a Clean Energy Future. Contributions to this stream are invited to explore applications of MBSE and digital engineering to structure, de-risk and streamline energy transformation to a resilient, net zero emissions future, considering the need for wide accessibility of capabilities and insights across society and enhanced stakeholder trust and experience.

Lead: Stephen Craig, Sam Mancarella
Domains: Energy & Nuclear Technologies, Sustainability and the Environment, Transport & Cities

An Austere Digital Engineering Approach for Energy Decarbonisation

Mark H Unewisse 1, Stephen C Cook 1, John Wharington 1, Duane Jusaitis 1, Ashok Samalam 1, Shoal Group Pty Ltd, Adelaide, SOUT AUSTRALIA, Australia

Keywords: Energy Decarbonisation,Modelling,Digital Engineering

Type: Full Paper
Category submitted: A.2. Energy futures

Digital engineering (DE) is an active area of research in systems engineering. This paper explores the application of digital engineering to complex, large-scale energy decarbonisation projects. Energy decarbonisation projects are highly diverse in nature, spanning multiple industries, such as: energy generation, transportation, and mining. A DE approach that combines systems engineering design and analysis, supported by physics-based modelling, can be used to effectively understand, design, and deliver these often complex projects. However, such an approach can quickly become highly resource intensive. The paper addresses this issue though a flexible yet cost effective approach that utilises a modular combination of model-based systems engineering, physics-based modelling, and operations analysis techniques to analyse a range of energy decarbonisation projects. Furthermore, many energy decarbonisation projects are enterprise activities with a range of critical externally controlled elements or effectively function as a strategic alliance with significant independence in the development of the component systems. The paper describes how lessons from defence mission engineering can be used to address these system-of-systems aspects and shape the modular DE approach. Finally, the paper outlines some examples from the mining industry of applying this modular digital engineering approach.

Disruption in Energy

Jawahar Bhalla 1, Shoal Group / University of Adelaide, Harrington Park, NSW, Australia

Keywords: Energy Disruption

Type: Panels and Workshops
Category submitted: A.2. Energy futures

There is growing discussion on energy sources, with political and technological motivation for cleaner, renewable energy catalysing a transition from traditional sources such as coal and gas to solar and wind, as well as options such as hydrogen, nuclear sources coming of age. Differing passionate perspective are leading to divergent initiatives that some say are being rushed through as symptomatic quick fixes, causing disruption in the energy market in the short term at best, with the potential for societal negative outcomes in the longer term. This panel brings together passionate professionals sharing personal and varying perspectives on this contemporary societal disruptor, fostering thought, discussion and insights to towards improving our collective understanding on the opportunities and challenges related to energy and in ideally fostering working a holistic way forward.

Taming the Complexity in Australia

Amro Farid 1, CSIRO Smart Energy Mission, Lyme, NEW HAMPSHIRE, United States

Keywords: energy systems,infrastructure systems,hydrogen systems,water systems,systems-of-systems

Type: Paperless Presentations
Category submitted: A.0. Advances in Domains (multiple streams)

Overview: In this presentation, we present a reference architecture for Australia's multi-energy, water, and hydrogen systems. For the first time, we begin to understand the inherent interdependencies between these systems using model-baseed systems engineering. Context:Australia has one of the greatest solar and wind energy resources in the world. And yet, it is one of the largest exporters of carbon-intensive energy sources. In the meantime, its arid, sub-tropical climate leaves it water scarce and vulnerable to extreme weather events. Purpose:As Australia proceeds with its own sustainable energy transformation, it must reconcile these realities so that energy services are sustainable, affordable, resilient, and equitable. The interdependencies between is multi-energy, water, and hydrogen systems can create opportunitistic synergies and inevitable trade-offs. Approach:This presentation exposits a reference architecture as a means of managing the complexity of Australias Nexus Infrastructure of Energy, Water and Hydrogen (ANIEWH). It argues that Australia must adopt an integrated approach to infrastructure systems engineering that explicitly tackles the coupling of energy, water, and hydrogen. It further argues that a model-based systems engineering reference architecture provides the disciplinary means by which to tackle this inherent complexity. Insights: The Hydrogen-Energy-Water Reference Architecture (HEWRA) is then presented in terms of system boundary, form, and function for the coal, oil, natural gas, electric power, hydrogen, potable water, and wastewater management sectors. The presentation concludes with thoughts on how this work can be further advanced within future initiatives.

Understanding the Asset-Level Resilience & National-level Sustainability of the American Multi-Modal Energy System

Amro Farid 1, CSIRO Smart Energy Mission, Lyme, NEW HAMPSHIRE, United States

Keywords: energy systems,infrastructure systems,water systems,hydrogen systems,systems-of-systems

Type: Paperless Presentations
Category submitted: A.0. Advances in Domains (multiple streams)

Overview: This presentation uses hetero-functional graph theory to understand the asset-level resilience and national level sustainability of the American Multi-Modal Energy System (AMES) Context:The challenge of global climate change necessitates a fundamental and holistic re-design of the AMES. Traditionally, the electric grid, natural gas, oil, and coal systems have been studied individually. More recent efforts have tried to study pairs of these systems but for a number of theoretical and practical reasons such efforts have fallen short of combining these four systems into an integrated model. Purpose:The "American Multi-Modal Energy System Synthetic and Simulated Data (AMES-3D)" project funded by the (American) National Science Foundation seeks to fill this gap and produce an open-source, physically-informed, machine-learning, structural and behavioral model of the AMES for potential use and expansion by the broader scientific community.This presentation seeks to introduce the audience to the AMES' data, model and development in several steps. Approach: Hetero-functional graph theory is briefly introduced as the scientific basis for producing structural and behavioral models where an arbitrary number of infrastructure networks of arbitrary topology are connected arbitrarily. Insights: We briefly compare the network statistics and resilience measures of the (traditional) formal and hetero-functional graphs of the American electric power system. Such a comparison motivates the use of hetero-functional graphs in systems with multiple energy carriers and facilities with fundamentally heterogeneous function. In particular, we show how such systems require 3D degree distributions that differentiate the processes and energy carriers in a hetero-functional graph. Finally, we demonstrate how such 3D degree distributions in the states of New York, California, Texas, and the entire United States differ as a result of their fundamentally different geographies and policies. The presentation concludes with several directions for future work using the AMES model and the hetero-functional graph theory toolbox.

Developing a Hetero-functional Graph State Estimator of the American Multi-Modal Energy System

Amro Farid 1, CSIRO Smart Energy Mission, Lyme, NEW HAMPSHIRE, United States

Keywords: energy systems,infrastructure systems,hydrogen systems,water systems,systems-of-systems

Type: Paperless Presentations
Category submitted: A.0. Advances in Domains (multiple streams)

Overview: This presentation develops a hetero-functional graph state estimator of the American Multi-Modal Energy System Context:As one of the most pressing challenges of the 21st century, global climate change demands a host of changes across at least four critical energy infrastructures: the electric grid, the natural gas system, the oil system, and the coal system. In the context of the United States, this paper refers to this system-of-systems as ``The American Multi-Modal Energy System (AMES)". Purpose:These combined changes necessitate an understanding of the AMES interdependencies both structurally and behaviorally to develop and enact effective policies. Approach:This work focuses on behavioral analysis methods to provide examples of how to analyze system behavior and the crucial flows of energy through the system. Building upon past works, the AMES is modeled and its behavior is analyzed using Hetero-functional Graph Theory (HFGT). Specifically, the work presents a state estimation model of the AMES. Insights:This work brings the state estimation analysis out of the single-operand electric grid environment and into the heterogeneous environment that is the AMES. Employing a data-driven and model-based systems engineering approach in combination with HFGT a Hetero-functional Graph State Estimation optimization program was developed to optimize the flows of mass and energy through the AMES. This provides the first example of using a state estimator with HFGT to model the flows of mass and energy across multiple energy systems contained within the AMES.

Transitioning to Net-Zero - a State-of-the-System Analysis

Thomas Manley 1, Decision Analysis Services (DAS) Australia, Fed Gov Lead / Systems Engineering Advisor, Canberra, ACT, Australia

Keywords: Net-Zero,Electrification,Renewable Energy,Energy Transition,Battery Storage

Type: Paperless Presentations
Category submitted: A.1. Electrification

The transition to net-zero by 2050 is a worthy (and critical) goal. It will require electrification of carbon-emitting processes (cooking, heating, transport) and clean sources of electricity generation. The good news is that industry is leading the way, and we may be closer to achieving net-zero than we think. This presentation is a 'State of the System' analysis of where we (Australia and the World) are at with respect to this transformation. It will cover: electrification of transportation assets (EVs, rail, aircraft, ships); clean electricity generation (distributed solar, large scale solar, wind and hydro); and storage (pumped hydro, grid-scale batteries, home batteries and Vehicle-2-Grid technology).

Applying Model-Based Systems Engineering to transforming power systems

Matthew Bird 1, Ricky Clayton 2, Energy Catalyst, Ferny Hills DC, QLD, Australia, Acmena, Brisbane

Keywords: Power System Architecture,Model-Based Systems Engineering,Complexity,Decarbonisation,Multi-stakeholder Participation

Type: Paperless Presentations
Category submitted: A.2. Energy futures

Systems Engineering disciplines and tooling have been successfully adopted by many other sectors that work with highly complex systems. By comparison, their application in the electric power sector has been negligible. Here we explore how MBSE can support the analysis, rationalisation and evolution of the massively complex architecture inherent in Australias largest legacy GW-scale power system as it transforms. GW-scale power systems are some of the largest and most complex systems ever created by humans. Global progress toward deep decarbonisation of legacy grids presents significant challenges as traditional sources of generation are withdrawn and new highly variable, weather-dependent, locationally dispersed, numerically large, and non-merchant resources take their place. Inthis transformational context, the purpose of this work was to explore MBSEs potential to: Provide tooling that enables the decomposition and taming of the massive complexity inherent to transforming legacy GW-scale power systems; Empower more informed, multi-stakeholder participation by making critical content explicit and tractable which would otherwise remain opaque and intractable; and, Increase decision quality, timeliness and traceability to increase the potential for full benefits-realisation and avoiding the propagation of unintended consequences. A key focus of the work was modelling the underlying as-built architecture of Australias National Electricity Market (NEM) power system, potential transitionary and plausible future step change architecture that accommodates the cyber-and physics-based realities of deeply integrating millions of diverse energy resources to become an integral part of a 21st century power system. Given limited precedence in applying MBSE to power systems, an important first step was the model configuration including a taxonomy of logical interface types. MBSE provides a shared systems-based methodology to develop integrated solutions in support of a transition to advanced whole-system coordination that spans bulk power, transmission, distribution, and aggregation of distributed resources to the benefit all.

K.I.S my MBSE (Keep it Simple)

Tony Warrior 1, David Elam 1, Energy Systems Catapult Ltd, Birmingham, N/A, United Kingdom

Keywords: MBSE,Energy System

Type: Paperless Presentations
Category submitted: A.2. Energy futures

The Energy System is immensely complex. Many actors participate in the Energy System performing a varied taxonomy of roles. Many of these actors are not engineers, let alone systems engineers, but have significant gravitas and influence over the Energy System and, consequentially, our journey to Net Zero. In recent decades, much of the development of the Energy System has been achieved through an incremental approach following established industry methods and practices. The adoption of contemporary systems engineering methods has, perhaps, been slower than in other industrial and innovation areas. Making robust decisions and changes is dependent upon having the best possible knowledge of the subject system. In the case of the Energy System, it is difficult enough to gain consensus on where the boundary of that system lies, let alone gather and present the structure, information and interdependence of the that system in a logical, repeatable and most importantly, usable way. MBSE presents itself as a potential discipline that is capable of achieving these objectives. Initial attempts at using MBSE to develop a model representing the Energy System have, however, proven to be difficult. The number of different diagrams and relationship types that can be utilised in MBSE modelling is off putting to none MBSE users and they quickly lose interest. Users want to be able to see the information, not learn a modelling language. A solution we propose is to hugely simplify the MBSE modelling diagrams, relationships and modelling techniques for the vast majority of users, creating a general model of the Energy System that can be repeatably expanded and be used by all for analysis, research and insight. This general model can then be used as a baseline for more detailed and bespoke modelling using the full power of MBSE on an as needs basis.

A Systems Approach to Procurement of a large Power Transmission Program in Europe

Bart van Luling 1 2, Dutch Boosting Group, Hoofddorp, NEDERLAND, Netherlands, TenneT (TSO), Arnhem, Netherlands

Keywords: Systems Engineering approach,Procurement of large Power Transmission program in Europe,Collaboration with market parties,Data-centric way of working,Risk-based contract management

Type: Paperless Presentations
Category submitted: A.2. Energy futures

This presentation explains how TenneT, A transmission system operator for 43 million domestic and business users in Germany and The Netherlands applied a systems approach to stakeholder management, Engineering, Procurement and change management to deliver its largest power transmission program ever. By 2050 the European Union aims to become the first carbon-neutral continent. By 2030, the EU wants to reduce CO2 emissions by 55%. To hit these targets, Germany and The Netherlands need rapid electrification, in industry, mobility and households. The share of electricity in the energy system will grow exponentially, from 20% today to 40-60% in 2050. As one of Europes largest Transmission Service Operators (TSOs), TenneT needs to develop a grid that can support societys climate ambitions: they call this their 2045 Target Grid. Therefore, several offshore wind energy areas have been designated to generate more sustainable energy. These need to be connected to the national grid and thus the 2GW Program was launched. To make the 2GW program successful TenneT decided it needed standardisation, scalability and optimisation; they wanted to ensure each of the 17 projects experiences benefited the next. They also wanted an approach where people within and outside TenneT can work together effectively.Tennet choseaprogressivesystems engineeringapproachto manage these issues.including the implementation of systems engineering, a data-centric way of working , forming partnerships with big contractors, and risk-based contract control to limit their review effort. This new approach for the largest energy transition program of Europe comes with a big organizational change while the projects are already running. Dutch Boosting Group and TenneT will present how they successfully applied and continue to apply Systems Engineering on the 2GW program in collaboration with the contractors, what challenges we have encountered, what the success factors are and what lessons they have learned.

Accelerate Electrification of Mine Operations through a Systems Approach

Nicholas McKenzie 1, MEMKO pty ltd, Melbourne, VIC, Australia

Keywords: MBSE,Digital Engineering,Simulation,Transformation,Electrification

Type: Paperless Presentations
Category submitted: A.2. Energy futures

The International Council on Mining and Metals (ICMM) has committed to achieving net zero emissions by 2050. Diesel-powered mining vehicles contribute 30 to 50% of direct emissions at mine sites, electrifying them will be critical to achieve global decarbonisation goals. Electrifying the mine presents challenges on assessing the impact on mine operations a change in fleet composition will have, as well as how best to operate the future of the mine with these new systems. Systems thinking and digital engineering tools can be used to enable timely, informed decisions to meet emission targets without productivity loss. The proposed solution combines system engineering and physics simulators to allow the contextualisation of changes to operations driven by electrification. Model-Based Systems Engineering (MBSE) will be used to create the Mine System Design, capturing the data and processes of the mine, the configuration of assets and the benchmark metrics and pass/ fail conditions. The Vehicle State Simulation will model detailed energy behaviour of the Haul Trucks (either Diesel or Electric). The Vehicle state simulation will receive variables from the Mine system to model the detailed energy consumption behaviour of trucks and incorporate this constraint into the system model. By leveraging co-simulation what-if scenarios of different fleet configurations and charging infrastructure can be benchmarked within the context of the mine as a system. Creating a realistic decision-making tool to accelerate the electrification process, driving efficient capital and investment planning and meeting emission targets.

A.3. Healthcare & biomedical systems

Healthcare & biomedical systems. Systems Engineering and Systems Thinking have much to offer to enhance healthcare outcomes, though these practices are not widely adopted. Healthcare systems are often complex, distributed, and safety critical. Contributions to this stream are invited to share case studies or contributions where a systems approach has or may improve outcomes.

Lead: Andrew Madry, Grace Kennedy
Domains: Healthcare Systems

Gene Therapy in Developing Countries

Joseph Aliwali 1, Individual, Yukon, OKLAHOMA, United States

Keywords: Gene therapy Implementation

Type: Full Paper
Category submitted: A.3. Healthcare & biomedical systems

Gene therapy is an emerging medical approach to providing a cure for inheritable or genetic diseases due to faulty genes and other infectious diseases. This paper seeks to analyze the prevalence of these medical conditions in low-and middle-income countries and investigate the factors stifling the access of this potentially lifesaving treatment. The approach will be to define the system framework and interactions within which gene therapy can be applied with the objective of proposing viable avenues of implementation.

Integrating Systems Engineering Principles into Healthcare: Enhancing Efficiency, Safety, and Patient Outcomes

Bohdan Oppenheim 1, Jawahar Bhalla 2, Andrew Madry 3, Healthcare Systems Engineering MS Program at LMU, Los Angeles, California, USA, JB Engineering Systems, Sydney, NSW, Australia, Madry Technologies Pty Ltd, Galston, NEW SOUTH WALES, Australia

Keywords: healthcare,lean

Type: Panels and Workshops
Category submitted: A.3. Healthcare & biomedical systems

This panel will explore the transformative potential of applying systems engineering principles to the healthcare sector. As healthcare continues to face complex challenges, including resource constraints, rising costs, and the need for digital transformation, systems engineering offers a framework to improve efficiency, enhance patient safety, and optimize outcomes. Our discussion will feature leading experts from both fields who will examine case studies demonstrating successful integrations and discuss methodologies that can be adapted for various healthcare settings. Attendees will gain insights into leveraging systems engineering tools such as process optimization, risk management, and technology integration to address pressing healthcare issues, paving the way for a more resilient and effective healthcare system.

Cyber Risks for Hospitals

Rob Relf 1, Alive Information, South Melbourne, VIC, Australia

Keywords:

Type: Paperless Presentations
Category submitted: C.8. Technical Leadership in a Digital Future

Cyber Risks From an engineers POV. A key step of the risk management life cycle is to determine the appropriate response to each risk. The goal of effective risk management is to identify ways to keep risk aligned with the risk appetite or tolerance in as cost-effective a way as possible. Engineers need to take an overall risk assessment of the project involved with IT, only focused on the software system. This outline is to look at all the inputs, the people involved and their responsibilities and how the risk concept can be applied, with a focus on hospitals. An outline of progressive steps will be given. A key item is, we are only focused on industrial projects and not consumer product developments. Asset managers run sophisticated data systems on their assets. In the medical industry, the co-ordination of cyber risks is going to be a good challenge in the future. As risk management processes are identified and improved, including specific strategies for responding to risks in the asset register, it will be important to ensure descriptions of those responsible, accountable, and informed about each activity therein and if Privileged Access needs to be considered. IT have a Common Vulnerability Scoring System for screening networks and examines the severity of vector strings. This standard is put forward by NIST. One of the items being brought to the table is AI and Machine Learning. This is no longer an IT challenge but a whole-of-business challenge. For Industry 4.0 era, selecting the data needed from multiple sources will be one of the key challenges for quality control and quantifiable risk management. We need leadership from system engineers. Fortinet in Australia, with two universities and industry bodies is developing a pilot project for industry review. Balancing Your Healthcare Cybersecurity & Compliance Efforts

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SE perspective on the effect of risk management on the performance of imaging systems

Sharad Rayguru 1, Philips Healthcare India, Pune, MAHARASHTRA, India

Keywords: Medical electrical equipment,fluoroscopy,Image Quality

Type: Full Paper
Category submitted: D. Other

The development of electrical medical devices requires compliance with a host of regulations and standards to help ensure their Risk management, safety, and effectiveness. Because patient and user safety are paramount in medical devices, we focused on risk-based methodologies to address safety. This paper discusses risk management methods to reach low residual risk levels using risk management matrices. The risk management process starts with the conception and follows each step of the product design phases up to and including the product's end of life. This paper will offer some systems implementable suggestions to address various safety and quality attributes to obtain the desired image quality for interventional therapies.

A.4. Interoperability & the electromagnetic environment

Interoperability through digitisation of the electromagnetic environment. With the advancement of digitisation of RF systems over large bands, this is opening up a whole world of a digital electromagnet environment in real time allowing for more options for interoperability of systems. This stream invites contributions that explore this problem and opportunities through improved communications.

Lead: Kris Daly
Domains: Defence, Telecommunications

A.5. Joint Force

Enabling Joint Force Interoperability. More and more Defence projects aim to deliver systems that are expected to accomplish joint missions. Submissions in this stream should explore how Systems Engineering can be applied to the Defence domain to enable the delivery of those systems, including applications of Mission or SoS Engineering.

Lead: Marco Meloni
Domains: Defence

A.6. Mission Engineering

Mission Engineering and Capabilities. Mission Engineering elevates thinking from system level to the concepts of Systems of Systems, Operational Concepts and the integration of Mission Capabilities. Presentations to further the theory as well as the practical implementation of Mission Engineering are invited.

Lead: Michael Edwards, Theo Venter
Domains: Defence

Integrated by Design: The use of Mission Engineering to achieve a focused Australian Defence Force

Michael Edwards 1, Mark Gilchrist 2, Raytheon Australia, Mawson Lakes, SA, Australia, Joint Warfare Development Branch, Force Integration Division, Canberra, ACT, Australia

Keywords: Mission Engineering,ADF

Type: Full Paper
Category submitted: A.6. Mission Engineering

Title submitted by M.Edwards as stream lead for Mission Engineering. Mark Gilchrist is only intended author/presenter and has committed to provide abstract by 14 June. Suggest we can use this title at least for initial agenda formulation and confirm later.

Designing Mission-Aware Systems through ME and MBSE Integration

Ebrahim Aly 1 2, Julian Reck 3, Sondoss Elsawah 1 2, Capability Systems Centre, UNSW, Canberra, Australia, School of Systems and Computing, UNSW, Canberra, Australia,, Raytheon , Adelaide , SA, Australia

Keywords: Mission-aware systems,MBSE,Mission Engineering,Causal models,Unified profile

Type: Full Paper
Category submitted: A.6. Mission Engineering

The Defence Strategic Review (DSR) highlights the need for effective Mission Engineering (ME) to develop capabilities that meet specific mission objectives efficiently and cost-effectively. For ME to be effective, adaptable systems need to be developed that can address a wide range of evolving problems and meet specific mission requirements. Such systems must be versatile and broad, remaining relevant across various scenarios and precise needs. This demands significant foresight and ingenuity in the design stages, where architects must anticipate future challenges and opportunities, embedding both flexibility and specificity into the system. Mission-aware systems offer a solution to this challenge by integrating mission goals directly into their architecture and development lifecycle, ensuring technical soundness and alignment with future mission requirements. This alignment is crucial in contexts where strategic planning and execution are essential, synchronizing technological and human capabilities for mission success. By aligning systems engineering efforts, which focus on technical development, with mission engineering, which emphasizes overall mission success, organizations can ensure that their technological solutions support strategic objectives. This paper proposes an approach for designing mission-aware systems by integrating ME with Model Based Systems Engineering (MBSE). The integration occurs in two stages: first, by introducing missions as an intermediary that influences system capabilities alongside operational capabilities through a structural causal model; and second, by mapping ME frameworks, such as the DoD ME guide, with systems architecting frameworks, such as the DoDAF or MoDAF, to create a unified profile. This unified profile is used to describe and document ME artefacts within the MBSE model, ensuring that mission requirements are integrated into the system design from the outset. This approach, also, provides a common language between ME and MBSE, producing mission-compatible products that facilitate mission guided system design and evaluation.

Mission Engineering Modelling & Reporting: Lessons from Model Based Capability Design

Matthew Wylie 1, Tommie Liddy 1 2, Kristen Coles 1, Shoal Group, Adelaide, SA, Australia, Turen Pty Ltd, Adelaide, South Australia, Australia

Keywords:

Type: Full Paper
Category submitted: A.6. Mission Engineering

Key to the effective employment of Model-Based Systems Engineering (MBSE) is the ability to effectively communicate the rich information contained in the model to stakeholders. This paper provides insights and examples for effective reporting of digital Mission Engineering models, drawing on lessons learned from similar approaches. Mission Engineering is the application of formal approaches to plan, analyse, organise, and integrate current and emerging system/operational capabilities to achieve desired effects. It is used to examine missions for several purposes, including identification of capability gaps, needs and solutions. Mission Engineering practitioners will define missions, timeframes and capability states to examine, then model functional and physical architectures to provide structural and behavioural representations to facilitate mission analyses. The Unified Architectural Framework (UAF) provides a standardised enterprise architecture framework, is being adopted by the United States Department of Defense, and has been demonstrated as an effective, consistent, and standardised means for the digital engineering implementation of Mission Engineering. The Whole of Systems Analytical Framework (WSAF) provides a digital engineering approach to Capability Design within the Australian Defence context. There is significant cross-over between the application of WSAF and the Mission Engineering process, and the lessons learnt from its application can be applied to the adoption of Mission Engineering. A key component of WSAF is a suite of report generating tools, that supplements the MBSE environment, enabling the modelled information to be consistently reported and presented in a form readily understood by decision makers (i.e. Capability Definition Document). This paper examines the reporting principles employed on WSAF, how these can be applied in the Mission Engineering context, and demonstrate the adaption of these principles in reporting UAF-based Mission Engineering architectures and analyses. The authors provide insights and practical examples based on their experience in developing and applying MBSE-based reporting.

Blurring the Line: Adopting Mission Engineering Methods in Product Development Programs

Mark Papinczak 1, Tom Davis 2, BAE Systems, Canberra, ACT, Australia, BAE Systems, Adelaide, SA, Australia

Keywords: mbse,methodology

Type: Paperless Presentations
Category submitted: A.6. Mission Engineering

Overview: With emerging customer trends toward rapid product development programs, and strategic capability accelerators, the traditional 'above-the-line' (ATL) to 'below-the-line' (BTL) systems engineering divide is eroding. Blurring of these lines has heightened the need for primes to understand mission engineering principles, and achieve better horizontal and vertical information integration such that confidence in the mission-product fit can be developed, assessed and evolved with pace. Context: Mission Engineering has traditionally been the purview of above-the-line (ATL) systems engineering efforts, undertaken by a customer in eliciting their internal mission and operational needs. The mapping of specific missions and capability needs to new platforms, requires bridging of the operational and system lenses, which is beyond the scope of any one method or architecture framework. Purpose: Developing a proactive understanding of the customers intended missions and concept of operations, via mission engineering, and achieving traceability from mission needs through to design is deemed a critical enabler for effective product development activities. Model-based systems engineering was proposed to help bridge this divide and provide a pattern for multi-project/program research and development. Approach: Modelling and architectural themes across mission engineering, operational/ service modelling and object-oriented systems modelling were analysed and mapped to derive a holistic metamodel, methodology and viewpoint set. The resultant method was applied to an internal product development program as a case study and means of validation. Insights: The investment in proactive mission engineering and alignment is feasible and effective, albeit expensive and assumption driven. Clear articulation of missions, capability needs and customer investment priorities would provide a more robust basis for proactive mission engineering and allow industry to deliver a more competitive set of products and capabilities. Mission modelling holds greatest value when used as the basis of program/ portfolio approach of research and development, thus allowing for re-use of the mission modelling investment.

A Short History of Mission Engineering

Michael Edwards 1, Jim Moreland 2, Raytheon Australia, Mawson Lakes, SA, Australia, Raytheon, Washington, DC, USA

Keywords: Mission Engineering,Systems of Systems

Type: Paperless Presentations
Category submitted: A.6. Mission Engineering

Note: this is a placeholder for a significant keynote or presentation slot for Dr Jim Moreland, placed by M. Edwards as presumptive stream lead for Mission Engineering. To be confirmed and expanded upon, but to start with: * Jim will explain the early development of Mission Engineering that he led through US Government, initially at Naval Systems Warfare Center, Dhalgren and then the Office of the Secretary of Defense. * Jim will explain the state of professional education and academic research of Mission Engineering in the US, relying on his teaching experience including at MIT, Virginia Tech, and Old Dominion universities. * Jim will explain the role and interest of US industry in Mission Engineering. * Jim will provide his thoughts on the future practice and development of Mission Engineering, in particular what are the needed lines of research to develop the discipline.

Minimum Viable Capability - Mission Engineering on a Budget

Jon Lancaster 1, Mott MacDonald, Melbourne, VIC, Australia

Keywords: Systems Integration,Mission Engineering,Capability

Type: Full Paper
Category submitted: B.2. Future of Systems Engineering

Overview This paper examines how Mission Engineering can be used to inform decision-makers attempting to deliver the most capability with the minimum amount of infrastructure. Where projects are delivered across migration stages, this paper explores how Mission Engineering and Systems Integration allow operators to map the staged capability uplift across multiple migration stages and manage the transient risk profiles across a suite of temporary configuration states. Context Decision-makers face the challenge of maintaining or growing capability amid decreasing budgets, rapidly changing operational environments, and phased delivery of complex systems. In situations where decisions can mean significant operational limitations, identifying the impact on mission and capability empowers decision-makers tofocus on best-for-project outcomes . Purpose This paper describes using Mission Engineering and Systems Integration methodologies to enable operators to make informed investment decisions to deliver the Minimum Viable Capability in the face of time, cost, and availability constraints. By understanding the relationship from capabilities to the people, process, technology, and associated risks, a delivery authority can manage project change and assess the consequences of changes in terms of capability rather than just in terms of time and cost. Approach Building on existing Systems Engineering frameworks used on complex projects in highly regulated industries, the view is expanded to include the lens of capability.A framework is provided that links existing artefacts (hazards, operational scenarios, test cases, GSN goals) to the mission. By viewing technical integration and operational readiness through the lens of missions and capabilities it enables delivery authorities to place complex systems into service effectively. Insights Projects / technology suppliers speak in terms of system functions,whilst operators speak in terms of operational capability. Establishing a framework that enables both parties to speak a common language aids collaboration and provides a common basis for making decisions.

A.7. Rail Systems Engineering

Rail systems engineering: digital advances. This stream invites submissions that explore digital advances in the Rail sector, such as the FRMCS (Future Railway Mobile Communications System). Submissions should share approaches to ensure that deliverables match business case objectives, lifecycle phases, and milestone criteria.

Lead: Obaid Khan, Khairulzaman Kamarulzaman
Domains: Telecommunications, Transport & Cities

A.8. Systems Security

Systems Security and Risk Mitigation. Management and mitigation of security risk is an essential component of modern technical and socio-technical systems. This stream will explore identification, management, and mitigation of risks in systems security themes, including security in electronic and information systems, physical systems, and cyber-physical systems.

Lead: Obaid Khan, Khairulzaman Kamarulzaman
Domains: Cybersecurity

Vehicle Diagnostic Security Advancement using an MBSE Approach

Sarah Rudder 1, Enola Technologies, ST. PETERSBURG, FL, United States

Keywords: security,MBSE,safety,reliability

Type: Full Paper
Category submitted: A.8. Systems Security

Overview Medium and Heavy-duty (MHD) vehicles often require maintenance and diagnostics during normal operations. Vehicle Diagnostic Adapters (VDAs) are the service tools that connect the vehicle network systems to the diagnostics and maintenance software. These diagnostic tools are intermittently, but frequently connected to the vehicle by a trusted technician, but many security models ignore technicians physically connecting to the vehicle. Context VDAs are made by third parties and the specification for them lacks security controls around this operation has prompted the trucking industry to develop new security protocols for diagnostics in the International Organization of Standards (ISO) 14229. In light of the potential security concerns associated with MHD vehicle diagnostics, a Threat Analysis and Risk Assessment (TARA) is presented using Risk Assessment and Analysis Modeling Language (RAAML). Purpose This research seeks to understand how RAAML can be utilized to follow a cybersecurity approach in a modeling environment in the context of Systems Engineering (SE) activities throughout the system lifecycle. SE responsibilities that pertain to risk identification, assessment, and management include, but are not limited to, deliverables such as Failure Modes and Effects Analysis (FMEA) and Fault Tree Analysis (FTA). Approach A digital representation of the MHD vehicle diagnostic and maintenance system can be designed using Model-based Systems Engineering (MBSE). The presentation will start with a model-based description of the diagnostics system of interest, then do a deep dive into the threat analysis and risk assessment using RAAML. Insights Capturing FMEA and FTA inputs and outputs in the model enables more complete traceability and re-usability, reducing re-work and giving more transparency for risk analysis of the system design.

A.9. Test & Evaluation: Advancing Strategy

Test &Evaluation : Advancing Defence T&E Strategy. Testing is a well-established systems engineering process, but systems assurance across the integrated capabilities for Defence are becoming more challenging. This stream invites contributions that realize the complexity of integrated force packages drives a need to improve T&E of systems-of-systems at Joint Force Level.

Lead: Contact the Technical Committee if you can assist in Chairing this session
Domains: Defence, Test & Evaluation, Strategy

Decision-Supporting Capability Evaluation throughout the Capability Development Lifecycle

Suzanne Beers 1, The MITRE Corporation, Colorado Springs, CO, United States

Keywords: decision support,evaluation,T&E continuum,model-based systems engineering,operational & technical capability evaluation

Type: Full Paper
Category submitted: A.9. Test & Evaluation: Advancing Strategy

Overview: For T&E to provide the most relevant information for developing and fielding capabilities to meet mission needs, planning should focus on gathering data for capability evaluation and decision-support. We propose an expansion of US DoD's acquisition cycle mandated Integrated Decision Support Key (IDSK) to Decision Support Evaluation Framework (DSEF) which guides a structured decision-evaluation-data critical thought process throughout the full capability development lifecycle. - Context: IDSK guides data collection from test and modeling and simulation (M&S) events for an acquisition systems operational and technical capabilities evaluation for operational, programmatic, and technical decision-support throughout acquisition lifecycle. As T&E expands outside the confines of the acquisition cycle to the full capability lifecycle, the DSEF provides the same expansion of the tests evaluation and decision-support. - Purpose: Inmoving from IDSK to DSEF, we must scale from the acquisition cycle to the full capability development cycle. The art and critical thought in developing a DSEF is properly stating the decision space (i.e., What decision needs to be made? When does the decision need to be made? What is the essence of the information needed by the decision-maker to make an informed decision?) and aligning it with the appropriate capability evaluation and data sources. We describe the decision space as a concept moves from early capability development planning, through S&T and P&E, to PoR and Operational SoS Architecture mission delivery. - Approach: Through analysis of the various stages in the capability development process, we've defined classes of decisions, decision-supporting questions, and capability evaluation strategies. - Insights: The value of the DSEF is two-fold. First, the DSEF thought process guides the capability evaluation planning focused on informing decisions. Second, the DSEF process guides wargames and exercise planning with a more rigorous focus on gathering the data needed for evaluation and decision-support.

Advance Modeling and Simulation in Acquisition Test and Evaluation

Jason Daly 1, David Wells 1, Melissa Wong 1, Angel Cortes-Morales 1, Luis Cortes 2, MITRE, McLean, VA, United States Technical Solutions Division, Huntington Ingalls Industries, Corona, California, USA

Keywords: Test and Evaluation,Modeling and Simulation,Acquistion,verification and validation,digital engineering

Type: Full Paper
Category submitted: A.9. Test & Evaluation: Advancing Strategy

Modeling and simulations (M&S) is an integral component of the U.S. Department of Defense's focus for delivering integrated, network-centric systems-of-systems (SoS) that provide the materiel solution to needed capabilities. M&S assists developers and decision makers in a wide range of technical processes like analysis of alternatives, concept development, requirements evaluation, production and manufacturing, test and evaluation (T&E), integration, training, logistics, and risk management as well as in assessing the capability over the entire operational space. M&S will continue to grow as a critical component of an overall test program strategy. In this presentation we examine the current state of M&S in acquisition T&E, as viewed from the lens of a small number of acquisition programs, and provide some useful hints to advance and get the most of its application. Specifically, we provide a perspective on the role of M&S in the T&E strategy, the sufficiency of M&S processes, identify gaps in M&S verification and validation (V&V), report on methods used for assessing model maturity, and identify digital engineering strategies that could help improve M&S V&V over the lifecycle.

A T&E Code of Practice advancing in an emergent digital world

Malcolm Tutty 1, ITEA, ITEA Southern Cross Chapter, Canberra, Australian Capitol Territory, Australia

Keywords: T&E Code of Practice,novel approaches,ground and flight test,experimentationtest and evaluation

Type: Panels and Workshops
Category submitted: A.9. Test & Evaluation: Advancing Strategy

Workshop on Round Tables. The International Test & Evaluation Associations Southern Cross Chapter held a Panel/Workshop at the SETE 2022 and ITEA 40th Annual Symposiums focused on the potential and need for the development of an T&E Code of Practice to complement the SESA / INCOSE Systems Engineering Body of Knowledge (SEBOK) using a Model-Based Systems Engineering and T&E approach or MBSETE. ITEA proposes to leverage INCOSE SEBOK material to underpin key principles. Based on these Panels/Workshops, ITEA have agreed to develop a T&E Code of Practice that would be suitable for many engineering and scientific disciplines including aerospace, cyber, modelling, simulation, Intelligent and Autonomous Systems, defence, network-enabled and autonomous weapons and future potentially disruptive technologies. Collaboration with SESA and INCOSE is strongly supported by ITEA. The SETE 2024 workshop will discuss and confirm the over-arching principles of T&E which are being proposed in The ITEA Journal International Test and Evaluation Association in June 2024. The workshop will also review The Technical Cooperation Programs (TTCP) Guide to Experimentation (GUIDEx, 2005) see Slim GUIDEx 2004 Dec 2004 (dodccrp.org) and subsequent similar developments for suitability and applicability to the T&E and MBSETE communities advancing in the digital world. 60-90 Mins

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UAS Test Ranges - Design concept for flight test ranges & access pathways

Mark Roots 1, QinetiQ, Brisbane, QLD, Australia

Keywords: UAS,flight test range design,CASA JARUS SORA

Type: Paperless Presentations
Category submitted: A.9. Test & Evaluation: Advancing Strategy

In Australia there is no dedicated flight test range or facility available for civil UAS test and development. UAS operations are expanding and continue to demand focus from the regulators to safely blend UAS and manned aircraft activity. Currently every activity requires an application to CASA for approval to conduct the planned activity and each of these can take a protracted time which can delay the development cycle. As UAS become more present in the skies, there is the need to assess, test and evaluate larger and larger platforms safely. Whilst it may be possible to test small UAS of modest speed close to larger city centres, the testing of platforms over 150kg and that operate at higher speed or higher altitudes, need access to areas of ground and airspace where the risk can be managed. This study provides a methodology that can be used to select an area to set up a flight test range. The methodology will be presented and then the process applied to the QFTR in Cloncurry as an exemplar but provides the final step - suggested pathways for range access. QinetiQ have developed this process and continue to work with CASA on this and other strategies to promote safe test of UAS platforms in Australia.

The Defence Test and Evaluation Strategy

GPCAPT Steve Young, CSM, GAICD 1, Department of Defence, Canberra, ACT

Keywords: Test and Evaluation,Strategy,Implementation,Enterprise,Plan

Type: Paperless Presentations
Category submitted: A.9. Test & Evaluation: Advancing Strategy

Australias rapidly changing strategic environment requires the Australian Defence Force to field increasingly complex capabilities over the coming decades. Advances in technology are changing the nature of the systems, and systems-of-systems that are subject to test and evaluation (T&E) to assure their fitness-for-purpose. Individual platform testing follows a well-established systems engineering process, but technologies like artificial intelligence and machine learning require the development of new test techniques. New technologies also enable novel, more efficient test methods. The growing complexity of integrated force packages also drives a need to improve T&E of systems-of-systems at the Joint Force Level. To meet Defences contemporary T&E needs, the Defence T&E Strategy was released on 24 August 2021. The Strategy aims to deliver a modern and networked T&E capability that underpins risk-based capability decisions and is actively supported by a strong sovereign base. The Strategy is currently in its second phase, modernising governance and conduct of T&E. This briefing will provide insights into the implementation of the Defence T&E Strategy under Horizon 2, and will invite discussion on challenges and opportunities presented by new and emerging technologies as well as visions of what the future Australian Defence T&E Enterprise should be.

Advancing Digitally Enabled T&E

Nazifa Dr Tahir 1, QinetiQ, Waverton, NSW, Australia

Keywords: Digital T&E,undersea command,control and communications,undersea surveillance,Maritime Robotics

Type: Paperless Presentations
Category submitted: B.9. Test & Evaluation of Systems of Systems

QinetiQ is effectively engaged in exploitation of digital Test and Evaluation (D T&E) to support our customers challenges and delivering capability in their undersea warfare missions. QinetiQs Underwater Robotics team has been working to provide complex state-of-the-art digital T&E capabilities to support undersea surveillance, undersea combat and undersea command, control and communications. These capabilities have enabled deployment of maritime systems with reduced inherent risks of losing or grounding valuable assets, supported underwater navigation and tracking with seamless communication among Maritime Autonomous Systems in challenging underwater and littoral environments. Through global collaboration in integrated autonomous systems and acoustic communication, QinetiQ has provided significant cost savings in field trials by reducing the risks of mission failures thereby helping our customers to train like you fight and ensuring success of critical missions.

A.10. Transport & Infrastructure

Transport & Infrastructure: advances in the infrastructure sector. This stream invites contributions that cover advances in SE in the Infrastructure, particularly in the areas of leadership, organisational integration, tailoring of approach, next-generation software tools, digitalisation, information management and other topics of interest that advance the application of SE in Infrastructure.

Lead: Ruben Welschen, Tom Castor, Sameera Bandara
Domains: Transport & Cities, Digital Futures

A Systems Engineer

Fernanda Tavares 1, Systems Engineering, SYSTRA ANZ, Sydney, NSW, Australia

Keywords: requirements management,information management,DOORS Next Gen,Report Builder

Type: Full Paper
Category submitted: A.10. Transport & Infrastructure

Overview:Major infrastructure and transport projects require a systematic and structured approach to information management. Such projects typically entail documenting, controlling, and managing relationships between various levels of requirements and their associated design, and verification and validation activities. Handling such a significant volume of artefacts poses considerable challenges. Context:Requirements management tools play an important role in capturing, organising, managing, and tracing requirements throughout the lifecycle of a system. These tools help manipulate and display data in tailored formats so that progress statuses and relationships can be easily visualised. One of the most common requirements management tools among systems engineering practitioners is the IBM Dynamic Object-Oriented Requirements System (DOORS), and the IBM Report Builder offers a variety of options for generating metrics and reports. Purpose:While pivotal for project analysis and decision-making, open-source information on report generation is scarce online. Only scattered information can be found on the internet across a few blogs, IBM documentation, and forum discussions. The paper aims at discussing differences in terms of handling and presenting data depending on the data source of the report. Approach:The points of discussion of the paper are based on the lessons learnt over several years of systems engineering practice in Major Infrastructure and Transport Projects in Australia using DOORS Next Gen. It will present examples elucidating differences between the use of Data Warehouse (DW) and Lifecycle Query Engine (LQE). Insights:In many cases, both data sources can meet the same reporting needs. However, key differences were observed in how long the data takes to update, the ability to add attributes, set filters and conditions to reports, and the ability to create custom expressions.

Operational Readiness for Brisbane Metro

Monica Dryden 1, Andrew Purcell 2, Mott MacDonald, Melbourne, VIC, Australia, Operational Readiness, Brisbane City Council, Brisbane, QLD, Australia

Keywords: Metro,operational readiness,assurance,operation,System engineering and integration

Type: Full Paper
Category submitted: A.10. Transport & Infrastructure

Brisbane Metro, an all-electric, high-capacity turn-up-and-go public transport system, is designed to link the city to the suburbs, through two new Brisbane Metro lines. Reducing congestion bottlenecks in the city for a better-planned network, the new service aims to meet the growing demand for reliable travel options. Brisbane Metro delivery includes the introduction of 60 new battery electric metro vehicles, a new technologically advanced depot, new and upgraded infrastructure providing targeted investment to augment the capacity of Brisbanes busway network, a new operational bus network, policy and operational changes, and a new intelligent transport system. The novelty of the project, the first of its kind in Brisbane, Australia, and the southern hemi-sphere, will unintentionally set a precedent for how future projects of similar nature may implement and delivery a successful operational service. While Brisbane City Council has delivered a wide range of major projects, the planning and delivery of Brisbane Metro has been its largest and most complex undertaking to-date. The integration of new and novel systems into an existing transport ecosystem has required a holistic network planning approach. The unique elements of Brisbane Metro has driven the need to assess Councils model for operational readiness and the implementation of a systems engineering and integration approach, particularly in regard to the transition to operations and handover of the assets. Utilising experience from different industries and external support, a methodology of combining best practice from the rail industry and bus industry along with scaling processes and approaches enabled the definition of its own distinct assurance process. This paper will discuss the process and methodology undertaken as part of operational readiness activities, highlighting lessons learnt, and how this can be applied to future projects as they transition into operations.

Novel uses of digital engineering tools for SESA processes

Nikhil NB Bharadwaj 1, Lina LL Legenhausen 1, KBR, Melbourne, VICTORIA, Australia

Keywords: Digital Engineering,SESA Process,Digital Tools,Novel Approach

Type: Paperless Presentations
Category submitted: A.10. Transport & Infrastructure

Rail transportation plays a pivotal role in facilitating economic growth and enhancing mobility; however, rail projects are often large and complex, requiring systems engineering and safety assurance (SESA) inputs. This paper explores how digital solutions can support and enhance traditional SESA frameworks. Traditionally, SESA tasks involve structured but sometimes time-consuming approaches for identifying stakeholder needs, defining system requirements, and integrating subsystems to achieve project objectives. While existing SESA frameworks provide a solid foundation for managing rail infrastructure projects, the use of digital engineering tools to solve the unique complexities of such projects are allowing SESA works to be completed more effectively and efficiently. Through the integration of Revizto on some NSW and Victorian rail projects, the SESA team along with the digital engineering team, were able to run safety in design workshops more effectively and efficiently by allowing participants to have accurate depictions of equipment locations and to see the exact location of hazards through the creation of tags. There are potential advances that can be made by integrating model-based systems engineering, architecting tools, requirements management tools, digital design simulation and modelling tools to further automate and streamline SESA tasks such as safety in design workshops, inter-disciplinary workshops, systems architecture, safety arguments, requirements management and development of assurance case reports.

Multi-Dimensional Systems Architecture Modelling for Transport and Infrastructure Projects

Daniel Spencer 1, Spencer Tech Pty Ltd, Tonsley, SA, Australia

Keywords: MBSE,Rail,Architecture,Methods

Type: Paperless Presentations
Category submitted: A.10. Transport & Infrastructure

Overview: This presentation explores approaches in Model-Based Systems Engineering that provide benefits for transport and infrastructure projects. These projects can be characterised by a focus on a detailed systems architecture, and the need for consistency and traceability in applying this architecture across multiple geographic locations. Using examples in an MBSE tool, this presentation will demonstrate how to rapidly build a coherent system model and provide meaningful artifacts to stakeholders and design teams. Context: A simplistic approach is often taken to systems architecture in teaching and initial project implementation. There is a system of interest, which is built from a hierarchy of systems components (from segments and subsystems down to individual configuration items). In many large projects, the physical systems architecture can be multi-dimensional, with multiple levels of system breakdowns, with implementation at multiple locations, along with the need for specific customisations or variants. Purpose: A sample model being presented demonstrates the basic characteristics of a rail transport infrastructure project. This sample is explored and extended via features available in MBSE tools, to show techniques that can improve the quality, speed and consistency of the models and artefacts being produced. Approach: For this approach, practical methods from product-line engineering, in object-oriented methods and in existing model-based systems engineering tools are explored and demonstrated. This includes aspects of model reuse, abstraction, inheritance and parameterisation, specifically applied to the physical architecture of a systems model. Insights: Using these techniques, improvements can be shown in the elegance of design (defined by forming the least complex sufficient solution), the minimisation of effort in modelling (and increased efficiency of implementing changes), and the quality, clarity and consistency of diagrams and representations drawn from the model content.

Systems Engineering (SESA) in Rail: benefits, challenges and why we need it

Caroline Crete 1, Aurecon, Melbourne, VIC, Australia

Keywords: Rail,SESA

Type: Paperless Presentations
Category submitted: A.7. Rail Systems Engineering

Overview The Rail industry is shifting towards a Systems Engineering oriented approach for major projects. This new way of delivering projects comes with challenges that the industry needs to overcome in order toachieve the benefits of this change. Context The past century has seen a significant increase of Rail Projects throughout Australia. Over the years, the evolution of the environment in and around major cities as well as in rural areas has introduced new levels of complexity for the design and delivery of Rail Projects. In this context, State Governments have started to shift their approach and mandate Systems Engineering to be applied on the most recent Rail Projects. Purpose For an industry historically adopting a Design and Construct approach, what does this mean? What are the benefits, but also the challenges of this shift? Approach This presentation gives an overview of the legacy Design and Construct approach and proposes a definition of SESA, as well as an overview of what this includes and where it applies in the lifecycle of a project. Drawing on data from projects in other industries where Systems Engineering methodologies have been applied for decades, we present the benefits and assess the relevance of Systems Engineering to the Rail Industry. Insights Based on observations from recent rail projects in Australia, we identify some of the challenges faced by multi-disciplinary teams to implement Systems Engineering, focusing on some differences between adding Systems Engineering on a project versus embedding Systems Engineering in the framework of the project. We discuss some aspects to consider when it comes to implementing better embedded Systems Engineering on projects, ultimately aiming at delivering projects through a Fully Integrated Systems Engineering process to see improvements in the delivery outcomes, including quality, costs, conformance to contractual requirements and client satisfaction.

B.1. Human systems

Human systems: the messy human component as antidote to emergence . Contributions to this stream are invited to highlight human variability, adaptability as under-utilized enablers of system resilience; challenge existing industrial, siloed perspectives of humans within complex socio-technical systems, and; question hierarchical command/control in favour of distributed/networked models that push information & decision-making to the edge of the organisation.

Lead: Derek Wade, Ren King
Domains: All domains welcome

B.2. Future of Systems Engineering

Shaping the Future of Systems Engineering: Pathways to SE Vision 2035. This session invites contributions that empower Systems Engineering through merging collaboration, standardisation, and educational initiatives to build the competencies and knowledge base essential for current and future engineers; encourage innovation and adaptation by integrating advanced tools, technologies, and methodologies to prepare for a digital future, and; emphasise value and evolution, highlighting the significance of systems engineering across various sectors and promoting its maturity to meet emerging challenges effectively.

Lead: Ren King, Erika Palmer
Domains: Education, Certification & Training, Human Systems Integration, Research Capabilities

Collaborating in the Systems Engineering Ecosystem for Realizing the Systems Engineering Vision 2035

William D Miller 1, Stephen Cook 2, Kerry J Lunney 3, Paul Pearce 4, INCOSE, BERKELEY HEIGHTS, NEW JERSEY, United States, SHOAL Group Pty Ltd, Adelaide, Thales Australia, Greater Sydney Area, ASC Pty Ltd, Greater Adelaide Area

Keywords: Education,Certification & Training,Human Systems Integration,Research Capabilities

Type: Panels and Workshops
Category submitted: B.2. Future of Systems Engineering

The panel moderator will describe the context for the Future of Systems Engineering (FuSE) initiative to realize the Systems Engineering Vision 2035 followed by the panelists presenting their position statements identifying challenges, opportunities, development needs, and opportunities for collaboration. The exponentially increasing aspects of scale, interactions, complexity, uncertainties, and emerging technologies challenges our engineering of systems and systems of systems. Together with stakeholders in the systems engineering ecosystem, we must foster collaboration to innovate and build quality professional practice of system engineering, which continues to evolve in response to technical opportunities and political, economic, social, technological, environmental, and legal (PESTEL) challenges. Anticipating what systems engineering will and should be in the future has significant implications for research, education, training, certification, and resources. The panel is 90 minutes with the intent to allocate 50 percent of the time for participants to then engage with the panel and each other.

INCOSE's Product Development Process

Christian Sprague 1, Erika Palmer 1, INCOSE

Keywords:

Type: Paperless Presentations
Category submitted: B.2. Future of Systems Engineering

Overview: This session will provide an in-depth overview of INCOSE's product development process where we examine its evolution and adaptation to the digital era. Attendees will gain a thorough understanding of the various stages and best practices employed in creating new and innovative systems engineering products. Context: In an era marked by rapid digital transformation, INCOSE is strategically refining its product development process to make better use of technology and foster collaborative endeavors. Each stage, from ideation, to team formation, to distribution, contributes an important part in shaping the final product and its wider impact on the systems engineering community. Purpose: This session seeks to equip attendees with a broad understanding of INCOSE's product development pipeline by providing them with the information and tools necessary to actively contribute to the future of systems engineering products. By highlighting the process and calling out opportunities for engagement, we will cultivate greater innovation and inclusion within the INCOSE community. Approach: This session combines expert insights, case studies, and interactive discussions to guide attendees through the stages of INCOSE's product development process. We will examine each part, from the sketching out a Technical Product Plan (TPP) and participating in technical reviews, to the style guideline for designing visually compelling and user-centric products. Attendees are encouraged to engage in discussion, share insights, and gain practical tips for navigating the project pipeline. Insights: Attendees will leave with a clear understanding and actionable steps to further their participation in INCOSE's product development. They will gain appreciation for the collaborative nature of product creation, recognizing the interactions between technical expertise, design, and effective distribution. By learning about INCOSE's stance in leveraging digital platforms, targeted marketing, and community engagement, attendees will be well-positioned to drive the success and impact of future systems engineering products.

INCOSE Product Spotlight: A Deep Dive into Recent Releases and Upcoming Content

Christian Sprague 1, Erika Palmer 1, INCOSE

Keywords:

Type: Paperless Presentations
Category submitted: B.2. Future of Systems Engineering

Overview: This session will cover INCOSE's recent and upcoming product releases. It will also discuss the collaborations between volunteers, working groups, and staff in providing valuable content to the systems engineering community. Context: INCOSE contains a broad and ever-growing product portfolio, encompassing magazines, guides, primers, and data tools, all developed through the efforts of the systems engineering community. These products are designed to push the boundaries of systems engineering practices and tackle the most pressing challenges facing society. Purpose: This session will provide attendees a deep dive into new INCOSE products, discuss the development behind them, and give a glimpse into the products on the horizon. By highlighting these innovative resources, we seek to inspire attendees to contribute to INCOSE product development. Approach: The session will kick off with a deep dive into the core articles of the April 2024 INSIGHT magazine, which tackles the challenge of advancing systems engineering in an increasingly complex world. From there, we will showcase a carefully curated selection of other significant recent releases, such as the Guide to Security Needs and Requirements, Agile Systems Engineering Primer, and Guide to ISO/IEC/IEEE 42020. Attendees will have an exclusive look at the roadmaps and timelines for highly anticipated upcoming releases, including the next version of our systems engineering competency framework, updates to the development of standards, and work towards a modular ontology for systems engineering. Insights: Attendees will leave this session with a comprehensive understanding of INCOSE's latest offerings, a detailed preview of new developments, and actionable insights into how they can leverage and shape these resources to elevate their practice and drive the profession forward. The session will underscore the role our volunteer community has in driving product development and how they can make their mark on INCOSE's mission of advancing systems engineering.

From I to We, From Vee to Us: A Model for Engineering Systems

David Long 1, Blue Holon, Blacksburg, VIRGINIA, United States

Keywords: Digital transformation,interfaces,lifecycle

Type: Paperless Presentations
Category submitted: B.2. Future of Systems Engineering

Overview The power of digital represents an opportunity to fundamentally accelerate and transform the engineering lifecycle, but we must do so correctly. Digitization done poorly will enhance practices but silo practitioners. Embracing a holistic systems perspective enables us to digitalize engineering, empower radical collaboration, and adopt a new model for engineering systems. Context The various engineering disciplines have largely digitized their practices including the advancement and adoption of MBSE for systems engineering. However, many organizations and their supporting practices remain siloed. Integrations between teams and lifecycle phases remain largely constrained by old practices and organizational constraints slowing engineering progress and losing knowledge. Purpose Transformation requires more than simply digitizing existing practices. We must reconceptualize what is possible given the unprecedented computing power and data storage capacity of today. This includes ways of working within given disciplines and processes. More importantly, it requires that we look across the engineering lifecycle addressing workflows and interfaces to transform the engineering system rather than its constituent components. Approach For over 30 years, I have worked with government and commercial organizations as they assess, adopt, and deploy new methods and tools to enhance their engineering enterprise first MBSE and now digital thread, digital twin, and digital engineering. I have observed common patterns across organizations and disciplines. Looking to fundamental system concepts allows one to transform from the traditional Vee lifecycle model to a series of Us through concurrency, modularity, and integration powered by digital flows. Insights By changing our perspectives from digitization to digitalization, from serial to parallel, from part to whole, from siloed to collaborative we embrace a new lifecycle model, meet the promise of digital engineering, and deliver transformative results as we engineer the future.

The Importance of Open Standards and Architectures for Integrated Digital Engineering Capabilities

JORDAN MARSHALL 1, QINETIQ AUSTRALIA, Mt Duneed, VICTORIA, Australia

Keywords: Digital Engineering,Open Standards,Integrated,Data,Systems Engineering

Type: Paperless Presentations
Category submitted: B.2. Future of Systems Engineering

Overview: One of the challenging concepts in shaping the future of Systems Engineering and preparation of a Digital future includes the complexity associated with Tools and Data integration. [SE Vision 2035] The complexity exists between many different types of tool sets and technologies used, and the effort required to exchange data between them. There is a Need to simplify this approach as much as possible. One such method, which we will explore to accomplish this, is through the use of Open Standards and Open Architectures. Context: Such approaches to this problem, may include the adoption of common interface standards, languages, schemas and modular based architectures. The presentation will provide a brief look into the relevant standards bodies; examples of existing open systems and languages, and how they may be utilised for developing Digital Engineering capabilities. Exploring the issues of stove piping, which typically inhibit the sharing of data openly across the system lifecycle. Purpose: This presentation will provide an outline of the challenges associated with closed systems, and a fresh look at the benefits of an open system in the context of implementing Digital Engineering capabilities. Outlining the key challenges associated with Tools and Data integration as described in the Systems Engineering vision for 2035. There is now a growing need and urgency to standardise our approach, in order to access, share, collaborate, and reuse data. Approach: By using Open Standards, the complexity of integration is reduced, resulting in a wide number of benefits, which this presentation will discuss in further detail. Insights: This is advantageous for the replacement of future Digital Engineering systems, which can then utilise those standardised interfaces and integrate easier. From this presentation, we will recognise the need for such open standards to enable us to implement Digital Engineering capabilities now, and in the future.

T&E for Model Validation to Support Synthetic V&V Outcomes

Terence De Jong 1, Janice Wong 1, Jeet Shah 2, Digital Engineering, Nova Systems, Newstead, QLD, Australia, Digital Engineering, Nova Systems, Southbank, VIC, Australia

Keywords: Digital Mission Engineering,Verification & Validation,Modelling & Simulation,MBSE

Type: Paperless Presentations
Category submitted: B.2. Future of Systems Engineering

In the emergent digital landscape, the evolution of Synthetic Test & Evaluation (ST&E) applications in systems engineering is essential, offering value in overcoming real-world testing constraints. This presentation explores the evolution of Synthetic Test & Evaluation applications in systems engineering, particularly for Uncrewed Aerial Vehicles (UAVs) and multi-UAV systems (swarms). We will present modelling and simulation of UAV power consumption to predict system performance, demonstrating how ST&E can complement traditional testing methodologies, addressing real-world constraints and enhancing efficiency. The operational adaptability and configurability of Commercial and Military off-the-shelf UAVs present significant challenges to conventional Test and Evaluation (T&E) methods, which are often costly, time-consuming, and logistically demanding. Existing methods struggle to keep up with the dynamic nature of UAV technology. The research aims to understand and demonstrate the effectiveness of a synthetic approach to Test and Evaluation for UAVs. The hypothesis is that validated Modelling & Simulation (M&S) can contribute to both ST&E and digital mission engineering throughout the life cycle, improving resource allocation, risk mitigation and overall mission performance assessment. Nova Systems hybrid Test and Evaluation framework combines Model-Based Systems Engineering (MBSE) and M&S with physical testing to verify and validate UAV performance. The study collected and analysed data on power consumption and battery utilization under various payloads and flight scenarios to validate the synthetic models presentation of real-world UAV behaviour. The benefits of synthetic testing extend beyond validation, with impacts across the system life cycle. By facilitating comprehensive system and mission analysis across the life cycle, ST&E can enhance operational efficiency, risk mitigation, and resource optimisation. Its integration into the broader framework of systems engineering not only augments traditional T&E practices but also drives the advancement of the digital mission.

Embracing AI in Digital Engineering: A Holistic Approach to Managing Work, Workforce, and Workplace

Erika Palmer 1, Ren King 2 3, Christian Sprague 1, INCOSE, Certification Training International, Johannesburg, South Africa, Project Performance International, Sedgefield, South Africa

Keywords:

Type: Paperless Presentations
Category submitted: B.2. Future of Systems Engineering

Workshop SessionOverview: This workshop presents the Sociotechnical Function Allocation and Risk Analysis (SFARA) Framework, a conceptual schema for evaluating the relationships between humans and technology in the context of digital engineering for AI integration. The workshop addresses the opportunities and shifting risk profiles of utilizing AI in systems and offers a holistic approach to managing work, workforce, and workplace. Context: Managing the interplay of human and technological elements within socio-technical systems is crucial, especially in the context of rapid AI advancements. AI integration in digital engineering requires frameworks like SFARA to make strides towards advancement while managing new risks. Purpose: The workshop aims to explore the challenges and opportunities of AI within digital engineering and to present the SFARA Framework as a valuable resource for engineers and designers to assess function allocation and risk within a sociotechnical context. Approach: The session presents an array of global perspectives and best practices, followed by a hands-on activity that challenges participants to apply the SFARA Framework for AI implementation to an example in digital engineering. Participants will then engage in group discussions and presentations to share their findings and receive feedback. Insights: Attendees will gain knowledge about the SFARA Framework, which involves functional decomposition, subfunction assignment of automatability along the Human-Technology Spectrum (HTS), and analyzing the resulting functional distribution and risk profile across the system. They will learn how to apply the framework for AI integration in digital engineering and explore a holistic approach to managing work, workforce, and workplace.

B.3. Modelling and Simulation Advances

Modelling and Simulation Advances. This stream invites contributions from all domains to share simulation and modelling advances relevant to systems engineering. These may include qualitative and quantitative approaches, and may be at any stage of development. Submissions are invited to share novel practice that can lead to better outcomes within the SE lifecycle.

Lead: Contact the Technical Committee if you can assist in Chairing this session
Domains: All domains welcome

The Role of Model-Based Systems Safety in Ensuring Safe Implementation of Autonomous Technologies

Faizan Mr Muhammad Ramzan 1, Julia Ms Gibney 1, Nova Systems, Nollamara, WA, Australia

Keywords: MBSE,MBSS,Modelling,Autonomous

Type: Full Paper
Category submitted: B.3. Modelling and Simulation Advances

Model-Based Systems Engineering (MBSE) offers a holistic approach to understanding complex system architectures, enabling early detection to design flaws and integration of multidisciplinary perspectives. By directly incorporating safety considerations and optimising system performance through the use of model-based-system safety (MBSS) processes, we can ensure safer, more efficient and reliable autonomous systems. This study aims to identify challenges and opportunities in assuring the safety and cybersecurity of autonomous systems, proposing Model-Based Systems Safety (MBSS) as a promising framework to address these complexities effectively. Through a comprehensive review of current safety processes, this paper identifies gaps exacerbated by disruptive technologies. Building upon model-based engineering principles, a framework for MBSS is formulated to systematically assess and mitigate safety risks in autonomous systems, emphasizing the seamless integration of MBSE and MBSS throughout the system lifecycle. The adoption of MBSS offers a structured approach to enhance safety and cybersecurity assurance in autonomous technologies. This paper provides both theoretical insights and practical implications for industry stakeholders, policymakers, and researchers, highlighting the potential of MBSS to foster trust and reliability amidst technological disruption. In conclusion, this paper underscores the pressing need for innovative strategies to navigate the intersection of disruptive technologies, system safety, and cybersecurity. By embracing MBSS, stakeholders can effectively manage risks associated with autonomous systems, ensuring resilience, and maximizing the transformative potential of emerging technologies.

Virtual Rehearsal: Enhancing Constructability and Safety in Cast-In-Place Construction

Luis Diaz 1, Case Civil and Structural Engineering, Brisbane, QLD, Australia

Keywords: Virtual Rehearsal,Construction,Safety,Constructability,Digital Construction

Type: Paperless Presentations
Category submitted: B.3. Modelling and Simulation Advances

This presentation delves into the transformative realm of virtual rehearsal and its profound benefits for the construction industry, spotlighting a recent Australian project exemplifying cast-in-place construction methodologies. The focus will be on the utilization of innovative techniques such as incrementally launched casting beds and balanced cantilevers from travellers. Subsequently, we will elucidate how these design principles can be seamlessly applied to more conventional structures and methodologies. Virtual rehearsal, a digital technique, empowers project teams to meticulously plan, test, and refine work sequences within a simulated environment before embarking on real-world implementation. Leveraging building information models (BIM), this form of virtual reality enables collaborative interactions among personnel involved in planning and executing tasks. The immersive technology facilitates a dynamic interaction with designs, allowing for the rehearsal of various aspects of construction, maintenance, repurposing, and risk assessment within the context of new infrastructure. Key Points: -Integration of virtual 3D models with the project program for visualizing and analyzing construction activities. -Visualization and analysis of project design before and during construction phases. -Enhancement of user understanding regarding the spatial relationships within the project. -Identification and proactive addressing of safety concerns or potential issues. Advantages: -Establishment of rich engagement with owner/operator stakeholders through immersive experiences. -Improvement of design and service outcomes through engaged reviews, comments, and option testing. -Automated prevention of safety risks, reducing reliance on human behavior. -Stakeholders gain a comprehensive understanding of the design, facilitating informed decisions early in the construction process. This presentation aims to showcase the transformative impact of virtual rehearsal on cast-in-place construction methodologies, underlining its potential to enhance constructability, safety, and stakeholder engagement across a spectrum of construction projects.

Early Evaluation of Environmental Impacts by Coupling Architecture Models with LCA Tools

Stephane Lacrampe 1, Obeo, Comox, BC, Canada

Keywords: Sustainability,Life Cycle Assessment,System Architecture Design,MBSE,Environmental Impact Assessment

Type: Paperless Presentations
Category submitted: B.3. Modelling and Simulation Advances

This presentation showcases the outcomes of the EcoPlex R&D project (https://www.ecoplex.fr/index_en.html), focusing on a novel methodological approach and software solution that integrates life cycle assessment (LCA) with systems architecture design. The EcoPlex project aimed to develop a comprehensive framework for evaluating the environmental impacts of systems throughout their entire lifecycle.By enriching system models with detailed information such as component life expectancy, material usage, consumption rates, and emissions, it becomes possible to generate a comprehensive inventory of the environmental flows associated with the system. This inventory is then processed by LCA software to analyze and identify the system's ecological impacts from raw material extraction to end-of-life. Integrating system models with LCA analysis not only saves time by eliminating redundant data entry but also enables the rapid identification of components with the most significant ecological impacts, thanks to the fact that the data in the LCA tool follows the component structure of the system model. This facilitates quick modifications to the architecture model, promoting an iterative process for environmental optimization early in the development of the system.The presentation will illustrate these concepts and processes using a case study in the naval domain, specifically focusing on the Mobula 8 and Mobula 10 boats, which are designed to collect plastic waste from the oceans. We will demonstrate the application of the Ecodesign for Capella add-on and its integration with OpenLCA, an open-source LCA software, to highlight the practical benefits and efficiency of this integrated approach.

Survive the Swam! How modelling and simulation of emerging threats can reduce warship vulnerability.

David Knight 1, Josh Neill 2, QinetiQ Pty Ltd, Port Melbourne, VICTORIA, Australia, QinetiQ United Kingdom, Rosyth Aquarius Court

Keywords: T&E,Maritime

Type: Paperless Presentations
Category submitted: B.3. Modelling and Simulation Advances

Overview-Over the last decade, there has been an increased need to combat emerging threats that exploit military systems weaknesses, and accelerate the delivery of new and improved systems to the war fighter. By establishing the capability Digital Thread, which is the use of digital tools and software to maintain through life data/models of a system. Digital assurance methods such as modelling and simulation can support Test, Evaluation, Certification and System Assurance (TECSA) during the early stages of system design and requirement development. Context-Digitally enabled assurance, through modelling and simulation supports capability risk decisions throughout the capability development and systems engineering process. Through the use of QinetiQs Survive Software, ship survivability and venerability can be modelled to provide feedback to customer and influence platform and combat system designs. Purpose-The presentation will provide an overview of how modelling and simulation can support TESCA, and provide an example of a modelling and simulation event, using the Survive Software. Approach-The presentation will outline the outcomes of the Survive Software modelling and simulation scenarios for warship vulnerability against swarming uncrewed aerial vehicles using Survive Software. Insights-The presentation will outline how modelling and simulation supports TESCA, and how it provides opportunities to undertake T&E activities at early stages in the capability lifecycle. This can remove the requirement to undertake additional testing during transition into service phases and can improve the delivery of new capability to the war fighter.

Revolutionizing Digital Test and Evaluation: Harnessing Unreal Engine for Enhanced Simulation and Scalability

Andrew Fellows 1, QinetiQ, Mawson Lakes, SA, Australia

Keywords: digital test and evaluation,modelling and simulation,technical innovation

Type: Paperless Presentations
Category submitted: B.3. Modelling and Simulation Advances

Overview This work explores the application of Unreal Engine in the digital test and evaluation (DT&E) domain, highlighting its potential to revolutionize testing methodologies. Context The DT&E domain is undergoing significant transformation, driven by the need for more precise and efficient testing frameworks that can support the capture of objective quality evidence and augment traditional assurance activities. Traditional methods often fall short in terms of scalability and adaptability to complex scenarios and the ability to deliver with an accelerated timeline. Purpose The primary objective of this research is to assess how Unreal Engine can support emerging trends within the DT&E domain. The evaluation criteria was based around the idea that Unreal Engine's advanced simulation capabilities can significantly improve the realism and scalability of DT&E processes. The investigation aims to understand the practical benefits and potential limitations of integrating Unreal Engine into DT&E workflows. Approach The research adopted an Agile Methodology to deliver a Minimal Viable Product that could demonstrate the viability of integrating Unreal Engine into DT&E workflows. Simulations were created using Unreal Engine, replicating various DT&E scenarios. These simulations were evaluated based on their realism, scalability, and efficiency compared to traditional methods. Integration options were also explored to ascertain the viable use of higher fidelity models and information sources. Insights Key insights reveal that Unreal Engine significantly enhances the realism of DT&E simulations, providing an immersive and accurate testing environment. Additionally, its scalability allows for the efficient handling of complex scenarios, which is often a limitation of traditional methods. These findings suggest that integrating Unreal Engine into the digital T&E domain can lead to effective and reliable digital testing processes, supporting future trends and technical innovations that support an accelerated operational delivery of capability.

B.4. Simulation-based Learning & Serious Games

Simulation-based Learning & Serious Games: designs for the era of digital education and training. Innovative simulation-based learning designs and their outcomes became pivotal during the transfer to e-learning during the Covid-19 pandemic. Contributions to this stream are invited to share understanding the experiences and what works in forging simulation-based learning in the digital era in your field.

Lead: Chair/Leads: Amanda Davies, Jan Roche
Domains: Simulation, Education, Serious Games

B.5. Sociotechnical Systems

Sociotechnical systems. How do we adequately ensure that our SE programs are including the broad range of socio-technical concerns? Share your work around contemporary human systems integration challenges, including Digital Humans, Industry 4.0/5.0, AI/Autonomy, Digital Work Design and Ethics in HIS

Lead: Grace Kennedy
Domains: Human Systems Integration, All domains welcome

B.6. Systems of Systems Engineering Applications

System of Systems Engineering entails the application of systems engineering and systems thinking principals to systems that are both independent and interdependent, and present unique and complex challenges to stakeholders. This stream is for advances in System of Systems Engineering across all application domains, including defence, aerospace, cybersecurity, transport and infrastructure, and more.

Lead: Usman Khan
Domains: All domains welcome

B.7. Systems Thinking & Complex Systems

Systems Thinking & Complex Systems. This stream will cover elements of systems thinking within complex, dynamic systems. Submissions are welcome that explore the application of qualitative and quantitative systems thinking tools and techniques to deliver better insights and drive better decision-making in complex socio-technical systems.

Lead: Contact the Technical Committee if you can assist in Chairing this session
Domains: All domains welcome

Identifying Effective Tools for Risk Management of Complex Systems

Ben Luther 1, Indra Gunawan 2, Nam Nguyen 2, Nova Systems, Adelaide, SA, Australia, University of Adelaide, Adelaide, SA, Australia

Keywords: complex,system,risk management

Type: Full Paper
Category submitted: B.7. Systems Thinking & Complex Systems

Experimental flight test routinelymanages risk within complex socio-technical systems. The flight test system already encompasses the crew, sothe potential catastrophic consequencespreclude typical mitigations of robustness and resilience. This leaves flight test professionals to manage risk using a framework of tools that is guided by cultural lore. Observation of the professional flight test community identified that their approach to managing risk in complex systems was unique. Yet with a few notable, tragic exceptions, their approach was clearly effective in circumstances that would otherwise be fatal. Ethnographic research into this flight test risk management framework identified a combination of statistical and non-statistical tools in use, in parallel. They always had both at hand, though the flight test crews did not have knowledge of why different tools were effective. Their blanket approach assured effectiveness at the expense of efficiency. Research identified that there is no grand theory of risk and that risk management is grounded in economic theory. Examination of economic theory finds that Friedman's Utility Theory and Probability Theory are being read across, though the context is not being maintained. For complexity, alternative theory from Knight and Keynes is being used by the flight test community in their adoption of non-statistical approaches that accept uncertainty rather than assign a subjective probability. Complicated systems respond to statistical approaches, though complexity denies these same tools. Complex systems require risk management approaches that accommodate emergence, dynamic configurations and non-deterministic system performance. An understanding of why the flight test risk management framework is effective provides a case study for the wider industry dealing with complex systems to emulate.

Beyond Solving the problem right

Varun Prakash 1, Nam Huynh 1, Jacobs CMS, Melbourne

Keywords: Systems thinking,Requirements Engineering,Problem Definition,Technical Debt

Type: Full Paper
Category submitted: B.7. Systems Thinking & Complex Systems

In complex systems engineering projects, solving the right problem is imperative to ensure that the solution addresses the root cause rather than treat the symptoms, which often result in the creation of technical debt. By focussing on the right problem, we can develop solutions that are effective, efficient and resilient in the long run, resulting in a sustainable solution, thereby creating opportunity for innovation. Project technical problems are not independent of each other and are often masked by inter-related technical issues making the identification of the right problem highly challenging. In this paper, we explore how we can identify the right problem for a specific project phase and scenario by asking the right questions leading to root cause identification. We also emphasise the importance of event-driven approach in the validation of engineering progress by gathering and analysing relevant data as well as continuous implementation of lessons learnt to minimise the risk of technical debt.

Setting up for Successful System Integration in Large Scale Projects

Jon Lancaster 1, Dave Healing 1, Mott MacDonald, Melbourne, VIC, Australia

Keywords: Complex Systems,Systems Integration,Role of the Integrator,Operational Integration

Type: Full Paper
Category submitted: B.7. Systems Thinking & Complex Systems

Overview The integrator, responsible for orchestrating the coming together of the entire system and its incorporation into the operational environment, must understand the holistic process from concept to disposal or upgrade.This paper provides some guidance to integrators for managing integration, and for delivery authorities in shaping the integration functions and teams on large complex engineering projects. Context Systems Integration plays a pivotal role in getting a project into service, ensuring seamless coordination among technical and operational elements of the system.Lessons learned from past projects frequently cite the lack of up-front integration work as a key cause of the project's troubles. Purpose This paper explores the significance of holistic integration and owning the whole, emphasising that problems often arise during the integration phase due to issues originating in earlier stages of developmentand most importantly how to avoid them. Approach Holistic Approach: Define integration across the lifecycle from concept to disposal, and frame it within the context of a wider capability uplift. Identify Common integration challenges: Highlight common challenges faced during integration,both technical, and human/organisational. Role of the Integrator: Define the role and qualities of a good integrator. Insights This paper underscores the need for proactive integration planning, emphasising the interconnectedness of people, processes, and infrastructure within engineering projects,and provides guidance on the qualities of the people on these essential roles.

Soft Systems Methodology - Another Layer to the 'V'?

Simon Hutton 1, JOHN HOLLAND GROUP, MELBOURNE, VIC, Australia

Keywords: Soft Systems Methodology,Systems Thinking,Systems Lifecycle,Requirements Definition

Type: Paperless Presentations
Category submitted: B.7. Systems Thinking & Complex Systems

Our minds solve problems by applying frameworks of ideas, concepts and methods to areas of interest. Clearly defined situations allow the re-use of themes and structured methods to progressively decompose, analyse, define and integrate systems as solutions. Systems engineering as a methodology is a structured framework typified by the familiar V lifecycle. However, socio-technical situations are complicated by unpredictable human responses, conflicting objectives, interdependencies and perceptions. These soft or wicked problems can be difficult to resolve without an understanding of the problem situation and viable improvements that may not be limited to a technical solution. Soft systems thinking methodologies evolved to encourage a holistic approach to exploring unstructured, complex problems and improve the integration of technology in society. Examples include ETHICS (Mumford), Multiview (Avison and Wood-Harper) and Soft Systems Methodology (Checkland). An early version of the latter is a seven-stage model, and SSM has evolved into a framework for exploration based on interacting logical and cultural streams of analysis. Irrespective of Checklands observation that only neophytes apply SSM as a seven-stage process it does provide a mosaic of activities suited to exploring the interplay between society and systems. This presentation describes the application of Soft Systems Methodology to understand complex socio-technical problem situations and identify improvements. In the spirit of Checklands action research approach the presentation uses research into a Marine Safety System to illustrate SSM in a real-world environment. Excursions into other methodologies including Information Systems Methodology (Wilson) and Socio-Technical Stages of Growth (Galliers) are introduced to illustrate the derivation of socio-technical requirements from the problem situation analysis. The findings are used to summarise the benefits of a soft systems thinking approach to understanding the problem situation and viable improvements alongside a structured system-based methodology, proposing another layer to the V lifecycle.

Assessing the practical implications of new developments within systems engineering practise on novel aircraft.

Edward Burnham 1, Alauda Aeronautics, Beverley, SA, Australia

Keywords: Aerospace,Hydrogen,Electric,Complex Systems

Type: Paperless Presentations
Category submitted: B.7. Systems Thinking & Complex Systems

Overview Novel aircraft and their systems have largely been developed with systems engineering practices that have had to be adapted to account for their novel nature. However, the last 12 months has seen the publication of updated guideline for aerospace systems engineering that may go some way to amend this issue. Namely; ARP4754B, ARP4761A and the INCOSE Systems Engineering Handbook. This presentation shares an industry-focussed analysis on the implications on these updates for complex and novel system-of-systems. Context The aerospace industry is well known to rely heavily on prescriptive certification standards to ensure airworthiness, and whilst systems engineering guidelines are not required, they are referenced significantly as an acceptable means of compliance, especially as evidence for design assurance. The advent of novel technologies such as hydrogen, batteries, UAVs and eVTOLs has led to a significant shift in the way airworthiness is being approached. Purpose The purpose is to analyse ongoing industry projects, a hydrogen fuel-cell powered aircraft and specialist-use manned eVTOL system and how the adoption of these guidelines may have impacted them from a systems engineering perspective. One area that is of interest in particular is the promotion of MBSE within ARP4754A and how this affects novel aircraft development. Approach The implications will be analysed in the context of 3 novel applications and the first-hand experience gained in their development. This evidence will be presented against a theoretical application of these standards against these completed projects and how this may impact future novel applications in aerospace contexts. Insights The new guidance material leaves less ambiguity for systems engineering in novel aerospace contexts The new guidance goes someway to aiding allowing MBSE as formal certification evidence in novel contexts The new guidelines may provide less ambiguity for certifying authorities of novel aerospace vehicles.

A Systemic Emergent Perspective of the UN SDG's

Jawahar Bhalla 1, Shoal Group / University of Adelaide, Harrington Park, NSW, Australia

Keywords: Systemic Approaches,Systems Thinking,Emergence,Human-Centric

Type: Paperless Presentations
Category submitted: B.7. Systems Thinking & Complex Systems

The United Nations Sustainable Development Goals (UN-SDGs) are a set of 17 interconnected goals that were adopted by all UN Member States in September 2015 as part of the 2030 Agenda for Sustainable Development.The SDG's cover a broad spectrum of issues, spanning poverty, hunger, health, education, gender equality, clean water, sanitation, affordable and clean energy, decent work, industry and innovation, reduced inequalities, sustainable cities, responsible consumption and production, climate action, life below water, life on land, peace, justice, and strong institutions, and partnerships for the goals. The SDGs were designed to guide international efforts towards a more sustainable and equitable future, with the intent of providing a universal framework for countries, organisations and individuals to work together towards addressing these global challenges.Given the complexity and interconnectedness of these global challenges, it is clear that they require a coordinated, comprehensive, and perhaps most importantly, a systemic approach. Symptomatic quick-fixes may well achieve specific goals in the short term, but only further exasperate the situation in the longer term.This presentation will consider the UN-SDG's from a systemic perspective, highlighting the complex and interconnected nature of the challenges, and suggesting a naturally emergent human-centred approach may well lead most efficiently and effectively towards their attainment.

B.8. Tailoring: frameworks and applications

Tailoring: effective frameworks and applications. This stream will explore tailoring Systems Engineering processes and case studies for tailoring on projects. Submissions are invited to explore frameworks, key criteria, decision points and software tools that enable good tailoring decisions in early projects phases, and case studies from various domains where tailoring has worked in practice.

Lead: Aaron Miles, Lauren Fraser, Tilo Franz, Alexandra Morey, Erica Barrett
Domains: All domains welcome

Aligning Strategy, Research, and System Development, Leveraging Model-Based Systems Engineering Techniques

Photi Karagiannis 1, Matthew Wylie 1, Tommie Liddy 1, Shoal Group, Adelaide

Keywords: MBSE,Tailoring,Research,Prototype

Type: Full Paper
Category submitted: B.8. Tailoring: frameworks and applications

Research groups are challenged with ensuring that their activities are appropriately aligned to evolving strategic intent. This paper aims to address that challenge by describing a systematic approach, using Model-Based System Engineering (MBSE) techniques, to bridge the gap between strategic intent and exploratory research activities such as Modelling and Simulation, and experimental prototyping. As strategic intent evolves, so too should the research activities. However, it is often the case that as strategic intent evolves, areas of research become unaligned. Further, there exists updated strategic intent that is not supported by research or technology development activities. To maintain alignment with strategic intent, this paper proposes an approach leveraging model-based systems engineering (MBSE) techniques. To demonstrate the approach, this paper presents a case study where a descriptive model was developed within CATIA Magic to: capture the structure and activities of a research group; link the elements of that groups research program with strategic intent; and, trace the strategic intent to exploratory prototyping conducted by the research group. The model was then used to capture operational-level analysis and subsequent system need derivation. The intent of this was to provide a more robust trace from strategic intent through to technology development by allowing development efforts, such as producing prototype systems, to be driven by operational analysis. The results from gathered from experimentation could then be used to further refine system needs and inform future prototyping/development activities. In doing so, experimental prototyping was more aligned to operational analysis and hence strategic intent throughout the entire research program duration.

Integrating Model and Simulation Based Testing with Virtualisation for Humanitarian Assistance and Disaster Relief

Ryan Messina 1, CASG, LC4S, Melbourne, Victoria, Australia

Keywords: modelling and simulation advances,future of systems engineering,cyber-physical systems,Systems of Systems Engineering Applications,digital twins

Type: Full Paper
Category submitted: B.8. Tailoring: frameworks and applications

This paper explores innovative testing methodologies tailored for complex software and cyber-physical systems in Humanitarian Assistance and Disaster Relief (HADR) environments for search and rescue operations. By integrating model and simulation based testing with virtualisation, we develop scalable testing frameworks customised to HADR application requirements. Virtualisation enables simulation of scenarios, facilitating thorough testing without operational disruptions. A key focus is on the comprehensive evaluation of Systems of Systems (SoS) behavior to identify integration issues and performance bottlenecks early in the development lifecycle. Simulated interactions between system components reveal vulnerabilities, consequently enhancing system reliability and resilience. Our approach emphasises continuous testing and validation throughout the system lifecycle. Leveraging digital twins and cyber-physical models, we ensure adaptability to evolving requirements and operational conditions. This iterative process enhances system robustness and responsiveness to dynamic HADR environments for search and rescue operations. This approach, employed in testing the lifecycle of complex software and cyber-physical systems, aims to generate reliable test cases, ensure systems adapt to changes observed in prior tests and uphold mission resilience by prioritising performance. It involves creating a surrogate model of a search and rescue mission, identifying failure modes to use as test cases and evaluating them through sensitivity analysis. The final sequence of test cases, relying on more expensive testing, is prioritised based on its impact on the search and rescue mission surrogate model. This paper provides insights into innovative advancements shaping the future of testing methodologies for systems used in HADR and search and rescue operations. The focus is on enhancing the reliability, resilience, and responsiveness of testing complex software and cyber-physical systems.

The Case for Employing MBSE in Early-Stage R&D Projects using Agile Development Approaches

Stephen Cook 1, Shoal Group Pty Ltd and the University of Adelaide, Adelaide, SA, Australia

Keywords: MBSE,Early-Stage R&D,Agile

Type: Full Paper
Category submitted: B.8. Tailoring: frameworks and applications

The case for using Model-Based Systems Engineering (MBSE) in large, complex projects is now well established and many sources are available from which a system engineer can make a case to project stakeholders for its inclusion. In contrast, there is much less available material to justify the use of MBSE in Early-Stage Research and Development (ESR&D) projects that are intending to use agile development methodologies. This paper addresses this deficiency by reviewing information from standards, handbooks, and research papers and tempering this with experience to assemble a compelling case targeted at audiences unfamiliar with contemporary industry systems engineering practices, such as those in small start-up companies, research laboratories, and universities. The review is followed by a discussion on the relevant nuances from contemporary thinking on systems engineering, digital engineering, and agile approaches for product development that further reinforces the business case developed from the review material.

Operational Readiness Roadmaps: A Cross-Industry Approach

Monica Dryden 1, Sean Squire 1, Mott MacDonald, Melbourne, VIC, Australia

Keywords: Operational Readiness,operations,Rail,Bus

Type: Full Paper
Category submitted: B.8. Tailoring: frameworks and applications

Operational readiness is term familiar in transport projects what are the things that need to be in place to ensure an organisations preparedness prior to accepting finished projects and transitioning operations. It often constitutes a significant yet underestimated aspect of project delivery. While the focus typically centres on the delivery of physical infrastructure and systems, a critical gap emerges during the transition from the completion of project delivery to placing the system into service. This challenge is further compounded when projects introduce new, novel, and/or complex systems into service and into their scope such as novel technologies, new operating environments and/or complex organisational change. This paper explores techniques and processes that can be adopted to facilitate a more efficient and effective journey to operational readiness. Drawing from case studies across various transport modes, it is discussed how these practices can be adapted and scaled to meet diverse operational requirements, irrespective of industry. By providing a detailed understanding of the necessary activities, this paper aims to bridge the gap in project preparedness during early delivery phases. Additionally, it presents examples of operational readiness delivery processes, highlighting their application in rail and bus projects within Australia and how these can also be adopted in other industries like Defence and Health.

Cost-Effective Systems Engineering: Exploration of tools for Systems Engineers on a budget.

Parth Thakur 1, Ediom, Melbourne, VICTORIA, Australia

Keywords: practical systems engineering,cost effective tool,Small scale systems engineering

Type: Full Paper
Category submitted: B.8. Tailoring: frameworks and applications

Overview This paper explores the feasibility of using cost-effective tools like DevOps and Jira for systems engineering tasks traditionally done on expensive tools such as DOORS or Relatics. This presentation would be of interest to people/businesses that work on small-medium size projects looking for a cost-efficient way to manage system lifecycle. Context Life cycle model approach is a Systems engineering framework that can help successful realisation of a system. Tools like DOORS and Relatics help engineers develop a system using the life cycle (V) model approach. However, the costliness of tools can pose as a potential barrier to effective systems engineering practices. In contrast, DevOps and Jira, tools widely used in the software development and IT industries, offer cost-effective alternatives with features comparable to DOORS or Relatics for certain situations. We know that DOORS and Relatics is not cost-effective for small-medium projects. Purpose The purpose of this paperis to provide insight on how inexpensive tools can provide a viable alternative and prevent cost from being a barrier to preforming good systems engineering practices. The paper will provide potential processes, templates and use cases that can be used to maximise the benefit of the cost-effective tools. We are trying to show that tools like DevOps and Jira can help make systems engineering more prominent byremoving the cost barrier as well as how to best use these tools. Approach The paper will simulate a project and showcase how the v-model approach can be achieved using one of the cost-effective tools. The presentation will go through a project life cycle and show how to best usethe cost-effective tool. Insights This paper aims to inform readers that there are alternative options available to DOORS and Relatics that may be more cost-effective, that are notExcel and Word.

Fearless Tailoring: The Art of Knowing When Good Enough is Good Enough

Brayden Donohue 1, Sanjev Naidu 1, Systra ANZ, Melbourne, VICTORIA, Australia

Keywords: Tailoring,Digital Transformation,Over-Engineering,Engineering Perfection,Good Enough

Type: Panels and Workshops
Category submitted: B.8. Tailoring: frameworks and applications

Format Facilitated group discussion exploring the "good enough" engineering principle. Overview In an era of rapid digital transformation, Systems Engineering grapples with a critical challenge: leveraging the potential of modern tools and processes while side-stepping the crippling effects of over-engineering. Addressing this challenge is becoming urgent. Despite the availability of modern innovations designed to streamline the engineering process like Model-Based Systems Engineering (MBSE) and AI-driven requirements generation projects are still grinding to a halt under the burden of excessive, inflexible and poorly tailored engineering approaches. Tackling this challenge demands a shift in mindset a departure from the relentless pursuit of engineering perfection, the inability to accept appropriate levels of risk, and the often-unyielding adherence to arbitrary engineering standards. It requires the uncomfortable acceptance that good enough is good enough. This workshop will explore how the good enough concept, when embedded as a core principle within our engineering approaches, can lead us out of the over-engineering trap, and unlock the full potential of our existing, and future, digital toolsets. Opportunity for interaction Participants will engage in a facilitated discussion exploring their experiences with over-engineering and the good-enough engineering approach. Line-up Brayden Donohue Sanjev Naidu Length 60

One drop at a time

Sofia Chouli 1, Jenny Lancaster 2, Alexander Mackie 2, SA Water, Adelaide, South Australia, Australia, Aurecon, Docklands, VICTORIA, Australia

Keywords: water,utilities,tailoring,process improvement,project delivery

Type: Paperless Presentations
Category submitted: B.8. Tailoring: frameworks and applications

Overview - SA Water identified the implementation of Systems Engineering (SE) as a key opportunity for process improvement, and engaged Aurecon to create a tailored methodology for the delivery of capital projects. Context - SA Water began reviewing the feasibility of implementing SE in 2021. This review identified that project delivery was siloed, with limited information flows and reliant on the knowledge of senior personnel to progress. As a result, projects suffered from scope creep or late changes, subsequent cost variations, and a lack of traceability to the original project aims and needs. Purpose - SA Water asked Aurecon to apply their SE knowledge to review existing processes for investigating high-level concept solutions; ensure that project selection is evidence-based; investigate options that consider and address all stakeholder needs; respect inputs from all stages of the project lifecycle; and enable data-driven decision-making. Approach - Aurecon conducted interviews and workshops with representatives from all teams and levels throughout SA Water to consolidate a list of issues experienced when delivering projects. From this, a bespoke SE approach was tailored to the organisational level of understanding to meet people where they are - introducing concepts that would deliver maximum value for limited effort, rather than just directing people to the SE body of knowledge. It started small, with a reduced set of activities to help the realisation of project needs, developing these into verifiable requirements for the project to meet, and managing interfaces and stakeholder expectations across the developing network. This has grown over the course of the engagement into a fully-fledged V-model, providing customised guidance and tailored approaches for SA Water. Insights - This work provided insights in how to collaborate with an organisation that was relatively new to the concept but welcomed engagement and change in the space.

B.9. Test & Evaluation of Systems of Systems

Test & Evaluation of Systems of Systems in all Domains. This stream welcomes submissions dealing with novel or noteworthy approaches to experimentation or testing at the systems, and systems of system level, and noteworthy instances of test programs employing more classical approaches. Model based approaches are especially welcome.

Lead: Tim Grabert, Robert Bunton
Domains: Test & Evaluation, All domains welcome

C.1. Artificial Intelligence and Machine Learning

Artificial Intelligence , Machine Learning and SE processes. Projects involving machine learning, or more broadly AI are becoming ubiquitous. Lifecycle models have been developed specifically for "Data Science" projects. This stream invites presentations on what can we learn from Systems Engineering to applications and lead to successful AI projects.

Lead: Andrew Madry, Jawahar Bhalla
Domains: Digital Engineering, All domains welcome

Scalable AI-Based Chiller Optimization System for Enhanced Energy Performance

Vincent WL CHIU 1, Tommy KC LAM 1, Ray WH LAM 1, Safiya WK YU 1, Charlie CH LO 1, Jenny TY IP 1, Electrical and Mechanical Services Department, Hong Kong

Keywords: Artificial Intelligence,Neural Networks,Air-conditioning,Genetic Algorithm,Evolutionary Computation

Type: Full Paper
Category submitted: C.1. Artificial Intelligence and Machine Learning

Overview Chiller plants in buildings consume the greatest electrical power in Air-conditioning system, playing a pivotal role in our journey towards carbon neutrality. Chiller plants have conventionally been controlled using traditional rule-based strategies, resulting in energy inefficiency and limiting system adaptability to environmental changes. This paper reveals the success of implementing Artificial Intelligence-based model for large-scale real-time monitoring and control of chiller plant which seizes every opportunity to enhance building energy performance. Context With the introduction of modern high-efficiency chillers and a central Regional Digital Control Centre, there is an opportunity to implement control strategies to achieve energy saving by varying Coefficient of Performance under different part-load and ambient weather conditions. To acquire optimized chiller parameters, there were past trials using Genetic Algorithm (GA), Particle Swarm Optimisation (PSO), or combination of both in achieving optimisation of engineering systems. Purpose This study aims to develop a scalable system, code-named ChillStream, based on the novelty in Artificial Intelligence (AI) chiller optimisation. Artificial Neural Networks were trained using historical plant data and weather data to predict power consumption and cooling load for individual chillers. In an attempt to combine the merits of evolutionary algorithm and swarm intelligence, a hybrid GA-PSO Algorithm was developed to calculate optimised setpoints at regular time intervals. Approach The developed AI control strategy was successfully deployed in a chiller plant with a significant cooling capacity installed in a clinical laboratory building in Hong Kong. Compared to the conventional rule-based system control, the chiller plants overall energy consumption was prominently reduced by 8% in autumn/winter 2023. Insights Through the autonomy of ChillStream to operate the chiller plant, considerable manpower resources are saved. This optimisation control strategy can be readily replicated and adjusted to accommodate the unique configurations of chiller plants in various buildings, resulting in substantial energy savings.

Application of Large Language Model - requirement management and system assurance on major infrastructure projects

Henry Wu 1, Eric Yang 1, JYW Consulting, Sydney, NSW, Australia

Keywords:

Type: Panels and Workshops
Category submitted: C.1. Artificial Intelligence and Machine Learning

A key challenge of major infrastructure delivery is the sheer volume of requirements that resides across multiple contract documentation, scope of works technical criteria, guidelines, standards, specifications and drawings. A lot of these requirements are project, proponent and/or jurisdictional specific. As an example North East Link (NEL) requirements covers multiple asset owners: VicTrack, Department of Justice and Community Services (DJCS), Department of Transport and Planning(DTP); and NEL Central Package (Spark Consortium); and State Tollroad Corporation (STC) With advancement in cloud infrastructure and Artificial Intelligence (AI) cost effective Large Language Model (LLM) services are now readily available in the market e.g. Open AI, Google, Microsoft, Facebook, Amazon. This workshop provides the target audience a hands on guide to how to apply different availableLLM as "co-pilot for system assurance/requirement management activities. This workshop will use current transport infrastructure examples to illustrate the pros and cons(key limitations) against various system assurance use cases. The workshop will conclude with targeted "hands on" LLM tutorial enabling participant toexperience the LLM on an example set ofpre-canned system assurance scenarios and get insight on how this can benefit their day to day SE&A activities.

Binary classification of mine-like-objects within side scan sonar images using deep learning algorithms.

Anto Chacko 1, Tim Grabert 2 3, Nova Systems, Taigum, QUEENSLAND, Australia, Test and Evaluation, Nova Systems, Melbourne, Victoria, Australia, Test and Evaluation, International Test and Evaluation Association (ITEA), Melbourne, Victoria, Australia

Keywords:

Type: Paperless Presentations
Category submitted: C.1. Artificial Intelligence and Machine Learning

The interpretation of imagery produced by autonomous underwater vehicle side scanning sonar system used for locating anti-shipping mines is a crucial operation for naval safety. Deep learning algorithms have shown potential to identify mine like objects within sonar imagery at a rapid pace with consistent results and with minimal human operator interaction. Traditional methods involved the technical operator manually scanning through a large dataset of sonar imagery. Increasingly, the Navy are looking to employ autonomous underwater vehicles fitted with side scanning sonar to perform remote sensing in the search for mines. The fact that side scanning sonar imagery is not available for inspection by the operators until after the mission has concluded and the vehicle has returned, add to onerous nature of this task. The purpose of this exercise was to perform a binary classification task to classify images as either containing a mine like object or not. Are deep learning algorithms more efficient at analysing sonar images and what are the limitations facing these algorithms now. The Convolution Neural Network model would be trained using sonar images that either contain a mine like object or none, the model would then be evaluated on its ability to classify images with mine like objects within a separate dataset. The results were then compared with a real-world operator attempting to manually complete the same task. Within the scope of testing conducted, the Convolution Neural Network tended to be more liberal in its classifications, as it displayed a higher false positive rate in comparison to the human classifier. Overall, the Convolution Neural Network showed good potential for operational use. Predictably, the performance of the Convolution Neural Network appeared to improve as the quality and quantity of training images increased.

A Framework for the Assurance of Simulated Environments Supporting Assurance Certification of Autonomous Systems

Jawahar Bhalla 1, Stephen C Cook 1 2, David J Harvey 3, Shoal Group / University of Adelaide, Harrington Park, NSW, Australia, School of Electrical & Mechanical Engineering, University of Adelaide, Adelaide, SA, Australia, School of Electrical & Mechanical Engineering, Uni of Adelaide, Adelaide, SA, Australia

Keywords: Autonomous Systems,Verification Validation and Accreditation,AI/ML,Modelling and Simulation,AS4AI

Type: Full Paper
Category submitted: C.2. Autonomy

The burgeoning adoption of Robotic and Autonomous Systems with Artificial Intelligence (RAS-AI) necessitates standardized approaches for Systems Engineering of AI-intensive systems (SE4AI) and Assurance of AI-intensive systems (As4AI). There is an increasing recognition of the need to employ simulated environments in an As4AI context, which in turn necessitates standardized approaches for the Systems Engineering of simulated environments (SE4SimE) and Assurance of Simulated Environments (As4SimE). This paper outlines a conceptual framework and methodology for the assurance of simulated environments (As4SimE) used in the assurance certification of (maritime) autonomous systems. It does this by first contextualizing As4AI in a (maritime) autonomous systems context, to highlight the need for simulated environments, and in the need for an associated As4SimE framework. This is followed by a literature and market review to identify enabling concepts and to identify gaps in available assurance capabilities. The core of the paper builds on these concepts to propose a generic As4SimE framework that can encapsulate all the aspects necessary for the certification of a simulated environment that may be employed to demonstrate compliance against a specific set of regulatory requirements in an As4AI context, supporting the conduct of a set of selected operational scenarios.The primary outcome from this As4SimE activity is a Certified Simulated Environment (C-SimE) that can then be selected (from a list of C-SimEs) to form a MAS Assurance Plan (MAP), that through the conduct of supported scenarios, in associated C-SimEs, collectively enable a compliance demonstration activity for a specific autonomous system. This includes associated processes, tools, techniques, and curation of reference technical data and assurance reports. The paper concludes with a summary and suggestions for future research.

C.2. Autonomy

Autonomy: engineering the right autonomy right. This stream invites presentations with a focus on innovation in the SE of AI-Intensive systems. Submissions should explore how traditional methodologies and frameworks will need to morph to build the autonomous system right and to build the right autonomous system in an evolutionary life-of-type context.

Lead: Jawahar Bhalla
Domains: Digital Engineering, All domains welcome

C.3. Capability Engineering for Industry 4.0

Capability Engineering for Industry 4.0. This stream invites submissions exploring how the application of Systems Engineering to Defence projects might need to evolve with CASG 2.0 aims to align the way Defence capabilities are acquired and sustained with the objectives, technologies, processes and tools used by Defence Industry to deliver those capabilities as part of Industry 4.0, also called the Fourth Industrial Revolution.

Lead: Marco Meloni
Domains: Defence

C.4. Data Science in Systems Engineering

Data Science in Systems Engineering. Modern capabilities are packed with sensors powering data-driven intelligence. What are the opportunities, challenges and achieved successes for systems engineering as a disciplined process to embrace big data? Furthermore, submissions in this stream should explore data science driven decision making within Systems Engineering and how data led insights lead to continuous improvement, lower risk, safer outcomes and competitive advantage.

Lead: Erica Barrett, Varun Prakash
Domains: All domains welcome

C.5. Digital Transformations

Digital Transformations. This stream invites submissions from all domains that explore efforts to transform systems engineering towards digital engineering, including the adoption and/or adaptation of digital practices, methods, applications & tools; the digitalisation of existing products/systems/solutions, and; emergent digital products/systems/solutions & corresponding challenges (eg safety assurance, end user skills, etc)

Lead: Kerry Lunney, Thomas Manley
Domains: All domains welcome

Modular image recognition on the edge and digital twin: A case study in accessibility auditing

Nick Pickering 1, Tim Young 2, Thomas Carnahan 3, University of Waikato, Hamilton, Waikato, New Zealand, Smart Access, Hamilton, Waikato, New Zealand, Pollin8 Ltd, Cambridge, Waikato, New Zealand

Keywords: Digital Twin,Image Recognition,System of Systems,Smart Cities,Accessibility auditing

Type: Full Paper
Category submitted: B.6. Systems of Systems Engineering Applications

Currently, disabled people and older people cannotplan a safe journeyaround ourbuilt environment and transport hubs.Smart Access has a solution based on accessibility audits covering 38 features. The solution, available online or via mobile, provides geospatial information thatsupportssound decision-making for commuters andcouncil planners. The manual data capture of featuresempowers people with impairments toengage moreinthe community but is labour-intensive and not scalable. Custom development of high-accuracynavigation and image recognition systemson the edgearenot typically financially viablein manysocial and environmental applications. This is especially true in scenarios where system utilisation is low, supply chain costsfor highavailability are high and the recruitment and retention of a widespectrumof human capability ischallenging. This paper undertakes thedesign, implementation and evaluation ofmodular edge units that can perform common high-accuracy navigation, sensor fused with image recognition on the edge, communicated over a common data standard into a reusable digital twin for affordabilityof research, development and operation. The resultsdemonstrate the benefit ofa modularHardware As A Service (HaaS)andSoftware As A Service (SaaS) modelto break down the traditional barriers associated withthe adoption of industry 4.0 solutions, with thecapabilitybeing leveraged acrossnumerousapplications ranging from traffic counting and on-truck recycling audits in smart cities, to autonomousground vehicles, human-assisted robotic harvesting and fruit condition monitoring in horticulture. Future work will focusonexpanding the data capture to enhance the reliability of neural network artificial intelligence models for existing use case validation, expand use cases across other domains andperformSystem of Systems modelling to validate the financial viability, incorporating the life cycle costassociated withhuman capability, spares holding, availability andutilisation to optimise emergent properties.

Is the Journey to the End of the Rainbow a Minimal Viable Capability (MVC)?

Kerry Lunney 1, Thales Australia, Sydney, NSW, Australia

Keywords: minimal viable capability (MVC),digital transformation,agile,systems of systems (SoS),complexity

Type: Paperless Presentations
Category submitted: C.3. Capability Engineering for Industry 4.0

Overview - With the growing interwoven dynamics of the world, speed to deployment is becoming more crucial. However, we often strive to deliver a perfect solution, sometimes warranted, sometimes not, potentially leading to cost and/or schedule overruns, and the introduction, or the appearance of poor quality systems at initial deployment. Adopting a Minimal Viable Capability (MVC) addresses this challenge, or does it? To understand the complexities for realising a successful MVC a number of interacting factors will be presented. Context - A MVC approach supports the delivery of needed capability as soon as possible with further capabilities being incrementally incorporated. It is not however just about "descoping a project". MVC requires a lot of change and flexibility both in acquisition and sustainment. Development lifecycles, contracting models, operational scenarios, mission threads, agility, to name a few, all require to be modified under MVC. These impacts are often not understood resulting in sub-optimum MVC deliveries. Purpose - To avoid/minimise the same problems preventing successful delivery of needed capability under a MVC, a holistic view must be taken. From this viewpoint,impacts of delivering MVCon development lifecycles, checkpoints, tailoring of practices, framework and tools, and technology evolutions must be addressed. Likewise, the importance of model-based engineering approaches increases. Underpinning these factors is being agile, particularly if speed to deployment is critical. This presentation provides the necessaryguidance to deliver a MVC. Approach - A combination of government-industry discussions, workshops, and industry experience with real life examples are used to illustrate this topic. The adaptations identified in this presentation can be readily applied to both the acquirer and supplier. Insights - The takeaways for participants are 1) understanding the value of MVC; 2) recognising the blockers; 3) steps needed to successfully adopt a MVC approach.

Practical Approach to Generation Site Using Digital Transformation Technology for Data Driven Monitoring

Ahmad Taufiq AT Abdullah Thani 1, Origin Energy, Spring Mountain, QLD, Australia

Keywords: IIOT,Digital Transformation,Smart Grid,SCADA

Type: Full Paper
Category submitted: C.5. Digital Transformations

The increase in available digital transformation technologies and applications has introduced new methods for intelligent asset monitoring and real-time data collection. This has led to digitalization in energy industries using Industrial Internet of Things (IIoT) which will improve intelligent asset monitoring through real-time models with more emphasis on communications, modern protocols, and Artificial intelligence (AI) as the underlying requirements. Traditionally, generation sites have been slow adopters in implementing digital transformation technologies. Thispresentation will look at how a traditional generation site has attempted to use digital transformation technology for data driven monitoring. The presentation will also look at how the generation site has addressed different issues associated with adopting digital transformation technologies, specifically evaluation criteria for IoT devices, interoperability and different architectures implemented on site. Thepresentation will alsoshow a completed end to end example of a practical install on a generation site.

Digital Engineering Illustrated: Moving beyond Lofty Promises and Acronym Soup to Understanding and Value

David Long 1, Blue Holon, Blacksburg, VIRGINIA, United States

Keywords: Digital Engineering,MBSE,Digital Thread,Digital Twin

Type: Tutorials
Category submitted: C.5. Digital Transformations

Format The tutorial is conducted in classroom format using PowerPoint slides with discussion throughout to improve learning and comprehension. Overview This tutorial explains and illustrates the foundations, concepts, and potential of digital engineering. We will move beyond the marketing, myth, and misconception to a practical understanding of what digital transformation means for systems engineering, the fundamentals we need to know, and the value we expect to achieve. After establishing the case for change and the opportunity represented by the power of digital, we will explore a connected set of models descriptive and analytic; mission, system, and detailed design to communicate the concepts, opportunities, and challenges of digital engineering. In the process, we will highlight the myriad of concepts (model-based systems engineering, digital thread, digital twin, digital engineering), how they interrelate, and what they mean for practitioners, their organizations, and the greater practice of engineering. Audience Participants should have a foundational understanding of systems engineering concepts. A basic understanding of MBSE concepts is beneficial but not required. Line-up David Long.

The A to Z for Implementing a Digital Transformation on a Systems Project

Kerry Lunney 1, Stephane Bonnet 2, Thales Australia, Sydney, NSW, Australia Thales Avionics, Bordeaux, France

Keywords: digital transformation,digital engineering,agile,systems thinking,capability

Type: Paperless Presentations
Category submitted: C.5. Digital Transformations

Overview - Digital Transformations (DT) continue to change our products, systems, services, and the way we work. Will we be ready for this future? To tackle the challenges we will present the "A to Z" guide for DT, including the digitalisation of SE practices. Context - In a global context, we will be moving towards model-based approaches, knowledge sharing will be exponentially increasing, digital technologies such as AI, autonomy and digital twinning will be incorporated into the various engineering disciplines as they better evolve to adjust to a dynamic world with increasing complexity. Collaborations and interactions will be paramount, largely through the management of the digital thread, enabled through the tools and environments of the digital ecosystem. To do this, the enterprise workforce will need to be diverse, agile, efficient, possibly distributed, and more strongly recognise knowledge as an asset. This level of transformation can be confusing, difficult to identify and even harder to implement. Purpose - To navigate a DT, guidance is required from behaviour adoption, technology evolutions,tonew/tailored practices and tools, balancing the need to change with the constraints of the enterprise. This guidance must be tailorable to apply to different system projects. Approach - A combination of workshops, and industry experience across multiple domains and countries with real life examples are used to illustrate this topic. Many of the guidance points will resonate with participants whether in industry, academia or government, as we all undertake a DT at some level in our enterprises. Insights - The takeaways for participants are 1) understanding of what is involved in a DT; 2) A to Z guide on DT, that is completely tailorable, to add to an engineer's toolkit; 3) mapping examples of the guide to 30 common SE practices.

Making requirements accessible, when you are tempted by spreadsheets but need an application.

Piotr PP Pytka 1, Andrew AP Pitsiakkos 1, KBR, Melbourne, VICTORIA, Australia

Keywords: Requirements Management Application,Verification and Validation automation,API based communication,Requirements Data Exchange Methodologies

Type: Paperless Presentations
Category submitted: C.5. Digital Transformations

Systems Engineers devote significant time to requirements management, which can detract attention from the valuable activity of requirements analysis. The issue stems from repetitive data exchange activity which requires systems engineers familiar with using requirements management tools such as IBMs DOORS NG to produce exports of requirements into excel for discipline engineers to action. This often results in reporting of stale data, and misinformation when managing requirements using spreadsheets. In order to solve this problem KBR looked at ways of digitally transforming the way discipline engineers interact with requirements managed by systems engineers. Learning to use specialist requirements management tools can be time consuming and an entry barrier for discipline engineers deployed onto Projects. We found that users were comfortable with the simplicity of spreadsheets but had no way of pushing verification and validation evidence directly into the database without knowing how to use the specialist tool. KBR have taken the simplicity of spreadsheets to present pertinent requirements in a format familiar to discipline engineers using a dedicated web application as an exchange to push verification and validation evidence data directly into the requirements management tool. This is achieved using IBM DOORS NG RESTful application programming interface (API) which is based on the Open Services for Lifecycle Collaboration (OSLC) standards. Integration proved to be quite challenging, not only in designing an intuitive user interface which streamlines efficiency and supports real time data interactions, but also how to make the application accessible by external users, as well as preserving user authoring permissions for historical audit purposes. The important lesson here is that digital transformation does not have to be complex, its the large volume simple repetitive tasks that we should be aiming to automate first, leveraging simple solutions for maximum gain, before embarking on elaborate complex automations.

Pathway to Success - Digital Engineering in Defence

Asha Mathew 1, Capability Acquisition and Sustainment Group (CASG), Director, Directorate of Digital Transformation and Systems, Adelaide, SA, Australia

Keywords: Digital Transformation,Digital Engineering,Defence,Digital Engineering Strategy

Type: Paperless Presentations
Category submitted: C.5. Digital Transformations

Placeholder for a potential talk on the "mission computing subsystem of the Block 2 Boxer, with its DDS approach, and how they simulate their digital solution in their software development environment".

Embracing AI in Digital Engineering: A Holistic Approach to Managing Work, Workforce and Workplace

Ren S King 1, Project Performance International, Lilydale, VIC, Australia

Keywords: fuse,future of systems engineering,AI,MBSE

Type: Panels and Workshops
Category submitted: D. Other

0

C.6. Education for Digital Natives

Education for Digital Natives. This session explores emerging issues in engineering education relevant to enticing digital natives into the systems engineering, testing, modelling and simulation workforce. Submissions are welcome that navigate topics such as the development of relevant content, improving diversity in STEM, industry-university partnerships, the research ecosystem, certification and life-long learning approaches.

Lead: Kumudu Amarawardhana, Sondoss el Sawah
Domains: Education and training, All domains welcome

Uses of simulation for assessment in VET

Elyssebeth Leigh 1, Katherin Coster 1, UTS, Sydney, NSW, Australia

Keywords: learning assessment,VET,simulation,teacher education

Type: Full Paper
Category submitted: B.1. Human systems

Overview Simulations are forms of social engineering often used in VET education contexts. However their use is not yet adequately supported by appropriate resources. Quality assessors have much to contribute to highlighting the significance of the gap and suggesting appropriate strategies for closing it. Context This research is being undertaken in the Australian VET sector with specific attention to documentation regarding assessment conditions for units of competence from Certificate 1 to Associate Degree. Purpose The purpose of this work is to identify what is available and what is needed to ensure that VET educators are provided with appropriately designed simulated environments and tools to adequately assess learning via their use. Approach Data collected from units of competence across VET sectors will be used to check that documentation employs terms such as - Skills in this unit must be demonstrated in a workplace or simulated environment where the conditions are typical of those in a working environment in this industry. A l two part literature search is being undertaken to identify - what is generally known about effective design and use of simulations in education what is available to VET educators about the use of simulations in their courses key stakeholders will be interviewed to provide guidance on the search and help with validating findings Analysis of the data collected will be summarised for presentation at the conference. Insights I have a recurring nightmare that someone will pop up and say youre wrong-look here it is! How did you miss that? At which moment I would with relief relinquish the torch Im carry and retire gracefully. I have not yet found evidence that could allow me to do so. This work will help identify what is needed to improve use of simulations in VET.

Enhancing Aeromedical and Tactical Combat Training using Mixed Reality Technology

Dale N Linegar 1, Ben I Krynski 1, Real Response, St Kilda, VIC, Australia

Keywords: Simulation,BlueRoom,Mixed Reality,Medical

Type: Paperless Presentations
Category submitted: B.4. Simulation-based Learning & Serious Games

BlueRoom is a revolutionary integration of mixed reality (MR) technology to revolutionise training methodologies for Aeromedical Evacuations (AE) and Tactical Combat Casualty Care (TCCC). This presentation explores how MR can significantly elevate the competency and preparedness of aeromedical professionals and flight crews. Our partnership with the Health Operational Conversion Unit (HOCU) at Royal Australian Air Force (RAAF) has led to the implementation of a BlueRoom simulator which creates immersive and realistic training environments. These simulations accurately replicate AE procedures and TCCC scenarios, allowing trainees to practice patient transport, in-flight medical interventions, and battlefield injury management under varied and challenging conditions. We emphasise the crucial role of trainers in MR simulations, providing them with control over every aspect of the scenario and enabling advanced debriefing and reporting. The MR technology facilitates hands-on training with medical and military equipment, simulating environments that are typically too expensive, dangerous, or logistically difficult for regular training. The presentation will also discuss the adaptability and scalability of MR platforms to meet RAAF's unique training needs, enhancing decision-making skills in a safe yet realistic setting. We will share insights into the challenges, successes, and future prospects of MR implementation within combat medical, aeromedical, and search and rescue domains, highlighting the transformative potential of MR technology.

Professionalising Mission Engineering in Australia: A Pilot Micro-Credentials Model

Kumudu Amarawardhana 1, Sondoss El Sawah 1, Ugur Turhan 1, Capability Systems Centre (CSC), UNSW Canberra, Campbell, ACT, Australia

Keywords: capability enhancement,industry adaptation,micro-credentials,mission engineering professionalisation

Type: Paperless Presentations
Category submitted: C.6. Education for Digital Natives

Australia faces complex global challenges that demand a resilient and integrated defence force capability. As these challenges continue to evolve and become more intricate by the day, it is imperative to simplify the processes involved in acquiring new capabilities. Additionally, it is vital to maintain the efficiency of the defence industry to strike a balance between capability acquisition and long-term sustainability. Moreover, modern systems are increasingly complex due to technological advancements, integration, and dynamic environments, posing challenges in understanding behaviour, predicting outcomes, and managing risks. Mission engineering (ME) provides a systematic approach to optimise system design, development, and operation, integrating technical, operational, and organisational aspects. Therefore, ME is crucial in accelerating capability development, extending its influence beyond defence to various sectors like health and manufacturing. It fosters innovation and efficiency in vital sectors, enhancing national resilience and competitiveness. Professionalising ME is vital for navigating these complexities, ensuring practitioners possess the skills and expertise to achieve desired outcomes effectively. Equipped with the skills to analyse evolving risks and develop innovative solutions, mission engineers ensure responsiveness to dynamic landscapes. UNSW Canberra introduced a stackable micro-credentials model in ME, comprising fundamental, intermediate, and advanced phases, which is a significant step towards professionalising the field in Australia. Co-designed with industry, this model not only demonstrates the gradual imparting of ME competency framework but also showcases the adaptability of ME competencies beyond defence, underscoring its relevance and importance. This presentation highlights UNSW Canberra's innovative strategy for addressing Australia's need for professionalised ME. Moreover, we demonstrate the models adaptability to different sectors' landscapes by tracing the evolution of ME concepts and competency frameworks across industry boundaries. Through this initiative, practitioners acquire the competence to navigate missions across various industries, signalling a new era of ME versatility with far-reaching implications in line with Australias needs.

On the use of modern technology and systems engineering to operationalise theory into practice

Sanath Darshana Kahagalage 1, Hasan Hseyin Turan 1, Sondoss El Sawah 1, Michael Shayne Gary 2, UNSW Canberra, Canberra, AUSTRALIAN CAPITAL TERRITORY, Australia, UNSW Business School, UNSW Sydney, Kensington, Australia

Keywords: Case study

Type: Paperless Presentations
Category submitted: C.6. Education for Digital Natives

This case study outlines a master's-level course in Systems Engineering. The course focuses on learning about model-based decision support frameworks and tools under conditions of deep uncertainty. Designed to equip students with essential tools for strategic decision-making in novel and uncertain situations, the course targets individuals interested in addressing decision problems within contexts of deep uncertainty. It utilizes a System Dynamics (SD) workforce simulation model, developed from a real-life case study, alongside the Exploratory Modelling and Analysis (EMA) Workbench.The course structure emphasizes the development of students' abilities to formulate decision problems and analyse outcomes to infer decision-making insights in the face of complexity and uncertainty. Delivering the course during Semester 2, 2022 and 2023 for a diverse student cohort in terms of age, discipline (such as engineering and business backgrounds), and technical backgrounds, allowed us to identify several aspects that succeeded and the reasons behind their success. These aspects include blended teaching, real-life case studies, power of modern technology, and interactive activities. Likewise, we identified several challenges and the underlying reasons. These challenges include a little overwhelming course content and lack of consideration of diversity of student cohort at the first iteration in 2022. While it was both interesting and challenging to deliver this course for the diverse student cohort, it was also a rewarding experience for both participants and course staff. The study reveals that students' grasp of complexity and uncertainty within decision contexts has advanced significantly through practical exposure and real-life case study involvement. Additionally, practical exposure provides students with a valuable opportunity to immerse themselves in the intricacies of the problem at hand. This experience not only imparts the skills needed to navigate complex situations but also cultivates the ability to arrive at well-informed decisions, even when confronted with uncertainties.

Industry-Focused MBSE Curriculum: Role-Specific Capabilities to Meet Industry Needs

Ebrahim Aly 1 2, Emiliya Suprun 1 2, Sondoss Elsawah 1 2, Capability Systems Centre, UNSW, Canberra, Australia, School of Systems and Computing, UNSW, Canberra, Australia

Keywords: MBSE,Capability development,Industry-focused curriculum

Type: Paperless Presentations
Category submitted: C.6. Education for Digital Natives

Model-Based Systems Engineering (MBSE) is rapidly gaining popularity across various industries due to its effectiveness in managing complex systems. Its utility is well recognized by researchers and systems engineering (SE) practitioners alike, who acknowledge its potential to streamline processes, improve accuracy, and enhance collaboration. Despite its recognized benefits, the adoption of MBSE still faces several challenges. Research has identified several challenges related to the adoption of MBSE, categorizing them into knowledge-based, tool-based, cultural and political, cost-related, and stakeholder understanding and acceptance-related challenges. Among these, knowledge-based and tool-based challenges are deemed the most critical. These challenges, particularly the knowledge related one, are closely linked to deficient coursework and training programs for MBSE. This highlights the pressing need for structured and robust MBSE curriculum that can adequately address these key barriers to MBSE adoption and ensure its successful integration into industry practices. To effectively address the disconnect between training programs and industry demands in MBSE, it is essential to thoroughly tackle the key components affecting the workforce readiness such as skills, competencies, and training levels. Additionally, these components should not be considered in isolation; rather, they should be viewed as an interconnected network where each element influences the others. This work proposes a framework that delineates these relationships and utilize it create a cohesive and comprehensive MBSE curriculum. By clearly defining the specific skills and competencies necessary for different roles in the MBSE ecosystem and matching them with corresponding training levels, the framework ensures a systematic and coordinated educational approach. The curriculum is applied for an MBSE professional education program delivered at UNSW Canberra. By incorporating the frameworks principles, the curriculum aims to equip students with the necessary skills and competencies to effectively apply MBSE, thereby addressing the key challenges in MBSE adoption and enhancing workforce readiness.

C.7. Modelling approaches

Modelling: bridging system modelling and analytical modelling. Contributions to this stream are invited to explore emerging applications and innovations in digital engineering that bring together MBSE and analytical modelling approaches to advance mission engineering, capability acquisition, and system design across defence, transport, energy and other domains.

Lead: Matthew Wylie, Stephen Cook, Indi Arachchige
Domains: Digital Engineering, All domains welcome

Measuring MBSE Model Maturity

Derek Rogers 1, Brett Morris 1, Shoal Group Pty Ltd, Adelaide, SA, Australia

Keywords: measurement,MBSE,maturity,metrics

Type: Full Paper
Category submitted: B.0. Advances in Approaches

This paper covers recent work undertaken at Shoal to investigate and develop maturity metrics to increase understanding of the maturity of MBSE models that are built on Shoal and Shoal client projects. Maturity metrics are an important engineering tool that can collectively serve as a leading indicator for project performance. If a project is at a lower level of maturity heading into a major milestone than required there is a good chance of cost and schedule over-run, or quality deficiency. The paper commences with a review of the open literature that identified different methods to track model maturity. The information uncovered during the literature review is then synthesised into an MBSE model maturity assessment method that includes the ability to select MBSE model maturity metrics from a library. The work undertaken to generate a metrics library is presented and the paper concludes with some observations and lessons learned, as well as plans for further work. The approach presented could be used by organisations undertaking MBSE modelling to build their own library of metrics to measure the maturity of their MBSE models they are developed.

The Mission Computing Subsystem of the Block 2 Boxer - tentative title

James Edge-Williams 1, Rheinmetall Defence Australia, Director of Tactical Systems, Brisbane, QLD, Australia

Keywords: Boxer CRV,Simulation,Mission Computing Subsystem,DDS,Vehicle

Type: Full Paper
Category submitted: C.7. Modelling approaches

Placeholder for a potential talk on the "mission computing subsystem of the Block 2 Boxer, with its DDS approach, and how they simulate their digital solution in their software development environment" by James Edge-Williams, Director of Tactical Systems, Rheinmetall Defence Australia.

STRATA: A Strategic Layers-Based MBSE Modeling Approach for Comprehensive Test & Evaluation Coverage

Brian Selvy 1, Zuken Vitech, Marana, ARIZONA, United States

Keywords: MBSE,Modeling Methodology,Digital Engineering

Type: Full Paper
Category submitted: C.7. Modelling approaches

Overview: This paper introduces the STRATA model-based systems engineering (MBSE) methodology, emphasizing its key aspects and unique advantages in verification, validation, test, and evaluation domains. Attendees will gain insights into its applicability and advantages in complex modeling scenarios. Context: Navigating the initial stages of MBSE model formulation in any tool can be challenging, particularly within collaborative teams. Implementing a methodology offers a structuredroadmap, enhancing model organization, usability, and collaboration. The STRATA methodology addresses these challenges, and combined with its model validation rulesets, provides the user feedback on model consistency and completeness. Purpose:The STRATA methodologyis structured in terms ofdefined levels or layers of the system architecture (the rows) and systems engineering,program management, and specialty engineering concept groups (the columns) affords.. The research aims to elucidate the benefits of adopting the STRATA methodology, particularly in the context of verification and validation. By defining clear model objectives and scope,the STRATA frameworkallows a modeling team to model what they know regardless of where it fits in the matrix. This supports the early involvement of test and evaluation teams in the requirements refinement and systems architecture definition processes. We will show how the STRATA methodology supports multiple engineering design scenarios. Approach: Utilizing the GENSYS MBSE tool, the paper demonstrates the practical implementation of STRATA through a representative problem.A comparison of the V&V concepts available in the Comprehensive Systems Design Language (CSDL), the natural language metamodel supporting STRATA, will be reviewed and compared to those provided in SysML v1 and v2. Interoperability of the languages will also be discussed. Insights: Participants will glean the value of modeling methodologies and discern the distinctive advantages of STRATA. We will see how utilizingSTRATA enhances modeling precision and efficiency, ultimately improving system design and development processes.

Model-based document engineering. A Cameo/CATIA Magic How To.

Emily Balaburov 1, Sam Mancarella 1, MEMKO, Melbourne, VICTORIA, Australia

Keywords: MBSE,Cameo/CATIA Magic,Document Generation,Metamodel

Type: Tutorials
Category submitted: C.7. Modelling approaches

Format: A hands-on tutorial on using CATIA Magic (aka: Cameo) to generate documents and tabular data automatically from system models. Overview: This tutorial will take the audience through the step by step process of producing deliverable documents using systems definition data defined as a Cameo/ CATIA Magic Model Based Systems Engineering (MBSE) model. It will detail the use of the Report Wizard to produce documents, spreadsheets and presentations from the MBSE model; and how to tailor the structure and format of the produced documents. This tutorial will also showcase how to represent derived model data in tabular format using the Metachain functionality. Audience: Model-Based Systems Engineering (MBSE) practitioners, engineering managers, Cameo/CATRIA Magic users. Line Up: refer presenters

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One Model to Rule them all (?)

Jawahar Bhalla 1, Shoal Group / University of Adelaide, Harrington Park, NSW, Australia

Keywords: Model of Systems Models,One model to rule them all

Type: Paperless Presentations
Category submitted: C.7. Modelling approaches

Models are central to understanding systems and to the engineering of systems. Systems engineers employ various types of models to communicate shared understanding, through system life-cycle models that enable the transformation of functional models to physical models, that are then realized as tangible systems of benefit to society. The recognition of the central nature of models to the engineering of systems resulted in the forming of Model Based Systems Engineering (MBSE) wherein the essence of the system of interest is contained within a system model in contrast to traditional documents. However, the evolution of model-types employed, both to understand and to engineer systems, appears to largely have been a pragmatic activity driven by the needs of the numerous individual engineering and management subdisciplines. This paper briefly examines extant taxonomy of systems models used in the engineering of systems and in understanding operational systems and considers the question of whether there is a suitable system meta-model that naturally contains all types of systems models used therein. It explores this question through a systems-thinking lens, in conjunction with concepts on mental models from biology and philosophy. This analysis gives rise to framework for systems models and to the proposition that all (systems) models take on one of two forms: as reference models that aid in the engineering of systems or as representative models that aid in understanding operational systems. The paper concludes that it is possible to propose an emergent model of systems models that combines these two classes in an evolutionary way. This construct is offered for consideration and refinement by the systems community.

Model-based Systems Engineering Methods for Rapid Product Development

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Keywords: mbse,method,acquisition,development

Type: Paperless Presentations
Category submitted: C.7. Modelling approaches

Overview: The current and emerging defence environment has placed heightened emphasis on the need to rapidly develop mission-fit products across land, maritime and air domains. This presentation provides an introduction to novel model-based systems engineering methodologies (MBSE) established and actively utilised at BAE Systems Australia. Context: It is well established that the development of certifiable, software intensive, systems must balance the rigour and traceability of conventional systems engineering (SE) programs with the demands of an agile and rapidly evolving product development program. This tension of delivering minimal viable capability and first-of-type systems at pace to validate customer need, whilst maintaining sufficient rigour to facilitate future certification and mitigate accretion of technical debt, is a difficult technical and programmatic challenge to navigate. Purpose: Blended MBSE methods adapting principles from above-the-line architecture frameworks and mission engineering concepts, object-oriented SE methods, and evolutionary lifecycle development models, was hypothesised to provide an optimal SE framework for such programs. Secondary aims included methods to support programmatic product development, product line management and variant management. Approach: A bespoke MBSE approach, encompassing training, processes and tool customisation, was derived, trialled and refined across a range of product development projects. Insights: It has been determined that prioritisation of several key SE drivers and core modelling viewpoints (at various stages of product maturity) provide a robust yet adaptable framework for system development. A summary of the problem drivers, key learnings and an introduction to the meta-method used in the derivation of this approach will be provided.

Mission Engineering with Capella - Aligning Systems with their Missions

Steven Spencer 1, Thales Australia, Eagle Farm, QLD, Australia

Keywords: Mission Engineering,MBSE,Capella,Digital Transformation

Type: Paperless Presentations
Category submitted: C.7. Modelling approaches

Overview A novel Capella viewpoint has been developed to enrich a Systems Engineering Model with Mission Engineering concepts. This presentation will explore the use and value of such a viewpoint when employed with Model Based Systems Engineering techniques. - Context Mission engineering provides an approach with appropriate rigour for the acquirer of capability to clearly outline their needs and expectations of solutions to meet their needs. Model Based Systems Engineering provides an approach to effectively master complexity of a system from concept to implementation. Harmonising the two viewpoints is not straightforward. - Purpose This presentation will demonstrate a prototype viewpoint for the Capella MBSE toolwhich willallow the representation of Mission Engineering concepts within the MBSE model. By enhancing the operational concept representation and enriching that representation with key Mission Engineering views and measures, the system designer shouldmake better decisions when architecting and implementing the system. - Approach A Capella model viewpoint (add on) has been developed and will be demonstrated interactively to show how the additional Mission Engineering concepts can be leveraged throughouta system's lifecycle in an example model. Key mission engineering concepts such as Mission Threads and Mission Engineering Threads, Measures of Success, Performance and Effectiveness will be demonstrated. How thesenew elements can be leveraged through a system design will be explored. - Insights By formally representing Mission Engineering concepts into the implementation of systems through Model Based Engineering approaches, Systems acquirers and designers should be able to talk the same language, across the different contexts, which will improve outcomes for the development of prime items and complex systems integration.

C.8. Technical Leadership in a Digital Future

Technical Leadership in a Digital Future. This session invites contributions that explore topics in technical leadership across all domains, particularly with respect to leadership in interconnected systems. Presentations should explore the challenges to expand the application of SE across industry domains, learning from other technical approaches, shaping policy, advancing tools and methods and growing SE capability in the workforce.

Lead: Contact the Technical Committee if you can assist in Chairing this session
Domains: All domains welcome

Project Governance, a critical system for Project and Programme Assurance of Infrastructure Investment outcomes.

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Keywords: Project,Systems Compliance,Resilience,Test and inspection planning.

Type: Full Paper
Category submitted: B.5. Sociotechnical Systems

Abstract Body This paper addresses key findings of the Productivity Commission report into Infrastructure investment 2014 and related reports that an estimated $30Bn pa of public money is wasted in the delivery of Infrastructure in Australia due primarily to failures of the Project Governance system used in delivery of project for outcomes. The Infrastructure Australia Plan (20160 also addresses the performance requirements of Governance and the need to refocus project deliverables on socially needed outcomes. For emphasis of the problem facing Engineering leaders if a private sector client had a $30bn pa revenues shortfall due to poor investment decisions then a major investment would be immediately called up to fix the issue. For Public sector Engineering leaders, the question needs to be asked of Engineers how much investment in better governance is immediately needed to make the shortfall available for unfunded investments. The paper outlines the reason for this shortfall and the ways that Assured Governance can avoid this annual loss in performance. Systems for Public Sector Governance, how they work in practice and how they can be verified or audited under a Quality assurance framework or gateway review process are explained and proposals for improvement offered. In addition, the erosion of value or wasted return on investment (ROI) and the transfer of benefits to the Project Delivery team of designers, contractors and suppliers is examined. System design and test and inspection plans (T&IP) for resilience audit are proposed and a Governance Maturity Model is provided to support intervention for poor Governance and to enable transformative Governance. This paper draws upon the work of the author, Ted Tooher, Tom Crow, Shankar Sankaran in their paper Enough is Enough and the plan for an upcoming Project Governance workshop series to enable Engineering leaders Executives to be delivered in 2022 and 2023.

Leadership and Management in the Age of Emerging Digital Technologies

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Keywords: Leadership; Management; Technical Transformation

Type: Panels and Workshops
Category submitted: C.8. Technical Leadership in a Digital Future

The proposed format is a facilitated Q&A session designed to summarize the presentations and themes of the day. All current and perspective leaders and managers should attend this session. Leadership around the use and implementation of emerging technology such as AI into business and everyday life provides some very interesting moral and ethical questions. The intent of this panel is to discuss the pros and cons of emerging technology within a leadership lens, and to hear from three distinguished leaders in their field how they are navigating this challenge.

Leadership and Organisational Implementation of Systems Engineering in the Infrastructure Sector

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Keywords: Leadership,Organisational Change,Sector Capability,Infrastructure

Type: Paperless Presentations
Category submitted: C.8. Technical Leadership in a Digital Future

Overview: In the Australian infrastructure sector, Systems Engineering (SE) is often practised in siloes, by systems engineers only. It is not well engrained in the organisational processes, and not actively championed nor driven by leaders and decision-makers. This results in a fragmented adoption of SE with reduced benefits; inefficiencies and cost overruns; or worse, projects not delivering the required outcomes. Context: There is a significant mandate and guidance for the application of SE in the infrastructure sector. Transport for NSW Asset Management Framework [1] mandates the adoption of an SE approach for complex transport infrastructure systems over their life cycles. The UK Institute of Civil Engineers extensively documented how systems thinking can improve the delivery of complex infrastructure projects [2]. The Dutch Guidelines for Systems Engineering within the Civil Engineering Sector [3] provide clear guidance for the successful implementation of SE within the sector and organisations. The UK Government recently published documents promoting systems thinking for civil servants [4]. Purpose: SE leadership and implementation in the Australian infrastructure sector is what can be done about it? Approach: This presentation will analyse and identify causes and solutions through: i) A review of recent literature, articles and industry reports (assisted by AI when appropriate); ii) Comparing approaches of the Australian infrastructure sector with other sectors and countries; and iii) Interviews with thought leaders across the sector. Insights: Insights will explore the link between improved implementation of systems engineering and productivity [5, 6, 7]; leadership and organisational motivations and competencies,to understandthe most significant barriers to adopting SE more effectively in the Australian infrastructure sector.

The view from the bottom

Jess Tucker 1 2, John Welford 2 3, Thomas McKay 1 2, Nick Pickering 2 4, Dhanush Laxman 2 5, Beca, Auckland CBD, AUCKLAND, New Zealand, INCOSE NZ, Auckland, New Zealand, WSP, Nelson, New Zealand, School of Engineering, University of Waikato, Hamilton, New Zealand, Aurecon Group, Auckland, New Zealand

Keywords: emerging practice,new zealand,diversification,SE adoption

Type: Paperless Presentations
Category submitted: C.8. Technical Leadership in a Digital Future

New Zealand is frequently missed off world maps, and until recently was also missing from the global list of INCOSE chapter locations. Happily in the last two years this has been rectified, through the establishment of the INCOSE NZ chapter. This presentation will discuss the current state of Systems Engineering adoption in New Zealand, and the specific challenges of progressing the discipline within a geographically isolated corner of the world, along with the future potential of Systems Engineering in NZ to support national and international challenges. Our discussion is based on inputs from a range of companies that were practicing SE in the country during the initial setup of an INCOSE chapter.We will also discuss the process of setting up INCOSE New Zealand as a chapter, including setting up an interim committee, jumping through regulatory hoops, voting on a full committee, agreeing a constitution, and recruiting and retaining members. As a modestly sized chapter spread across an entire country, digital and electronic technologies have been core to our operations. We will present approaches that have worked well alongside those that havent. This presentation will be of relevance to those interested in introducing and promoting Systems Engineering within other countries, and to others considering setting up new INCOSE chapters elsewhere. It will also give a useful overview of engineering in New Zealand that could be of interest to those who might consider working in the country.

Perspective and Influence and Leverage, Oh My! Leadership for Systems Engineers

David Long 1, Blue Holon, Blacksburg, VIRGINIA, United States

Keywords: Technical Leadership,Facilitation,Collaboration,Influence,Perspectives

Type: Paperless Presentations
Category submitted: C.8. Technical Leadership in a Digital Future

Overview As systems engineers, what can we do to create a better tomorrow? our principles and positions, we have the opportunity to make a unique and positive impact. But we must look beyond our technical contributions and embrace our leadership responsibilities. Context Systems engineers are familiar with the concept of perspective in the technical domain using viewpoints to explore, analyze, and specify their solution. Embracing perspectives from the human dimension is the starting point for systems engineering leadership. To satisfy and delight, the systems engineer must see the world, the challenges, and the opportunities from the perspective of others as they look at the problem and solution space. This requires the social dimension, emotion, interest, and empathy. Purpose Systems engineers can have a unique and positive impact if we look beyond our technical contributions and embrace our leadership responsibilities. Doing so requires that we apply perspective, influence, and leverage to unlock our strengths in combination with those around us and lead for a better future. Approach Perceptual Positions by Gary Koyen provides framework beyond self, other, and team that enables us to position the systems engineer to leverage the power of perspective for leadership. Based upon 30 years of personal experience and insights from INCOSEs Technical Leadership Institute, these ideas have been synthesized with the concepts of leadership through influence and the leverage of transdisciplinarity. Insights Perspectives enable the systems engineer to perceive through the viewpoint of customer, user, team and self, unlocking essential insights. Influence is how the system engineer most often leads not from a position of authority and power but from within the team. Transdisciplinarity including both holism and looking across the full lifecyle empowers the systems engineer to leverage team insights for maximum effect.

A model-based digital engineering approach to realize enterprise transformational programs

Sam Mancarella 1, Memko, Melbourne, VIC, Australia

Keywords: MBSE,Enterprise Transformation,System of Systems,Digital Engineering,Data Sovereignty

Type: Paperless Presentations
Category submitted: C.8. Technical Leadership in a Digital Future

The Systems Engineering Vision for 2035 (SE2035), defined by the International Council on Systems Engineering (INCOSE), sets the engineering vision to direct investments, foster greater collaboration, and advance the systems engineering discipline. SE2035 sets the North Star to enable systems engineers to timely respond to key trends including digital transformation, sustainability, smart systems and complexity growth. Technology advancements in modelling, simulation, and visualization provide practitioners with decision-making data that is more representative of a system of interest than ever. The combination of these technologies and their utilization is referred to as Digital Engineering. However, the misconception that digital engineering can only be utilized if adopted early in the system lifecycle inhibits its adoption in operation/sustainment phases of a systems lifecycle. Transformation programs require the deliberate and staged planning and implementation of significant changes to a system of interest. The number of stakeholders, suppliers and other interested parties grows exponentially if that system is a System of Systems (SoS) and that SoS is a complex enterprise. In these circumstances, careful consideration needs to be given to how these enabling technologies integrate, how they interoperate, and how data sovereignty is preserved and enforced between organizations. This presentation discusses an approach to adopt digital engineering in a complex transformation program. The approach uses Model Based Systems Engineering (MBSE) techniques as the conning tower for planning and decision making which brings together input from Integrated Project Teams (IPTs), supply chains and consumer groups whilst preserving data sensitivity constraints. This presentation outlines the experiences of an adopting organization using MBSE practices for engineering change management and digital transformation planning in a heavy industry context.

Exploring the Role of Digital Twins in Advancing SORA Compliance for BVLOS Operations in Australia

Elita Huynh 1, Philip Swadling 1, Thales, Melbourne, VIC, Australia

Keywords:

Type: Paperless Presentations
Category submitted: C.8. Technical Leadership in a Digital Future

Uncrewed Aerial Systems (UAS) technology shows great promise in providing economic and societal benefits across the world. In response to this demand, the Australian Civil Aviation Safety Authority, as well as their counterparts internationally, has been actively refining its regulations to address the rapidly evolving landscape of UAS technology and applications. One notable development in this regard is the adoption of the Specific Operations Risk Assessment (SORA), which represents a significant step towards enhancing the safety and regulatory oversight of UAV operations in Australia (Denney et al., 2018). The complexity of the UAS ecosystem, taking in a plurality of stakeholders, requires a comprehensive approach to assessing both technical and regulatory architectures. The complexity is such that using modelling and simulation, in the form of digital twins of the ecosystem, is likely to be the only way to achieve this comprehensive assessment. The emergence of digital twin (DT) technology in aviation and airspace is a significant shift towards data-driven, proactive safety management practices. Leveraging digital twins to simulate, analyze, and optimize aviation systems and operations, stakeholders can improve safety, mitigate risks, and foster innovation. This paper will discuss how digital twins can facilitate the application of SORA in the Australian regulatory context. By synthesising insights from literature on digital twins and their applications, and drawing Thales experience in this area, this paper provides a comprehensive understanding of the way in which DTs can be used to enable complex operations, including the associated benefits, challenges, and opportunities. The paper will also consider the broader use of digital twins in the airspace management ecosystem in Australia.

An Information Management Framework and its Application for Managing a System Engineering Workforce

Derek Rogers 1, Jon Hallett 1, Shoal Group Pty Ltd, Adelaide, SA, Australia

Keywords: information management,strategic workforce management,tactical workforce management,competency,lessons

Type: Full Paper
Category submitted: D. Other

This paper presents a framework for managing and using the information associated with a system engineering workforce. The typical uses associated with information regarding an organisations systems engineering workforce can be grouped into strategic workforce management and tactical workforce management. Strategic workforce management covers the aggregate of people in the organisation whilst tactical workforce management is directly concerned with the individuals. Strategic workforce management makes decisions about the general areas to recruit, develop or subcontract to address the long-term capability needs for the positioning of the business. In contrast tactical workforce management makes decisions about who to allocate to projects or specific training courses, and supports considerations related to promotion. To make these decisions in a repeatable and reliable manner, processes need to be defined and use authoritative information covering the knowledge, competencies, and skills of people. The definition and use of that information is the subject of this paper.
