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Keynote Speaker

Title: Embracing complexity
Keynote Speaker: Frances Brazier

Absract:
Complexity is a challenge with which all designers and engineers of complex socio-technical systems are confronted. This challenge is key to creativity and innovation and as such needs to be embraced and not throttled. As new materials, technologies, environmental considerations and insights emerge so does the realization that system designs need to be able to adapt during the course of their lifespan (and not only during the course of their development) to support participation of multiple (types of) actors and potentially evolving needs and desires. The values and mission on which a system's design is based are crucial and leading in this process. The need for new value-based approaches to system design and engineering are the focus of this talk.

Bio:
Frances Brazier chairs the Systems Engineering and Simulation Group in the Faculty of Technology, Policy and Management at Delft University of Technology She holds a MSc in Mathematics and a doctorate in Cognitive Ergonomics from the VU Amsterdam. Parallel to her academic career she co-founded EurOpen and EUnet at the European level, and NLnet and NLnet Labs at the national level.

With a strong interdisciplinary background in Computer Science, AI and Design, HCI, and Systems Engineering her research focuses on value-based design (and engineering) of complex socio-technical systems, so-called participatory systems. Such systems require new design approaches that embrace and orchestrate emergence and self-organization during their life cycle. Areas of application include critical infrastructures such as distributed energy management, crisis management, and dynamic supply-demand networks, but also aircraft design and organisational design.

Special Sessions

Reliability, Availability, Maintainability, and Safety (RAMS) in Systems Engineering : new perspectives for research and industry

Organizer:

Lorenzo Ciani

Abstract:
Nowadays in many contexts it is mandatory to fulfill performance of Testing and Diagnostics, Reliability, Maintainability, Safety and Risk assessment. Such tasks play a fundamental role in different fields of application (energy, transportation, information and communication technology, logistics, etc.) and are considered as fundamental in high-tech industry and plants. This Special Session represents an interesting opportunity for engineers and researchers who work in this area to meet and discuss about live issues. In particular, useful and beneficial discussion can be promoted with the aim to provide an increasing of knowledge and an easier diffusion of the most recent developments.

Topics: Prospective authors can provide original contributions in this topic which can cover, but not only, the following aspects:

- Condition monitoring and maintenance of industrial process, plants and complex systems
- Fault detection and diagnosis in Systems Engineering
- Evaluation of Reliability, Availability, Maintainability and Safety (RAMS), Risk assessment and management for Systems Engineering
- Impact of RAMS requirements in systems application devoted to Life and Society, environment and new energy sources

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Model-Based Sustainable Systems Engineering Context

Organizer:

Prof. Pierre de Saqui-Sannes (pdss@isae-supaero.fr)

Abstract:
In 2015, the seventeen Sustainable Development Goals were formally adopted by the UN in by the General Assembly of the United Nations (UN) as its 2030 agenda for sustainable development.

Sustainability awareness has accordingly become a concern shared by many research programs and industry projects.

Design of sustainable systems requires evolutions in terms of thinking the systems themselves.

It also requires to revisit system engineering so as to rely on practices, in particular Model Based Systems Engineering, that will be sustainable by themselves.

This special session welcomes contributions that address sustainability awareness at the system level, at the systems engineering level, and both.

Topics: Prospective authors can provide original contributions in this topic which can cover, but not only, the following aspects:

- Systems Evolution to comply with new laws and regulation
- Designing systems with sustainability awareness in mind
- Refactoring systems models to cope with evolutions of the originally models systems
- Optimizing simulation and verification of models to efficiently checked refactored models
- Multi paradigm modeling to cover systems engineering as well as social and environmental

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Resilience of Agent Systems: Modeling, Design and Operation Management

Organizers:
Wenjun Zhang, Department of Mechanical Engineering, University of Saskatchewan (chris.zhang@usask.ca)
Tan Zhang, College of Computer Science and Software Engineering, Shenzhen University (tan.zhang@qq.com)

Abstract:
A generic model of many complex dynamic systems is that the system consists of a group of agents, which could be intelligent and non-intelligent. The word 'intelligent' refers to being able to learn, to change, and to making decision, while the word 'non-intelligent' refers to missing one, two or all of the three intelligent behaviors. The complexity refers to uncertainty of changes in the structure of each agent and the communication among agents. It is worth to mention that such a system differs from traditional multi-agent systems, in which all agents are intelligent, in that in such a system, non-intelligent agents need "help" from intelligent agents. Such a system may be called the under-intelligent agent system.

Critical Systems and Infrastructure

Organizers:
Haifeng Zhu, Otis Elevator Company
Fuhua Ma, Pratt & Whitney

Abstract:

Critical systems and infrastructure, in particular aerospace systems, are often complex and pose significant challenges to systems engineering. Similar to the Aerospace Systems Engineering session in IEEE SysCon, this special session welcomes a broader discussions on systems engineering issues related to aerospace and all critical systems/infrastructures

(such as automotive, elevators, medical, etc.) that include but are not limited to: Systems Issues, Requirements and Architecture, Physics Modeling, Simulation and Analysis, Systems Integration & Verification, Autonomous Systems, Robotic Systems, Sensors Integration & Application, Human Machine Interfaces, Cybersecurity and Critical Communication Systems. Authors may submit theoretical or practical use case papers in aerospace and other critical systems areas.

A Bibliometric Analysis on Model-based Systems Engineering

Zihang Li (Beijing Instisute of Technology, China); Jinzhi Lu (KTH-Royal Insititute of Technology & Suzhou Tongyuan Software Control and Technology Company, Sweden); Guoxin Wang (Beijing Institute of Technology, China); Lei Feng (KTH Royal Institute of Technology, Sweden); Didem Gurdur (University of Cambridge, United Kingdom (Great Britain)); Dimitris Kiritsis (EPFL, Switzerland)

Abstract: *Model-based systems engineering (MBSE) has been accepted as an extremely important approach to understanding the multi-domain research field comprehensively. In this paper, a bibliometric analysis is used to conduct a comprehensive survey of model-based systems engineering literature of the last five years. The VOSViewer is used to implement visual network analysis for co-authorship, citation, and co-occurrence of the MBSE related papers. The results of the bibliometric study, firstly, reveal the influential research teams and sources. Secondly, research hotspots in the current MBSE domain are identified. The findings of this study aim to help researchers to gain a faster and deeper understanding of the current literature on MBSE.*

A Categorical Framework for Collaborative Design of Safety Critical Mechatronic Systems

Nourhene Kharrat Abdeljabbar (SUPMECA, France); Faïda Mhenni and Jean-Yves Choley (SUPMECA & Laboratoire Quartz, France)

Abstract: *Systems engineering relies on a diversity of views of the same mechatronic system built by different design teams from several domains at different abstraction levels and using different modeling languages and tools. These views must be and remain consistent throughout the engineering process. To this end, a collaboration methodology based on a unique and formal collaborative framework is needed to connect these views while ensuring their consistency.*

The aim of this paper is to introduce such collaborative methodology. The category theory is chosen as formal basis to enhance collaboration between different design teams and help them maintain consistency between their corresponding models.

The main objective of applying category theory in the current research is to model collaboration and consistency via interaction, transformation and synchronization, considering that all these model management scenarios can be implemented by the category theory. Moreover, our proposed methodology is mainly focused on the construction of a model that merges the different model elements according to three systems engineering aspects: requirements and constraints, behavior, and structure. To this purpose, a category based Meta-Model is established for the collaboration between systems engineering (SE) and safety assessment (SA). In this categorical framework, each model is represented by a category and, in order to link and maintain connection between these models, functors will be used. The proposed methodology was applied to a case study from the aeronautics domain, namely an Electro-Mechanical Actuator (EMA) modeled using SysML, Modelica and AltaRica languages.

Therefore, the proposed collaborative methodology implemented in a categorical framework may be generalized and enhanced to take into account any other model involved in systems engineering, such as a 3D model for geometrical modeling.

A Heterogenous, reliable onboard processing system for small satellites

Konstantin Schäfer, Clemens Horch and Stephan Busch (Fraunhofer Ernst Mach Institut, Germany); Frank Schäfer (Fraunhofer EMI, Germany)

Abstract: *Small satellites like CubeSats and Nanosatellites have been constantly evolving over the last decades. From the early academic projects in the late 90s to nowadays commercial earth observation constellations, small satellites have gone through an extraordinary development.*

Due to the minimization of development costs and time by using commercial off the shelf (COTS) components for their construction, small satellites have become a suitable alternative to conventional satellites for many applications, particularly for earth observation from low earth orbit.

Since they are not designed to withstand such harsh environmental conditions like extreme temperature ranges and high radiation levels, COTS components provide only a limited lifespan and a reduced reliability in space. On account of the cost reduction a short lifespan can mostly be tolerated, but poor reliability is still a hindrance for many professional applications.

To overcome this issue an advanced onboard processing unit is currently developed at the Fraunhofer EMI that will provide strong and reliable onboard processing capabilities for the upcoming ERNST Nanosatellite mission. Based on Xilinx' latest ZynqMP System on a Chip (SoC), this processing subsystem features multiple multicore processors with different architectures and an additional Field Programmable Gate Array (FPGA). The heterogeneity of the multi-processor SoC enables the implementation of well proven concepts like redundancy and watchdog timers on a single COTS-system, which simplifies the integration and boosts the performance of the subsystem.

The implementation of the protective measures is currently tested by extensive Hardware in the Loop (HiL) tests. During these long-term tests errors, like they typically occur in radiation environments, are injected in the systems different memory regions and registers. The subsequent observation of the system allows a selective sensitivity analysis of the vulnerable components and as well as the verification of the error mitigation measures.

Furthermore, the system has already undergone thermal-vacuum tests and once the HiL-testing is completed, radiation tests will be carried out to validate the outcome of HiL-tests.

For 2022 two independent in orbit demonstrations are planned to prove the systems performance and reliability directly in space.

This contribution will elaborate on the different protection mechanisms implemented in the SoCs gate- and firmware and will discuss their effectiveness based on the results of representative error injection tests.

A Model-Based Systems Engineering Approach to Support Continuous Validation in PGE - Product Generation Engineering

Constantin Mandel (IPEK – Institute of Product Engineering at Karlsruhe Institute of Technology (KIT)); Jannis Boening, Matthias Behrendt and Albert Albers (IPEK – Institute of Product Engineering at Karlsruhe Institute of Technology (KIT))

Abstract: *Increasing customer demands, especially regarding functionality, safety and environmental sustainability, are major drivers of nowadays product development processes. Those increasing demands as well as today's product development context of distributed interdisciplinary development teams lead to an increasing complexity of systems as well as their respective development processes. MBSE - Model-Based Systems Engineering is regarded as a promising approach to cope with this complexity. MBSE aims at supporting during the whole product lifecycle in system analysis, requirements management, design as well as verification and validation. Especially validation plays a central role in product development as it is the only activity that can ensure customer satisfaction and thus a successful product on the market. However, comprehensive MBSE-approaches to support validation in product development seem to be missing. This paper describes such a MBSE approach to support validation in product development. The approach includes an ontology*

of terms and their interrelations in the context of validation. The ontology is used to construct viewpoints, views and a modeling framework to structure a system model in the understanding of MBSE. In addition, a modeling method interacting with the constructed views is developed and presented. The presented approach aims at enabling a continuous validation concept, starting in the early phase of PGE - Product Generation Engineering and continuing throughout the entire lifecycle. Furthermore, the approach should support in integrating the development of products and appropriate validation systems, creating a consistent traceability of information throughout the created models. Finally, a specific focus of the approach lies on usability in order to guarantee individual and organizational acceptance. This acceptance is of particular importance to realize a human centered development as it is envisioned in approaches such as ASE - Advanced Systems Engineering.

A Systems Approach to Developing an Outdoor IoT Network for Wildlife Image Capture

Ethan Martin, Serena Raso and Yael Rogoszinski (Worcester Polytechnic Institute, USA); Shamsnaz V Bhada (Worcester Polytechnic Instiute, USA); Robert Starr and Alexander M. Wyglinski (Worcester Polytechnic Institute, USA)

Abstract: *This paper highlights the impact of Just in Time Systems Engineering education on a senior design or capstone project in Electrical and Computer Engineering. The goal of the senior design project was to design an Internet of Things (IoT) network using multiple wireless network protocols and devices for purposes of wildlife tracking and image capturing. A novel IoT network for motion capture was built utilizing low-power microcontrollers, passive-infrared sensor modules, and an IoT-based camera module. The network was studied in an outdoor environment using weather-proofed encasements and Google Drive connectivity. Systems Engineering approaches were essential for validation and verification of the success criteria of this senior design project.*

A Vehicle Routing Problem and Product Quality Embedded with a Scalable Reconfigurable Manufacturing System

Abdul Salam S Khan (National University of Sciences and Technology & Pakistan, Pakistan)

Abstract: *Reconfigurable Manufacturing System can accommodate high functionality, throughput, and product variety. It offers several routes to produce the same product which makes it difficult to analyze the product quality in each route. In addition, in RMS, the use of different configurations incurs different production, changeover and modular times. This can cause variability in delivering the product to customer location, depending on the configurations selected for production. To address the quality issues and arrival concerns, this study designs a scalability characteristic based reconfigurable manufacturing system in the context of a supply chain i.e., a vehicle routing problem (RMS-VRP). In addition, the analysis considers quality variation of a reconfigurable manufacturing system due to defects. A multi-objective model is proposed that considers the objectives of the total cost and the scalability of a reconfigurable manufacturing system and a vehicle routing problem. The scalability is necessitated by defective manufacturing and delayed delivery to the depot. A hybrid and automatically calibrated version of genetic algorithm and variable neighborhood search is used for implementing the model. Finally, key findings, conclusion and future research streams are provided.*

Adaptive test case selection for DNN-based perception functions

Johannes Norbert Bernhard (Karlsruhe Institute of Technology & ZF Friedrichshafen, Germany); Eric Sax and Mark Schutera (Karlsruhe Institute of Technology, Germany); Thomas Schulik (ZF Friedrichshafen, Germany)

Abstract: *The progress in deep learning methods has bolstered the development of automated vehicles during the last decade. The deployment of deep learning methods in safety-critical applications raised questions on their safety. Like other vehicle components, a testing process has to prove the reliability of perception systems. Scalability issues arise when using real-world data to validate perception algorithms due to the immense amount of sensor data that needs to be tested. Simulation tools can complement this testing process, as they can fabricate synthetic data based on variable specifications of test cases. Identifying test specifications that pose risks to the perception algorithms is crucial to utilize computing resources and estimate functional reliability efficiently. We present a pipeline for adaptive test case selection to expose the faults of a deep learning system using synthetic image data generated by a simulation framework. We apply our concept to a state-of-the-art object detector and implement multiple adaptive sampling strategies to demonstrate their ability of early fault detection.*

An Architectural Description for the application of MBSE

Kofoworola Adebowale Odukoya (BAE SYSTEMS & University of Strathclyde, United Kingdom (Great Britain)); Robert Whitfield and Laura Hay (University of Strathclyde, United Kingdom (Great Britain)); Neil Harrison and Malcolm Robb (BAE SYSTEMS, United Kingdom (Great Britain))

Abstract: *The design of a complex warship is a multi-disciplinary effort which often encounters major challenges, particularly with respect to the integration of interfaces across the System of Systems (SoS). In principle, the goal of Model Based Systems Engineering (MBSE) with respect to system design is to deliver a flow of information that: is simple to follow; rigorous in its complexity management; enables rapid identification of enterprise and product system interface problems that may arise; and, provides an easy interchange of toolset information across the SoS lifecycle. Enterprise and product system-related information are interconnected, this is captured within the SoS 'model' which reflects the state space and maturity levels of the system development. Rigor is manifested through the language, abstraction, and automation toolset in a SoS. People also play a critical role in the engineering of systems and the integration of interfaces in the SoS as they interact with other elements (descriptions, relationships and behavioural attributes are considered to be elements) in the system though the language that is used.*

Undesirable outcomes often stem from mismatches in the ontology that underpins a language-based description. One source of this mismatch is the implementation and emergence of different Architectural Frameworks (AF) with inconsistent viewpoints and data structures, which makes it difficult to compare or integrate the constituent information in a meaningful and coherent way. The adoption of different AF in the same domain, and across different domains within industrial entities, results in significant challenges during collaboration efforts as data is not easily transferable across different AF.

The need to maintain coherence is key. That is, the use of different language must be compatible across interacting elements within the system, to minimise rework. A common ontology for the entire System Engineering (SE) domain would accelerate end-to-end operations, resulting in delivery of capabilities at an accelerated pace. In the near future, current state-of the art AFs will become obsolete. Therefore, exploring a pragmatic alternative by way of formal language to achieve linguistic rigor and clarity when describing the state spaces and processes is the way forward.

The creation of an extensible Architectural Description (AD) to consolidate AFs will be beneficial for the implementation and integration of interfaces in MBSE, as the AD has the power to unite multiple AFs. It provides a shared foundation and means to unifying the metamodel and ontology with MBSE Standards. Through the consideration of state-of-the-

art AFs such as Department of Defence Architectural Framework (DoDAF), The Open Group Architecture Framework (TOGAF), NATO Architectural Framework (NAF), Unified Architectural Framework (UAF), the AD will be based on a generic ontology for MBSE, ultimately aiming to be easily adaptable to any framework, and coherent with MBSE standards and best practices. An AD requires the key tenets of MBSE to be identified to ensure that system development is coherent with standards, pre-existing processes and pre-existing frameworks.
This study clarifies the call to develop a generic AD and clearly define the fundamental tenets of state-of-the-art AFs in Naval Ship Design. A critical analysis of the viability of a methodology that uses ontological approaches to achieve consistent descriptions during the SE process will be presented. It is essential to minimise the mismatch in requirements early and avoid an extended design lifecycle.

An electronic system with integrated alerting and cooling mechanisms to save the life of an unattended child in a vehicle
Anya Vaish (Tesla STEM High School, USA)

Abstract: *Every year, approximately 40 children in the United States die due to hyperthermia from accidentally being left in a hot car. A change in normal routine can make even a careful parent inadvertently leave a child behind in the car seat. When the outside temperature is 80 °F, the temperature inside the car can rapidly climb to 109 °F in 20 minutes, causing child death due to hyperthermia. There are currently no reliable electronic reminders and cooling systems that work independent of the car engine. Described in this article is a smart electronic system embedded in a child car seat, namely a smart car seat that provided electronic reminders that a [simulated] child is left behind in the car seat after the car engine is turned off, and after two minutes sent a distress signal to emergency services, and automatically activated a cooling mechanism to maintain a comfortable temperature near the child to avoid death by hyperthermia. The cooling was achieved by an Arduino controlled thermoelectric cooling system incorporated in the electronic system which maintained ambient temperature around the child. The temperature in the car with and without smart car seat intervention was compared on a normal day to demonstrate that the smart car seat was effective in achieving ambient temperature around the child within three minutes. In conclusion, the system described here may be useful in preventing the death of a child left in the car due to hyperthermia.*

An English-Japanese Twitter-Based Analysis of Disaster Sentiment during Typhoons and Earthquakes
Bernadette Joy Detera, Akira Kodaka, Naohiko Kohtake, Akihiko Nishino and Kaya Onda (Keio University, Japan)

Abstract: *Having proper situational awareness during disaster situations is crucial in planning and mitigation. Knowing people's perception, needs and behavior during disasters is critical in developing the right management strategies. However, cities with multilingual and diverse international populations may react differently to disasters and gaps still exist in understanding this issue. Microblogging with social media has become a prevalent tool during emergencies and disasters. In this paper, we present a method in analyzing the sentiment of both the local residents and foreigners in Tokyo during case studies of earthquake and typhoon. Through the use of Twitter data, we retrieve individual tweets specifically on the onset of the disaster both in Japanese and English. After preprocessing, we develop Machine Learning algorithms using Support Vector Machine and XGBoost to classify tweet sentiment. The sentiment analysis models obtain fair accuracy and could be scaled and applied to sentiment classification of tweets during other types of natural disasters. Moreover, since our model is trained specifically on disaster tweets, it could yield*

a more accurate and contextual result when applied to future disasters. Furthermore, we analyzed information through Word Cloud, keyword analysis and time series analysis of sentiment polarity. We deduce that Japanese show a more positive sentiment than foreigners at times of disaster. Additionally, we observe that negative sentiment of both groups is lower for typhoons than earthquakes overall. Lastly, using this methodology could provide insights specific to typhoon and earthquake contexts to elicit requirements for disaster information or warning systems catered towards foreigners in the area which could be used in disaster management.

Applying model-based Co-Simulation on modular Production Units in Complex Automation Systems

Christoph Binder and Christian Neureiter (Salzburg University of Applied Sciences, Austria); Arndt Lüder (Otto-von-Guericke Universität Magdeburg, Germany)

Abstract: *Contemporary manufacturing systems face major challenges driven by the ongoing integration of intelligent manufacturing components, mainly caused by the emergence of the Industrial Internet of Things (IIoT). As the interplay of those Cyber-physical Systems (CPS) itself forms a System of Systems (SoS), engineering such a system becomes a difficult task. This is mainly attributed to the evolutionary development of its independently operating components, which results in some kind of unpredictable and often undesirable behavior. Considering this from a developer's perspective, it is important to investigate the system's behaviors before its actual implementation. However, as methods applied in Model Based Systems Engineering (MBSE) have proven to be a major technology driver when it comes to developing the architecture of these industrial systems, their simulation is still not standardized. Thus, this paper introduces an Industry 4.0 specific toolchain enabling the co-simulation of components within any developed industrial system architecture. This allows the investigation of varying industrial CPS and their interplay during run-time with the goal to detect undesired emergent behaviors. By doing so, the model is developed regarding the specifications of the Reference Architecture Industrie 4.0 (RAMI 4.0), while Mosaik is the tool of choice for creating the Co-Simulation environment. In order to validate the developed toolchain, a case study utilizing modular production units within an industrial automation system is applied.*

Change management and continuous improvement for Smarter Care: A Systems Viewpoint

Safa Elkefi and Onur Asan (Stevens Institute of Technology, USA); Mo Mansouri (Stevens Institute of Technology & University of South-Eastern Norway, USA)

Abstract: *Patients with cancer suffer poor quality, disparities, higher mortality, and unmet medical need due to communication issues with doctors. Medical errors are also driving them to lose trust in their healthcare providers. Thus, efforts to improve patient-centered communication consisted of implementing new technologies that aim to facilitate services procurement in healthcare. Between efficient and inefficient tools, patients find themselves lost and do not trust technology which results in failure of the initiative. This paper emphasizes on the fact that all components of a complex system are interrelated and interdependent and the behavior of the system depends on these interdependencies. A healthcare system as decorticated in this article is complex and new initiatives like technology adoption are not easily embedded and accepted by all stakeholders. We use the Lean Six Sigma approach (L6S) to show how continuous improvement system thinking methods can help achieve better quality, value chain and performance in healthcare in addition to the organizations' KPIs used.*

Cloud-based V2X communication for dynamic intelligent guidance in connected traffic systems

Soeren Scherler, Sven Jacobitz and Xiaobo Liu-Henke (Ostfalia University of Applied Sciences, Germany); Markus Henke (TU Braunschweig, Germany)

Abstract: *This paper presents the design and verification of a network infrastructure for cloud-based V2X communication and dynamic intelligent guidance in connected traffic systems. With help of the designed infrastructure, the limited range of wireless network based V2X communication using WiFi IEEE 802.11p is increased, so that dynamic information about disturbances of the traffic flow are available in a wide radius. An interface at vehicle level for integrating this information into the map material enables dynamic guidance, which calculates optimal alternative routes at an early stage. The results of dynamic guidance using the new cloud-based V2X communication will be validated under real-time conditions using an urban pilot application.*

Comprehending Concurrency and Consistency in Distributed Systems

Nitin Naik (Aston University, United Kingdom (Great Britain))

Abstract: *Concurrency and consistency are the two inherent and complex characteristics of distributed systems. Their type, level and implementation procedure determine the nature and efficiency of a distributed system. Concurrency and consistency are not easy to understand and there is more to their under- standing than meets the eye. Applying a deeper understanding of concurrency and consistency to the design of a distributed system will yield desired outcomes. This paper analyses both concurrency and consistency in a distributed system to present a comprehensive understanding about their requirement, type, level, benefits and limitations. Initially, it analyses concurrency and compares it with parallelism to distinguish two related but distinct terms. Subsequently, it analyses consistency and different consistency models including a comparative analysis of strong and weak consistency, and data-centric and client-centric consistency.*

Concurrent Design for PHM Systems in Harsh Environment

Haifeng Zhu (Smart Machinery Lab, USA)

Abstract: *Prognostic and Health Management (PHM) systems rely heavily on signal processing algorithms which are often challenging and thus continuously develop or improve some even after deployment. Thus, it is important to allow concurrent design and co-design with the whole system's architecture and implementation. This work develops a concurrent co-design framework that adapts to requirement changes instantly, and also demonstrates it through a challenging use-case study on PHM systems with harsh channel conditions such as high noise. We proved that the developed concurrent design workflow is useful and robust for PHM system development.*

Conflict Management for Mechatronic Systems Design

Mouna Fradi (Quartz Laboratory, ISAE-SUPMECA, France & Laboratory of Mechanis of Sousse (LMS) University of Sousse, Tunisia); Faïda Mhenni (SUPMECA & Laboratoire Quartz, France); Raoudha Gaha (Laboratory of Roberval of Mechanics, France); Abdelfattah Mlika (Laboratory of Mechanics of Sousse, France); Jean-Yves Choley (SUPMECA & Laboratoire Quartz, France)

Abstract: *Due to the multidisciplinary and complex nature of mechatronic systems, collaborative design becomes necessary in order to reduce the design cycle time and cost.*

This collaboration involves the use of numerous languages and expert models in order to represent distinct views on the same system. Consequently, conflicts among these models are likely to happen and need to be detected and resolved carefully. In order to capture and handle these conflicts in an easy and simple way, a unifying formalism based on mathematical concepts is required.
Thus, we suggest the use of Category Theory (CT), motivated by its mathematical and formal foundation to handle conflicts in a formal way. This work presents a new framework able to check and manage conflicts in collaborative design. This framework has two key features. First, to detect the conflicts between the expert models in a formal way based on category theory concepts. And second, to manage these conflicts in order to ensure the coherence of the system under design. Our approach is illustrated through its application to an Electronic Throttle Body (ETB) from the automotive industry since it involves the collaboration among several expert domains.

Data Analytics Architecture for Energy Efficiency Optimization in Industrial Processes
Daniel Nohl (Hochschule Ruhr West, Germany); Friedhelm Meister (GIWEP GmbH, Germany); Kai Daniel (Hochschule Ruhr West, Germany)

Abstract: *This paper proposes a novel control system that uses ontology models in combination with machine learning algorithms in order to increase the energy efficiency of the hot rolling mill process. The system architecture as well as the implemented modules, that will be developed, are going to be explained by the author. An OPC UA Server will be used as the data acquisition system and platform for a Semantic Ontology Engine. The overall energy usage can be calculated with empirical and physical formula that lead to a mathematical model of the process. This model will be used in combination with Deep Neural Networks to predict the energy demand aiming to implement a model predictive closed-loop control. Furthermore, a new communication interface for the existing control system can be obtained by combining ontologies with the derived information about the energy consumption of the process.*

Delay Aware Dynamic Risk Assessment for Logistics Delivery
Yuan Wang (University of South Florida, USA); Shiqi Hao and Yang Liu (JD Logistics, China); Shiyan Hu (University of Southampton, United Kingdom (Great Britain)); Wenming Zhe (JD Logistics, China)

Abstract: *On-time delivery is the most critical target of logistics industry that significantly impacts the efficiency of society and customer experience. Therefore, a wide variety of strategies have been employed for the operation of logistics systems to ensure the on-time rate. Despite these efforts, there could still be some delay in delivery induced by the factors such as the non-ideality of scheduling and extreme situations, which can potentially lead to severe consequences like economic losses. A potential approach to guarantee the time efficiency and prevent potential losses is to upgrade the processing priority of the packages with high delay risk. This motivates us to accurately recognize these packages and allocate the limited resources appropriately. A major challenge of this approach is that the risk needs to be assessed when the packages are being processed, in which scenario the information of the later steps is not known. In order to tackle that difficulty, this paper casts the risk assessment task into a classification problem, where the states of packages corresponding to the unfinished steps are treated as missing values. Subsequently, the optimization of the strategies for handling missing values is formulated using maximum likelihood estimation, which is solved simultaneously when training the model utilizing the decision tree structure. Finally, the proposed method is validated using real JD Logistics data. As demonstrated by the experimental results, the proposed method can accurately detect the packages with high*

delay risk even when they are still in early processing steps. Furthermore, our technique significantly outperforms a state-of-the-art method for classification with missing values.

Demystifying Properties of Distributed Systems
Nitin Naik (Aston University, United Kingdom (Great Britain))

Abstract: *Distributed systems are inevitable part of an IT infrastructure as they offer several benefits over centralized systems. However, designing a distributed system is very complex and challenging task as it requires a complex infrastructure comprising several components and properties to offer the desired benefits to its users. These properties of a distributed system are the most crucial for its design, implementation and debugging purposes. The inclusion of different type and level of these properties results in different types of distributed systems. However, it is very difficult to understand and analyse all the properties of distributed systems due to their types, levels, complexities, variations in different application areas. Additionally, some properties are very similar to the properties of other types of systems, which requires a system-specific understanding. Therefore, this paper will analyse the following most important properties of distributed systems: resource sharing, openness, concurrency, consistency, idempotency, scalability, availability, reliability, fault tolerance and transparency. It will explain their meaning, type, level, requirement and trade-off in the distributed system. Finally, it will summarise the main strength and limitation of these properties of the distributed system.*

Design Structure Matrix Generation from Open-source MBSE Tools
William Pons, Sophia Salas Cordero and Rob Vingerhoeds (ISAE-SUPAERO, France)

Abstract: *The usage of Design Structure Matrices is widely applied to represent, cluster, and partition complex systems information for different purposes, one of them being systems design. Nevertheless, open-source software for their automatic creation is rare. This leads to manual workshop sessions for subject matter experts to fill in the design structure matrices, a practice that is very tedious and time-consuming. The importance and application of Model-Based System Engineering has increased over the years. Nowadays, there are several open-source MBSE software such as StarUML, Papyrus, TTool, Modelio, Capella. This paper describes a novel approach to generate design structure matrices and extract information automatically from xml and xmi formats used widely in open-source Model-Based System Engineering tools. This work presents the algorithm and a tool to extract data from the output model files, in order to automatically create a Design Structure Matrix (DSM) of modeled systems.*

Determination of an effective implementation of the differential evolution method to power shortage minimization
Dmitrii Iakubovskii (Melentiev Energy Systems Institute of Siberian Branch of the Russian Academy of Sciences, Russia); Dmitry Krupenev (Melentiev Energy Systems Institute of SB RAS, Russia); Denis Boyarkin (Melentiev Energy Systems Institute of Siberian Branch of the Russian Academy of Sciences, Russia); Nadejda Komendantova (IIASA, Austria)

Abstract: *Constant development of electric power systems leads to their constant enlargement and complication; new ways of their control appear. In this regard, the existing models and software for adequacy assessment may work defective and ineffectively from the point of view of the adequacy of the obtained results, as well as the speed and accuracy of calculations. The key role in adequacy assessment of electric power systems (EPS) are played by optimization methods that allow to correctly determine the minimum of power*

shortage that occurs in various states of the EPS. A review of modern computational systems for adequacy assessment showed that the general concept of mathematical models is the same and can be described within the framework of the flow distribution problem. Despite this, each mathematical model is unique in its own way and requires an individual approach to its optimization. The purpose of this work is to analyze the efficiency of calculations in terms of accuracy and speed of various versions of the differential evolution (DE) method for the specified mathematical models within the framework of adequacy assessment of EPS. To achieve this goal, we solved several problems: two mathematical models were identified - a nonlinear model for minimizing the power shortage with the quadratic losses in flows and its modification with the controlled sections; differential evolution methods, including standard DE, composite DE, JDE, chaotic DE, adaptive DE; mutation strategies: DE/rand/1, DE/best/1, DE/rand/2, DE/best/2, DE/rand/3, DE/best/3, DE/current-to-rand/1, and DE/current-to-best/1. In this paper we tested the effectiveness of differential evolution methods, with different mutation strategies and different scales of EPSs. The experimental part was carried out using a software that was independent development by authors using C++. This complex includes the implementation of mathematical models and methods. The methods were tested on two systems with different numbers of adequacy zones, including those with three and seven adequacy zones. According to the research results, self-adaptive methods of DE are of the greatest interest for the further use and development of methods for this problem, due to automatic adjustment of the method parameters for each of the considered models and systems.

Does Sovrin Network Offer Sovereign Identity?

Nitin Naik (Aston University, United Kingdom (Great Britain)); Paul Jenkins (Cardiff Metropolitan University, United Kingdom (Great Britain) & University of Portsmouth, United Kingdom (Great Britain))

Abstract: *The Sovrin Network is an emerging public service utility based on the Self-Sovereign Identity standard aimed at providing sovereign digital identity for all. However, sovereignty is independence with regard to liberty of action, therefore, any sovereign identity should offer similar liberty to its users. Here, it is important to understand the meaning of sovereignty in terms of digital identity and what users gain in terms of its control, through the sovereign identity provided by the Sovrin Network. This paper examines the questions, what does sovereignty mean in terms of digital identity and does the Sovrin Network really offer sovereign identity. To understand the meaning of sovereignty, this paper assesses sovereignty in different contexts such as in the real world, cyberspace and digital identity. Following a discussion on the meaning of sovereignty in different contexts, it performs an analysis of the type of digital identity provided by the Sovrin Network and the type of sovereignty. Furthermore, it discusses the possible constraints on sovereignty of the Sovrin identity.*

Enabling model-based engineering of service-oriented Architectures within complex industrial Systems

Christoph Binder and Christian Neureiter (Salzburg University of Applied Sciences, Austria); Arndt Lüder (Otto-von-Guericke Universität Magdeburg, Germany)

Abstract: *Caused by the transformation of traditional production lines towards ubiquitous interconnected manufacturing networks in the context of Industry 4.0, the original product-orientation is evolving towards service-oriented systems. Thus, various service-oriented architectures (SOAs) have been recently proposed in order to deal with the increasing complexity in such production systems. However, most of those reference architectures look good on paper, but are missing practical applications, as this is also the case with the Reference Architecture Model Industrie 4.0 (RAMI 4.0). Therefore, in order to increase the*

usability of RAMI 4.0 in terms of its service-orientation, a detailed architecture definition of its Communication Layer is proposed in this paper. The SOA thereby integrates the characteristics of the ISO 42010 and provides a particular domain-specific language (DSL). Finally, the applicability and usability of the resulting architecture is evaluated with the help of a real-world case study considering a manufacturer of copper-plated metal plates.

Enhancing predictive maintenance architecture process by using ontology-enabled Case-Based Reasoning

Juan José Montero-Jiménez (ISAE-SUPAERO, France & TEC, Costa Rica); Rob Vingerhoeds (ISAE-SUPAERO, France); Bernard Grabot (ENIT, France)

Abstract: *A common milestone in systems architecture development is the logical architecture. It provides a detailed overview of the system components and their interfaces but keeps the architecture as generic as possible, meaning that no component is bound to a specific technology. Subsequently, the architect searches for physical/informational components to fulfill the logical architecture and can apply structured creativity to look for innovative solutions. This search can turn out to be a difficult and long-lasting task depending on the system complexity. Too many options may be available to fulfill the logical system components and not always the most suitable ones are identified. This problem is for instance encountered in the design of new predictive maintenance systems, especially when selecting the components to carry out the diagnostics and prognostics. The current study proposes to support the choice of suitable components combining case-based reasoning and ontologies. A domain ontology has been developed as a terminology framework to support the case base, case structure and similarity measures for a case-based reasoning Decision Support System (DSS). The DSS uses attributes of the new problem to solve and suggests the most similar cases from past experiences. The retrieved solutions can be adapted to develop a new predictive maintenance architecture. The decision support system has been tested with data coming from proved predictive maintenance solutions documented in scientific publications.*

Evaluating MBSE Methodologies Using the FEMMP Framework

Marco Di Maio (TH Ingolstadt, Germany); Tim Weilkiens (oose Innovative Informatik eG, Germany); Mostafa Aboushama, Omar Hussein, Irfan Javid, Sophian Beyerlein and Michael Grötsch (TH Ingolstadt, Germany)

Abstract: *Model-Based Systems Engineering (MBSE) is an effective and efficient approach to implement systems engineering. Storing valuable system information in models increases the consistency, traceability, and availability of the information. Early validation and testing of system information enable timely feedback on requirements and design decisions. Many MBSE methodologies exist, making it difficult for practitioners to select the proper methodology for their particular engineering challenge. In 2016, Tim Weilkiens et al. have proposed a Framework for the Evaluation of MBSE Methodologies for Practitioners (FEMMP) and used it to evaluate their methodologies (SYSMOD and MDDM). In this paper, the Vitech Methodology (STRATA), Object-Process Methodology (OPM), RePoSyD, and ARCADIA are presented and evaluated using FEMMP. In addition, the current criteria offered by FEMMP are discussed, and new criteria are proposed.*

Evaluating System Architecture Safety in Early Phases of Development with MBSE and STPA

Alexander Ahlbrecht and Oliver Bertram (German Aerospace Center (DLR), Germany)

Abstract: *Emerging segments such as autonomous driving require new by-wire system architectures for steering and braking. These system architectures are highly safety-critical and currently not commonly used in the automotive industry. This results in challenges for traditional development approaches. One issue is that a well-thought-out architecture selection is already required in early phases of development. Within this paper, a concept is proposed to help consideration of safety in this timely architecture selection, using a safety trade-off concept. An early consideration of system architecture safety is achieved by utilization of a formalized System-Theoretic Process Analysis on a Systems Modeling Language model. This underlying system model was developed with a Model-based System Engineering approach. Additionally, it is explained how classical safety considerations and safety principles can be integrated into this safety trade-off. Finally, the approach is demonstrated in an architecture comparison for a simplified Steer-by-Wire architecture. Results show that it is possible to find relevant safety requirements and use them to compare solution architecture candidates.*

Evaluation of the SAIC Digital Engineering Validation Tool as applied to an Independent Systems Engineering Effort

Chris Swickline (SAIC, USA); Oscar Guerrero and Pratik Patel (NGC, USA)

Abstract: *The barrier to entry in adopting and applying Digital Engineering and Model Based Engineering to practical systems engineering efforts should not be underestimated. The quantity of systems models being produced continues to grow while the quality and ability of teams to effectively leverage existing tools lags. SAIC is one of the few organizations attempting to drive quality into digital engineering by releasing, as open source, a set of development tools intended to improve model quality and initiate a standardized approach to modeling complex systems for practitioners. This paper asks the questions: How has the application of SAIC's tool set impacted our systems engineering effort? What value added does this tool set bring to practicing systems engineers and what opportunities for growth and improvement exist? In answering these questions, our systems engineering team leveraged these tools in our agile development effort. Our team was composed of systems engineers with a variety of experiences in the industry as well as exposure to model based engineering concepts and tools. We constructed behavioral/functional, logical, and physical versions of our system's architecture, while along the way taking note of our successes and pitfalls. Finally, throughout the duration of the effort we identified additional tools/capabilities that we concluded would be beneficial. Our results include a series of specific benefits and opportunities for improvement. In general the use of SAIC's Digital Engineering Validation Tool set resulted in a significantly more rapid development of the system model than typical. Furthermore, the quality of our model improved relative to other efforts and the barrier to entry for systems engineers new to model based engineering was reduced. Our conclusion is that this tool set should be leveraged on a broader range of systems engineering efforts to stress its capabilities via diversity of systems content and systems engineering teams. Furthermore, some additional features should be added to further simplify modeling efforts, improve quality, and allow more rapid progress of development.*

Extension of Contracts for Variability Modeling and Incremental Update Checks of Cyber Physical Systems

Houssem Guissouma (Karlsruhe Institute of Technology, Germany); Janis Kröger (University of Oldenburg, Germany); Sebastian Vander Maelen (OFFIS eV, Germany); Eric Sax (Karlsruhe Institute of Technology, Germany)

Abstract: *Due to the increasing electronic and software portions in Cyber Physical Systems (CPSs), such as highly automated cars, and their safety-criticality, thorough verification and validation activities are an essential part of their development process. Meanwhile, software life cycles are getting shorter, and Over The Air updates are becoming state of the art, even in safety-critical domains. However, validating each software update for a wide range of system variants and versions is a challenging task, which requires efficient verification methods to reduce time, effort and costs. Contract-based Design (CBD) is an emerging design paradigm to handle the complexity of safety-critical CPSs. Though, due to the multitude of maintained variants and versions, using CBD for continuous products improvement in form of updates may rapidly become challenging. In this paper, we integrate CBD into a product line development approach by mapping variant and fine-grained contracts to reusable components. Applying our approach to a case study from the automotive domain showed a significant reduction of the effort for contractifying the systems. Besides, it offers a basis for conducting incremental analysis and verification of modular updates.*

Function to Form Mapping and Search for Civil Aeroplane Energy Efficiency

Aleksandar Joksimovic (ISAE-SUPAERO, France); Frances Brazier (Delft University of Technology, The Netherlands); Rob Vingerhoeds and Xavier Carbonneau (ISAE-SUPAERO, France)

Abstract: *The contemporary debate on the need for the civil aeronautical industry to reconcile its global warming impact and the continuous air traffic growth is gaining in prominence. While solutions exist to tackle different aspects of this complex problem individually, the core of the response lies in rethinking the conventional aeroplane architecture in order to reach new energy efficiency optima. This paper presents a function-to-form framework used for describing different aspects of architectural design of an aeroplane as technological system. Firstly, a brief overview of different existing ways to improve aeroplane architectures is given. With that background, a preliminary definition of multi-level system composition of an aeroplane is presented. A physics-based framework is then correlated to the Functional, Behavioural, Structural and Experiential requirement framework, in order to characterise the different physical phenomena experienced by an aeroplane for a single operating point. These provide basis for definition of a qualitative figure of merit dubbed Integration Potential of an architecture, which serves as proxy for describing function-to-form mapping of aeroplane system architectures. Using both the historical, contemporary and projected tendencies of aeroplane technology advances, existence of an asymptotic limit of this parameter is inferred. This limit arguably indicates the extent to which it could still be possible to go in search for energy efficiency gains by virtue of system architecture design.*

GONG: an open source MBSE toolset
Thomas Peugeot (MOSS SAS, France)

Abstract: *Advances in computer sciences in the last decade have boosted software productivity. This upset the "make or buy" of MBSE tools. GONG, an open-source toolset based on the latest software technologies, is presented. GONG enables generation of MBSE generic tools as well as tools specific to a project. GONG tools manage different kinds of system engineering data. GONG tools are open source, license free and lightweight (<100MB). They can be shipped with the engineering data to be reviewed by all stakeholders, enabling MBSE to meet its full potential.*

How to Analyse the Safety of Concepts for a System-of-Systems?
Stephan Baumgart (Volvo Construction Equipment, Mälardalen University, Sweden); Joakim Fröberg (Rise, Research Institutes of Sweden, Sweden); Sasikumar Punnekkat (Mälardalen University, Sweden)

Abstract: *Developing safety-critical products like cars, trains, or airplanes requires rigor in following development processes, and evidence for product safety must be collected. Safety needs to be considered during each development step and traced through the development process. The current standards and approaches focus on single human-operated products. The technical evolution enables integrating existing products and new autonomous products into system-of-systems to automate workflows and production streams.*
Developing safety-critical systems-of-systems requires similar processes and mapping to safety-related activities. However, it is unclear how to consider safety during different development steps for a safety-critical system-of-systems.
The existing hazard analysis methods are not explicitly mapped to the development of a system-of-systems and are vague about the required information on the intended behavior.
This paper focuses on the concept phase for developing a system-of-systems, where different technical concepts for a specific product feature are evaluated. Specifically, we concentrate on the evaluation of the safety properties of each concept.
We present a process to support the concept phase and apply a model-driven approach to capture the system-of-systems' relevant information. Finally, we show how this knowledge is used for conducting an FMEA or a HAZOP. Lastly, the results from the analysis can be mapped into the model.
We apply the method during the concept phase for designing the automated quarry site developed in the electric site research project.
Our approach helps to design complex system-of-systems and supports concept evaluation considering the criticality.

Impact of Behavioral Dimension of Employees on Business Continuity at Industrial Complex
Akira Kodaka (Keio University, Japan); Natt Leelawat (Chulalongkorn University, Thailand); Eri Ino (Nagoya Institute of Technology, Japan); Jing Tang (Chulalongkorn University, Thailand); Jaehyun Park (Kyoto Institute of Technology, Japan); Naohiko Kohtake (Keio University, Japan)

Abstract: *In order to maintain business continuity of tenant companies in an industrial complex, it is important to understand the interdependencies with other stakeholders and properly assess their vulnerabilities against common threats. Area Business Continuity Management is a framework and direction of coordinated disaster damage mitigation measures. However it is still unclear that how a behavioral dimension of society including communities and individuals is incorporated to business continuity of private sectors to realize public private partnership. In the industrial complex, employees who work in tenant*

companies are also local residents living around the complex. In other words, intention and possibility of employees to go to work is one of the most important dependent factors of business continuity of the employer. Thus, this study applied the concept of system dynamics with Dynamic Bayesian Network dependency analysis in order to understand the factors related to employee attendance to business continuity to incorporate behavioral dimension of communities and individuals for designing Area BCM. As a preliminary result with the case company at the Rojana Industrial Park in Phra Nakhon Si Ayutthaya Province, Thailand, we were able to validate the developed model for determining a possibility of employees to go to work by taking related variables into account.

Interaction between capabilities of Model Based Systems Engineering on sensor models

Marvin M Schmidt (Fraunhofer IPK, Germany); Simon Schmidt (Volkswagen AG, Germany); Rainer Stark (TU Berlin, Germany)

Abstract: *In modern product development, models are often used for different purposes, e.g., system synthesis, trade-off analysis of system parameters or visualization and creation of design concepts. For some models, this purpose as well as the model itself might change over time. New interactions with the target system can occur and new details are added over time. Both have to be integrated immediately into the development procedure. When models are not maintained up to date and not used by different stakeholders, the benefits of the model-based approach are lessened due to the effort for generation and maintenance. The five development capabilities of MBSE, comprising Systems Environment Analytics (SEA), Systems Definition and Derivation (SDD), Systems Interaction Modeling (SIM), Systems Lifecycle Engineering (SLE) and the MBSE Capability and Maturation Matrix (CMM) address this topic on a capability level. In this article, the authors point out the interaction between these development capabilities on the example of a Pedestrian Emergency Braking System (PEBS) development in automotive industry, with a focus on sensor models. It will be shown exemplary how one development capability might influence another and how this interaction supports the development of complex systems.*

Knowledge Transfer Aligment Between Universities and Regions. A Graduated Programs Perspective

Arturo Melo (Universidad Nacional de Colombia & Researcher, Colombia); José Ismael Peña Reyes (Universidad Nacional de Colombia, Colombia); Angel Díaz (Universidad Nacional de Colombia, Colombia)

Abstract: *Developing countries have bet for the Knowledge Transfer (KT) via human capital with high level of education like Master and PhD degrees, which is a fundamental element to improve the Science Technology and Innovation (STI) capabilities of the peripherical regions, because high level graduates generate, in a midterm, better innovative and competitive conditions, hence economic development and welfare to regional communities. The KT effectiveness is heterogeneous among regions, and it is mediated by the educational offering and demand alignment of the KT channels. This paper analyzes the KT alignment via human capital through a composite index applied to 31 Colombian regions (or departments). To create the index is taking into account two supply variables, the Science, Technology,*

Engineering, and Math (STEM) high level graduates, and the researchers quantity. Also, it takes three demand variables, regional productive initiatives, STI projects, and eight long-term thematic of development proposed by "The International Mission of Wise Men" for the advancement of science, technology and innovation 2019. Results show there exists alignment faults between human capital created by universities and social, economic, productive and environmental regional needs. This condition could be corrected by educative and STI public policies, which should be pertinent to their development initiatives and projects of each region.

Mastering Complexity for Indoor Inspection Drone Development
Eric Razafimahazo, Pierre de Saqui - Sannes and Rob Vingerhoeds (ISAE-SUPAERO, France); Claude Baron (LAAS-CNRS, France); Julien Soula and Romain Mege (CSTB, France)

Abstract: *Drones have successfully been used for many outdoor uses, notably inspection of buildings. Using drones for indoor inspection of buildings raises new design challenges, in particular with respect to Building Information Modeling and indoor navigation issues since satellite-based localization does not work inside a building.*
The authors of this paper advocate for using a Systems Engineering approach to address these design challenges. The paper surveys systems engineering methods published in the literature and addresses a method adapted to complex systems which are subject to evolving environment such as drones for indoor inspection of buildings. The chosen method provides several views of the system from a global perspective including mission and operational analyses, to more specific perspectives including requirement, functional, logical and physical analyses.

MBSE analysis for energy sustainability improvement in manufacturing industry
Romain Delabeye (ISAE-SUPMECA & Quartz Laboratory EA7393, France); Olivia Penas (ISAE-Supméca & Laboratoire Quartz EA 7393, France); Martin Ghienne, Arkadiusz Kosecki and Jean-Luc Dion (ISAE-SUPMECA & Quartz Laboratory EA7393, France)

Abstract: *With the ever increasing complexity of Industry 4.0 systems, plant energy management systems developed to improve energy sustainability become equally complex. Based on a Model-Based Systems Engineering analysis, this paper aims to provide a general approach to perform holistic development of an autonomous energy management system for manufacturing industries. This Energy Management System (EMS) will be capable of continuously improving its ability to assess, predict, and act, in order to improve by monitoring and controlling the energy sustainability of manufacturing systems. The approach was implemented with the System Modeling Language (SysML).*

MBSE Graduate Level Education: A 5 years feedback
Omar Hammami (ENSTA, France)

Abstract: *In this paper we will provide a 5 eyars feedback on MBSE training and education at graduate levle using Arcadia/Capella MBSE methodology and tool. Students with both mechanical and embedde systems profile have been trained with a UAV case study.We report students perception of system engineering and MBSE in particular, the use of the tool and the collective engineering approach.*

MBSE meets HW/SW Codesign for System On Chip Seamlessly Down to the Chip
Omar Hammami (ENSTA, France)

Abstract: *Hw/sw codesign have long been associated with EDA tools far from system engineering tools and methods. Design space exploration and system complexity have therefore been handled at System on Chip (SOC) level but not at system level. In this paper we propose a seamless flow from MBSE to the hardware chip taking full advantage of both MBSE and SOC design automatic design space exploration with HIL for FPGA device.*

Method for solving the problem of adequacy optimization of energy power systems based on simulated annealing
Denis Boyarkin (Melentiev Energy Systems Institute of Siberian Branch of the Russian Academy of Sciences, Russia); Dmitry Krupenev (Melentiev Energy Systems Institute of SB RAS, Russia); Dmitrii Iakubovskii (Melentiev Energy Systems Institute of Siberian Branch of the Russian Academy of Sciences, Russia)

Abstract: *The article deals with the development of a method for solving the problem of adequacy optimization of power systems. The adequacy optimization is understood as the definition of such a composition of infrastructure objects of the electric power system, which would correspond to the target value of the probability of a deficit-free system operation at minimal financial costs. This problem belongs to the class of combinatorial optimization problems. Due to the peculiarities of the formulation of problems of this type, the use of traditional optimization methods is difficult here and the most used algorithms are search and stochastic algorithms. So, to solve the problem of synthesis of reliability, it is proposed to use an adaptive simulating annealing. When using this method, the states of the electric power system are randomly generated, where each random state is characterized by a special composition of the generating equipment. Since each generation object has different properties, as well as the degree of influence on the system adequacy, when using the simulated annealing method, it is proposed to use two types of weighting factors. The former includes the initial weighting coefficients formed from the characteristics of the generation units, the latter - the dynamic importance coefficients formed from the point of view of the influence of the generation units on the system deficit. The latter are proposed to be retrieved and updated using the random forest method. The task of such coefficients is to regulate the frequency of blocks exit from the generation in accordance with their efficiency. Additionally, the article proposes to introduce a coefficient of mass distribution of blocks. The use of the above coefficients should increase the speed of convergence of the problem at the point of minimum generation when outputting the least efficient generating elements. The work of the method is shown in experimental calculations of the adequacy optimization of a test electric power system. The results of their implementation have shown the effectiveness of the proposed method.*

Model Based Systems Engineering Approach to Representing Communications Subsystems within a Distributed System Architecture
Chris Swickline (SAIC, USA)

Abstract: *The process of applying digital engineering and model based engineering concepts to systems architecting is as much an art as a science in that there are often multiple correct approaches. The problem we consider in this this paper is how best to represent communications subsystems, within a SysML based descriptive model, to maximize the flexibility of defining interfaces, without diminishing the role of communications as subsystems within the architecture of the larger system. This consideration is relevant for those motivated by stakeholders who view communications and network based systems as essential complex subsystems and anyone who seeks to find a best path forward to resolve*

the ambiguity of communications systems being both interfaces between subsystems as well as subsystems in their own right. Four differing approaches are considered based on two orthogonal decisions. The first decision is whether to use a generalized or specialized representation of all contributing subsystems within the model. The second decision is whether to use system blocks or interface blocks to model the communications subsystems. Each one of these four approaches were individually modeled in SysML and presented to the development team for consideration and down selection. The resulting choice was to use the specialized approach while representing communications subsystems as blocks within the model. Our conclusions are that program specifics will likely result in different decisions across efforts, and in our case our customer/stakeholder views on the importance of communications drove our selection.

Model-based Attack Tree Generation for Cybersecurity Risk-Assessments in Automotive

Matthias Kern, Bo Liu and Victor Pazmino Betancourt (FZI Research Center for Information Technology, Germany); Juergen Becker (Karlsruhe Institute of Technology, Germany)

Abstract: *Networked and highly automated driver assistance systems require interfaces to the outside world and within the vehicle. These can potentially be used for cybersecurity attacks. Therefore, cybersecurity risk analyses are essential to adequately counter cybersecurity threats. Through UNECE Regulations No. 155, cybersecurity risk assessments, are mandatory for all new cars from 2024. The ISO/SAE 21434 standard "Road vehicles - Cybersecurity engineering", defines requirements for cybersecurity risk management with regard to electrical/electronic systems and components. In this context, it is imperative that possible attack paths are investigated. The creation of these attack paths is labor-intensive and should relate to the preliminary system architecture. Automatic attack tree generation could help to reduce the effort to create attack paths manually. This paper presents a new approach to generate relevant attack paths in a semi-automated way, taking the attack motivation and functional dependencies into account. This can shift the effort of creating attack trees in the concept phase to the preliminary system description and allows cybersecurity experts to focus more on aspects that require their creativity and expertise.*

Model-Based Design Space Exploration for Fail-Operational Mechatronic Systems

Christian Ebner and Kirill Gorelik (Robert Bosch GmbH, Germany); Armin Zimmermann (Ilmenau University of Technology & Systems and Software Engineering, Germany)

Abstract: *The increasing level of automation in safety-critical applications such as automated driving leads to additional requirements for functional availability of mechatronic systems. It is thus important to consider fail-operability and functional safety in order to optimize the performance and cost of the overall system in early design phases. The evaluation of feasible designs requires also the analysis of possible malfunctions and robustness of appropriate safety mechanisms in erroneous system states. This includes the examination of not only single faults but also the sequence and impact of possible fault combinations in dynamic systems.*

The work presented in this paper proposes a methodology and modeling approach suitable for design exploration of mechatronic systems under consideration of functional safety. It enables to automatically generate feasible design variants by varying the functional system architecture at different abstraction levels and by mapping the functions to a set of hardware components. Furthermore, it combines logical and behavioral modeling with the goal to automatically evaluate the impact of component failures for various design variants under consideration of system dynamics and possible reconfigurations. A stochastic process of each design variant is set up automatically to estimate relevant safety metrics. The applicability and benefits of the proposed model-based design exploration of fail-operational

mechatronic systems are demonstrated on exemplary drivetrain variants by investigating multiple safety mechanisms at different abstraction levels.

Model-Based Development of Design Basis Threat for Physical Protection Systems
Bedir Tekinerdogan (Wageningen University, The Netherlands); Murat Kaan Ozcan, Sevil Yagiz and İskender Yakin (ASELSAN, Turkey)

Abstract: *Physical protection system (PPS) is developed to protect the assets or facilities against threats. A systematic analysis of the capabilities and intentions of potential threat capabilities is needed resulting in a so-called Design Basis Threat (DBT) document. A proper development of DBT is important to identify the system requirements that are required for adequately protecting a system and to optimize the resources needed for the PPS. In this paper we propose a model-based systems engineering approach for developing a DBT based on feature models. Based on a domain analysis process, we provide a metamodel that defines the key concepts needed for developing DBT. Subsequently, a reusable family feature model for PPS is provided that includes the common and variant properties of the PPS concepts detection, deterrence and response. The configuration processes are modeled to select and analyze the required features for implementing the threat scenarios. Finally, we discuss the integration of the DBT with the PPS design process.*

Model-based Systems Engineering Supporting Cost Analysis of Aircraft Development Process
Hao Wang, Shaofan Zhu and Tang Jian (COMAC, China); Jinzhi Lu (KTH-Royal Insititute of Technology & Suzhou Tongyuan Software Control and Technology Company, Sweden); Junpeng Wu (Zhongke Fengchao Ltd, Switzerland); Dimitris Kiritsis (EPFL, Switzerland)

Abstract: *In the fact of increasing complexity of aircraft development programs, development processes of aircraft and their subsystems are continuously becoming complicated which leads to the growing risks of development cost across the entire lifecycle. In this paper, we propose a model-based systems engineering approach to support process modeling of aircraft development using a multi-architecture modeling language KARMA. At the same time, property verification and hybrid automata simulation are used implement the static cost analysis of each work task and dynamic cost analysis of the entire development process. Finally through one case study, a system-level aircraft development process "V model" is created which cost analysis is implemented by the KARMA language.*

Modeling A UAV in Practice: A Comparison between Rhapsody and Capella
Lorraine Brisacier-Porchon (ENSTA PARIS, France)

Abstract: *MBSE (Model-Based System Engineering) is the formalised application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. This paper is a practical approach of MBSE methods and tools comparison. It introduces a new COmparative FRAmework, named COFRA, that aims at putting MBSE methods and tools to test. The article proposes the evaluation of the ARCADIA method and its tool Capella and the evaluation of Nexter's custom-made PROXIMITY method using Rhapsody tool. We have detailed the motivations for choosing these tools and methods as a stepping stone for MBSE tools benchmark. The article presents a few practical representations*

of an electrical UAV, which is an example of multi-physical system that suits our interrogations about methods and tool comparisons. Then, this paper concludes with our future works, with the need to anchor systems engineering with formal comparative analysis for MBSE, and how to tailor the methods and tools to the system purpose and category. This introduces the requirement of system-driven engineering, so that development costs and delays be formally related to business income.

Modeling the Adoption of Internet of Things in Healthcare: A Systems Approach
Batyr Charyyev (Stevens Institute of Technology, USA); Mo Mansouri (Stevens Institute of Technology & University of South-Eastern Norway, USA); Mehmet Hadi Gunes (Stevens Institute of Technology & University of Nevada, Reno, USA)

Abstract: *The Internet of Things (IoT) has great potential to transform the healthcare industry. While there are data security and privacy challenges, the adoption of IoT advances healthcare with the integration of instantaneous and continuous data analytics. IoT enables connected monitoring systems, sensor instruments, and miniature detectors that can capture real-time health data to provide more reliable healthcare service. This paper describes a systems approach to model and analyze the adoption of IoT in the healthcare industry, seeking to provide a better understanding of shaping forces, major stakeholders, subsystems, and their interactions. We analyze how healthcare system dynamics change with IoT and how those changes impact the overall adoption rate of smart devices in healthcare. Finally, we provide an overview of the security and privacy issues that may arise with the integration of IoT in healthcare.*

Multiobjective Design Optimization of Hybrid Electric Rail Vehicle Powertrains
Herbert Palm and Fabian Rang (University of Applied Sciences Munich, Germany); Florian Mueller (Technical University of Munich, Germany); Markus Guerster (Massachusetts Institute of Technology, USA)

Abstract: *Technologies for rail vehicle powertrain systems are in a phase of disruptive transition. While existing electrification approaches fail to meet cost targets for many application scenarios, established cost-efficient diesel vehicles start to fall victim to CO2 regulations. Innovative hybrid electric powertrain technologies have the potential to stop this predicament but suffer from low degrees of engineering experience.*
Within this VUCA (volatile, uncertain, complex, and ambiguous) environment, the paper on hand reduces railway powertrain decision making risks by applying the Hyper Space Exploration (HSE) approach to quantify the potential of innovative hybrid diesel-electric alternatives during design phase. Thereby stated multicriterial Pareto-optimal target trade-offs are identified by applying multiobjective optimization (MOO) algorithms on virtual prototypes. As underlying simulations with the Toolbox for Optimal Railway Propulsion Architectures (TORPA) are computationally expensive, efficiency of MOO search algorithms is of crucial importance. Accordingly, three types of search algorithms are compared concerning their performance: Latin Hypercube Sampling (LHS), a Genetic Algorithm (NSGA2), and the Surrogate Optimization of Computationally Expensive Multiobjective Problems (SOCEMO) approach.
The outcome of this work enables railway product managers, system architects, and operators to choose appropriate search algorithms for effectively and efficiently quantifying the potentials of innovative rail vehicle powertrain technologies and, thereby, reduce their risk of decision making.

New Methods for Continuous Communication within the 3D-Model-Based Process Chain

Christopher Saal (Siemens AG, Germany)

Abstract: *The digitization of industrial manufacturing and quality assurance processes is currently being implemented in the majority of companies to cope with the ever-increasing quality and individuality requirements of customers. Functional 3D-CAD-models are developed to form the basis for the partially or fully automated control of virtually all product-related processes - from design to final acceptance by the customer. But there are still existing gaps interfering with the continuity of the digital CAD-CAM-CAQ workflow and impairing process transparency within product engineering processes. It is not yet possible to guarantee the complete and error-free implementation of PMI within the CAQ/CMM software. The methods described in this paper ensure that the quality-relevant inspection characteristics and the associated design elements are defined semantically consistent and are unambiguously recognised along the product creation process by using uniform characterisation.*

Open Source Framework for the Concurrent Design of CubeSats

Thibault Gateau, Lucien Senaneuch, Sophia Salas Cordero and Rob Vingerhoeds (ISAE-SUPAERO, France)

Abstract: *In this paper, we propose a software architecture relying on Nanospace. Nanospace is a software component dedicated to facilitate direct information exchange between third party expert software, while allowing transparent data visualization to a team member. It provides a web based GUI, relies on a database with ACID properties and provides a RESTful API.*
After reviewing current open source solutions for CubeSats preliminary design, we will introduce the modular software architecture of Nanospace, and the different options to connect third party specialized software and the database.
Source code is available

Populating MBSE Models from MDAO Analysis

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Abstract: *Over the past decade, Systems Engineering has switched from document-centric approaches to model-based ones. In this context, Model Based System Engineering (MBSE) and Multidisciplinary Design Analysis and Optimization (MDAO) have emerged as two complementary disciplines. How to combine MBSE and MDAO approaches for the benefits of systems engineers is still an open issue. This paper discusses a case study of coupling MBSE and MDAO. The MBSE part relies on SysML and timed automata, two modeling languages that are supported by the TTool and UPPAAL-SMC tools, respectively. The MDAO part is developed in the context of Open MDAO. The paper uses a drone as a case study and focuses discussion on battery usage. The SysML model of the drone is enhanced with a timed automata model of the battery. The SysML model of the battery is populated with results from MDAO analysis.*

Progressive Data-driven RUL Prediction Model for Pure Electric Bus Battery
Haijian Sun (Haylion Tech Inc., Canada)

Abstract: *An effective mobility cloud framework(EMC) is presented and a progressive data-driven RUL (remaining useful life) model of EV battery is proposed with experiment results from 100 buses operated by Shenzhen Bus Group.*
This paper has 5 contributions:
A cloud-based EMC(efficient mobility cloud) platform(figure 1), which comes with three layers: data, modules, and solutions, is an all-in-one solution that covers data collecting, system monitoring, vehicle diagnosis, prewarning, maintenance, reporting, management, and public transportation solution support on all aspects of any pure EV fleet operation.
As an EMC data layer, a vehicle onboard terminal named as ebox is designed to collect vehicle data from the vehicle controller area network(CAN) bus. The ebox onboard terminal is also capable of receiving data from sensors that support WIFI or Bluetooth connection. Therefore, we can collect the vehicle and environment data even if it is not in the content list of the vehicle CAN bus.
EMC module layer has all kinds of aspects of mining, learning, and analyzing data collected from the EMC data layer and provides corresponding reporting or prediction. As a part of the EMC module, a comprehensive battery life prediction model is presented based on a set of vehicle and environmental data including SOC series, voltage, current during battery charging procedure and related charging time, bus weight(mass of the bus, cargo, and weight of a number of passengers), wind and rolling resistance(with a windward area of the bus and air and rolling resistance coefficient), temperatures(ambient and battery temperature), power consumption of vehicle equipment(including interior and exterior lighting systems, surveillance equipment, network equipment, sound system, heating, and cooling system, etc.), speed and acceleration related factors including road conditions such as road gradient, road surface condition, traffic congestion, traffic lights, etc., driving regulations from the bus operator and driving behavior of the diffident driver, and each driving experience such as routes, road conditions, driving habits, etc.
A progressive battery remaining useful life prediction model is presented for the buses equipped with ebox onboard terminal and operated by Shenzhen Bus Group, based on the 3 days' average of SOC reducing from 100% to 30% and the power consumption of 3 days' average of battery charged from SOC 30% back to 100%(in KWH, estimated based on the integral of the charging voltage, charging current and charging time). In the absence of some driving specific vehicle and environmental data, the model can be simplified and customized according to the conditions including the regulation from the bus group operator, daily usage specifications of each bus, which is, the same driver drives the same bus on the same routine on daily basis, and the temperature in the city is basically between 10-30 degrees which are in the range of temperature for normal battery usage, etc.
The data is collected for about 6 months and the predicted RUL result is generally reliable with a simplified progressive battery life prediction model. With the increase in the collection of the vehicle and environmental data related to driving, the model can be promoted to the comprehensive battery RUL prediction mode with an overall accuracy increase in the range of 5-10%. So we leave the operator to decide if it worths the effect to install each sensor.

Reduce the time to classify the signals incoming from EEG BCI devices
Georgi Dimitrov (University of Library Studies and Information Technologies & ULSIT, Bulgaria)

Abstract: *In the recent years the attention to Brain-Computer Interface (BCI) devices and their potential for decoding human brain signals have risen considerably. However, a number of issues related to the classification of received signals still remain unresolved. This study focuses on increasing the speed of classification of data obtained from the Brain Computer Interface (BCI), without significantly affecting the accuracy of processing and classification. Our research team focuses on the possibilities to reduce the number of channels as one of the potential factors for increasing the speed of incoming data classification.*

Experimental data is obtained by using Emotiv Epoc 14+. For data processing we used Python. The data is classified with K-Neighbors algorithm.
Our research has shown that the removal of certain channels such as. T7, P7, O1, O2, P8, T8 according to the "10/20 international EEG system" greatly reduces the time required to classify incoming signals.

Reliability Allocation: an iterative approach for complex systems
Marcantonio Catelani, Lorenzo Ciani, Giulia Guidi and Gabriele Patrizi (University of Florence, Italy)

Abstract: *Reliability Allocation is a top-down technique implemented to assign a reliability target to all the components making up the system based on a system reliability goal. It is therefore fundamental to perform an accurate and effective reliability allocation during the early phase of the system's design. Despite several reliability allocation techniques are available in literature, every existing method is based on the assumption of a series reliability configuration of the system under analysis. However, redundancy plays a fundamental role in many different fields of application where it is absolutely required to ensure continuity of service in case of failure of a critical component. Therefore, this simplifying hypothesis is too simplistic for many industrial systems characterized by the presence of several redundancies and fault tolerant architectures. Starting from a previous work, this paper presents an iterative allocation procedure based on the hierarchical decomposition of the studied system. The proposed approach allows to successfully overcome the assumption of a series architecture without changing the main core of the allocation procedure. A lube oil console for Oil&Gas applications has been taken as case study to test and validate the performances of the iterative approach.*

Reliable Unmanned Autonomous Systems: Conceptual Framework for Warning Identification during Remote Operations
Rialda Spahic, Vidar Hepsø and Mary Ann Lundteigen (Norwegian University of Science and Technology, Norway)

Abstract: *In the offshore industry, unmanned autonomous systems are expected to have a permanent role in future operations. During offshore operations, the unmanned autonomous system needs definite instructions on evaluating the gathered data to make decisions and react in real-time when the situation requires it. We rely on video surveillance and sensor measurements to recognize early warning signals of a failing asset during the autonomous operation. Missing out on the warning signals can lead to a catastrophic impact on the environment and a significant financial loss. This research is helping to solve the issue of trustworthiness of the algorithms that enable autonomy by capturing the rising risks when machine learning unintentionally fails. Previous studies demonstrate that understanding machine learning algorithms, finding patterns in anomalies, and calibrating trust can promote the system's reliability. Existing approaches focus on improving the machine learning algorithms and understanding the shortcomings in the data collection. However, recollecting the data is often an expensive and extensive task. By transferring knowledge from multiple disciplines, diverse approaches will be observed to capture the risk and calibrate the trust in autonomous systems. This research proposes a conceptual framework that captures the known risks and creates a safety net around the autonomy-enabling algorithms to improve the reliability of the autonomous operations.*

Requirement Engineering in the Age System and Product Complexity
Maximilian Vierlboeck and Roshanak Rose Nilchiani (Stevens Institute of Technology, USA)

Abstract: *Product, service, and system development can be approached with numerous methodologies. Many of these models begin with the definition of requirements to fulfill. Thus, these requirements outline the purpose of the development. Furthermore, said requirements are directly related to the problem that the system is supposed to address. Due to the inherent attribute of the requirement definition and the product development process, the aspects to design are usually defined in the beginning and subsequently implemented or realized. This time difference between the definition and the actual realization of the requirements creates a high potential for uncertainty and risk, which is especially critical when it comes to emergent behaviors and complexity of the product or system. With this connection between requirements and complexity, the presented research set out to assess the current state of the research for both topics in form of a comprehensive literature review. This review includes the topics of general complexity, requirement engineering, and system/product complexity as a sub-section. The literature research and current state of the research showed ongoing and active research for all fields with a longer history for complexity. Going back all the way into the year 1948, complexity has evolved over time and expanded its application and research to various engineering domains which were identified based on cross connections. Requirement engineering showed its origins in computer science/engineering and successive expansion into other domains such as mechanical engineering, for example. Both fields, the one for complexity as well as requirement engineering, also show recent trends, such as the application and inclusion of AI and Machine Learning, Agile, and certain security/resilience foci. All in all, a comprehensive overview is provided with new insights into research expansion and evolution.*

RobAFIS: Lessons Learned from a Robotic Systems Engineering Challenge
Nga Thi Viet Nguyen (ETIS Laboratory & ESILV, France)

Abstract: *This paper describes our feedback and experiences while supervising teams during several years to participate in RobAFIS, a robotic competition using a systems engineering approach. Lessons learned from how to teach systems engineering in an effective way to motivate students in computer science are given. The strength and the weakness in apprehending different steps in a complex system life-cycle, from the stakeholder requirements analysis to the system design, implementation, deployment and maintenance are discussed. We think that the competition is really an excellent opportunity for students and teachers to discover systems engineering and to exchange with experts to improve their knowledge and best practices in this interdisciplinary field.*

Sovrin Network for Decentralized Digital Identity: Analysing A Self-Sovereign Identity System Based on Distributed Ledger Technology
Nitin Naik (Aston University, United Kingdom (Great Britain)); Paul Jenkins (Cardiff Metropolitan University, United Kingdom (Great Britain) & University of Portsmouth, United Kingdom (Great Britain))

Abstract: *Digital identity is the key to the evolving digital society and economy. Since the inception of digital identity, numerous Identity Management (IDM) systems have been developed to manage digital identity depending on the requirements of the individual and that of organisations. This evolution of IDM systems has provided an incremental process leading to the granting of control of identity ownership and personal data to its user, thus producing an IDM which is more user-centric with enhanced security and privacy. A recently promising IDM known as Self-Sovereign Identity (SSI) has the potential to provide this*

sovereignty to the identity owner. The Sovrin Network is an emerging SSI service utility enabling self-sovereign identity for all, therefore, its assessment has to be carefully considered with reference to its architecture, working, functionality, strengths and limitations. This paper presents an analysis of the Sovrin Network based on aforementioned features. Firstly, it presents the architecture and components of the Sovrin Network. Secondly, it illustrates the operation of the Sovrin Network and develops a DApp for the Sovrin Network to demonstrate and evaluate their functionalities and operational services. Thirdly, based on the developed DApp and empirical evidence, it performs an analysis of the Sovrin Network, evaluating its various functionalities and metrics. Finally, based on the experimental analysis, it presents the strengths and limitations of the Sovrin Network.

State Machines Consistency between Model Based System Engineering and Safety Assessment Models

Julien Vidalie (Supméca - Quartz Laboratoire & IRT SystemX, France); Mohamed-Sami Kendel (Lurpa Laboratoire ENS Paris-Saclay, France); Faïda Mhenni (SUPMECA & Laboratoire Quartz, France); Michel Batteux (IRT SystemX, France); Jean-Yves Choley (SUPMECA & Laboratoire Quartz, France)

Abstract: *Nowadays with the development of industrial systems, engineers are having more difficulties to design complex systems, meaning that they have to conduct several simulations to design system models. In the case of safety assessment, this creates a need for the safety model to be consistent with the systems engineering model, since both models are supposed to represent the same architecture. In this work we present a methodology for synchronisation of two kinds of state machines, Harel's Statecharts and Guarded Transition Systems. These formalisms are used to model system behavior respectively in MBSE (Model Based System Engineering) and MBSA (Model Based Safety Assessment) tools. This methodology, based on the SmartSync framework that aims at asserting structural consistency between MBSE and MBSA, is composed of 3 steps: abstraction to a pivot formalism, comparison and concretization. We compare two mappings of concepts used for translation from our state machines to the S2ML language.*

Systems Thinking Approach to an Artificial Intelligence Reality within Healthcare: From Hype to Value

Olga Strachna (Stevens Institute of Technology & Memorial Sloan Kettering Cancer Center, USA); Onur Asan (Stevens Institute of Technology, USA)

Abstract: *The healthcare system is undergoing a transformational change due to the buildup of frustration against rising costs, inefficient services, long wait times and declining population health outcomes in the United States (US). At the same time, there is a growing excitement about the deployment of artificial intelligence (AI) technologies in order to mitigate these inefficiencies. Many of the AI initiatives in healthcare are generally focused on highly domain specific solutions. There has not been widespread adoption of systemic solutions proposed. Improving care coordination is a national priority in the US and it is thought to be critical to avoiding unnecessarily hospitalizations. Given the increase in the aging population and the mounting complexity of care dynamics as patients age, the time is ripe to apply systems thinking approaches to model the dynamics of these complex care trajectories with the implication of utilizing AI technologies to augment care transitions. This paper outlines the rationale and approach for utilizing systems thinking in AI implementation design focused on improving care coordination as a driver for high value care.*

The Paradigm of Design Thinking and Systems Engineering in the Design of Cyber-Physical Systems: A Systematic Literature Review

Julian Tekaat (Fraunhofer Research Institute for Mechatronic Systems Design IEM, Germany); Harald Anacker and Roman Dumitrescu (Fraunhofer-Einrichtung für Entwurfstechnik Mechatronik IEM, Germany)

Abstract: *Digitization has been driving technological design in mechanical engineering and related industries such as the automotive, electronics and medical technology sectors. A change from classic, mechanics centered systems to mechatronic systems and further to intelligent, cyber-physical systems is becoming apparent. To counter the resulting increase in complexity, research and industry are adapting values and practices of agile approaches to extend conventional design solutions like systems engineering. In many cases, the aspects of volatility regarding changing requirements and a fast response time are addressed by implementing agile approaches like SCRUM into the design of cyber-physical systems. In contrast, the aspect of uncertainty is rarely considered. Uncertainty is characterized by an increasing number of challenges, which are often intertwined and ill-defined which sums up to so-called wicked problems in systems design. There is neither an industry-specific nor an industry-independent clear understanding how to tackle such challenges. Furthermore, also classical systems engineering does not explicitly offer practices to tackle the increasing percentage of uncertainty in design. In contrast to this, however, design thinking is said to offer processes and methods to tackle wicked problems in systems design. To get an idea for potentials and workarounds how design thinking can work in synergetic interaction with classical systems engineering, this contribution presents the result of a Systematic Literature Review that condenses different interpretations and understandings of design thinking. To address the stated objective the focus is set on the applicability in combination with classical systems engineering as well as an understanding applicable to the context of cyber-physical system design.*

Virtual Verification of E/E Architectures for Secure Automated Driving Functions

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Abstract: *Automotive trends, such as autonomous and connected driving, are increasing the number of sensors to percept the environment precisely. To support automated driving functions, vehicles share information via wireless interfaces (e.g., cellular) with Other Road Users (ORUs). This growing degree of connectivity also increases the risk of cyberattacks. According to the United Nations Economic Commission for Europe (UNECE) regulation authority (WP.29), the integration of security countermeasures (e.g., Intrusion Detection System (IDS)) is mandatory for Original Equipment Manufacturers (OEMs). To verify the effectiveness of such security measures for Advanced Driver Assistance System (ADAS) functions, aspects such as vehicle behavior, network communication and the environment have to be taken into account. The use of model-based simulation approaches enables an early virtual verification of electrical/electronic architectures (E/E architectures) before the associated hardware is completely developed. In this paper, we describe a multi-domain co-simulation approach for a scenario-driven and reactive testing of E/E architectures that form with their corresponding environment cyber-physical systems (CPSs). It is based on deriving simulation models from the established E/E architectures modeling tool PREEvision. Moreover, we show the development of an IDS by applying our simulation approach in a model-based manner and evaluate it with a pre-defined attack scenario. As a conclusion, we discuss how this approach can support identifying design flaws for developed countermeasures and help to improve or establish standards for model-based security testing of E/E architectures.*