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The International Association for the Engineering Modeling, Analysis and Simulation Community

CONFERENCE PROGRAM & AGENDA

Model-Based Engineering

What Is It & How Will It Impact Engineering Simulation?

October 1st, 2019 | Columbus, OH

nafems.org/americas

Keynote from the NASA Jet Propulsion Laboratory on "*From SysML to Mars: Mars2020's MBSE Infusion*" and **Invited Presentation** from the SMS_ThinkTank on "*System Modeling & Simulation and its Relation to MBE / Development & Promotion of Data Standards.*"

Two Tracks with presentations from industry, software providers, researchers, and academia

Panel Discussion led by the SMS_ThinkTank on "*Challenges When Implementing Simulation in a Model-Based Engineering Environment*"

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NAFEMS americas events

Business growth depends on developing new and improved products and technologies, and getting these to market ahead of the competition. The digitalization of our lives today is driving an ever faster-paced environment, and developing products based on skills and capabilities in specific engineering domains is no longer sufficient. The demand for systems-level solutions is driving a need to merge systems engineering and engineering simulation to a new level.

Combining the modeling and simulation perspectives of both systems engineering and engineering simulation can improve communications and coordination across the product development lifecycle. An early reliance on simulation can enable agile approaches in which prototypes and visualizations contribute to elicitation and refinement of expectations and alternatives in collaboration with system stakeholders. Simulation throughout the product lifecycle can reduce risk, more thoroughly explore alternative solutions, and reduce costs over physical testing.

This conference will explore how model-based engineering, along with the challenges that accompany it, will need to be applied within engineering simulation to help address the increasing sophistication of models and tools to predict a wide range of physical phenomena, including how to understand the user domain, to define functions and concepts, and to capture system requirements across the levels of a system architecture.

Conference Overview

NAFEMS and participating speakers will cover these topics, and more, at the "Model-Based Engineering: What Is It & How Will It Impact Engineering Simulation?" Conference. Attendees from all industries will gather at this event, in a non-competitive environment, to exchange ideas, identify best practices, and drive the near-future direction of technology.

This conference aims to deliver information and insights on critical topic areas in a manner that maximizes the "take-away" value for attendees. An event agenda and concept championed by several leading figures in industry will provide the opportunity to learn about the latest technologies and practices, which attendees can later share and apply within their own organizations.

AGENDA - Tuesday, October 1st

Plenary Session: Clinton

8:30

Welcome & Introduction
A. Wood, Americas Regional Manager, NAFEMS

System Modeling & Simulation and its Relation to MBE / Development & Promotion of Data Standards
F. Popielas, SMS_ThinkTank

From SysML to Mars: Mars2020's MBSE Infusion
E. Fosse, NASA Jet Propulsion Laboratory

10:30 Break in Ballroom / Exhibitor Area

Room: Clinton

TRACK 1: SESSION 1
Chair: D. Tolle, CIMdata

11:00

Accelerating Full Vehicle Simulation and Reinforcement Learning with Model-Based Design
M. Carone, MathWorks

Artificial Intelligence Applied to Smart Model Based Systems Engineering
A. Ayala, Ford Motor Company

The Impact of MBE on Simulation: From Embedded Software to Digital Twins – Leveraging System Simulation Models
T. Karam, ANSYS

Room: Hancock

TRACK 2: SESSION 1
Chair: F. Popielas, SMS_ThinkTank

Combining Systems Engineering and Simulation - What's So Hard About That!
M. Panthaki, ARAS Corporation

Examples of Model-Based Systems Engineering as the Heart and Soul of Digital Twins
J. Ryan, Altair Engineering, Inc.

Leveraging Systems Thinking, MBSE & Sim. in the Design & Analysis of Highly Distributed Autonomous Vehicle Systems
C. Davey, Ford Motor Company

12:30 Lunch in Ballroom / Exhibitor Area

TRACK 1: SESSION 2
Chair: S. Arnold, NASA Glenn Research Center

1:30

Model Based Engineering Overview
K. Kulkarni, Detroit Engineered Products

Emerging Standards for Model-Based Systems Engineering
D. Tolle, CIMdata, Inc.

Art and Science of Surrogate Modeling of Joints
J. Kim, The Ohio State University

TRACK 2: SESSION 2
Chair: A. Ayala, Ford Motor Company

Model-Based Engineering (MBE) Methods for Multi-Threaded, Reactive, and Data-Intensive Platforms
S. Mehta, L3Harris Technologies

Optimizing Organizational Models to Improve Simulation Efficiencies
B. Hauser, Medtronic

Platform-Independent Integration of SysML with 1-D Simulation
M. Dadfarnia, NIST

3:00 Break in Ballroom / Exhibitor Area

TRACK 1: SESSION 3
Chair: M. Dadfarnia, NIST

3:30

2040 Vision Study: An Enlargement of Model Based Engineering
S. Arnold, NASA Glenn Research Center

Aircraft Survivability Modeling and Simulation Framework (AirSurF)
I. Lunsford, Northrop Grumman

TRACK 2: SESSION 3
Chair: J. Shah, The Ohio State University

Towards Traceable and Reliable Model-Based Engineering: Adopting the Benefits of the Model Identity Card for Simulation
S. Silverans, Siemens Industry Software NV

Application of ML on Car Body Structure Design
Y. Jiang, The Ohio State University

4:30

PANEL DISCUSSION: Clinton
Challenges When Implementing Simulation in a Model-Based Engineering Environment
Led by E. Ladzinski, SMS_ThinkTank

5:30 **Networking Reception in the "Coach's Club"**

Sponsors

We would like to extend a special thanks to the sponsors of the 2019 NAFEMS Americas Conference on "Model-Based Engineering: What Is It & How Will It Impact Engineering Simulation." Please be sure to visit and speak with each of our sponsors during the conference to see and hear about the latest advancements in their technologies.

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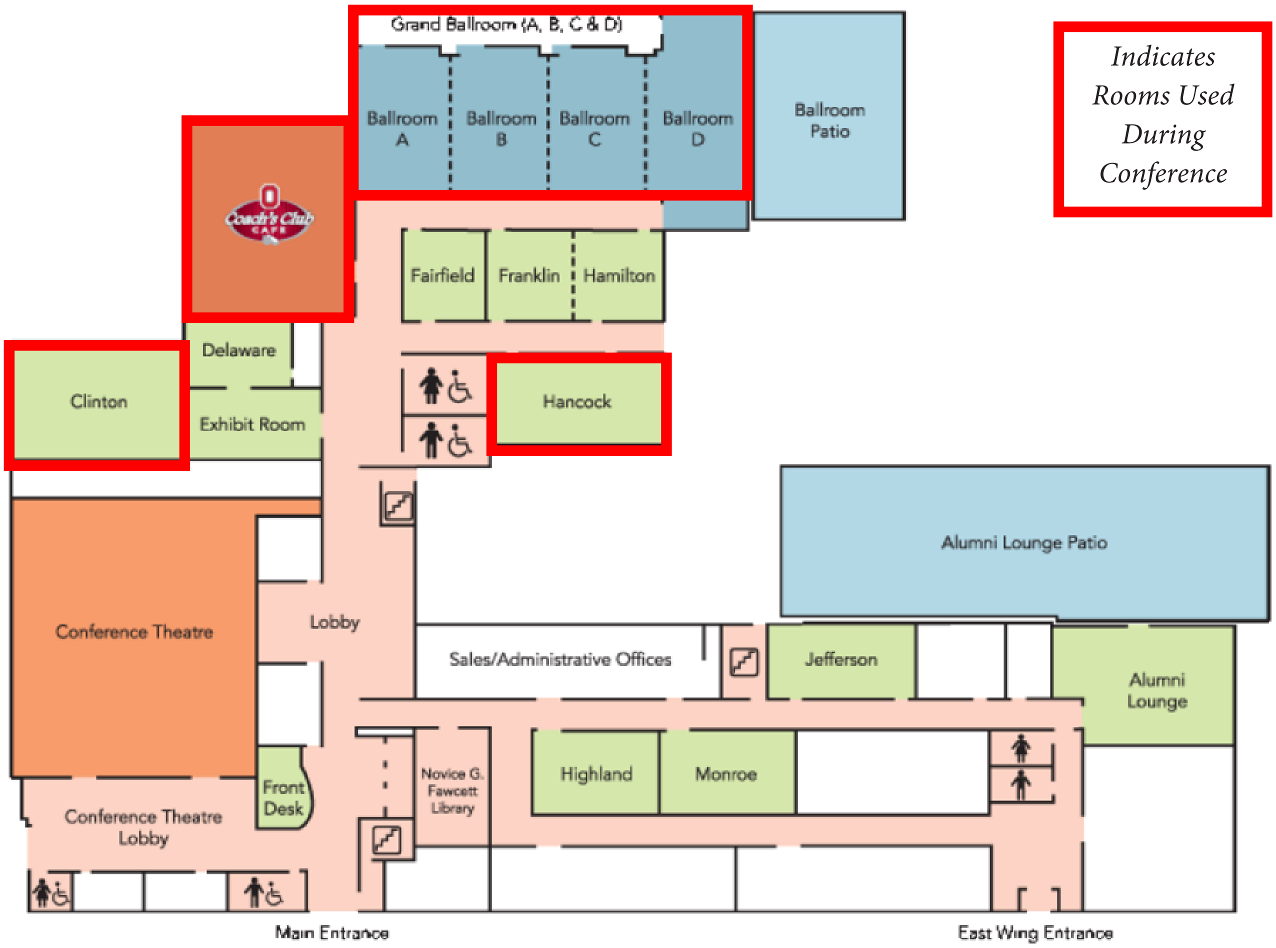

Exhibiton Hall (Lobby Areas)

Exhibitors will include:

- *TotalCAE*
- *SIMCenter*
- *Dassault Systemes SIMULIA Corp.*
- *Altair Engineering*
- *ARAS Corporation*

NAFEMS

As the only non-profit international association dedicated to the analysis, simulation, and systems engineering community, NAFEMS has established itself as the leading advocate for establishing best practices in engineering simulation. Over 35 years later, industry end-users, software and hardware solutions providers, researchers, and academic institutions continue to recognize NAFEMS as a valued independent authority that operates with neutrality and integrity. NAFEMS Americas supports over 400 member companies located in the Americas region who are actively engaged in the analysis, simulation, and systems engineering community.

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Conference Venue

The Fawcett Center
2400 Olentangy River Rd.
Columbus, OH 43210

Presenter Name: Arnold, Steven

Presenter Company: NASA Glenn Research Center

Presentation Title: 2040 Vision Study: An Enlargement of Model Based Engineering

Keywords:

Abstract:

Over the last few decades, advances in high-performance computing, new materials characterization methods, and, more recently, an emphasis on integrated computational materials engineering (ICME) and additive manufacturing have been a catalyst for multiscale modeling and simulation-based design of materials and structures in the aerospace industry. As a result, NASA's Transformational Tools and Technology (TTT) Project sponsored a study (performed by a team led by Pratt & Whitney) to define the potential 25-year future state required for integrated multiscale modeling of materials and systems (e.g., load-bearing structures) to accelerate the pace and reduce the expense of innovation in future aerospace and aeronautical systems. This talk will briefly review the findings of this 2040 Vision study (e.g., the 2040 vision state; the required interdependent core technical work areas, Key Element (KE); associated critical gaps and actions to close those gaps; and major recommendations). The study, NASA CR 2018- 219771, envisions the development of a cyber-physical-social ecosystem comprised of experimentally verified and validated computational models, tools, and techniques, along with the associated digital tapestry, that marries two non-mutually exclusive paradigms – "design of the materials" (material scientist viewpoint) and "design with the materials" (structural analyst viewpoint) – into a concurrent transformational paradigm that impacts the entire supply chain to enable cost-effective, rapid, and revolutionary design of fit-for-purpose materials, components, and systems. Although the vision focused on aeronautics and space applications, it is believed that other engineering communities (e.g., automotive, biomedical, etc.) can benefit as well from the proposed framework with only minor modifications. Finally, it is TTT's hope and desire that this vision provides the strategic guidance to both public and private research and development decision makers to make the proposed 2040 vision state a reality and thereby provide a significant advancement in the United States global competitiveness.

Presenter Name: Ayala, Alejandro

Presenter Company: Ford Motor Company

Presentation Title: Artificial Intelligence Applied to Smart Model Based Systems Engineering

Keywords: Artificial Intelligence (AI), Automation, Deep Learning, Dynamic Simulation, Machine Learning, Optimization, Smart Model Based Systems Engineering (SMBSE), Reusability, Supervised Learning, Unsupervised Learning, 3D models self-design machine

Abstract:

Smart Model Based Systems (SMBSE) engineering is an evolution from Model Based Systems Engineering (MBSE), by incorporating digital capabilities to expedite a quality execution and minimize unintended effects. SMBSE integrates Systems Engineering (SE) functionality with a suite of smart tools, by modelling complex systems, requirements, constraints, targets, validation and verification plans, to develop the simplest solution. The SMBSE distinctive features from the conventional MBSE include reusability, automation, dynamic simulation and optimization. SMBSE incorporates Artificial Intelligence (AI), as an enabler of the optimization element with machine learning algorithms, to facilitate the overall design effort and develop an optimal design solution. The AI application in SMBSE framework drives the opportunity for optimizing design processes, with learning capabilities for different system scenarios and objectives. AI tools will enable engineers to focus on the Systems Engineering roles that add more value to prevent unexpected results and ensure user needs compliance, as well as providing more time to optimize solutions from the early stages of designing complex systems engineering. The increasing complexity of disruptive technologies requires the application of smart systems engineering tools to develop digital methodologies, enhanced by AI, oriented to automate as possible, the complex design processes. This effort requires the application of automation and AI capabilities, but also systems integration tools to facilitate the interface between different software platforms and hardware, to expedite the design iterations to generate the optimal solution. The proposed SMBSE framework provides the opportunity to release time, for product designer teams, by automating complex design process of conventional technologies and focus on disruptive technologies generation. There is a never-ending race to innovate based on new technologies that require design cyber tools in accordance with the increasing complexity of today's products and services. The conjunction of AI and systems engineering provides the design path to face this permanent challenge.

Presenter Name: Carone, Michael

Presenter Company: MathWorks

Presentation Title: Accelerating Full Vehicle Simulation and Reinforcement Learning with Model-Based Design

Keywords: Full-vehicle simulation, reinforcement learning, Model-Based Design, powertrain, walking robot, deep learning, artificial intelligence

Abstract:

As the electrification of systems continues, it is becoming increasingly important to be able to evaluate tradeoffs and alternatives as soon as possible, so that engineers can determine which components would work best and how they should be connected within an overall system. At the same time, organizations are looking to artificial intelligence in order to control these systems as they get more and more complex. In this talk, we will review two application areas that can be accelerated through the use of Model-Based Design: full vehicle simulation and reinforcement learning. Full vehicle simulation models are used to assess alternatives according to specific objectives, such as fuel economy or performance. At times, this requires the integration of models from different engineering teams, who use different modeling and simulation tools, into a single system level simulation. This can be difficult to do in a traditional testing environment where different coded algorithms need to be stitched together. In the first part of this talk, we will review a case study to see how to evaluate different architectural candidates for an electrified powertrain and how using a simulation integration platform can help with the selection of the best candidate, given our objectives. In the second part of the talk, we will review how Model-Based Design can be applied toward reinforcement learning. Reinforcement learning is an exciting new area due to its potential to solve complex problems in areas such as robotics and automated driving, where traditional control methods can be challenging to use. In addition to deep neural nets to represent the policy and algorithms to train them, reinforcement learning requires a lot of trial and error. Although this can be done with hardware, it can not only take a lot of time to collect the required amount of data, but for some applications it could also be both expensive and dangerous for systems, even if they are prototypes, to repeatedly fail during training. This is where using a simulation platform is advantageous – you can run thousands or millions of simulations to train your system to complete its objectives in an optimal manner. Using a walking robot case study, we will go through the steps needed to set up and solve a reinforcement learning problem, and how to take advantage of parallel simulations and automatic code generation to quickly get to an implementation that works.

Presenter Name: Dadfarnia, Mehdi

Presenter Company: NIST - National Institute of Standards & Technology

Presentation Title: Platform-Independent Integration of SysML with 1-D Simulation

Keywords: SysML; model-based systems engineering; model transformation; debugging; lumped parameter simulation; 1-D simulation; equation-based languages

Abstract:

Model-based systems engineering uses representations of system requirements, behaviors, and architectures to communicate complex system specifications among engineering teams and their stakeholders. Systems modeling languages capture these representations to help organize a wide variety of engineering activities, many of whom develop discipline-specific simulation models. Many simulation models are built with equation-based languages, containing detailed behavior specifications and analytics to predict system dynamics. They are often built separately from systems models, leading to additional work to resolve inconsistencies and lower quality due to fewer multi-disciplinary simulation concerns reflected in the overall systems design. To address these problems, a widely used systems modeling language (SysML) has been extended to represent physical interactions and signal flows (also known as 1-D or lumped parameter models) that can be translated to simulation tools for execution. All translated simulation structures can be traced to their corresponding systems structure, along with any simulation errors related to the systems model. This presentation describes the SysML Extension for Physical Interactions and Signal Flow Simulation (SysPhS), which enables automated translation of SysML models to executable simulation models. The extension fills modeling gaps between SysML and simulation tools and languages. These gaps (simulation concepts missing from SysML) were identified by a comparison of constructs and semantics in SysML to constructs and semantics that simulation tools and languages have in common. This presentation also gives an overview of best practices for using the extension to develop and translate SysML models. These guidelines for modeling and debugging systems models ensure smooth translation to and execution of engineering simulation models. They emphasize transformation and transmission of conserved physical substances and numeric information within system structures, with equations chosen to describe these processes. Debugging procedures identify defects in system models that cause simulation execution failure or incorrect simulation results. Finally, an example SysML model built with the extension is translated and executed on different simulation platforms, showing consistency with the same results.

Presenter Name: Dutré, Mathieu (S. Silverans)

Presenter Company: Siemens Industry Software NV

Presentation Title: Towards Traceable and Reliable Model-Based Engineering: Adopting the Benefits of the Model Identity Card for Simulation

Keywords: Model-Based Engineering, Traceability and Reliability in Simulation, Model Identity Cards

Abstract:

With the ever-increasing speed of technology advancements in development of cyberphysical systems, there is a corresponding struggle to grasp system complexity and to establish an efficient development process. The different verification and validation (V&V) phases are becoming an increasingly vital part in today's engineering processes having to address stricter safety and environmental regulations. A model-based design methodology is widely adopted for verification and validation, but its true potential is being limited as simulation is used within an ecosystem of often disconnected engineering activities. Due to the lack of a platform providing traceability and reliability support for collaborative engineering, test results often reflect outdated development status or regression testing after requirement changes cannot be automated. Consequently, engineers are discovering bugs only at final integration or system testing, even though approximately 60% of them are already introduced at the requirements phase. OEMs and suppliers require integrated platforms that can describe and orchestrate the processes between various engineering activities and stakeholders, including the management of large amounts of requirements or test cases and the connection to simulation for running validation and verification scenarios and cross-domain integration activities. In this presentation, we introduce such an innovation platform that allows companies to sketch out, orchestrate and optimize the different processes currently followed in their development cycles. To achieve this a technology concept called Model Identity Cards (MIC) is introduced. The MIC framework is built on three main pillars, of which each will be given an introduction and more technical explanation. The first pillar focuses on providing traceability and reliability to the engineering community. This can be ensured by creating bidirectional links between the requirements, test cases and all simulation artefacts created during the implementation and testing phases. A formalized information model implemented in the backend gives an overview of the possible links that can be created. This information model then also creates the basis for a plug-and-play platform where artefact types can be added and removed based on a company's best practices. On each of these artefact types, a formalized workflow is then imposed to create a reliable business process that is adopted company-wide. This is for example important in context of certification. The second pillar of the platform is an architecture model of the simulation components. This model allows the engineering team to describe and monitor how the different components will integrate with one another. The architecture model furthermore streamlines the communication to successive development teams, who can then implement executable simulation components in their simulation platform of interest. Successively, by being able to retrieve up-to-date development and test information on related simulation components, the architecture model forms the basis for the automation of regression tests. The third pillar is the specification and execution of the V&V platform. Based on the available tooling, methods, and IT infrastructure, the MIC connects to an automated server-based test framework. Built on a continuous integration solution, this framework sets up a co-simulation environment based on the information received from the MIC. It then executes this environment to validate the executable simulation models. Results from these tests again complete the Model Identity Cards, facilitating re-use of models, documentation generation and clear results reporting between different development teams. To summarize, the presentation will introduce the concept of Model Identity Cards to the audience. The talk will focus on the supported processes, will give insights in the back end metamodels and will give an outlook on how we plan to further extend capabilities. Finally we'll discuss how adopting Model Identity Cards for simulation could streamline collaboration, reduce design iterations and reduce manual testing effort by automating verification and validation activities.

Presenter Name: Fosse, Elyse

Presenter Company: NASA Jet Propulsion Laboratory

Presentation Title: From SysML to Mars: Mars2020’s MBSE Infusion

Keywords:

Abstract:

Mars2020, NASA’s next Mars Rover inherited a majority of Mars Science Laboratory (MSL)’s Flight hardware and software. It also inherited the technical baseline described in disparate presentations, spreadsheets, document repositories, emails, and intelligent minds that have long left the project. The Mars2020 Systems Engineering leadership wanted to define their technical baseline in an integrative, data driven manner, that would incorporate the inherited design with the new science instruments and Martian sample caching system. The team chose to leverage advancements in MBSE to garner a better understanding of the complexities facing the mission. Now, less than one Martian year until launch, it is an opportune time to discuss MBSE’s impact on the Systems Engineering products and processes created by Mars2020. I will discuss what the objectives for Mars2020 MBSE were and evaluate how well those objectives were met. Additionally, I will evaluate the implementation’s alignment with JPL’s vision of MBSE and discuss what future missions can learn from Mars2020’s infusion.

Presenter Name: Hauser, Bret

Presenter Company: Medtronic

Presentation Title: Optimizing Organizational Models to Improve Simulation Efficiencies

Keywords: Organizational Models, Optimization, Simulation Efficiency

Abstract:

BACKGROUND: The benefits of Modeling and Simulation (M&S) are well known and documented both within Medtronic and in external literature. However, there is a question concerning the most efficient means to organize the inclusion of M&S into the product development cycle. We tested the hypothesis that a hybrid development process (PDP) involving both Empirical and M&S methods in Centralized or Decentralized organizational structures lead to improvements in throughput and resource utilization. PROBLEM: Modeling and Simulation, like many engineering and scientific disciplines, requires specific training and skill development. In the Distributed model, all design engineers and scientists are responsible for their own simulations. However, human factors literature supports that for skilled activities, a proficiency curve exists whereby efficiencies improve with repeated practice; and degrade during periods of inactivity. For a Distributed Model, this proficiency curve can be a significant obstacle when M&S activities are only needed occasionally during a project. In the Centralized model, M&S activity occurs within a specific group or department, providing a skilled workforce that remains 'on top of' the proficiency curve given their service role in support of multiple projects. A challenge with this organizational method is the speed and efficiency with which learning can be given back to the project team; a challenge that is not experienced by the Distributed model where M&S activity is directly embedded within the team and results are incorporated instantaneously. METHODS: A discrete event simulation was conducted to evaluate a generic PDP process including concept, development and V&V loops with potential for rework due to design and analysis errors. Organizational models including Distributed, Centralized, and a proposed Mix based on the complexity of the M&S activity were evaluated and compared to a baseline model where M&S was not included. Potential for Design error and Simulation efficiencies are guided by both literature and practical experience. Analyses were conducted stochastically to support statistical evaluation of results. Key comparisons include the number of projects produced via each model in a given period, project time in system, resource utilization and others. RESULTS & CONCLUSIONS: A discrete event simulation was conducted to compare the organizational modeling efficiencies of multiple strategies for incorporating the benefits of M&S to a project. Results confirmed that the use of M&S is beneficial when compared to the baseline Empirical model. Advantages and disadvantages were identified for Distributed and Centralized organizational models. A proposed Mixed model was identified that balances the key parameters for an overall improved result. Guidance from both literature and practical experience is used to support a finding that a Mixed organizational model outperforms both Distributed and Centralized models and that all uses of M&S outperform the baseline Empirical model.

Presenter Name: Karam, Tony

Presenter Company: ANSYS

Presentation Title: The Impact of MBE on Simulation: From Embedded Software to Digital Twins – Leveraging System Simulation Models across the Product Lifecycle

Keywords: Safe Architecture, Virtual Prototyping, modularity of simulations, requirements driven engineering, Digital Twins, physics-based models, IIoT

Abstract:

Simulation is key in driving data-driven decision-making throughout the product design and development process, creating a virtual environment where engineers can optimize and make design trade-offs for cost and function. While simulation practices are well established in the design and development phase, physics-based models are rarely leveraged after a product is released. These physics-based simulation models provide insights into the operational conditions of the product, which cannot be captured by sensors. These models can enable “what if analysis” and diagnosis of problems, to aid the decision-making process well into the operations and sustainment cycle. At the same time, high-investment industries, like aerospace and defense, support programs that are planned for use over decades, in a highly evolving technology environment. These programs need to be designed not just for a successful roll-out but for continuous development and upgrades over the product lifecycle. Modularity, therefore, needs to be considered up-front as part of any digital engineering methodology, starting with the architecture, not only as part of a solid MBE strategy, but to ensure the safety and robustness of the system. The architecture of these high-investment, safety-critical systems needs to be validated against the threat of cyberattacks. It is critical, at the early architecture stage, to identify system vulnerabilities that can be exploited to execute attacks, so the appropriate measures can be taken. Embedded software, which defines the actions of systems, can help provide scalable, fully-integrated avionics software, to meet strict standards as well as development timelines, in a modular environment. For such an environment, it is essential that the digital design model database is maintained in an open format that seamlessly accesses the existing model data and can add new model data based on the latest practices and standards. Requirements-driven engineering is on the horizon and the MBE paradigm will create the need for modularity of simulations for engineers to "plug and play" from existing libraries of simulations. Model requirements, therefore, need to be defined up-front, in order for engineers to leverage insights from physics-based models which evolve from design to deployment and through operations, spanning from embedded software to Digital Twins.

Presenter Name: Kim, Ji-Hoon

Presenter Company: The Ohio State University

Presentation Title: Art and Science of Surrogate Modeling of Joints

Keywords: FE idealization of joints, Modeling methods for auto body joints, Thin walled structures, SPR, FDS, Bolts, Welds, nails

Abstract:

Automotive body structures contain several thousand thermal, mechanical, adhesive and hybrid joints. For structural FEA simulations of the full-detailed geometry including joints is computationally prohibitive. This includes modeling of threads, fastener engagement, deformation contour and material property change due to the joining process with very small size elements. These elements would lead to very long solve time which is unnecessary. While this can be acceptable for stress analysis of the joint, it is impossible to model each joints in such detailed level in larger-scale models such as crash test model where several thousands of joints are existent.We have conducted a survey of various methods of idealized joint modeling to reduce model size while accounting for the joint stiffness. These methods aim to simulate the “global” behavior of the joint, by calibrating the material parameters to fit the actual test result through optimization process. Detailed procedure of the calibrating of these simplified models have been discussed as well. Several methods are discussed in this paper, from element-based methods to constraint-based methods. There are already commercially available methods for modeling spot welds, either through beam elements or solid elements and those methods are already implemented in the FEA packages. Bolts and nuts could be modeled with beam with spider elements, solid elements, and spring elements. However, such modeling scheme for bolts are still for small-scale models to avoid threaded contact. For other mechanical fasteners such as FDS (Flow driven screws) and SPR (Self-piercing rivet), cohesive elements and multi-point constraint methods were recommended, due to the advantage on handling the mixed mode loading. Solid elements cannot handle mixed mode loading, because the failure criteria of the solid element do not consider mixed mode loading. Adhesive joints are predominantly modeled with cohesive elements because the element itself is based on the fracture mechanics which the behavior of the adhesive is addressed. Also, adhesive joint is a simple layer of adhesive, so there no need to further simplify the geometry of the joint. For hybrid joints, a combination of the methods appears suitable. Calibration of the idealized joint model is an optimization problem to manipulate the material parameter to fit the force-displacement curve obtained from actual testing. Optimization software may be used along with FEA solver to perform iterative study to find best parameter combinations that has the lowest error. Calibration may be done with coupon level tests, where a single joint is under various types of load cases, or comparison with full detailed FEA. While these simplified joint models decrease the computational burden, information on the failure modes of the joints are missing. It would be highly beneficial for these joint models to have a design curve describing the relationship between the type of loading and failure modes, to address the failure behavior of the joint under various cases. Additionally, the calibrated material parameters are nominal values. That is, variability of the joining process, such as the material engagement of the joint and the surface quality of the joining plates that are not consistent from one joint to another is not considered. Variations on the quality of the joint due to these factors needs to be addressed in order to provide more comprehensive information on the joint rather than just a block of element having nominal parameter with no failure mode information.

Presenter Name: Kulkarni, Kuldeep

Presenter Company: Detroit Engineered Products

Presentation Title: Model Based Engineering Overview

Keywords: Model, system architecture, requirements, validation, simulation, graphical model

Abstract:

Model-Based Engineering is the methodology of developing a set of domain system models, which help to define, design, and document a system under development, which eventually replaces traditional document driven communication to different stakeholders such as Requirements Engineers, Systems Engineers or System Verification and Validation Engineers. In Model based Engineering data will be shared using models, rather than any textual communication, reducing risk of any language barrier. The models created are often graphical or mathematical in nature depicting domain under consideration. Model based Engineering may include system architecture and interactions within subsystems, performance analysis, requirement analysis and flow, simulation of overall system with different components, verification and validation. The process of applying Model based engineering starts by analysing system level requirements. Further by identifying subsystems to satisfy current domain or system and interactions amongst different subsystem should strengthen the behavioural requirements. Each subsystem can carry its own requirement set by thorough analysis. System Architecture created by this process can be central or focal point of entire product development life cycle, as each product development stage, may it be low level design, subsystem testing or system testing can refer to System Architecture and Requirements. To apply Model based Engineering it is absolutely needed to define the system under consideration with specified inputs and outputs, to keep the models more user friendly and self-explanatory, to validate the models, if required then addition of the data driven models for simulation purpose. It is also important to define modelling tools, technologies and methodologies in advance, matching the domain after deliberate considerations and trade-offs. It is important to record objectives and assumptions for any model based engineering. Models can be either abstractions or representations of reality that facilitate the understanding of complexity. A critical task and challenge in Model Based Engineering is the upfront trade and analysis process to ensure the best value system is developed to satisfy the objective. The Model Based Engineering tools are looking beyond just graphical modelling and integration of data and models are becoming increasingly popular. By bringing together different models into a data driven architecture environment, more efficient and predictable product life cycle management can be achieved. With Model Based Engineering, requirements traceability can be handled more efficiently and overall process can be achieved using programming methods. An overall top level system model can be created, which helps to all the stakeholders to visualize the entire system and the surrounding environment and components. The top level system model can be further decomposed into different subsystems, which facilitates verification and validation of the entire system so that, stakeholders can catch any early defect. Thus, Model based Engineering uses model centric approach to drive whole product development process.

Presenter Name: Lunsford, Ian

Presenter Company: Northrop Grumman

Presentation Title: Aircraft Survivability Modeling and Simulation Framework (AirSurF)

Keywords: Modeling and Simulation, Aircraft Survivability, Killability, Susceptibility, Vulnerability, Systems Engineering, Model-Based Systems Engineering, Systems Architecture, Object-Orientation, Sensitivity Analysis, Verification and Validation, IBM Rhapsody, C

Abstract:

The original aircraft survivability analysis, hit calculations, has been around since the beginning of aircraft survivability. Described in the renowned Aircraft Survivability Bible, The Fundamentals of Aircraft Combat Survivability Analysis and Design by Robert E. Ball, essentially, slow, low flying, and easy to detect aircraft will have poor survivability. Also, Ball describes as hits on the aircraft increases, the aircraft survivability greatly decreases as seen in Figure 1. Two components are described by Ball to make up an aircraft survivability, susceptibility and vulnerability. Where, susceptibility is the aircraft's likelihood to be hit and vulnerability is the aircraft's likelihood to withstand a hit. With Ball's established aircraft survivability methodologies, other efforts have arisen to expand upon and improve aircraft survivability existing methodologies in more detail. Recently developed methods with addition to Ball's approach form a higher fidelity assessment of aircraft survivability. The new considerations take into account various qualities including aircraft velocity, reload speed, lethal envelope, and others. The idea to supplement Ball is to more consider the entire scenario, rather than just hits on the aircraft. By taking into account other important factors, more reasonable aircraft survivability metrics can be attained. The lethal envelope and detection envelope is a powerful consideration, giving context to the aircraft and enemy entity relationship. A lethal envelope and the detection envelope are volumes in which the aircraft is detectable and/or vulnerable to hits from an enemy entity. The envelopes are dome-like volumes with the enemy entity centered; Figure 2 describes each envelope. There are many lethal envelope factors associated to calculate the total aircraft survivability as seen in Figure 3. With the combination of envelopes and Ball's methods, a basis for advanced aircraft survivability analysis is founded. Next step is to apply various analyses to adapt to more challenging and new aircraft survivability threats. These include digital pheromones, loyal wingman, and swarming. Having the analyses described and understood, the base architecture of the framework was created. In Figure 4, the initial, high-level architecture of the framework is shown. The architecture organizes the framework in an object-oriented sense, enabling the various strengths of object-orientation to be translated into the framework development (i.e. scalability, readability, etc.). At the highest-level, the framework is shown, existing in its entirety. The framework acts mostly as the main method by compiling, executing, and referencing the lower level classes. Composed of analysis, scenario, and simulation at lower levels, each is designed to support important roles. Today, most aircraft survivability tools are models coveted by various agencies for expensive licenses or US government contracts. Many analyses exist with strong capabilities to provide better aircraft survivability understanding. By generating an open-source aircraft survivability framework, the analyses have been implemented to promote a robust tool. The open-source and available framework encourages the aircraft survivability and M&S communities to fortify, enhance, and create robust aircraft survivability aware aircraft and aircraft survivability methodologies. Model-Based System Engineering (MBSE) methodologies have been implemented to better VV&A system requirements early. An object-oriented language with the AGILE method leverages System Engineering (SE) strengths including attributes, requirement and constraints, and system life cycles. With these methods combined, the aircraft design process would greatly benefit from utilizing AirSurF to effective know critical flight performance parameters, mitigating present and emerging threats to the modern aircraft. In all, AirSurF provides great opportunities for new and existing aircraft designs and survivability analyses to be implemented, further developed, and better understood.

Presenter Name: Mehta, Sachin

Presenter Company: L3Harris Technologies

Presentation Title: Model-Based Engineering (MBE) Methods for 'Multi-Threaded', 'Reactive', and 'Data-Intensive' Platforms

Keywords: MBE, SysML, fUML, Architecting, Engineering, Architecture, SCXML, Simulation, Multi-Threaded, Reactive, Data-Intensive, Behavioral Modeling

Abstract:

Behavioral modeling is common practice in the systems branch. It lies along the architecting-engineering continuum and is integral in gaining understanding of a system of interest (SoI), requirements derivation, technical optimization, and client satisfaction. Yet, the unprecedented systems that are to be pervasive in years to come will be so complex that systems modeling, alone, is not at all enough to answer stakeholder questions. Developers must consider the logical consequences of hypothetical scenarios, especially when the SoI exhibits quasi- to non-deterministic behavior. Thus, the execution of models over time (i.e. simulation) gives visibility into system design and acts as a rigorous supplement to ensure completeness & correctness. This paper/presentation discusses unique methods that can be applied when taking model-based engineering (MBE) approaches utilizing the Systems Modeling Language (SysML), the Foundational Subset for Executable UML (fUML), an appropriate development environment, and a W3C SCXML - fUML standards compliant simulation engine. Characterized by multiple levels of abstraction, these methods are defined using a broad set of constructs, formalisms, capabilities, and non-homogeneous dialects. An example case study of an integrated architecture model is discussed throughout the paper/presentation, such that the audience can better understand the application of engineering simulation within the systems branch. The investigation focuses on the development of functional and logical system architectures of platforms that exhibit 'multi-threaded', 'reactive', and 'data-intensive' characteristics. Examination takes place into simulation modeling of different phenomena for each of the characteristics mentioned prior. The analyses behind 'multi-threaded' behavior considers flexible techniques for sharing global memory resources during run-time—allowing multiple service requests to be managed with ease. The exploration of 'reactive' behavior outlines innovative practices to exploit comprehensive timescales—without having to rely solely on the simulation engine's built-in clock. Lastly, the discussion on 'data-intensive' behavior reviews concepts of initializing large data sets at run-time, for model-based testing—with little to no effort by the architect/engineer. Approaching product development with the ideas reviewed in this paper/presentation has a high degree of utility that is desirable when attending to complex intractable questions. Cohesively defined and loosely coupled, the methods described assist in providing rapid, definitive, answers to stakeholder questions and prove pivotal when architecting-engineering dependable systems. For these types of problems, with no closed form solution, having simulation/execution contexts allows for human reasoning and mathematical analyses to complement each other—creating powerful problem-solving synergy.

Presenter Name: Panthaki, Malcolm

Presenter Company: ARAS Corporation

Presentation Title: Combining Systems Engineering and Simulation - What's So Hard About That!

Keywords: Unified data model, systems engineering, simulation, mixed-fidelity modelling, open tool-agnostic product innovation platform

Abstract:

"Combining the modelling and simulation perspectives of both systems engineering and engineering simulation can improve communications and coordination across the product development lifecycle." The authors firmly believe that this conference tag line is not only true but is achievable today with the right infrastructure, (existing) building blocks, and product development methodologies. If so, then why has this desirable goal been elusive? The authors believe that many pervasive issues in the simulation landscape have prevented the seamless merging of systems engineering and simulation data, tools and processes. Here are some of the primary issues: 1. Silos of SME's, tools, data and processes: MBSE and multiple simulation silos within an organization have encouraged the separation of these domains, spawning the independent development of data models and tools. The data in these silos must be "integrated" manually and, often, in a serial manner by the engineers, with a severe impact on accuracy and efficiency, limiting the number of simulations that can be performed at the right mixed-fidelity level. 2. Independent development of taxonomies: In the early decades, a "wild west" attitude existed amongst disparate software vendors, each developing their own taxonomies, data formats and APIs. Of late, while multiple related standards efforts have attempted to bring some order to the chaos, MBSE standards and simulation standards have evolved largely separately. 3. Independent development of tools: The tool landscape has for decades been severely fragmented and highly competitive. While standards and consolidation have brought much order and, hence, a stable base for rapid progress in many other technological domains, the systems engineering and simulation domains (product lifecycle tools) have lagged. Each of the tools has its own data model, file formats and API's, resulting in a veritable Product Development Tower of Babel. 4. Manual processes that are inefficient and effort-prone are a barrier to mixed-fidelity modelling: Despite the tools requiring experts, the processes employed by them are highly manual and fraught with human error. Lack of integration of the tools, models and results into a broader enterprise engineering backbone results in the need to manually search for inputs, manually generate reports and manually insert key results into the enterprise platform. The added burden and difficulty of mixed-fidelity modelling – the manual process of bringing systems analysis and high-fidelity simulation models together into a single simulation model – has proven to be too time-consuming and error prone within the current environment. Using a case study involving the multi-physics and multi-fidelity simulation of a complex laser system, the authors will present a solution that successfully overcame many of the issues described above. In this case study, the Air Force Research Laboratory wanted to simulate an early design that was being tested in the lab and was showing aberrant behavior. For computational efficiency, it was necessary to combine lumped-parameter systems models for most of the laser system with 3-D models of certain subsystems that required higher-fidelity, using co-simulation techniques within a unified simulation platform - the simulation is a mixed-fidelity, multi-physics simulation. The simulation process was automated, significantly increasing the efficiency of the transient co-simulation trade studies that were required. [1] The authors will present some of the details of the solution including the unified data model and API, and a simulation automation platform that is robust across significant changes to the design. They will also present an open enterprise product innovation platform approach that is requirements-driven and systems-centric, while seamlessly integrating systems modelling with simulation at all mixed levels of model fidelity. References: [1] Model-Based Engineering for Laser Weapons Systems, Malcolm Panthaki, Steve Coy, SPIE Proceedings, August 2011.

Presenter Name: Popielas, Frank

Presenter Company: SMS_Thinktank

Presentation Title: Systems Modeling and Simulation and its Relation to MBE

Keywords:

Abstract:

Model-based thinking and related approaches are essential in the modern engineering environments to remain competitive. To properly implement these approaches, a fundamental understanding its definition; the composition of the related ecosystem; and the requirements to deploy is necessary. The Systems Modeling and Simulation Working Group (SMSWG) plays the pivotal role to provide that directional guidance, discuss and share ideas, help to channel the applicable standards environment, establish proper taxonomy, and much more. In this presentation we will provide an overview of our activities, outline the SMS roadmap and discuss the holistic picture of SMS as it relates to MBE and related activities.

In addition, this presentation will highlight the partnership with INCOSE since the SMSWG is a joint working group between NAFEMS and INCOSE. The recent renewal of our MoU for another three years shows the strength of this partnership.

Presenter Name: Ramnath, Satchit

Presenter Company: The Ohio State University

Presentation Title: Application of ML on Car Body Structure Design

Keywords: Machine learning, CAD & Simulation Data, Large Data Creation

Abstract:

Machine leaning is opening up new ways of optimizing designs, but it requires large data sets for training and verification. While such data sets already exist for financial, sales and business applications, this is not the case for engineering products design data. This study discusses our efforts in curating a large CAD data set with desired variety and validity for automotive body structural compositions. We have examined several approaches that can be automated with commercial CAD systems such as Parametric Design, Feature Based Design, Design Tables/Catalogs of Variants and Macros. We discuss pros and cons of each method, and how we devised a combination of them to have a robust set of data that are both valid and has enough variation. This hybrid approach was used in association with DOE methods to cover a large design space. In the meantime, a set of constraints are developed to check validity of the created designs, and modify the parameters' range in the DOE table, if required. Since, the geometric configurations and characteristics need to be correlated to performance (structural integrity), this study also demonstrates automated workflows to perform FEA on CAD models generated. Key simulation results can then be associated with CAD geometry and fed to the machine learning algorithms. Another challenge addressed in this study is, the design and architecture of the PDM (product data management) system storing CAD and simulation data and passing it to the ML module. These data sets can be used to perform both supervised and unsupervised learning of structural integrity with respect to predefined and latent features, respectively. The information obtained from Computer Aided Design (CAD) models created over the past decades, helps to understand the reasoning behind the experiential design decisions. With the increase in computing power and network speed, such datasets could assist in generating better designs, which can be obtained by a combination of existing ones, or might provide insights into completely new design concepts meeting or exceeding the performance requirements.

Presenter Name: Ryan, Jim

Presenter Company: Altair Engineering, Inc.

Presentation Title: Examples of Model-Based Systems Engineering as the Heart and Soul of Digital Twins

Keywords: Model-based, systems, engineering, development, MBD, MBE, MBSE, CAE, simulation, reduced-order modelling, ROM, machine learning, artificial intelligence, sensors, data collection, data preparation, data visualization, data intelligence, data science, IOT,

Abstract:

Digital Twins are a hot market trend right now – and for good reason. They offer companies the tantalizing promise of further-optimized product performance and extended life. This fits well with (and is enabled by) both computer-aided engineering (CAE) and the rapid emergence of data intelligence. The value of model-based engineering and virtual prototyping has evolved and improved over decades. Now, due to the availability of better information about how products are actually operating, physics-based digital twins can be more tightly coupled with data-driven digital twins thanks to real-time data collection, communication/transmission, analysis, and to machine learning. In this presentation, we will share several real-world cases to illustrate that the promise afforded by physics-based digital twins and data-based digital twins is real and available today. The examples presented will showcase different industries and pertain to companies large and small. They will show how a complete and open digital twin platform gives every company the flexibility needed to accommodate its own unique workflows and tools. Our examples will show interesting and valuable combinations of the use of two or more of the following building blocks for this platform: 3D CAE; OD and 1D system-level modeling & simulation leveraging open standards such as Modelica; reduced-order modeling (ROM); the ability to include 3rd-party tools through the Functional Mock-up Interface (FMI); data intelligence; machine learning; and Internet of Things (IoT) technology. These building blocks can be categorized into those which help companies to Develop better future-generation products, to better Operate current-generation products, and to tightly Connect the virtual and real worlds for optimized results and continuous improvement. Model-Based Systems Engineering serves as the heart and soul of this important, enterprise-wide product lifecycle activity. Examples will include: • Physics-driven digital twin combined with data-driven digital twin for a wind turbine, as used to predict remaining useful life and time to failure. • Reduced Order Modeling (ROM) coupled with physical testing, as used to optimize the “flight” (path) controller of undersea drones. • Automatic code generation for embedded systems and real-time data communication via Internet of Things (IoT), as used to automatically update 19,000 rooftop cooling units in need of new controller software. • Condition monitoring and machine learning, as used to enable predictive maintenance on belt-driven systems while reducing the number of sensors required. • Pattern recognition, as used to help significantly reduce robot breakdowns. Not surprisingly, companies have leveraged one or more Digital Twin building blocks in different combinations at different times as they matured their process. This has allowed each to start wherever they would like, to use whatever tools they believe to be best-in-class for their purposes, and to methodically progress their work step-by-step in ways that best support their corporate vision and goals for digital twins. These examples hit home the reality that there is no one-size-fits-all approach. As each company defines its own standardized processes and best practices for its digital twins, a complete and open digital twin platform will help them get there faster without hitting dead-ends or wasting precious time and energy.

Presenter Name: Tolle, Don

Presenter Company: CIMdata, Inc.

Presentation Title: Emerging Standards for Model-Based Systems Engineering

Keywords:

Abstract:

Engineering organizations are experiencing a rapid increase in product complexity, driven by the need to continually innovate to survive and based on the exponential increase in the use of sophisticated electronics and software content in virtually every industry. The traditional “stage gate” methods of product development with separated “silos” of data, models and information across the engineering domains of mechanical, electrical/electronics, software, controls, chemical formulations, etc. is no longer adequate to define, optimize, assess and validate the performance of today’s complex systems… and systems of systems. Collaborating virtually with globally distributed product development groups as well as suppliers and teaming partners is also becoming an increasingly critical aspect of the product development lifecycle for most industries. The risk of “business as usual” is now becoming well understood across all industries based on companies that have recently experienced systems level failures resulting in costly product recalls, warranty claims, and non-compliance with government regulations. These trends and other forces related to the rapid digitalization of all business processes and the movement towards Industry 4.0 have led to an increased focus on defining and adopting model-based processes and technologies for developing and maintaining complex systems, commonly referred to as Model-Based Systems Engineering (MBSE). Concurrent with the movement towards model-based approaches in the various engineering domains, industry has recognized and begun to address the need for more robust systems modeling languages and data interoperability standards. While systems modeling languages such as UML, MARTE and AADL and data interoperability standards such as the STEP AP2xx series have existed for some time now, the adoption rate has been limited to certain specialized domains and standards have had far less business impact than desired in the engineering domain as a whole. While still in the early stages of maturity, significant progress has been achieved just within the past several years based on emerging systems modeling languages such as OMG SysML and Modelica and data interoperability standards such as XML/XMI, FMI/FMU, ReqIF, MoSSEC and OSLC. In this session, Don Tolle will provide an overview of the key model-based engineering standards efforts underway in the major industry organizations and discuss the status of the most promising systems modeling languages and data interoperability standards and de facto standards. Don will also highlight the greatest challenges to enable the collaboration required across engineering disciplines and support the achievement of the “digital thread” vision across the entire product development lifecycle.