

SMSWG - SMS Roadmap Team

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Systems Modeling and Simulation:*

The use of interdisciplinary functional, architectural, and behavioral models (with physical, mathematical, and logical representations) in performing MBSE to specify, conceptualize, design, analyze, verify and validate an organized set of components, subsystems, systems, and processes.

Content

- Members
- Charter and how we will operate
- Status and Topics to be covered
- Open discussion

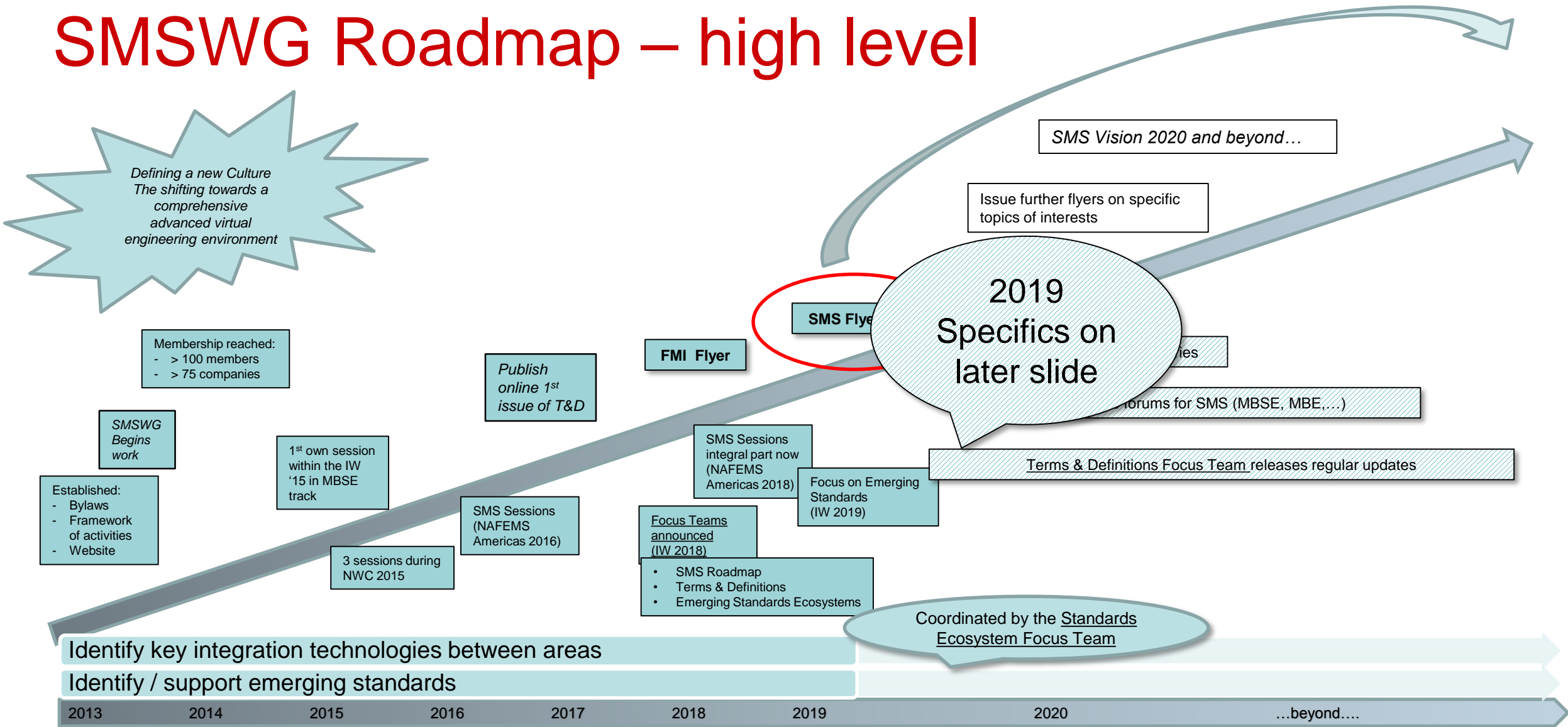
Members

- Frank Popielas
- Roger Burkhart
- Rod Dreisbach
- Ed Ladzinski
- Matteo Nicolich


Charter and How we will operate

- Will meet on a regular basis as defined by the members (at least every other month)
- Will report back to general SMSWG at least twice a year
- Develop and maintain the roadmap for SMS
- Be the focal point for further developing the space and topic of SMS
- Share best practices with focus on end users
- Provide overviews / educational material

SMSWG Roadmap – high level




SMS Flyer – released for printing



What is Systems Modeling and Simulation?

THE INTERNATIONAL ASSOCIATION FOR THE ENGINEERING MODELLING, ANALYSIS AND SIMULATION COMMUNITY



What is Systems Modeling and Simulation?

Getting there to the market ahead of the competition. The digitalization of our last today is driving a new historical environment. Developing products based on skills and capability in specific engineering domains is no longer sufficient. The demand for system-level solutions is driving a need to merge systems engineering and engineering simulation at a new level. Systems Modeling and Simulation relies on an integrated use of engineering models to fill this need. Following is a brief definition:

Systems Modeling and Simulation: The use of interdisciplinary functional, architectural, and behavioral models (with physical, mathematical, and logical formalizations) in performing MBE to specify, conceptualize, design, analyze, verify and validate an organized set of components, subsystems, systems, and processes [1].

The International Council on Systems Engineering (INCOSE) defines Model Based Engineering (MBE) as the formalized 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 [2]. The emphasis of MBE is on leveraging virtual representations of a system and its performance without actually testing the system in the real world. It should be noted that the two words modeling and simulation are sometimes used interchangeably, however, they clearly refer to two distinct activities.

Modeling and Simulation: Modeling is the act of building a physical or digital model that represents an entity of interest in a system. A simulation is the process of using a model to predict and study the behavior or performance of the system or process in question. One purpose of a simulation is to study the operational characteristics of a system by manipulating variables associated with the model that are not easily controlled in the real system. This approach provides data that supports technical and business decision-making to optimize a product and its performance without actually testing the system in the real world. It should be noted that the two words modeling and simulation are sometimes used interchangeably, however, they clearly refer to two distinct activities.

Systems Engineering has recognized the importance of models in a wide range of roles. Early in the development of a system, models may be used to understand the user domain, to define functions and concepts, and to capture system requirements across the levels of a system architecture. Such models may specify functional, interface, performance, and physical requirements, as well as other nonfunctional requirements such as reliability, maintainability, safety, and security.

Engineering Simulation has been an essential part of product development engineering across many industries and disciplines for decades. This work is typically performed by technical specialists with deep knowledge in their respective domains, and with respect to specialized mathematical and analytical tools. A definition of Engineering Simulation is the use of numerical, physical or logical models of systems and scientific problems in predicting their response to different physical conditions [3].

The use of Engineering Simulation is being driven by the increasing sophistication of models and tools to analyze a wide range of physical phenomena. Many kinds of analysis are highly mature. From analysis of physical structures to computational fluid dynamics to dynamic system behavior, increasingly such models can be integrated across physical domains at multiple scales.

Figure 1: Model-based integration across multiple technical disciplines.

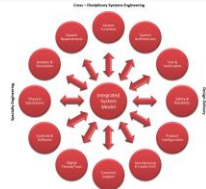



Figure 2: Iterative product development with systems engineering and simulation (derived from the INCOSE Final Report [2]).



meet the program requirements. The decomposed functions can then be allocated to the elements of proposed solutions, and to their corresponding engineering disciplines, to create and apply a variety of architectural models. MBE recognizes that at these levels of specifications can be captured in formalized models, even when this information is purely descriptive.

Once proposed solutions are sufficiently detailed, a further step is the creation of engineering models that are composed of mathematical and physical descriptions of the system. These models could include the CAD geometry of each component in an assembly, as well as the system response characteristics, for example, by finite element analysis, computational fluid dynamics, or dynamic system models, and possibly enhanced with software and control logic.

For technical specialists who develop and verify detailed designs of subsystems and components, Systems Engineering can offer clear boundaries of problems to be solved without overly constraining the freedom of possible designs. Both systems engineers and designers can explore combinations of technologies and solutions that may be considered a system in effective and flexible ways. As Systems Engineering becomes more widely adopted for the development of complex products, larger numbers of discipline-specific engineers will need a basic familiarity and literacy of MBE models to integrate their work into a larger whole.

System engineers will need to develop a familiarity with a wide variety of system simulation capabilities, including those of Engineering Simulation. An early reliance on simulation can enable agile approaches in which prototypes and visualizations contribute to elicitation and refinement of requirements and alternatives in collaboration with system stakeholders. Simulation throughout the product life cycle can reduce risk, more thoroughly explore alternative solutions, and reduce costs over physical testing.

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What is Systems Modeling and Simulation?

The Systems Engineering "Vee" Diagram is widely used to depict the process of decomposing a system into subsystems and then validating the successful integration of partial solutions back into the larger whole. Figure 2 illustrates how simulation can contribute to rapid iteration at each stage in this process.

Systems Engineering encourages the use of modeling and simulation throughout the early stages of the specification and development of a system [5]. During these early stages, simulation can provide a means to analyze complex behavior of systems, software, hardware, people, and physical phenomena. These early stage simulations may take many different forms, such as agent-based, discrete-event, stochastic, and interactive simulations, and the integration of many such simulations may occur [6].

These operational simulations of a system can provide key inputs to the purely physical forms of a system. Data specific to different usage scenarios and operating conditions can be fed into engineering simulations of physical structure and components. Such inputs, which may be requirements or other simulations can provide time histories of loads and other boundary conditions. At the physical level, coupling of simulations across multiple levels of physics, and at different scales and levels of fidelity, may be required for detailed analysis, and to optimize designs across multiple alternatives.

Systems Modeling and Simulation Working Group (SMSWG)

To explore the benefits of Systems Modeling and Simulation, and to promote specific technologies, practices, and standards which enable them, NAFEMS, the International Association for the Engineering Modelling, Analysis and Simulation Community, and INCOSE, the International Council for Systems Engineering, launched a joint working group on Systems Modeling and Simulation under a Memorandum of Understanding in 2013.

The mission of the NAFEMS / INCOSE Systems Modeling & Simulation Working Group (SMSWG) is to develop a shared model, and lead-driven consensus that will promote the advancement of the technology and practice associated with integration of Engineering Simulation and Systems Engineering, but also act as an advisory body to drive a strategic direction for technology development and standards in the space of complex engineering. The further Reading link below serve as a living document to cover more detailed activities and focus areas of the SMSWG in support of Systems Modeling and Simulation.

Further Reading

Home page for NAFEMS-INCOSE Systems Modeling and Simulation W/G at NAFEMS: nafems.org/about/technical-working-groups/systems_modeling/

Home page for NAFEMS-INCOSE Systems Modeling and Simulation W/G at INCOSE: www.incose.org/MBE/Info.php/#MembersMeeting

References

- [1] INCOSE Terms & Definitions, October, 2010 November 2010. Available from: http://www.incose.org/about/technical-working-groups/systems_modeling/
- [2] INCOSE MBE WG, (2014) (20 November 2015). Available from: <http://www.incose.org/MBE/>
- [3] NAFEMS, THE NAFEMS Glossary, (2014) (20 November 2015). Available from: <http://www.nafems.org/publications/glossary/>
- [4] Systems Engineering Body of Knowledge (SEB), Final Report of the Model Based Engineering (MBE) Working Group, (2014) (20 November 2015). Available from: [http://www.incose.org/wiki/Final_Report_of_the_Model_Based_Engineering_\(MBE\)_Subcommittee](http://www.incose.org/wiki/Final_Report_of_the_Model_Based_Engineering_(MBE)_Subcommittee)
- [5] Systems Engineering Body of Knowledge (SEB), Sub-Committee: Supporting Systems with Models, (2014) (20 November 2015). Available from: http://www.incose.org/wiki/Supporting_Systems_with_Models
- [6] Systems Engineering Body of Knowledge (SEB), Sub-Committee: Supporting Systems with Models, (2014) (20 November 2015). Available from: http://www.incose.org/wiki/Supporting_Systems_with_Models

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Topics / Focus 2019

- The flyer is the foundation
- Providing a better focus around “What is Model-Based...?”
 - Working together with T&D Focus Team to update / create proper definitions
 - Create a flyer on this topic
- Start to roll out the MBSE Series 101 and combine with company experiences (use cases from end users)
 - Will identify the sequence of the various topics (see next slide)
 - Provide those as part of the SMSWG meeting and make the material available to the group

MBSE Education

- **MBSE 101** – MBSE High Level View for Newcomers
- **MBSE 102** – Introduction to MBSE (*How We Explain MBSE without using the Traditional “V Model”*)
- **MBSE 103** – MBSE Existing and Emerging Standards
- **MBSE 104** – MBSE Deeper Dive
- **MBSE 105** – Systems Engineering - *Challenges for Management*
- **MBSE 106** – Systems Engineering – *Deployment Challenges*
- **MBSE 107** – Digital Twin – *Its Role and structure within a modern Systems Engineering Approach*
- **MBSE 201** – MBSE Implications within the OEM/Supplier Community

Discussion