V12 update

www.incose.org

www.nafems.org

NAFEMS-INCOSE Systems Modeling & Simulation Working Group (SMSWG)

"Bridging the worlds of Systems Engineering and Engineering Simulation"

MBSE:	Systems Modeling and Simulation:	Engineering Simulation:
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.	***The combined use of Systems Engineering models and Engineering Simulation models with interdisciplinary functional, architectural, structural, behavioral, mathematical, logical and/or physics-based representations … to specify, conceptualize, design, analyze, verify and validate an organized set of elements (parts, components, assemblies, aggregates, modules, subsystems, systems …) and processes in their operational environment.***	*The use of physics-based mathematical (numerical) models and/or logical models, including relevant data derived from their physical model counterparts, as representations of a conceptual or real-world system, phenomenon, or process in studying its technical requirements and operational behaviour.*

SMSWG – Terms & Definitions: https://www.nafems.org/community/working-groups/systems-modeling-simulation/smstermsdefinitions/s-u/

V10 update

Systems Modeling & Simulation WG supporting INCOSE – NAFEMS collaboration

History & Governance

- Following 2011 agreement to develop a collaborative relationship, 1st Joint MoU signed at INCOSE Symposium in 2012 with announcement to form the NAFEMS-INCOSE SMSWG
- SMSWG launched in 2013 with founding steering committee to promote membership
- Joint MoU renewed at INCOSE Symposium in 2015 and NAFEMS World Congress in 2019
- Common INCOSE Charter & NAFEMS Terms of Reference established 2020 & updated end of 2021
- **10th Anniversary of collaboration and renewal of Joint MoU in June 2022**
- **2023 updates on MoU addendum A (joint activities) and B (certification)**


MEMORANDUM OF UNDERSTANDING
Between
NAFEMS and International Council on Systems Engineering

Collaboration

- Promotion of jointly developed products and opportunities for members to participate in each organisation's activities
- Mutual recognition of certifications offered by each organisation & reduced certification costs
- Mutual support for specific key events of each organisation, examples as follows
  - NAFEMS sponsorship at INCOSE IS 2021 and INCOSE sponsorship at NWC21
  - NWC19 special panel session "Systems Engineering meets Engineering Simulation"
  - NWC21 special panel session "Connecting Two Worlds Through Leadership" (inc SE vision & grand challenges)
  - IS 2024 special panel session "Building the digital bridge between MBSE and Engineering Simulation"
  - NWC25 paper "What simulation engineers need to know about systems engineering and MBSE"

INCOSE

NAFEMS

SMSWG Purpose & Mission

Purpose

- **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 non-functional 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 expertise in specialized mathematical and analytical tools.
- **Combining the Modelling and Simulation perspectives of both Systems Engineering and Engineering Simulation can improve communications and coordination across the product development life cycle.**

Mission & Goal

- To develop a **vendor-neutral, end-user driven** consortium that not only promotes the advancement of the technology and practices associated with **integration of engineering simulation and systems engineering**, but also acts as the advisory body to drive strategic direction for **technology development and international standards** in the space of complex engineering.
- **The SMSWG supports activities that bridge engineering simulation and systems engineering to optimize the integration of Systems Engineering and Engineering Simulation solutions for both OEM and supplier. This includes education, communication, promotion of international standards, and development of requirements that will have general benefits to the Engineering Simulation and Systems Engineering communities.**

SMS WG organisation (2025)

Contact nafems-incose@incose.net if interest to join any Focus Team

V12 update

NAFEMS leadership & 20 Working Groups

nafems.org/community/working-groups/systems-modeling-simulation/

Collaboration MoU

+ SMSWG Charter / ToR

www.incose.org/incose-member-resources/working-groups/transformational/incose-nafems-collaboration

INCOSE leadership & > 50 Working Groups

12 SMSWG Members

- Roger Burkhart | Thematix
- Alexander Busch | Ansys
- Peter Coleman (Chair) | Airbus Operation
- Hans Peter de Koning | DEKonsult
- Tom Deighan | UKAEA
- Rodney Dreisbach | NAFEMS Technical Fellow
- Greg Garstecki | Garstecki Modeling Solutions
- Phyllis Marbach | INCOSE Assistant Director Transformational Enablers
- Frank Popielas (Co Chair) | SMS_Think
- Ian Symington | NAFEMS Technical Officer
- Hubertus Tummescheit | Model Based Innovation LLC
- Mark Williams | PDES-LOTAR

Focus Team - **ACTIVE**
Roadmap & Best Practices
Frank Popielas

Focus Team - ***NEW in 2024***
Refining understanding of SMS
Alexander Busch

Focus Team - **restart 2026**
SMS Standards Ecosystem
HP de Koning

Focus Team - **on-hold since Feb'25**
Terms & Definitions
~~Greg Garstecki~~

Focus Team - ***NEW in 2024"**
SMA/PSE competencies mapping
A.Busch, R.Dreisbach

Focus Team - **completed**
SE Handbook 5E MA&S
HP de Koning

SMS Community

Open to all INCOSE or NAFEMS

713 registered members (May'25)

624 NAFEMS

125 INCOSE

36 both NAFEMS & INCOSE

From > 300 different organisations

And ~35 different countries

- Americas = 39%
- Europe = 45%
- Asia = 13%
- Rest of the world = 3%

+ **641** members from INCOSE Engage SMSWG Community

74 meetings from 2013 to 2025

Avg 30 participants (since Sep 2020)

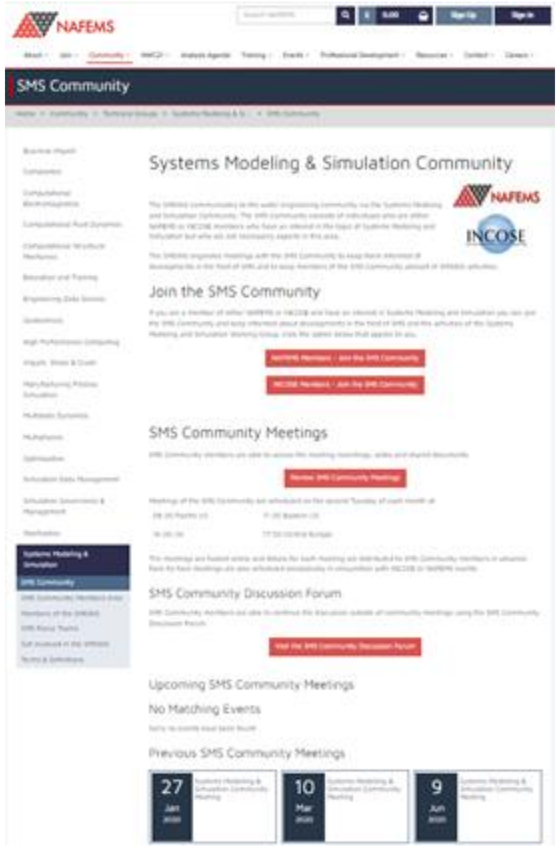
INCOSE

NAFEMS

SMSWG Web Pages + SMS Community shared material

V5 update

Ensure you are signed up to the SMS Community via the NAFEMS website in order to access the SMS Community Members' Area and to receive future event notifications and SMS Community correspondence



https://www.nafems.org/community/working-groups/systems-modeling-simulation/

New SMSWG pages for INCOSE launched at IW2023

https://www.incose.org/incose-member-resources/working-groups/transformational/incose-nafems-collaboration

SMS WG activities - 2025 retrospective

V12 update

3 February
incose.org/iw2025
SMS#70

- **SMSWG overview & plans** - P.Coleman (Airbus)
- **Overview of the System Structure and Parameterization (SSP) and the SSP Traceability Layered Standard** - H.Tummescheit (Model Based Innovation LLC)
- **T&D's Focus Team update** - G.Garstecki (Garstecki Modeling Solutions)

21 May
NWC-2025
\+ Paper

- **What Do Simulation Engineers Need To Know About Systems Engineering And MBSE** - A.Busch (Ansys); R.Dreisbach (NAFEMS); F.Popielas (SMS_ThinkTank)

30 July
incose.org/symp2025
\+ INCOSE Q3 Members newslett

- **Panel - Bridging the Divide: Linking Architectural Specification and Verification by System Simulation** - Moderator: P.Marbach (INCOSE); Panelists: A.Busch (Ansys); M.Nicolai (Siemens Digital Industry Software); S.Pavalkis (Dassault Systemes); B.Petteys (MathWorks)

WG#46 WG#47 WG#48 WG#49 WG#50 WG#51 WG#52 WG#53

24 April
SMS#71

- **Update of Modelica Association Standards** - H.Tummescheit (Model Based Innovation LLC)

24 June
SMS#72

- **SMS Standards and Release of SysML v2.0** - Hans Peter de Koning (DEKonsult)

30 September
SMS#73

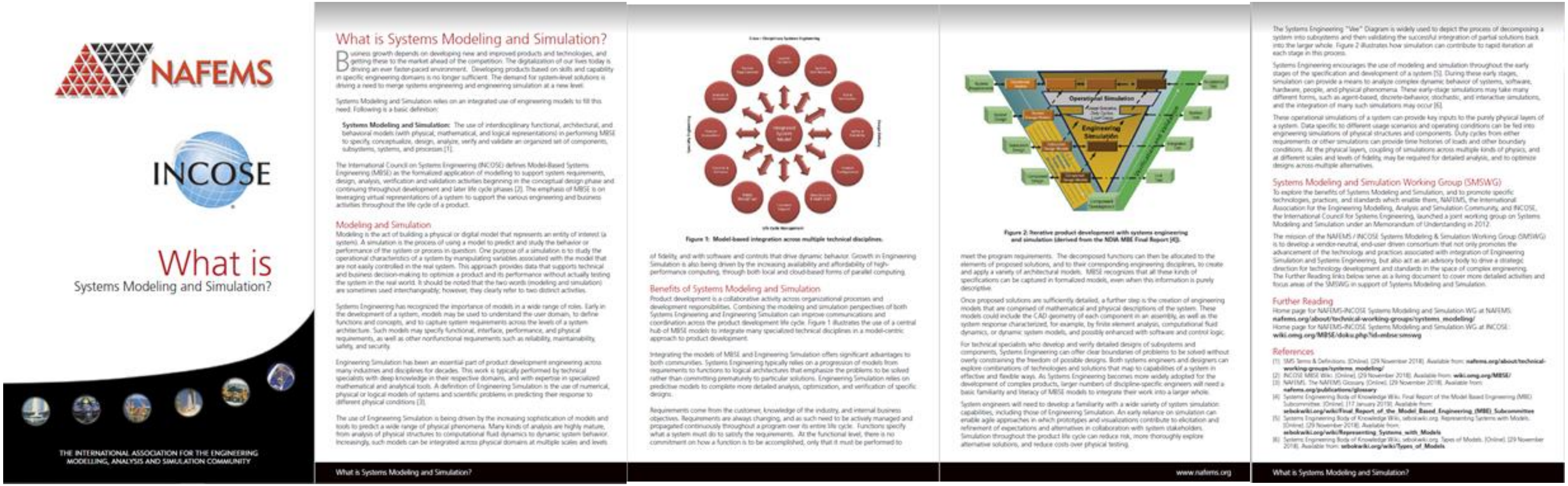
- **Refining the Understanding of Systems Modeling and Simulation: An Invitation to Engage** - Alexander Busch (Ansys)

18 November
SMS#74

- **Panel - MBE / MBD & QIF – their Role for Digital Transformation and Industry 4.0** - Moderator: F.Popielas (SMS_ThinkTank); Panelists: H.Vega (Pratt & Whitney); A.White (MBDA); J.Brino (CCAT); P.Pradoura (Schneider Electric); L.Bergquist (Capvidia) to be refreshed

SMSWG “What is SMS?” publication 2019

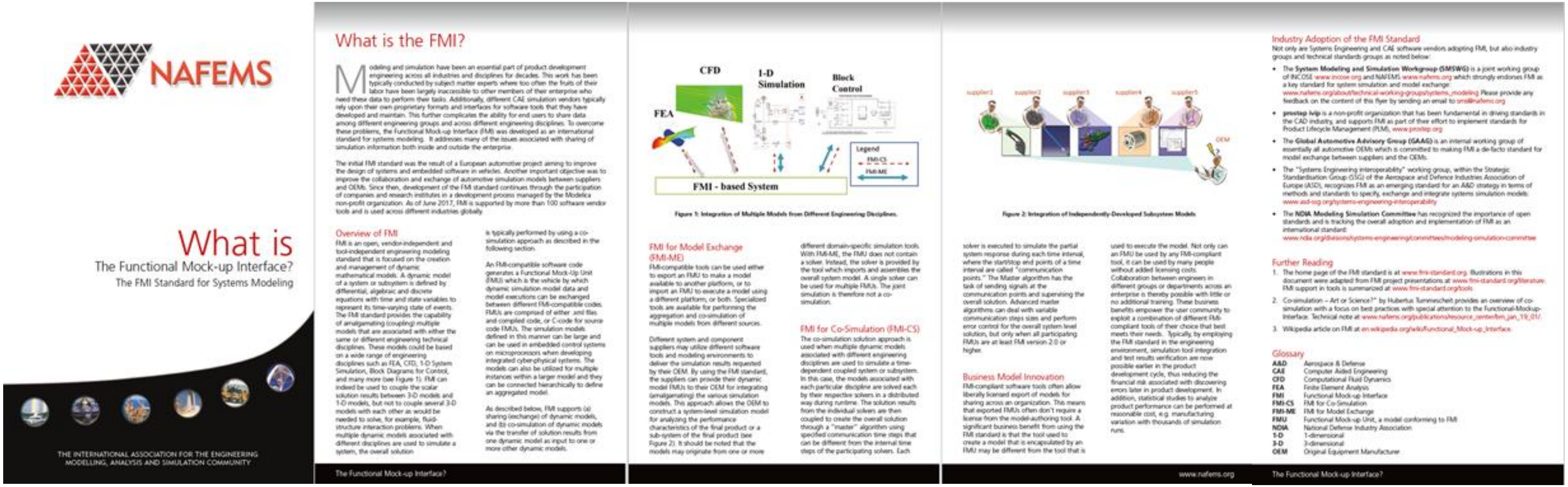
- Short guide promoting awareness of both MBSE and Engineering Simulation for successful product development and Model-based integration across multiple disciplines
- First co-branded product available for INCOSE or NAFEMS members via:
- https://connect.incose.org/Pages/Product-Details.aspx?ProductCode=what_is_sms
- https://www.nafems.org/publications/resource_center/bm_apr_19_11/



to be refreshed

SMSWG “What is FMI?” publication 2018

- Short guide promoting awareness on the Modelica FMI standard for Model Exchange and Co-simulation
- NAFEMS branded product freely available via: https://www.nafems.org/publications/resource_center/wt06/



SMSWG focus team - SMS Terms & Definitions

On-hold => Need new Focus Team lead!

V10 update

- First published 2016 with regular updates on dedicated pages hosted via NAFEMS website:
  - https://www.nafems.org/community/working-groups/systems-modeling-simulation/smstermsdefinitions/
  - 173 terms in total at end of 2023
- 12 additions in 2020:
  - Democratization of Simulation / Digital Twin / Engineering Simulation / Generative Design
  - Model-Based Definition (MBDef) / Model-Based Design (MBD) / Model Based Development (MBDev) / Model-Based Engineering (MBEng) /Model-Based Enterprise (MBEnt) / Model-Based Safety Analysis (MBSA) / Model-Based Systems Engineering (MBSE)
  - Simulation Governance
- Additions in 2022
  - Hardware, Software, Model, Human, Processor … "in the loop"
- Additions & updates in 2024 (also to be added to NAFEMS Glossary)
  - 12 model related terms i.e. behavioural model, conceptual model, descriptive model, empirical model, engineering simulation model, logical model, metamodel (revision), metadata (revision), physics-based model, physical model, surrogate model
- Collaborative reviews with other working groups or organisations e.g. Review T&D's from NAFEMS SDMWG
  - NAFEMS SDMWG, related to existing terms within ISO 10303 and specific terms (such as simulation model, simulation state, and simulation step)
  - INCOSE SEBoK

Systems Modeling & Simulation Working Group

The following was compiled by members of the Systems Modeling & Simulation Working Group to provide the model-based systems engineering community with a common set of shared terms and definitions.

A-C | D-F | G-I | J-L | M-O | P-R | S-U | V-X | Y-Z

Terms & Definitions (M-O)

Term	Definition	Source	Comments
Mathematical Model	A symbolic model whose properties are expressed in mathematical symbols and relationships. (IEEE 610.3-1989)	Modeling & Simulation Coordination Office	
Measure Of Effectiveness (MOE)	A metric used to quantify the performance of a system, product or process in terms that describe a measure to what degree the real objective is achieved.	Modeling & Simulation Coordination Office	
Measure Of Outcome (MOO)	A qualitative or quantitative measure that defines how operational requirements contribute to end results at higher levels, such as campaign or national strategic outcomes.	Modeling & Simulation Coordination Office	
Measure Of Performance (MOP)	A qualitative or quantitative measure of how the system/individual performs its functions in a given environment (i.e., number of targets detected, reaction time, number of targets nominated, susceptibility of deception, task completion time). It is closely related to inherent parameters (physical and structural) but measures attributes of system behavior.	Modeling & Simulation Coordination Office	
Measures of Effectiveness Data	Data provided to quantify Measures of Effectiveness.	INCOSE	
Measures of Effectiveness Needs	The "operational" measures of success that are closely related to the achievement of the mission or operational objective being evaluated, in the intended operational environment under a specified set of conditions (i.e., how well the solution achieves the intended purpose).	INCOSE	
Measures of Performance Data	Data provided to quantify the Measures of Performance.	INCOSE	
Measures of Performance Needs	Key performance characteristics the system should have when fielded and operated in its intended operating environment.	INCOSE	
Metadata	Information providing the characteristics of data.	NAFEMS SMSWG T&D Focus Team	
Metamodel	A representation of a model containing astractions of data types and classes along with their relationships.	NAFEMS SMSWG T&D Focus Team	

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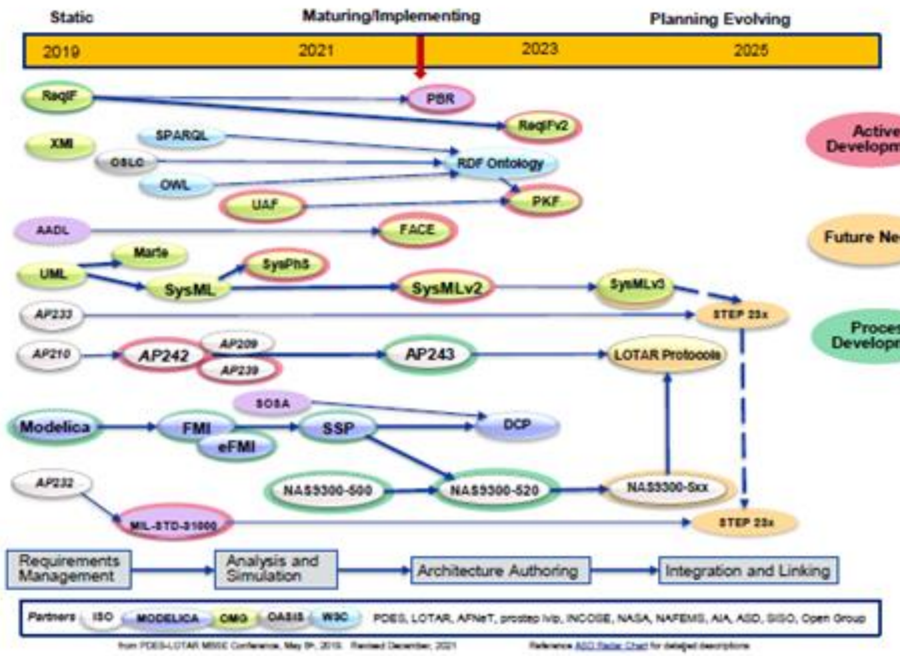
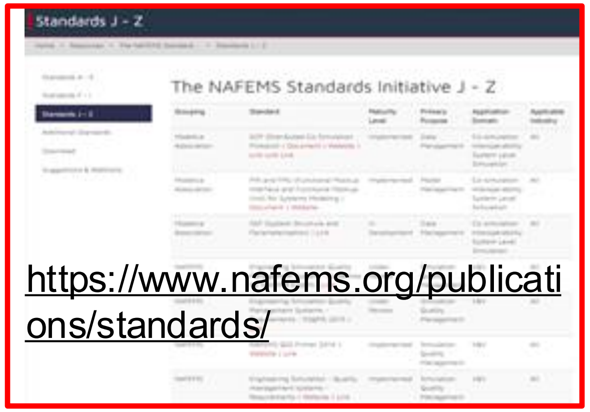
SMSWG focus team - SMS related standards

Restart 2026

- SMSWG aim to identify and promote the maturity and industry adoption of relevant international standards that enable Systems M&S and the integration of MBSE with engineering simulation
- “Unknown or no standards” identified as major gap in survey from MBSE workshop at 2018 GPDIS
- Need for improved model/data interoperability and cross-domain engineering collaboration
- Connect with industry groups working on developing or promoting adoption of standards for MBSE and Engineering Simulation
- Ongoing liaison with NAFEMS Standards Initiative
- Examples:
  - Modelica Assoc. standards e.g. FMI/FMU, SSP …
  - ISO STEP standards e.g. AP209ed2, AP243 (MoSSEC), link with LOTAR
  - Web standards e.g. OSLC, RDF, XML/XMI, UML
  - OMG standards e.g. ReqIF, SysML v2, UAF





https://www.nafems.org/publications/standards/

Completed

SMSWG focus team – INCOSE Systems Engineering Handbook 5th Edition

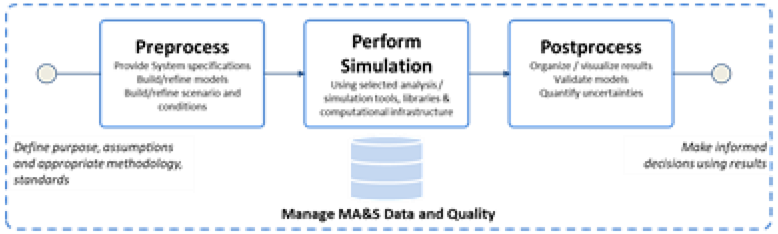
- SMSWG & Community team contributing to SEH5E revision:
  - Hans Peter de Koning + Peter Coleman, Alexander Karl, Maurice Theobald, Hubertus Tummescheit, Rod Dreisbach
- Adapted chapter title => Modeling, Analysis and Simulation
  - Modeling - the conception, creation and refinement of models
  - Analysis - the process of systematic, reproducible examination to gain insight
  - Simulation - the process of using a model to predict and study the behavior or performance of the system-of-interest
- Dec'20 to Apr'21 - Major re-write:
  - Streamlining content & narrative
  - Reference to "What is SMS" flyer
  - Proposed additional terms & definitions
  - Reviews & feedback with Editorial team
  - Overall prototype draft issued to reviewers
- Jan'22 to Mar'22 - Restructured SEH5E and MA&S revisions in response to reviewers comments for final draft submission
- Oct/Nov'22 and Jan'23 - Review significant reduction of text by Editorial team + Further revisions of System Development "vee" figure for final publisher ready version.

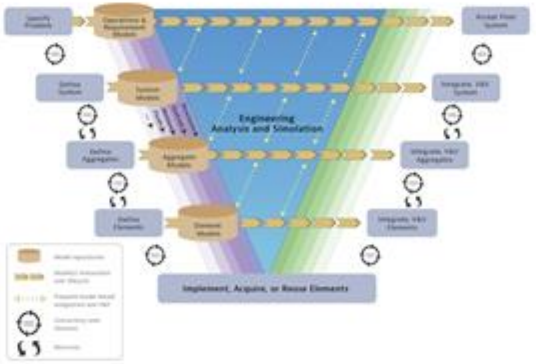
SEH5E - Part III - Life Cycle Analyses and Methods

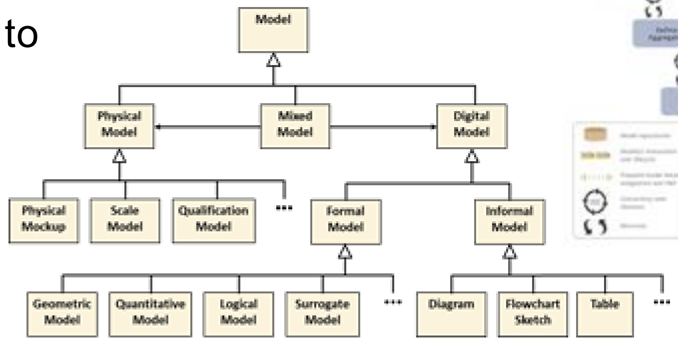
3.2 – Systems Engineering Analysis and Methods

3.2.1 – Modeling, Analysis and Simulation

- Overview and Purpose
- Benefits
- Classifying and Characterizing Models
- Model Interoperability
- Tools
- Modeling Quality and Metrics
- MA&S Industrial Practice







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V12 update

SMSWG outlook for 2026 – proposals … What are your ideas?

- Maintain & update SMS WG content on NAFEMS and INCOSE webpages
  - Continuous communication
- SMS WG core team management meetings
  - 2026 dates tbc
- SMS Community meetings
  - IW26 (#75) + Apr (#76) + Jun (#77) + Sep (#78) + Nov (#79)
- SMS Roadmap focus team
  - Ongoing monthly - Plan SMS community sessions + SMS WG participation at other events + Identify & support emerging products
- INCOSE SMA / NAFEMS PSE competencies focus team (new in 2024)
  - Target to finalise SMS competence area in NAFEMS PSE
- SMS T&D's focus team meetings
  - On-hold since Feb'25, pending new leader to restart update of SMS Terms & Definitions and integrate in T&D's website
- SMS Standards focus team
  - Aiming to restart in 2026 e.g. "How to develop effective engineering digitisation standards?" primer + updated/extended "What is FMI" related products
- Refining understanding SMS focus team (new in 2024)
  - Output – defining SMS + revised/extended "What is SMS" product + papers
- Support key events
  - INCOSE IW26 (Torrance) SMS#75 community event
  - INCOSE IS26 (Japan) submissions inc 2 presentations on Competencies + Understanding SMS and 2 panels on SysML v2 + Digital Thread

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Interested to join the SMSWG or SMS Community?

Get Involved in the Systems Modeling & Simulation Working Group

If you are an expert in the area of SMS and would like to get involved in the **Systems Modeling & Simulation Working Group** activities, please complete the form below.

First Name

First Name

Last Name

Last Name

Company

Company

Email

Email

My organisation is a NAFEMS member

Please Select

I am a member of INCOSE

Please select

If your organisation is not already a member of NAFEMS, would you be interested in receiving information on membership?

Please Select

If you are not already a member of INCOSE, would you be interested in receiving information on membership?

Please select

www.nafems.org/community/working-groups/systems-modeling-simulation/get_involved/

Join the SMS Community

If you are an INCOSE member please complete the form below in order to join the SMS Community.

If you are a NAFEMS member and wish to join the SMS Community please visit the Technical Communities tab in the "My NAFEMS" section of the website.

Visit the SMS Community page to find out about SMS Community events.

First Name

First Name

Last Name

Last Name

Company

Company

Email

Email

Are you a member of INCOSE?

Please select

Submit

By clicking submit and providing us with your contact details, you are giving NAFEMS your explicit consent to contact you using these details regarding your enquiry and our related products and services. You can view our privacy policy here

www.nafems.org/community/working-groups/systems-modeling-simulation/get_involved_sms_community/

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