



**34<sup>th</sup>** Annual **INCOSE**  
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July 2 - 6, 2024



# Importance and Status of Relevant Standards for Systems Modeling and Simulation

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## 10.1.1 Panel

# Building the Digital Bridge between MBSE and Engineering Simulation

# Personal Background

- M.Sc. Applied Physics from Delft University of Technology
- ~40 years' experience as thermal | software | systems engineer
- 1984 – 1999: Industry (mostly space)
- 1999 – 2019: European Space Agency – retired end 2019
- 2020 – now: Own consultancy company DEKonsult



- 2010 – 2019: Responsible for standards, methods and tools for the [ESA Concurrent Design Facility](#) for space mission development
- Author of / contributor to many standards (ECSS, ISO, OMG)

- Digital engineering R&D projects
- Core member KerML and SysML v2 development team for OMG
- Member INCOSE/NAFEMS Systems Modeling & Simulation WG

# Engineering Complex Systems Requires Integrated Multi-Disciplinary Teams

My motto for Model Based / Digital Engineering:

Getting the **right** view  
of the **right** version  
of the **right** information  
to the **right** team member  
at the **right** time ... always

Getting the **wrong** view  
of the **wrong** version  
of the **wrong** information  
to the **wrong** team member  
at the **wrong** time ... always

Major challenge ... much easier to get one **wrong**  
than everything **right** ...

# Essence of Transition to Model Based Systems Engineering

Separation between **representation** and **presentation** of information

Information sharing between  
all project disciplines  
(domains of expertise)

**Representation**  
of system information  
“Authoritative Source of Truth”

Many different **Presentations** i.e. **Views**  
Static or Dynamic  
Correct by construction (typically generated)

System Engineering

Attitude & Orbit Control

Communications

...

Propulsion

Thermal Control

Repository of Models  
Role-based access rights  
Including version control  
(possibly federated)

Trees (Collapsible)

Tables (Flat / Hierarchical)

Diagrams

Plots

Documents / Reports

Dashboards (Web Apps)

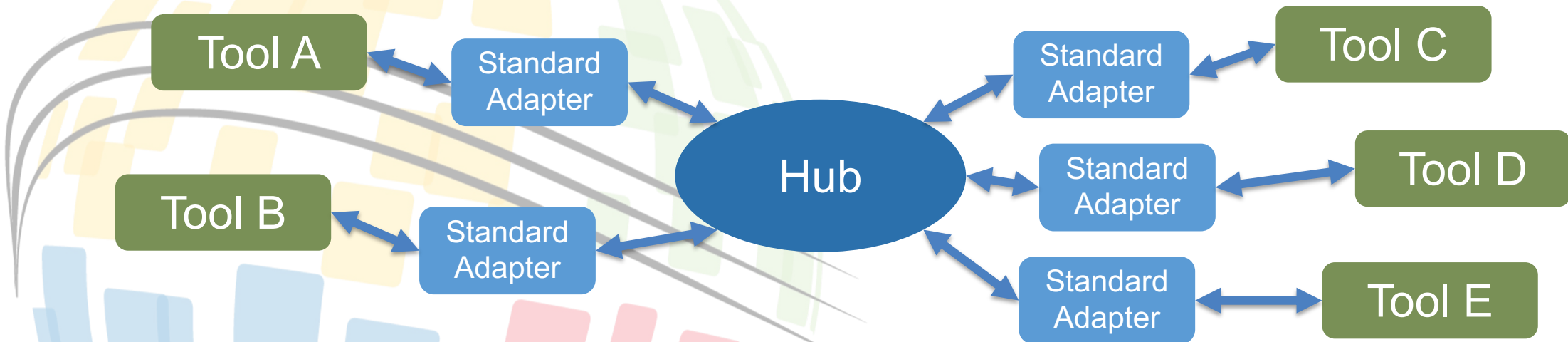
2D & 3D Graphics

- Incremental evolution – not revolution
- Main focus on collaboration, rigor (in terms of information quality) and automation
- Similar to transition from 2D drawings to 3D CAD (1985 – 2005) – but now interdisciplinary
- Gradually achieving continuity across the lifecycle – Continuous digital thread

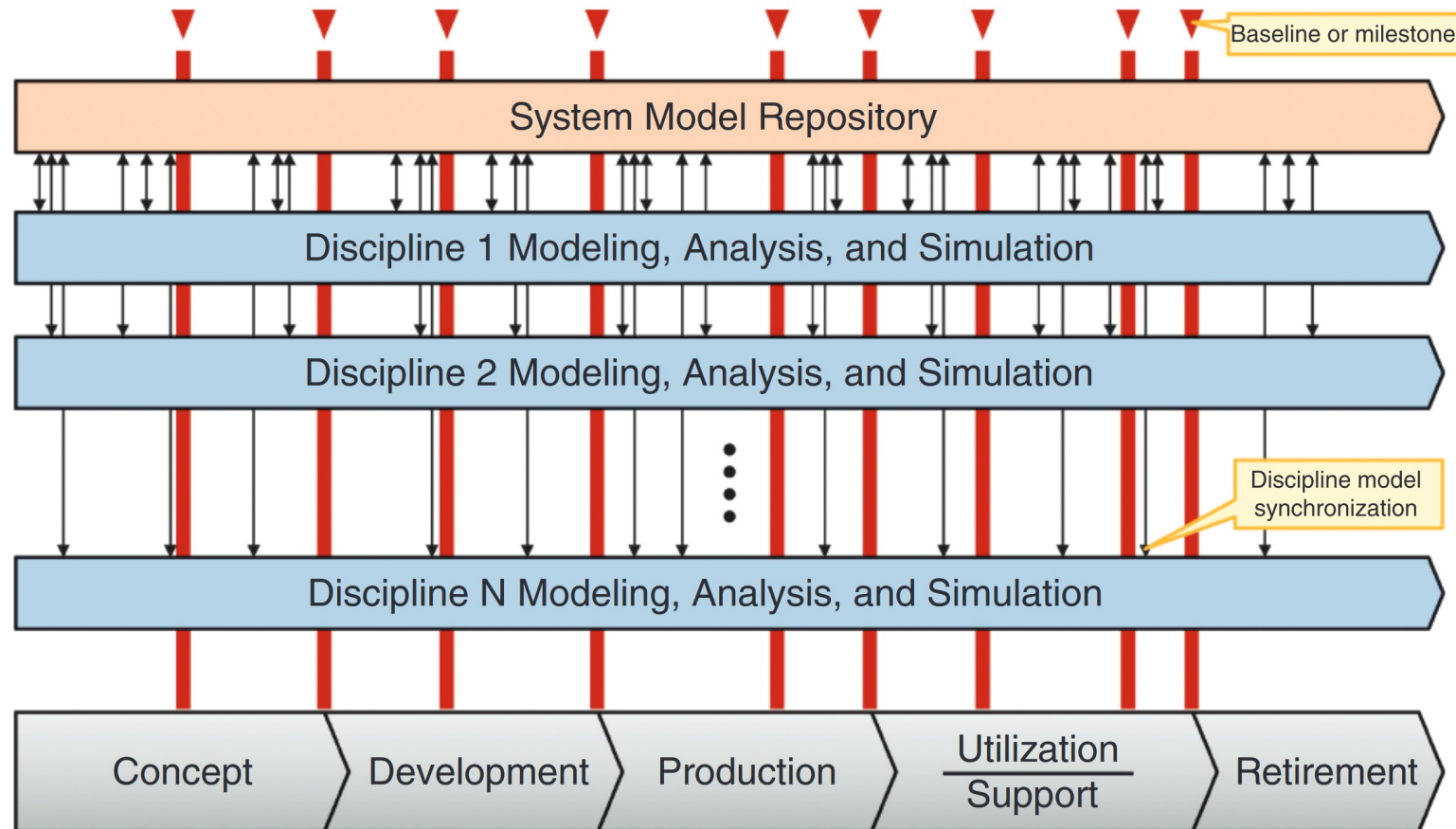


# Effective Digital Engineering Eco-System

- Eco-System necessarily comprises many different tools
- No single vendor's integrated toolset will ever cover all
- Open data standards (files & APIs) are needed to achieve interoperability and data ownership by user organizations
- Typical implementation via hub-and-spokes pattern



# Continuous Multi-Disciplinary Digital Thread



Source: INCOSE SE Handbook Edition 5  
• Section 3.2.1 “Modeling, Analysis and Simulation”  
• Contribution of NAFEMS/INCOSE SMS WG

**FIGURE 3.12** Multidisciplinary MA&S coordination along the life cycle. INCOSE SEH original table created by the NAFEMS-INCOSE Systems Modeling and Simulation Working Group (SMSWG). Usage per the INCOSE Notice pages. All other rights reserved.

# SMS WG – Standards Focus Team

## Existing Resources (1/2)

- NAFEMS Standards Initiative
  - <https://www.nafems.org/publications/standards/>
  - Categorized list of 110 standards
    - maturity level, primary purpose, applicable industries, application domain
- INCOSE SE Standards
  - <https://www.incose.org/about-systems-engineering/se-standards/>
  - ~40 standards
- Both in need of updating / maintenance

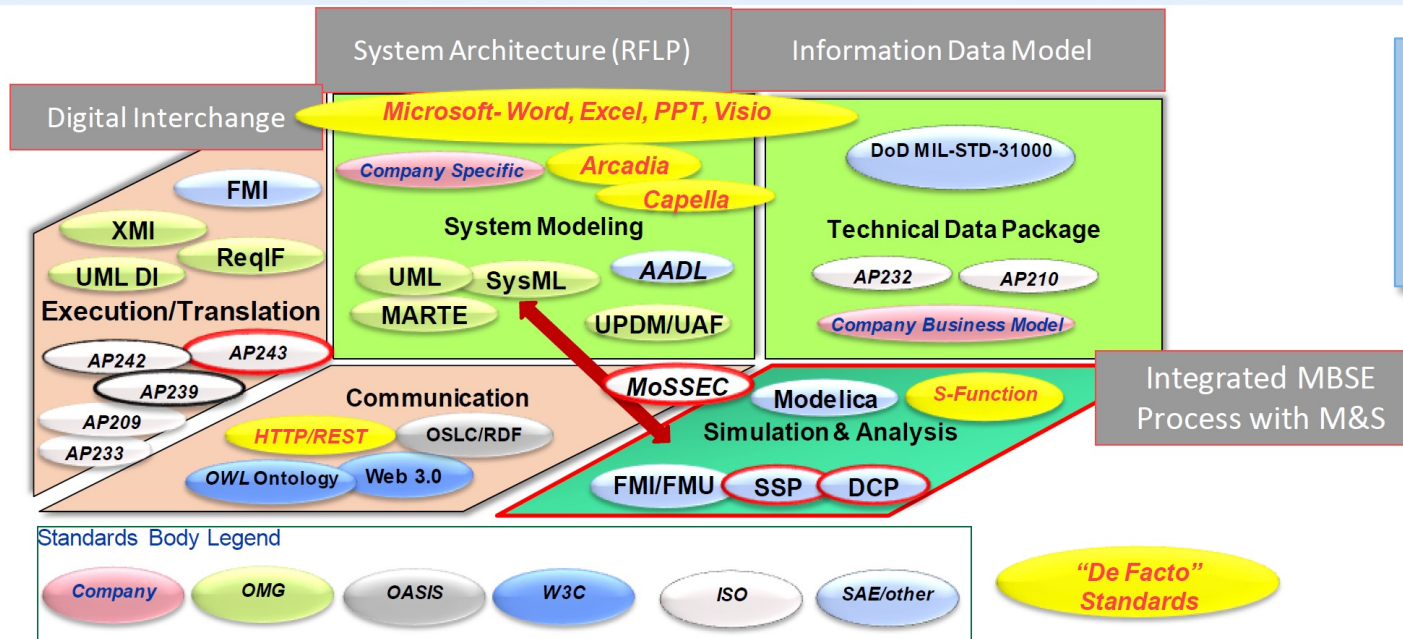


# SMS WG – Standards Focus Team

## Existing Resources (2/2)

### High Impact “Standards” – MBSE Process Enablers

*Combination of formal international standards and industry “de facto” standards will enable MBSE*



#### Overview presentations by

- CIMdata (Don Tolle)
- Mentor Graphics (Bill Chown)
- Boeing (Mark Williams)

Adapted from Original Graphic: CREDIT to Bill Chown, Mentor Graphics; MBSE Roundtable, 2015 GPDIS

CIMdata®

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Observation: Many huge standards – Very long development times

2-6 July 2024

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slide 9

# SMS WG – Standards Focus Team Priorities

## Focus on MBSE ↔ multi-disciplinary analysis & simulation

SDO = Standards Development Organization

SDO	Standard(s)	Title / Description
ISO	10303 (STEP)  24641	Part 242 – Managed model-based 3D engineering Part 243 – Modeling and Simulation information in a collaborative Systems Engineering Context – MoSSEC Part 209 – Multidisciplinary analysis and design Systems and Software engineering - Methods and tools for model-based systems and software engineering
LOTAR	NAS 9300-520 ...	Long term archiving and retrieval of analytical models ...
Modelica Association	FMU SSP DCP eFMI	Functional Mockup Unit System Structure and Parameterization Distributed Co-Simulation Protocol Functional Mock-up Interface for embedded systems
NAFEMS (& ASSESS)	ESQMS ESMS	Engineering Simulation Quality Management Standard Engineering Simulation Metadata Specification (Draft) (formerly Unified Model Characteristics for Engineering Simulation)
OMG	SysML v1 SysML v2 SysPhs	Systems Modeling Language – version 1 Systems Modeling Language – version 2 (In progress) SysML Extension for Physical Interaction and Signal Flow Simulation
SystemX	MIC	Model Identity Card (Draft)

# Idea 1 bridging MBSE ↔ SMS: SysML v2 for analysis / simulation interface

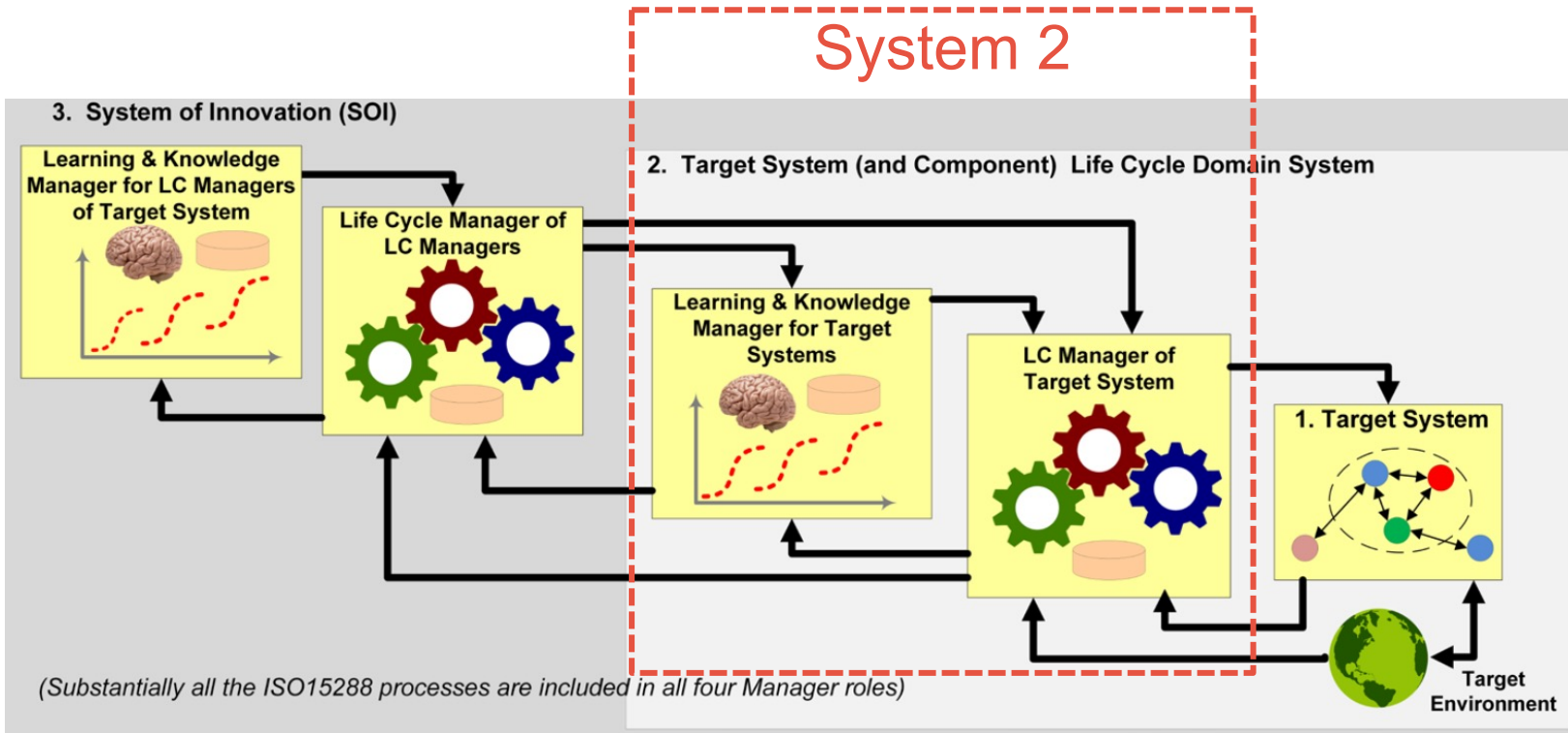
- SysML v2 has **AnalysisCase**, **VerificationCase**, **SampledFunction**
- Fully descriptive digital representation of case
  - id, name and textual description
  - purpose
  - subject (i.e. system element under analysis / simulation)
  - optional parameterization, including any KPI, MoE, ..., condition
  - related requirements and/or constraints to be satisfied / verified
- Discretely sampled function(s) can capture (consolidated) results of any case execution
  - E.g. time series, frequency spectra, multi-variate samplings, ...
  - Easily converted to dataframe / pandas like in big data analytics
- Develop examples to show feasibility and practice

# Idea 2 bridging MBSE ↔ SMS: One harmonized model metadata standard

- Currently 4 similar / overlapping standards
  - ISO 10303-243 MoSSEC (partially)
  - ISO 24641 Methods and tools for MBSSE (partially)
  - ESMS Engineering Simulation Metadata Specification
  - Model Identity Card
- Can create harmonized SysML v2 standard library
  - Practical, fast, cheap, robust implementation possible
  - Similar approach as AADL integration into SysML v2

# Idea 3 bridging MBSE ↔ SMS:

## Best practice to develop interchange adapters



- Make use of INCOSE System of Innovation Pattern
- Apply MBSE also to System 2 that realizes the target system-of-interest (System 1)
- Use MBSE / SysML v2 to model adapter / interchange and proceed with SW generation
- Note: SysML v1 is already used to model business processes in ISO STEP, e.g., MoSSEC

Source: S\* / INCOSE System of Innovation Pattern  
Bill Schindel (ICTT System Sciences) – [patterns\\_storybook\\_v1.3.1.pdf](#) on [INCOSE/OMG MBSE Patterns WG Wiki](#)



# Summary

- Open data standards are necessary to realize effective bridges  
MBSE ↔ multi-disciplinary engineering analysis & simulation
- Standards development too slow
  - Needs modernization following SW engineering best practices
  - During development standards should be continuously validated via pilots
- INCOSE / NAFEMS SMS WG well-placed to help
  - Opportunity for SMS WG to unify model characterization standards initiatives into single standard
  - SMS WG welcomes new Standardization Focus Team members
- Role for SysML v2 as integration / bridging standard
  - In particular via its descriptive *Analysis Case* concept
  - Get a lot of needed robust systems modeling concepts “for free”
  - Highly suitable basis for SW code generation, in particular for interchange adapters



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