Defining Product and Process Requirements Using MBSE: A (Very) Brief Overview

Bill Schindel, ICTT System Sciences

INCOSE/OMG MBSE Patterns Working Group

ICTT System Sciences®
Understand your systems.

schindel@ictt.com

V1.2.1

Contents

- Introductions
- MBSE is first about _representation_
- Defense, other federal acquisition programs weigh in on MBSE
- Organizing opportunities, challenges, lessons, learning
- How to learn more

Introductions

- International Council on Systems Engineering (INCOSE)
  - https://www.incose.org/
- Object Management Group (OMG)
  - https://www.omgsysml.org/
- INCOSE/OMG MBSE Patterns Working Group
  - https://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns
- ICTT System Sciences
  - https://www.ictt.com/
- Bill Schindel
  - https://www.linkedin.com/in/bill-schindel-9379573/
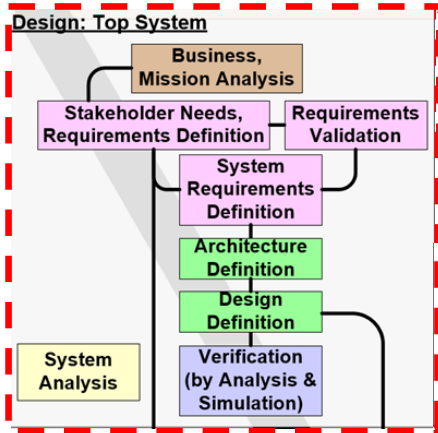
INCOSE MBSE Patterns Working Group

- Ten years old INCOSE working group, part of INCOSE-OMG MBSE Initiative.
- Working Group is focused on:
  - Configurable, reusable MBSE models, which are additionally . . .
  - Based on the STEM-based S*Metamodel
  - Mapped to various popular COTS languages and tools (including SysML).
- MBSE Patterns:
  - Avoid manually creating new models for each program, project, product.
  - A proxy for group learning (enterprises, supply chains, market segments).
  - In the tradition of the sciences, which are based upon model-based patterns.
- Order-of-magnitude improvement in time, completeness, consistency to generate new product models, for use across the system life cycle.
- Integrated requirements, design, FMEAs, and more.
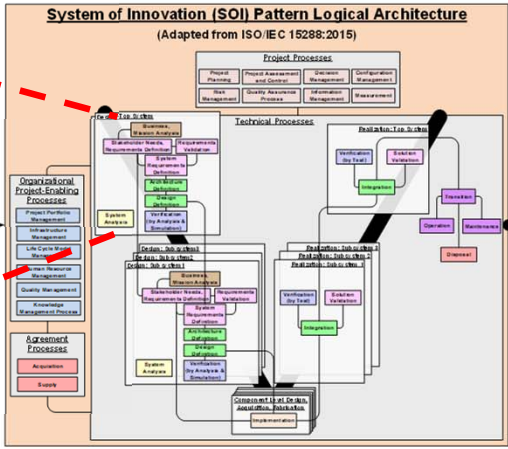
MBSE is first about _representation_

PROCESSES:

For years, Systems Engineering was described in a process-intensive way; for example--

- ISO/IEC 15288
- INCOSE Systems Engineering Handbook

INFORMATION:

MBSE rebalances the emphasis, so that the information itself is promoted to its place in the other STEM-based disciplines having their own "models".

Processes
(Consume and Produce Information Segments)
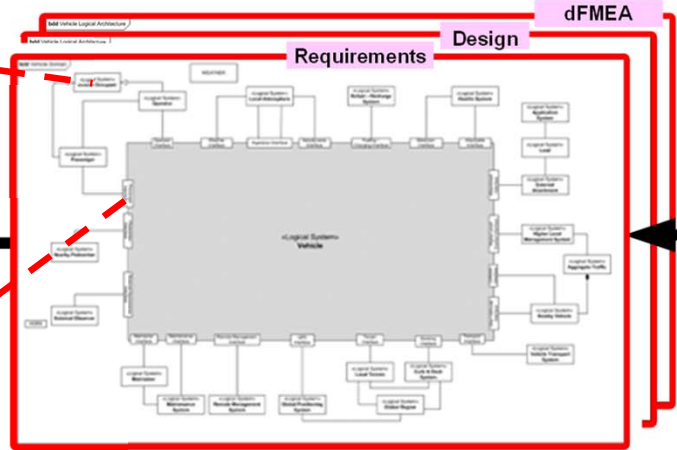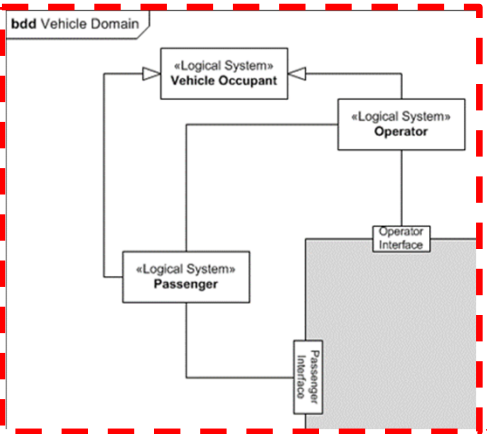
Information Segments
(Produced and Consumed by Processes)

Two different perspectives on intentions for models

1. **The traditional (~1950-Present) Business IT perspective:**
   - "Information Models" of the information handled by human business processes—including Engineering and other technical business processes.
   - This is how databases were built for countless automation applications of all kinds.
   - This leads to "models of <u>information about </u>systems"
   - Related IT criteria: "Does this model conform to an IT standard on which we have group agreement?"

2. **The traditional (1700-Present) Physical Sciences perspective:**
   - "Scientific Models" of natural and human-made phenomena, from Newton to now.
   - This formed the theoretical foundations of the sciences and the engineering disciplines that they support.
   - This leads to "models <u>of</u> systems"
   - Related scientific criteria: "Does this model accurately describe the "real" modeled system?"

Case (1) and Case (2) need not conflict—if managed accordingly:
   - As MBSE unfolds, this has not always occurred—because there are complex historical forces involved.
   - MBSE modeling languages, tools, and standards <u>allow us to do both</u>, but <u>not without extra attention</u>.
   - One can easily create impressive-looking models that people agree with, but are nonsense.
   - The reason for the S*Metamodel, ASELCM Pattern, and more.

- Requirement Statements:
  - Are Transfer Functions!
  - Always describe behavior during Interactions between domain Actors, playing Roles.
  - Can still be described in "traditional requirements prose".
  - But become an embedded part of the model.

- These and other capabilities flow from the S*Metamodel:
  - What Is the Smallest Model of a System, for purposes of engineering, life cycle mgmt.?
  - Download--What Is the Smallest Model of a System?   ← Link

Link→   Requirements Statements Are Transfer Functions   Interactions--Making the Heart of Systems More Visible ← Link

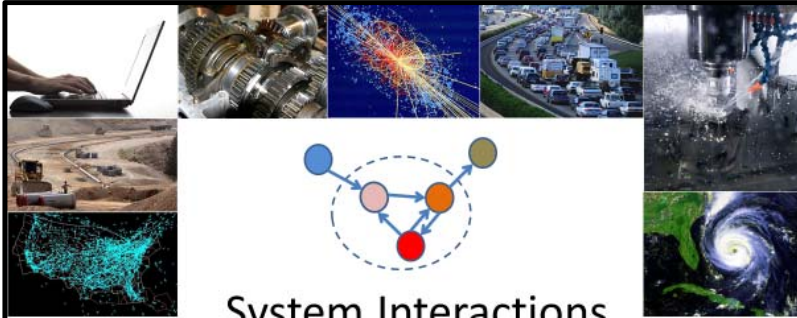INCOSE 2005 International Symposium "Best Paper" Award in Modeling and Tools

Requirements Statements Are Transfer Functions:
An Insight from Model-Based Systems Engineering

William D. Schindel
ICTT, Inc., and System Sciences, LLC
378 South Airport Street, Terre Haute, IN 47803
812-232-2062 schindel@ictt.com

Copyright © 2005, 2019 by William D. Schindel. Published and used by INCOSE with permission.

Abstract. Traditional systems engineering pays attention to careful composition of prose requirements statements. Even so, prose appears less than what is needed to advance the art of systems engineering into a theoretically-based engineering discipline comparable to Electrical, Mechanical, or Chemical Engineering. Ask three people to read a set of prose requirements

System Interactions
Making the Heart of Systems More Visible

7

What about Requirements for Manufacturing and other <u>Process</u>-Oriented Systems?

External "Actors"

System

System Component
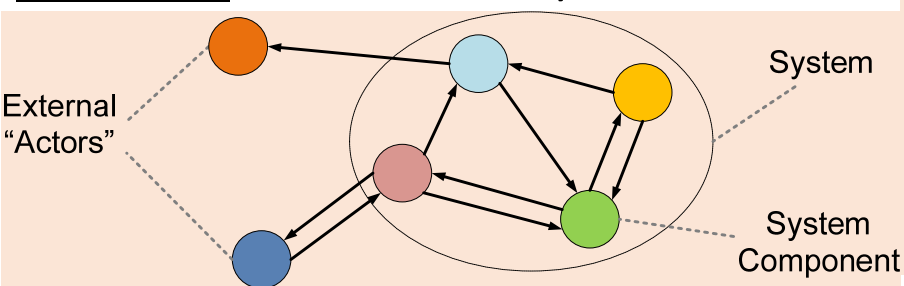
- All systems of any type are made up of set of <u>interacting elements</u>.

- By "Interact", we mean exchanges of Force, Energy, Material, Information, leading to changes of state.

- System level properties emerge from these interactions.

Works for Manufacturing and other "Process" oriented systems, too →

Link to Manufacturing MBSE Patterns Paper, SAMPE

Link to Procter & Gamble Manufacturing Paper

8

What About <u>Stakeholder</u> Requirements?

- The Stakeholder S*Features Model describes <u>mission</u>, stakeholder <u>value</u>, trade and <u>optimization</u> space, <u>risk</u> space, and <u>configuration variation</u> space—all collapsed to the Features part of the model!

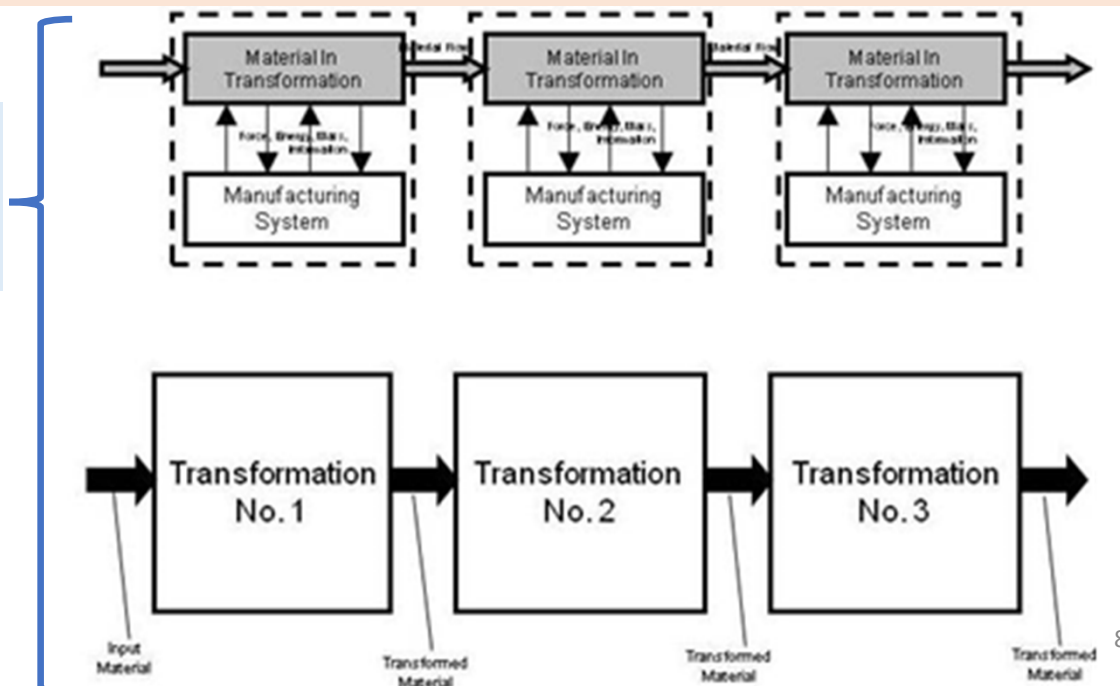[Download Link--Introduction to Feature Space](#)

Feature Space: Integrating Value, Purpose, Mission, Risk, and Variation — INCOSE

INCOSE North Texas Chapter Meeting
June 14, 2022   V1.2.2   Copyright 2022, W. D. Schindel   Permission granted to use with attribution

Bill Schindel
INCOSE Patterns Working Group
schindel@ictt.com

What about "<u>Non-Functional</u> Requirements?"

- They are all likewise visible at the system boundary external interactions!

Defense and other federal acquisition programs weigh in on MBSE

- A surge of federal defense acquisition initiatives across the service branches and DoD Office of SecDef have emphasized requirements for MBE descriptions during and following acquisition.
- This mandate has generated a flurry of supplier MBSE activities, centers, consortia, buzz.
- Related mandates have even begun appearing in the (4000+ pages) National Defense Authorization Acts (NDAA, 2022, 2023).
- This does not necessarily imply coordination of the specifics.
- Indeed, a very big issue is the lack of coordination of models—even evident to Congress!
- Some of this originates in mis-perceptions that buying the same modeling tools, languages, and training will create compatibility—profoundly untrue.
- Other misunderstandings abound.
- Further, MBSE is embedded in larger areas of evolution/revolution: Digital Engineering, Systems Engineering and life cycle management as a whole; and the engineered systems themselves (cities; networks; ABMS; joint command; public health; economies; markets)
- These are reasons the INCOSE Patterns Working Group has been prioritizing the Innovation Ecosystem Pattern since 2014—recently adopted by AIAA as its aerospace industry reference model for Digital Threads and Digital Twins.

Calendar No. 445

JAMES M. INHOFE
NATIONAL DEFENSE AUTHORIZATION
ACT FOR FISCAL YEAR 2023

R E P O R T

[TO ACCOMPANY S. 4543]

ON

TO AUTHORIZE APPROPRIATIONS FOR FISCAL YEAR 2023 FOR MILITARY ACTIVITIES OF THE DEPARTMENT OF DEFENSE, FOR MILITARY CONSTRUCTION, AND FOR DEFENSE ACTIVITIES OF THE DEPARTMENT OF ENERGY, TO PRESCRIBE MILITARY PER-SONNEL STRENGTHS FOR SUCH FISCAL YEAR, AND FOR OTHER PURPOSES

COMMITTEE ON ARMED SERVICES
UNITED STATES SENATE

JULY 18, 2022.—Ordered to be printed

STATUS OF ADOPTION AND IMPLEMENTATION OF DIGITAL ENGINEERING INFRASTRUCTURE AND WORKFORCE DEVELOPMENT WITHIN THE DEPARTMENT OF DEFENSE

House Report 117-118, page 69, accompanying H.R. 4350, the National Defense Authorization Act for Fiscal Year 2022

Mr. Thomas W. Simms
Acting Principal Deputy Director, Systems Engineering & Architecture
Office of the Under Secretary of Defense for Research and Engineering
October 1, 2022

Distribution Statement A: Approved for public release. Distribution is unlimited. DOPSR 22-C-1097

BATTLE MANAGEMENT

DOD and Air Force Continue to Define Joint Command and Control Efforts

---

Coordination of investments for model-based systems engineering

The committee is aware of the Department of Defense (DOD)'s interest in model-based systems engineering (MBSE) approaches and tools to help improve the rigor and application of digital tools for systems engineering practices through reusable and extensible systems engineering artifacts. The committee recognizes that MBSE approaches support both improved research and development, but also make the transition into acquisition systems of record and ultimately sustainment more seamless. MBSE digital artifacts can also support related efforts by providing inputs that

---

DATA ITEM DESCRIPTION
Title: DIGITAL SYSTEM MODEL

Number: DI-SESS-82364	Approval Date: 20220201
AMSC Number: 10279	Limitation: N/A
DTIC Applicable: No	GIDEP Applicable: No
Preparing Activity: MDA	Project Number: SESS-2021-036
Applicable Forms: N/A	

Use/relationship: The Digital System Model provides a consistent and cohesive representation of the system. It includes digitally traceable interrelationships between data and information grounded in an authoritative source of truth.

American Institute of Aeronautics and Astronautics (AIAA) has released both its Digital Thread & Digital Twin Reference Models

June, 2023

January, 2023

Both of these are based on the
INCOSE MBSE Patterns Working Group
Innovation Ecosystem (ASELCM) Pattern.

Click to Download Related INCOSE Publication

ASELCM = Agile Systems Engineering
Life Cycle Management

Click to Download AIAA Digital Thread Reference Model

Click to Download AIAA Digital Twin Reference Model

ASELCM Pattern: Organizing opportunities, challenges, lessons, learning

Processes

(Many different approaches for same Information structure)

Information

(Potentially more fundamental and invariant structure)

ASELCM Level 0 Reference Model

System 3: Innovation Ecosystem

Process Life Cycle Management Processes

System 2: Life Cycle Domain system

Engineering and Life Cycle Management Processes

Deployment

Deployment

System 1: Engineered System

Observations

Observations

Observations

Environment 3

Learned Descriptions of System 2 and Environment 2

Environment 2

Learned Descriptions of System 1 and Environment 1

Environment 1

Definition, advancement of engineering, production, support, scientific methods

Engineering, production, support, science

Products we design; markets; Nature

INCOSE Innovation Ecosystem (ASELCM) Pattern

INCOSE ASELCM Level 1 Reference Model

- Innovation (delivery of new or rearranged value).
- Whether human-engineered, natural (e.g., biological), or hybrid.
- Analyze any system of innovation--descriptive, not prescriptive; whether innovation is effective or flawed, any methodology.
- Emphasis on group learning, uncertainty, information.
- Diverse applications and theory insights, listed in part below.
- Related INCOSE publications began in 2014, more nearly every year.

INCOSE ASELCM Level 2 Reference Model

Stakeholder Features

INCOSE ASELCM Level 1 Reference Model

3 more levels below this

(Separation of *learning new information* from *acting on what is already known*.)

How to learn more

- Check out the links
- Join the INCOSE MBSE Patterns Working Group
- Questions: schindel@ictt.com