# The Role of Advanced Data Architectures in the MBSE Universe

NDIA ASME Oct. 2019, Tampa FL

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# Model-Based System Engineering

"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."

- *INCOSE*

Increased Quality

Reduced Risk

Reduced Cost

# MBSE Modeling Challenges

| Challenges |
| --- |
| • Lack of modularity and reusability<br>• Lack of model interoperability<br>• Static and brittle models<br>• Descriptive nature of models<br>• Lack of model sustainability and obsolescence<br>• Complexity of change management |

*http://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:incose_mbse_iw_2015:australia_mbse_for_sos_-_opportunities_and_challlenges_iw2015.pdf*

# Other Models v. Data Models

*Laying the Groundwork*

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"A representation of a system and its environment used to specify, design, analyze, and verify systems and share information with other stakeholders" (SEBok)

logical representation of a
ss (DoD 1998);

**DOMAIN-SPECIFIC**

pts that may be realized in the
d Steiner 2009);

**FORMAL**

a simpl resentation of a system at some particular point in time or space inten ed to promote understanding of the real system (Bellinger 2004);

# Model

**INFORMAL**

**PHYSICAL**

an abstraction of a system, aimed at understanding, communicating, explaining, or designing aspects of interest of that system (Dori 2002); and

**LOGICAL**

**HYBRID**

a selective represen **ABSTRACT** e system whose form and content are chosen based on a specific set of concerns; the model is related to the system by an explicit or implicit mapping ( Group 2010).

**SYSTEM**

**MATHEMATICAL**

# Types of Models

## CONCRETE

**Physical**

model airplane

## ABSTRACT

**Mathematical**

math-based model representing flight trajectories

**Logical**

descriptive relationships among aspects of airplane failure

*The United States "Department of Defense Modeling and Simulation (M&S) Glossary"*

# Data Models

CONCRETE

**Physical**

ABSTRACT

**Mathematical**

**Logical**

**Data Model**
Organizes **elements of data** and standardizes how they relate to one another and to the properties of real-world entities.

*The United States "Department of Defense Modeling and Simulation (M&S) Glossary"*

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# Data Architecture

Data Architecture includes models, rules and standards that define the data management blueprint by aligning with organizational strategy and operational requirements

What is our organizational strategy?

What is the best form, fit and function to meet our mission?

What are our requirements?

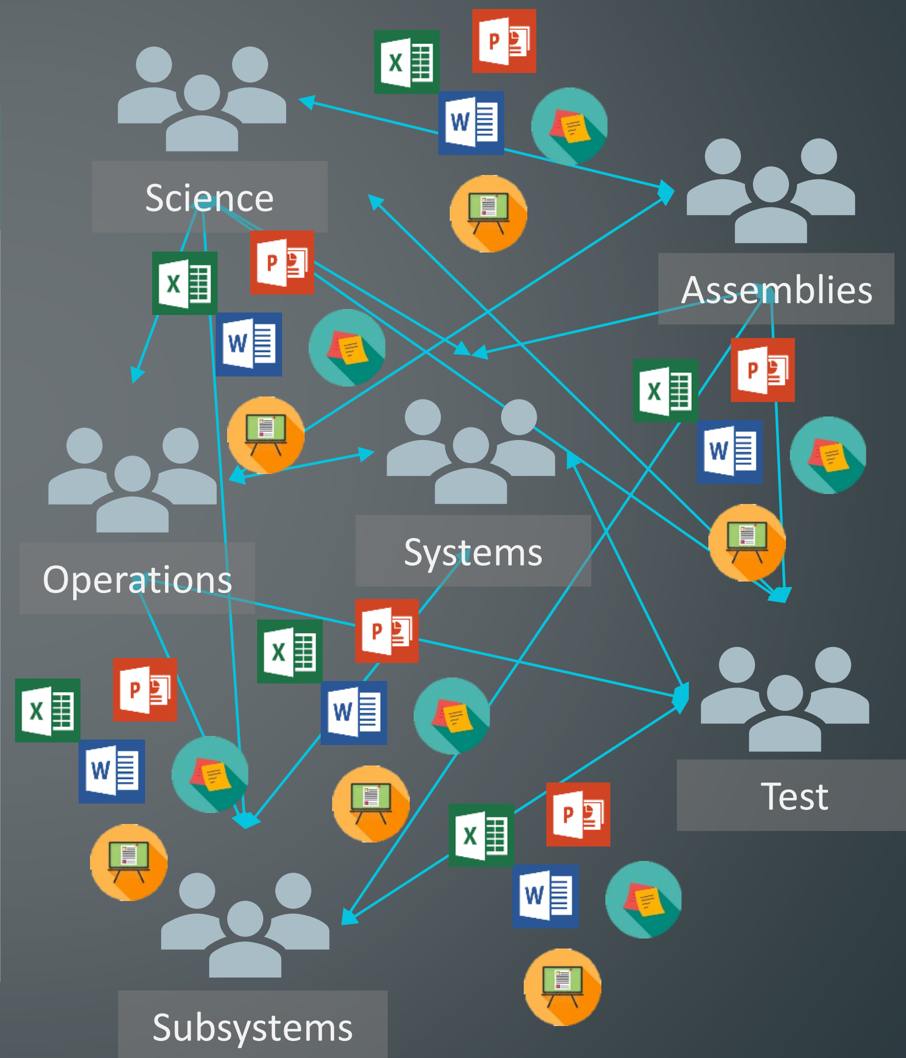
# Innovations in Data Architecture & MBSE

*Finding Solutions to Modeling Challenges*

# Traditional SE Practices

## Traditional

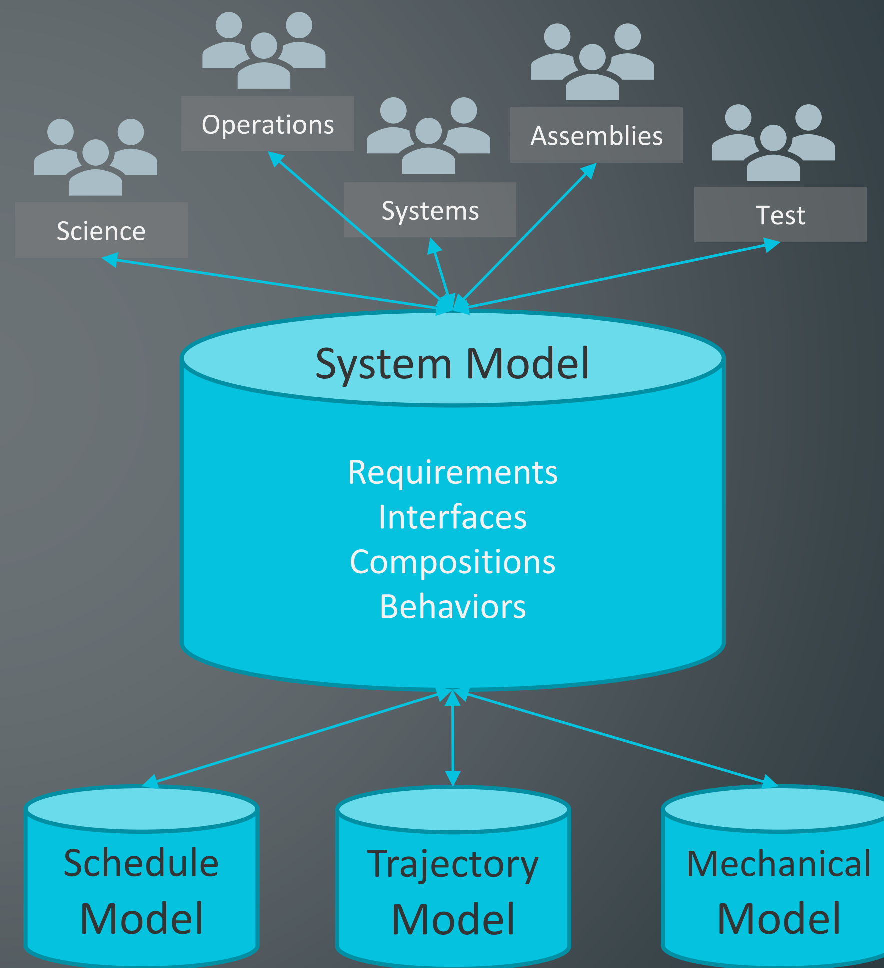
- Stand alone domain models
  - Institutional life cycle documents
    - Requirements Documents
    - Interface Documents
    - Deployment Plans
- Formal review presentations
- Informal communications
- Reliance on Institutional Knowledge



# Modern MBSE Practices

## Modern

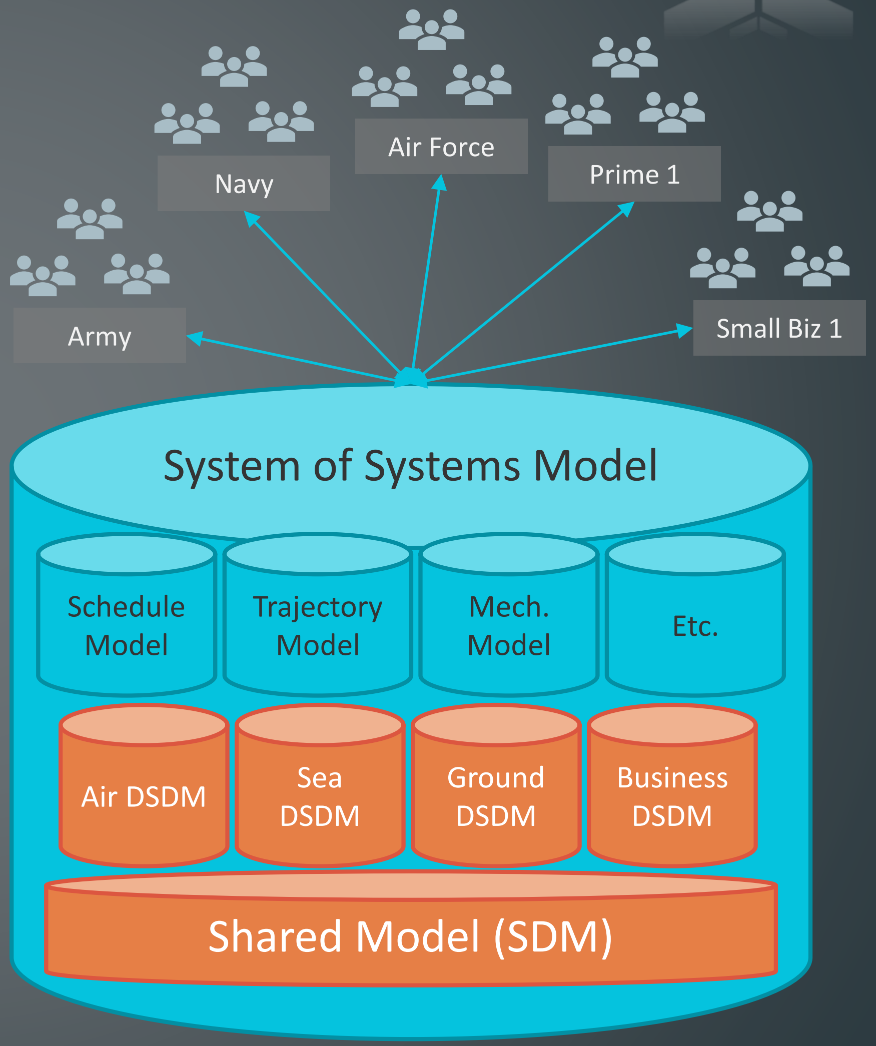
- Integrated system model with multiple views, connected to discipline models
  - Authoritative source of information
  - Exchanges information to/from analysis and stakeholders via projections of model information
  - Information accessible to all members of the project



# Advanced MBSE Practices

## Advanced

- Integrated system of systems (SoS) model
  - Machine leverageable
  - 1 Shared Data Model
  - Multiple Domain Models
  - Captures syntactic, *semantic and temporal*
  - Captures relationships *and* behaviors
  - Single source of truth
  - Collaborative knowledge sharing among enterprises



# Advanced Data Architecture & Interface Documentation

*A Brief Look Inside the Foundational Advancements*

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# Application to Interface Interoperability

## Traditional

- ICS & IDDs
- Informal communications (notes in margins)
- Reliance on Institutional Knowledge

## Modern

- Integrated system model
- Electronic Data Definition
- Entity Relationships / Entity Model
- Machine Readable SysML

## Advanced

- Integrated System of Systems (SoS) Model
- Machine Leverageable
- Allows for automated integration through configurable infrastructures

# EVOLUTIONARY INTEROPERABILITY

## INTERFACE DOCUMENTATION MATURITY LEVELS

*advanced*

### ENTITY MODEL WITH RELATIONSHIPS

Formal documentation of the messages against a data model using containment and tracing through related contexts.

### ENTITY MODEL WITH CONTAINMENT

Formal documentation of the messages against a data model in which the entities reflect their real-world analog and the message attributes project to their corresponding attributes through the related entities that build the context of the attribute.

*mid*

### ENTITY MODEL WITH DIRECT PROJECTIONS

Formal documentation of the messages against a data model in which the entities reflect their real-world analog and message attributes directly project to the attribute they represent.

### MESSAGE MODEL

Formal documentation of the messages against a data model in which the entities directly mirror the message structure.

### ELECTRONIC DATA DEFINITION

This is an electronic version of the ICD/IDD in which the document exists in a format easily parsed by a computer. The data still requires a human for interpretation.

*early*

### INTERFACE CONTROL / DESCRIPTION DOCUMENT (ICD / IDD)

There exists a text-based document that explains the meaning of the interfaces, how the data is transmitted, and how the data is formatted.

### SOURCE CODE

There is no explicit data model. All documentation is captured by the source code that implements it.


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BOLD. VISIONARY. INTEGRATED.

Last Revised 8/2018

# Benefits & Next Steps

*Data Architecture & MBSE*

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# Benefits of the Advanced Architecture Approach

## Challenges

- Lack of modularity and reusability
- Lack of model interoperability
- Static and brittle nature of models
- Descriptive nature of models
- Lack of model sustainability and obsolescence
- Complexity of change management

## Solutions / Benefits

- Built-in modularity
- Fully-integrated models
- Dynamic, flexible models & integrations
- Executable models enabling automated integration
- Reusable Shared and Domain Specific Models
- Opportunities for collaborative, guiding tools
- Decreased redundancy
- Increased Accuracy (SSOT)
- Inherent Traceability & Testability

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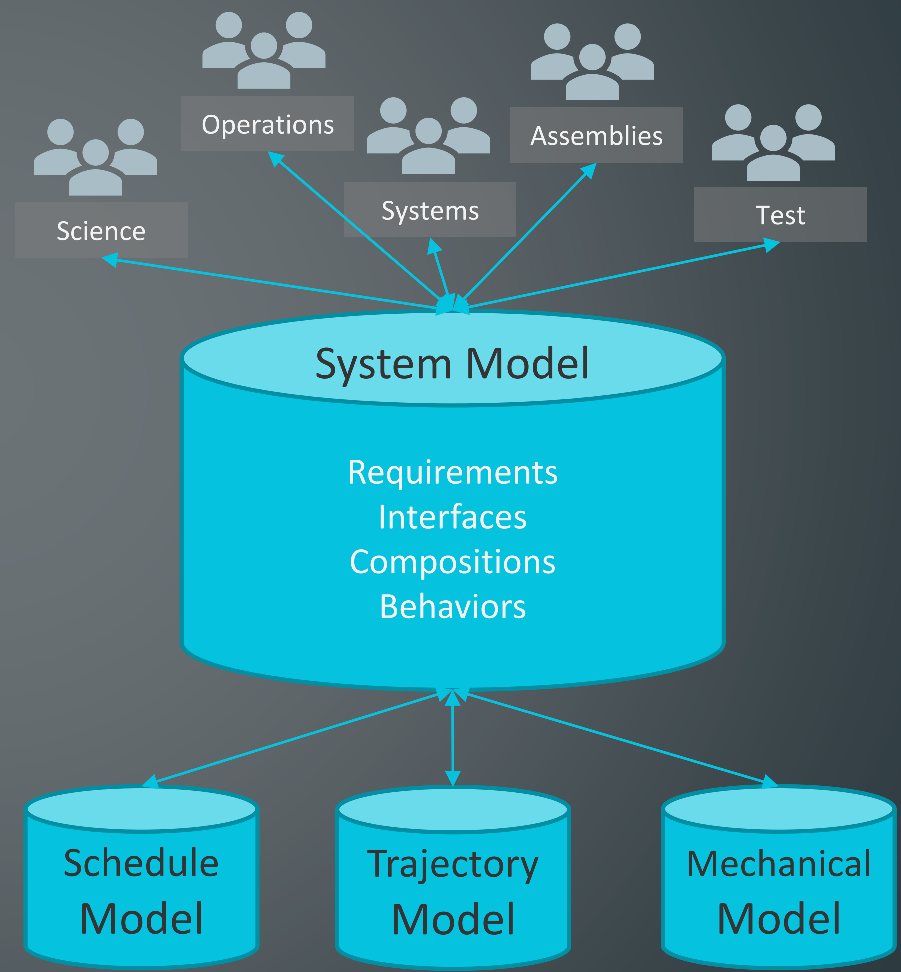

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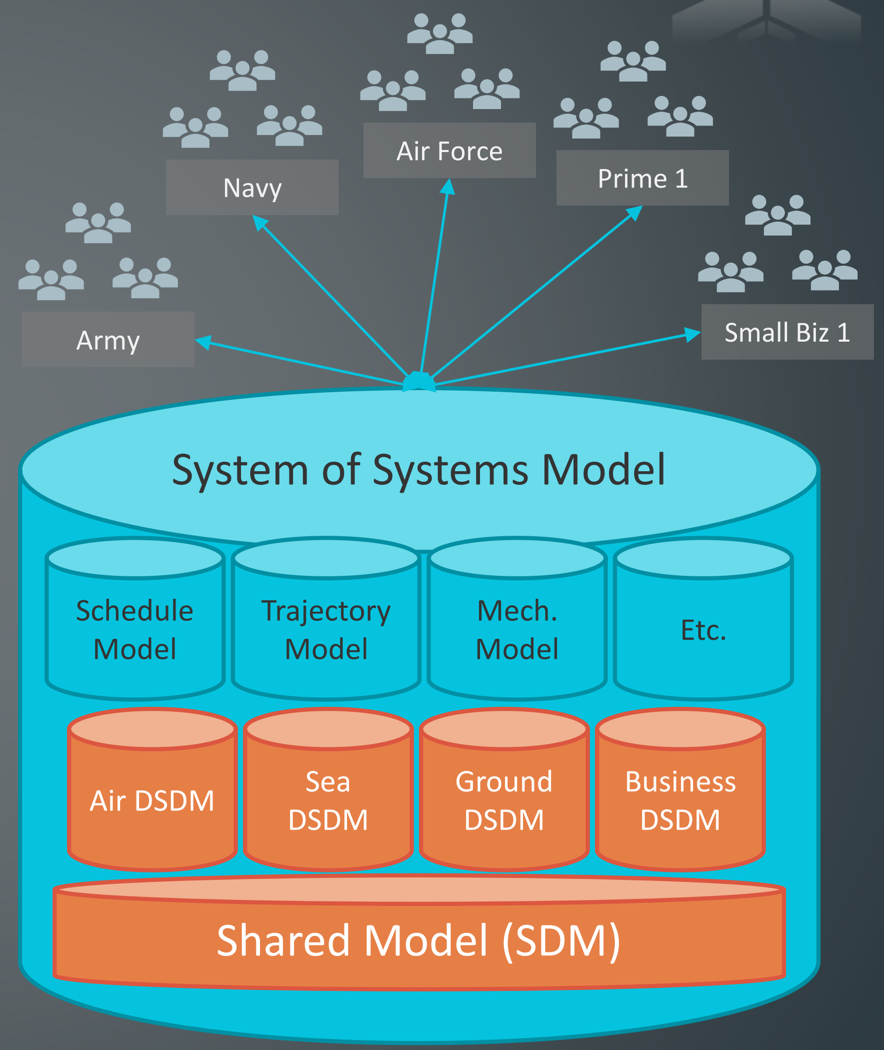

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# How do We Go About It?

**Rigorous Machine-Leverageable Documentation**

- Form
- Fit
- Function

**Begin with the End in Mind**

- Top-Down (mission and requirements)
- Bottom-Up (messages, functions & interactions)

**Capture the Meaning of the Data**

- Syntactic – Structure and form of data
- Semantic – Meaning and intent of data
- Behavioral – Semantics of the interaction

**SySML and UML + Advanced Tools**

- Semantic and temporal characteristics
- Collaboration
- Change management

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# A Perspective Shift

Increased Quality

Reduced Risk

Reduced Cost

Inherent Testability

Optimization

Analytics

Rapid Integrations

Future Advancement

Operational Automation

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# Sources & Resources


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