Refining the Shared Framework for Model Element Reuse

By: Paul Trevidic and Michael Pennock

27th Annual NDIA Systems and Mission Engineering Conference

October 31, 2024

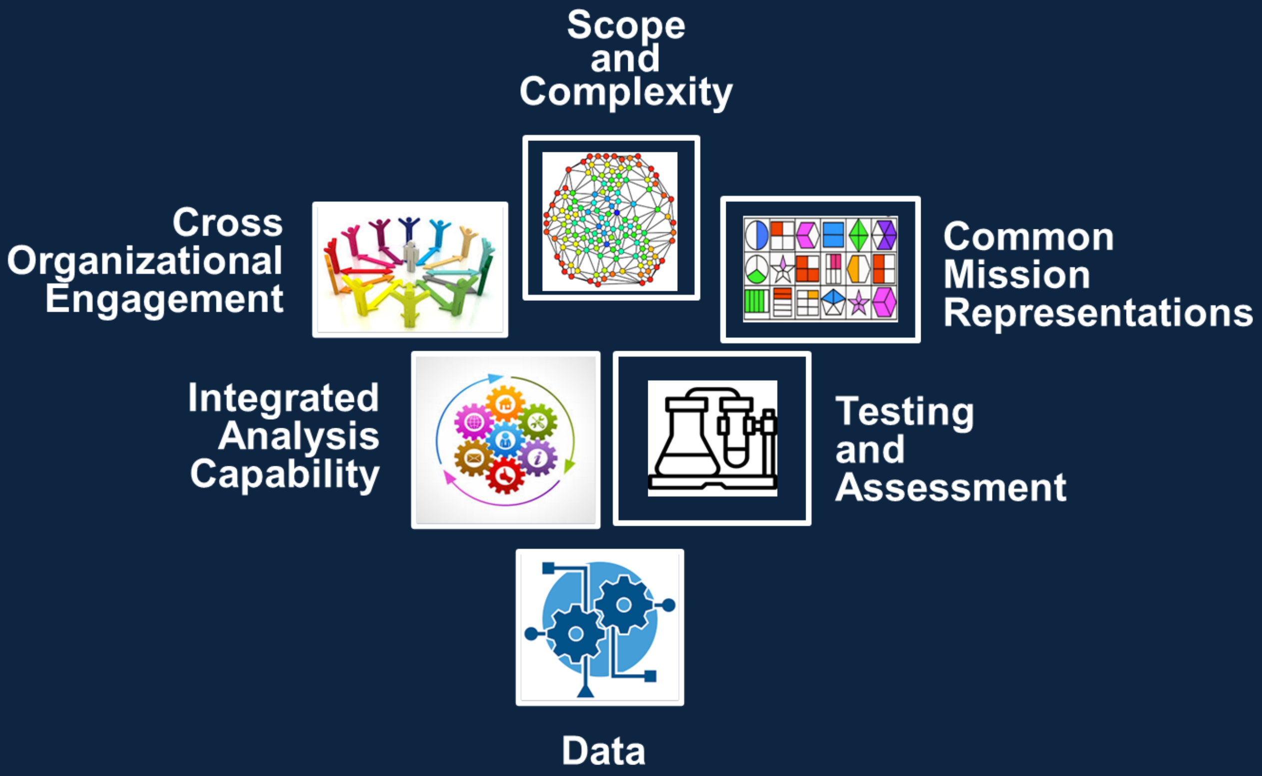
MITRE | SOLVING PROBLEMS FOR A SAFER WORLD®

Introduction

- MITRE sponsors are pursuing Mission Engineering (ME) as a means to address their rapidly evolving challenges
  - Digital engineering is used to enable these efforts
- Short cycle times preclude repeated development of models from scratch
- The Shared Modeling Framework was developed to mitigate this issue
  - Based on experimentation to determine the appropriate approach to reuse over multiple, real-world Mission Engineering efforts
- In the following slides, we'll discuss the history of the Shared Modeling Framework, the approach, its benefits, how we updated it using an open standards approach, and its future

Background

Challenge: *Systems engineering (SE) is evolving to address more complex systems, including SoS*



How can we address this challenge?

Mission Engineering (ME)

The deliberate organization and integration of a system of systems (SoS) to achieve a particular goal or mission

using

Digital Engineering (DE)

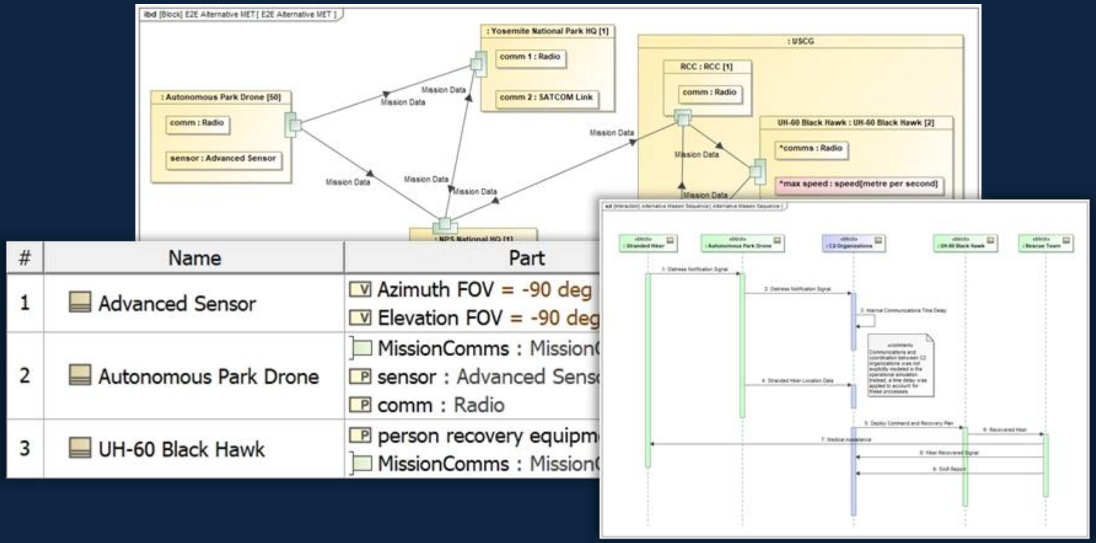
Leverages a digital thread to manage the propagation of changes across the various models of a system and maintain consistency

Approach

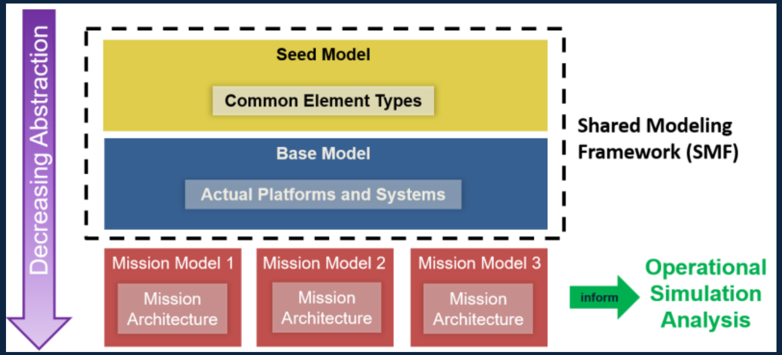
Needed to identify a set of stable architectural components that entail a reasonable level of tailoring over multiple, related applications

To accomplish this we…

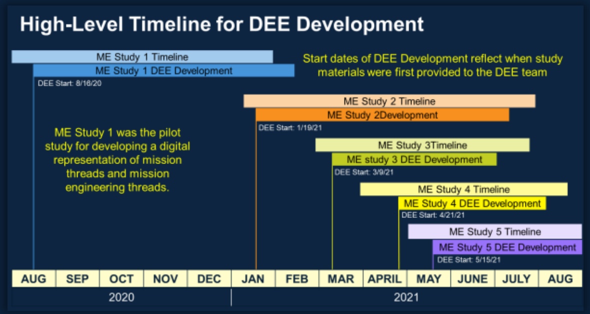
Developed a re-usable and flexible Shared Modeling Framework (SMF) that anticipated that architectural components would evolve over time

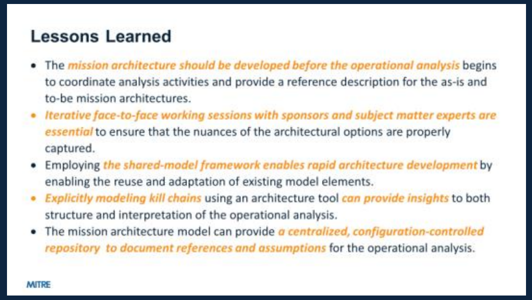


Populated the SMF over multiple ME studies



Tracked lessons learned and impacts on study execution





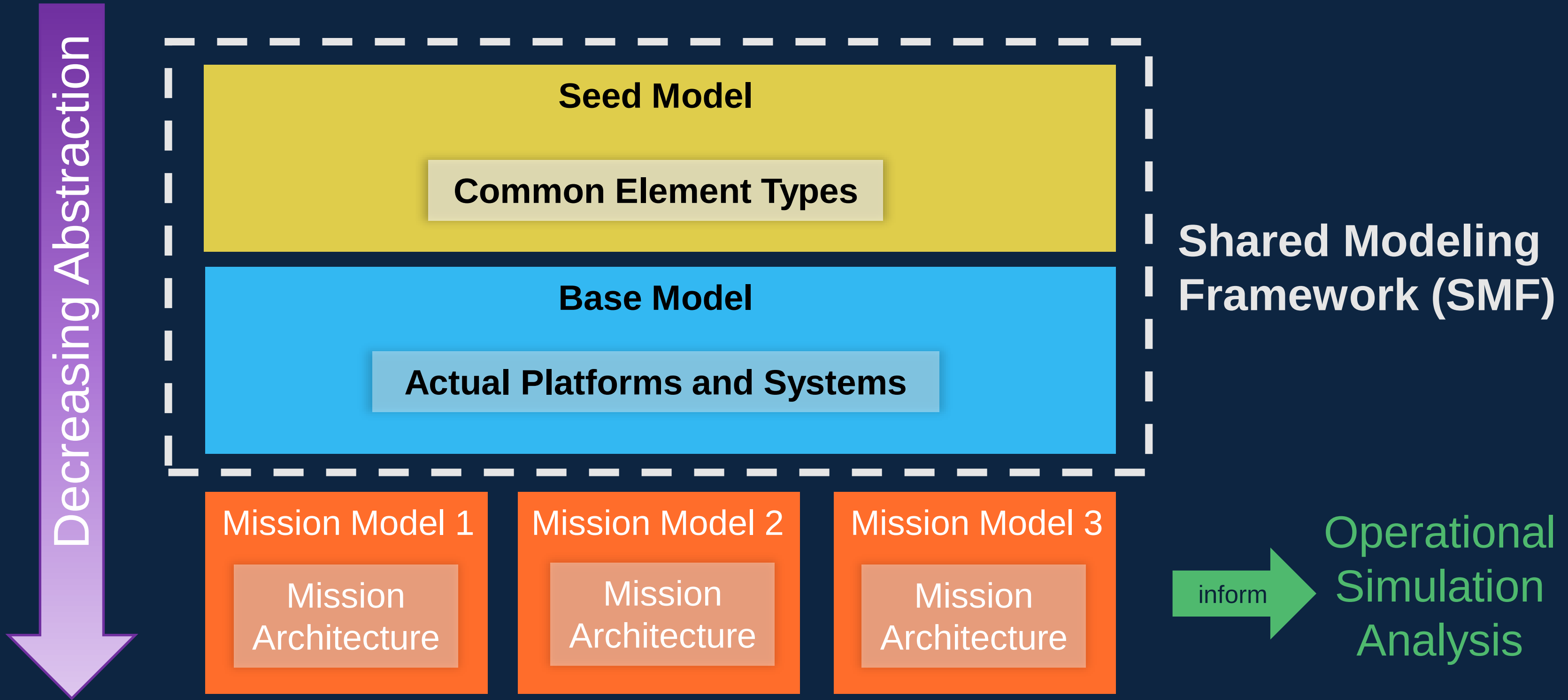
Lessons Learned

- The *mission architecture should be developed before the operational analysis* begins to coordinate analysis activities and provide a reference description for the as-is and to-be mission architectures.
- *Iterative face-to-face working sessions with sponsors and subject matter experts are essential* to ensure that the nuances of the architectural options are properly captured.
- Employing *the shared-model framework enables rapid architecture development* by enabling the reuse and adaptation of existing model elements.
- *Explicitly modeling kill chains* using an architecture tool *can provide insights* to both structure and interpretation of the operational analysis.
- The mission architecture model can provide *a centralized, configuration-controlled repository to document references and assumptions* for the operational analysis.

MITRE

Shared Modeling Framework

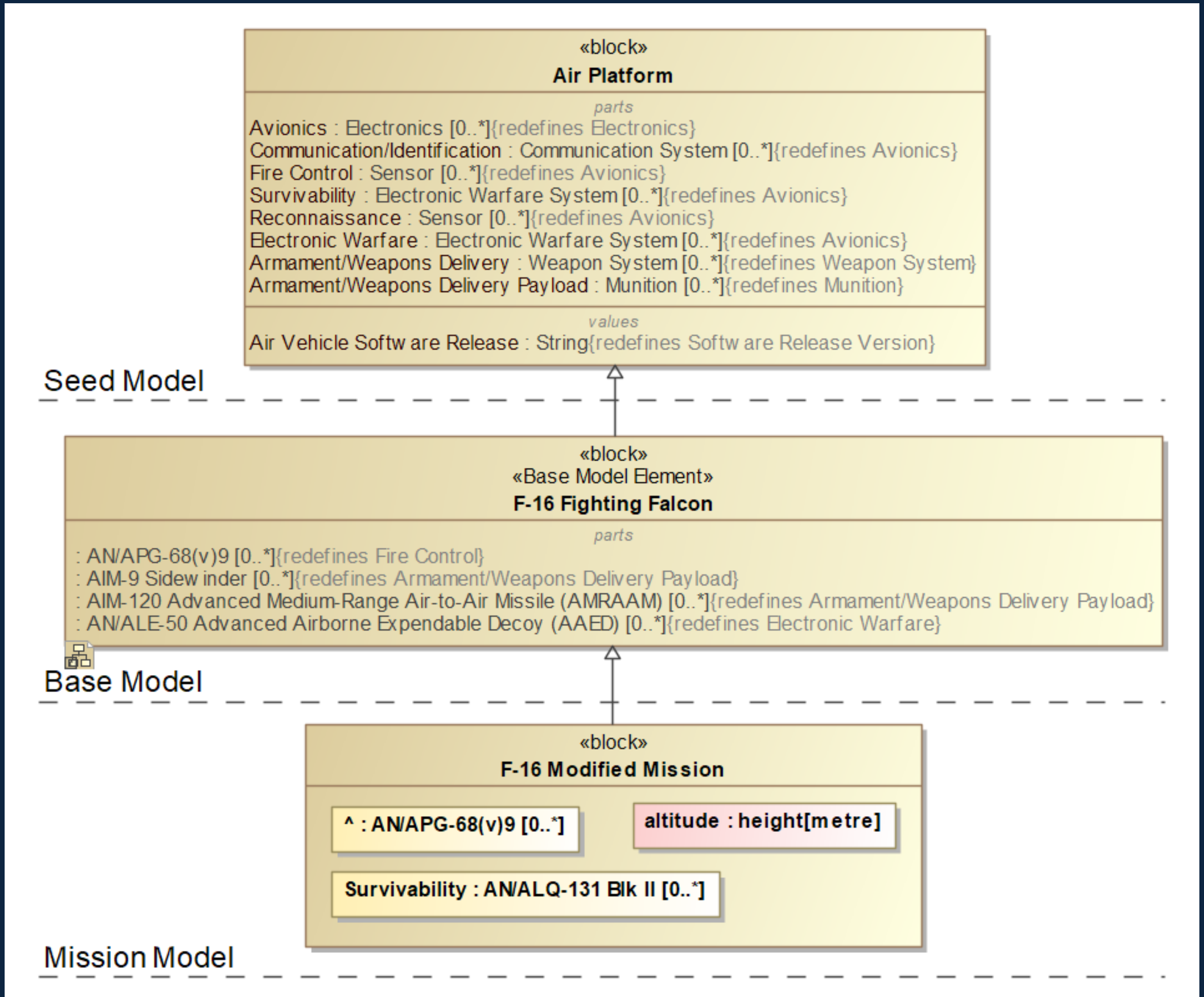
- The Shared Modeling Framework (SMF) is a set of SysML models developed in a Model-Based Systems Engineering (MBSE) tool for use in Mission Engineering Studies
- Common Element Types (e.g. Air Platform, Radio, etc.) are defined in the Seed Model
- Reusable model elements are maintained in the Base Model as building blocks for use in various Mission Models
- Mission models use the Base Model and other data to address different ME studies
- The mission models inform the operational simulation analysis



- The digital nature of MBSE tools like Magic Systems of Systems Architect / Cameo / MagicDraw is key to enabling reuse in the Shared Modeling Framework
- Objects (i.e., “Blocks” in SysML) and inheritance relationships are leveraged to reuse elements from the Seed and Base Models
- The same Block can be instantiated in various mission architectures across different mission scenarios

MITRE

Reuse Systems from the Shared Modeling Framework



Seed Model – Element Classifier

- Contains generic properties for a class of systems and serves as “blueprints.”

Base Model – Baseline System Definition

- Specifies properties inherited from the Seed Model classifier for specific systems.
- Properties are independent of scenario context.

Mission Model – Mission System Definition

- Redefines properties inherited from the Base Model system to reflect changes for the scenario context.
- Adds new properties as needed for the scenario context.

MITRE

Benefits: Enabling Structure and Flexibility

Standard Containment Window Structure

Layered Architecture gives modelers flexibility

New system addition is not prohibitive

Built in SysML to also allow definition in other frameworks

Use across MITRE sponsors and projects

Network of Users

MITRE

Current Update

- **Reusability is key to direction and speed**
- **Sponsor list using DE for Mission Engineering is growing rapidly**
- **In order to share the SMF more openly, an effort was undertaken to redefine the Seed and Base models using open unclassified standards**
- **To expand the Seed and Base models:**
  1. **Remove AFSIM/CUI dependence via clean slate**
  2. **Leverage Open Standards**
  3. **Use similar MITRE ME model structure to what works for our use cases**

Open Standards can provide:

- Enumerations/ Lists of Systems
- What is in a System
- How a System can be categorized

However, Standards are not always 1-to-1 and require tailoring to fit our purposes

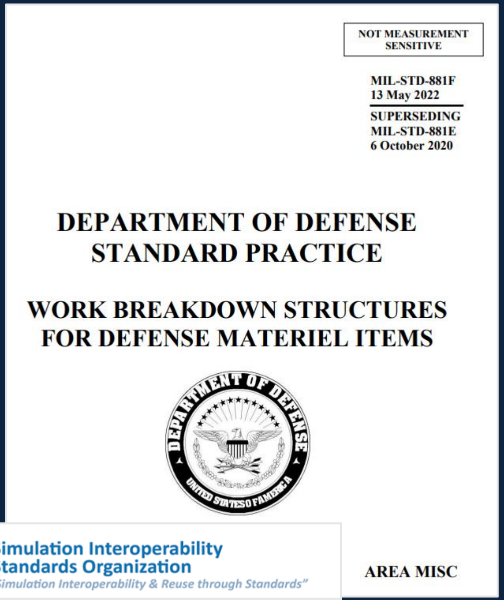
MITRE

Leveraging Open Standards

- In the Seed Model, system types were based on standards like:

- **MIL-STD-881** – framework for DoD Program Managers to define their program's Work Breakdown Structure (WBS)
  - Refined system parts for MITRE ME studies

- **SISO-REF-010** – enumerates systems for Distributed Interactive Simulation (DIS)
  - Utilized many elements in Base Model and included some system types in Seed Model


NOT MEASUREMENT SENSITIVE

MIL-STD-881F
13 May 2022
SUPERSEDING
MIL-STD-881E
6 October 2020

DEPARTMENT OF DEFENSE
STANDARD PRACTICE

WORK BREAKDOWN STRUCTURES
FOR DEFENSE MATERIEL ITEMS

AREA MISC


SISO Simulation Interoperability Standards Organization
"Simulation Interoperability & Reuse through Standards"

SISO-REF-010-2024

Reference for
Enumerations for Simulation
Interoperability

Version 33

29 May 2024

SAC Approved: 07/10/2024 EXCOM Approved: 07/11/2024

Prepared by:
Standards Activity Committee Special Working Group
Reference for Enumerations for Simulation
(SAC SWG Enumerations)

MITRE

Leveraging Open Standards, cont.

Additional standards used for system definition include:

- **MIL-STD-196** – Joint Electronics Type Designation Automated System (JETDAS): nomenclature for electronic and associated equipment
- **DAFI 16-401** – Designating and Naming Defense Military Aerospace Vehicles
- **SECNAVIST 5030.8** – General Guidance for the Classification of Naval Vessels and Battle Force Ship Counting Procedures: how the US Navy designates its ships

MIL-STD-196G

Table I Table of equipment indicators

AN / ARC - 7 3

Installation (1st Letter)	Type of Equipment (2nd Letter)	Purpose (3rd Letter)	Misc. Identification
A. Piloted Aircraft	A. Invisible Light, Heat Radiation	Auxiliary Assembly	Single * are for NSA use only
B. Underwater Mobile, Submarine	B. Comsec*	Bombing	X,Y,Z Changes in voltage, Phase, or Frequency
C. Cryptographic*	C. Carrier- Electronic Wave/Signal	Communications Receiving/Transmitting)	T. Training
D. Pilotless Carrier	D. Radiac	Direction Finder, Reconnaissance and urveillance	(C) NSA use only
F. Fixed Ground	E. Laser	Ejection and/or Release	(P) Units accept plug-ins
G. General Ground Use	F. Fiber Optics	Fire Control or Search Light Directing	(V) Variable Items
K. Amphibious	G. Telegraph/Teletype	Recording/Reproducing	(-FT,-IN) Identical items with varying lengths
M. Mobile (ground)	I. Interphone and Public Access	Computing	( ) Developmental/Experimental
P. Portable	J. Electromechanical or Inertial Wire Covered	Maintenance/ Test ssemblies	Automatic Data Processing (ADP)
S. Water	K. Telemetering	Navigational Aids	1. Digital Equipment Only
T. Transportable (ground)	L. Countermeasures	Special or Combination	2. Analog Equipment Only
U. General Utility (Multiple)	M. Meteorological	Receiving/Passive Detecting	3. Hybrid (1&2 Combined)
V. Vehicular (ground)	N. Sound in Air	Detecting/Range and bearing, Search	4. Input/output Device
W. Water Surface and	P. Radar	Transmitting	5. Magnetic Media
Underwater Combined	Q. Sonar/underwater sound	Automatic Flight or Remote Control	6. Others
Z. Piloted-Pilotless Airborne	R. Radio	Identification and Recognition	Indicator Letter Previously
Vehicles Combined	S. Special or Combination	Surveillance (search, detect, and	Removed From This Table
	T. Telephone (wire)	ultiple target tracking) and control	Installation: C-Air Transportable
	V. Visual/Visible Light	oth fire and air control)	Type: B-Pigeon, E-Nupac,
	W. Armament (peculiar to armament not otherwise covered)	Secure*	F-Photographic Purpose: L-Searchlight Control, P- Reproducing
	X. Facsimile to Television		
	Y. Data Processing or Computer		
	Z. Communications*		

DAF Instruction 16-401 / Army Reg 70-50 / NAVAIRINST 13100.16

Table A2.1. MDS Designator Positions for Standard Aircraft.

Position:	1	2	3	-	4	5	6	7
Symbol:	Status Prefix (Optional)	Modified Mission (Optional)	Basic Mission (Required)	-	Design Number (Required) (Hundreds)	Design Number (Required) (Tens)	Design Number (Required) (Ones)	Series (Required)

Table A2.2. Notional Examples of MDS Designators for Standard Aircraft.

Position:	1	2	3	-	4	5	6	7
F-16A	0	0	F	-	0	1	6	A
AT-38B	0	A	T	-	0	3	8	B
XWC - 130J	X	W	C	-	1	3	0	J
YF-22A	Y	0	F	-	0	2	2	A

MITRE

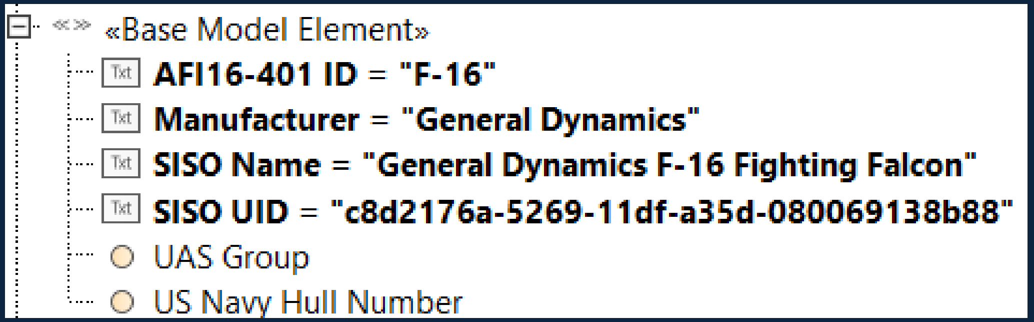
Updates to Shared Modeling Framework

- SISO-REF-010 allow us to bring in a large list (1000s+) of systems with additional information about them
  - Scoping and verification needed

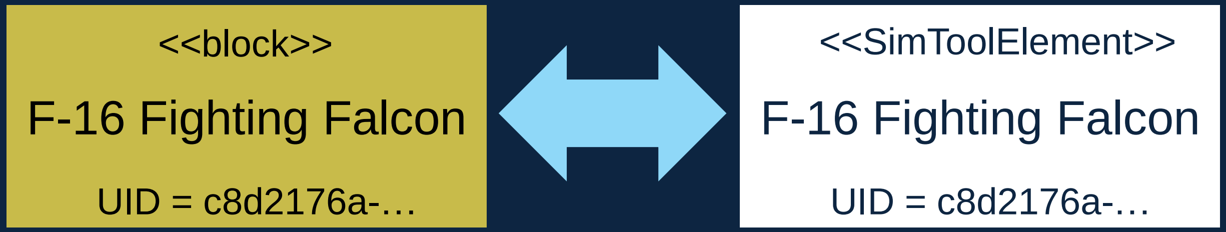
Reprinted with permission from SISO Inc.

25,000+ elements in SISO-REF-010

- Adding metadata fields to store tags for additional information – “Cameo Database”
  - Metadata comes from aforementioned standards

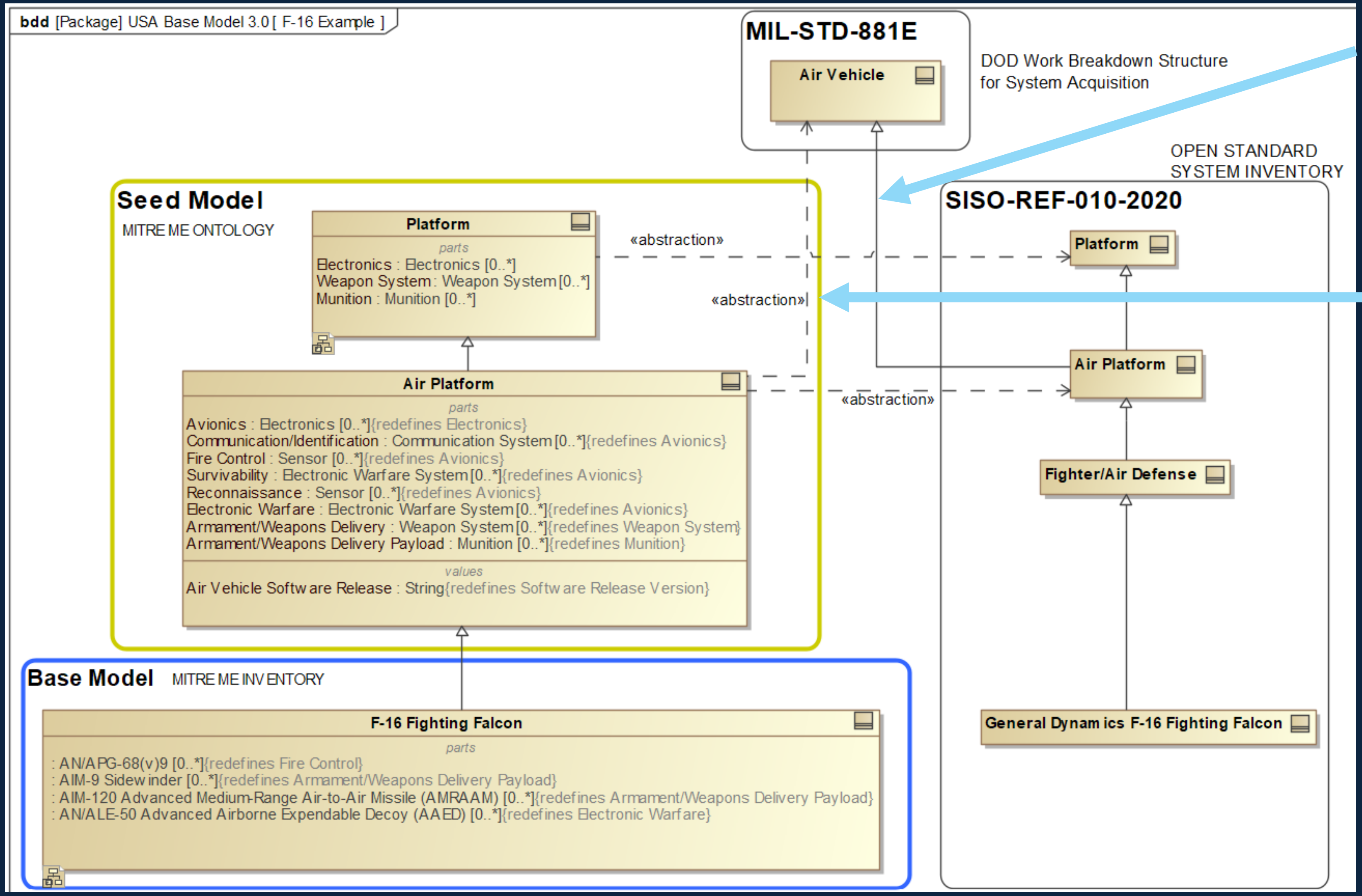


- Unique Identifiers (UIDs) should improve cross-tool coordination



MITRE

Example Metamodel and Relations



- <<generalization>> relationship used for inheritance between model elements
- <<abstraction>> relationship used to relate Seed Model elements to other Standards models
- Base Model elements related to SISO model elements via unique identifier
- Seed and Base Models can be used independently of other standards models

Redefinition of part properties allows for platform-specific Parts

MITRE

Status and Next Steps

- Shared Seed and Base Models amongst small group at MITRE to get in-depth technical feedback first
- Continued development to build out common elements, use cases, and metadata
- IP Disclosure and Public Release approved for sharing with Sponsors and external stakeholders
- Configuration Management will be handled on GitHub with User Guide and example model available to public
- GitHub will allow users to submit issues, enhancements, and questions, serving as central repository for managing feedback

Some Final Thoughts

- Model reuse is never perfect and tailoring is usually required.
  - The shared modeling framework reduces the amount of work required to construct a new architecture model. We are not anywhere near “plug and play.”
- A good architecture provides the blueprint for operational analysis
  - Precisely describes the starting conditions of the mission
  - Helps everyone understand what is in the operational analysis
- The framework and models can only get better with more use and feedback!!

MITRE

Thank you for listening!
Any questions?

Paul Trevidic – ptrevidic@mitre.org
Michael Pennock – mpennock@mitre.org