Lessons Learned While Applying Mission Engineering to the Military Acquisition Process

(using the Unified Architecture Framework)

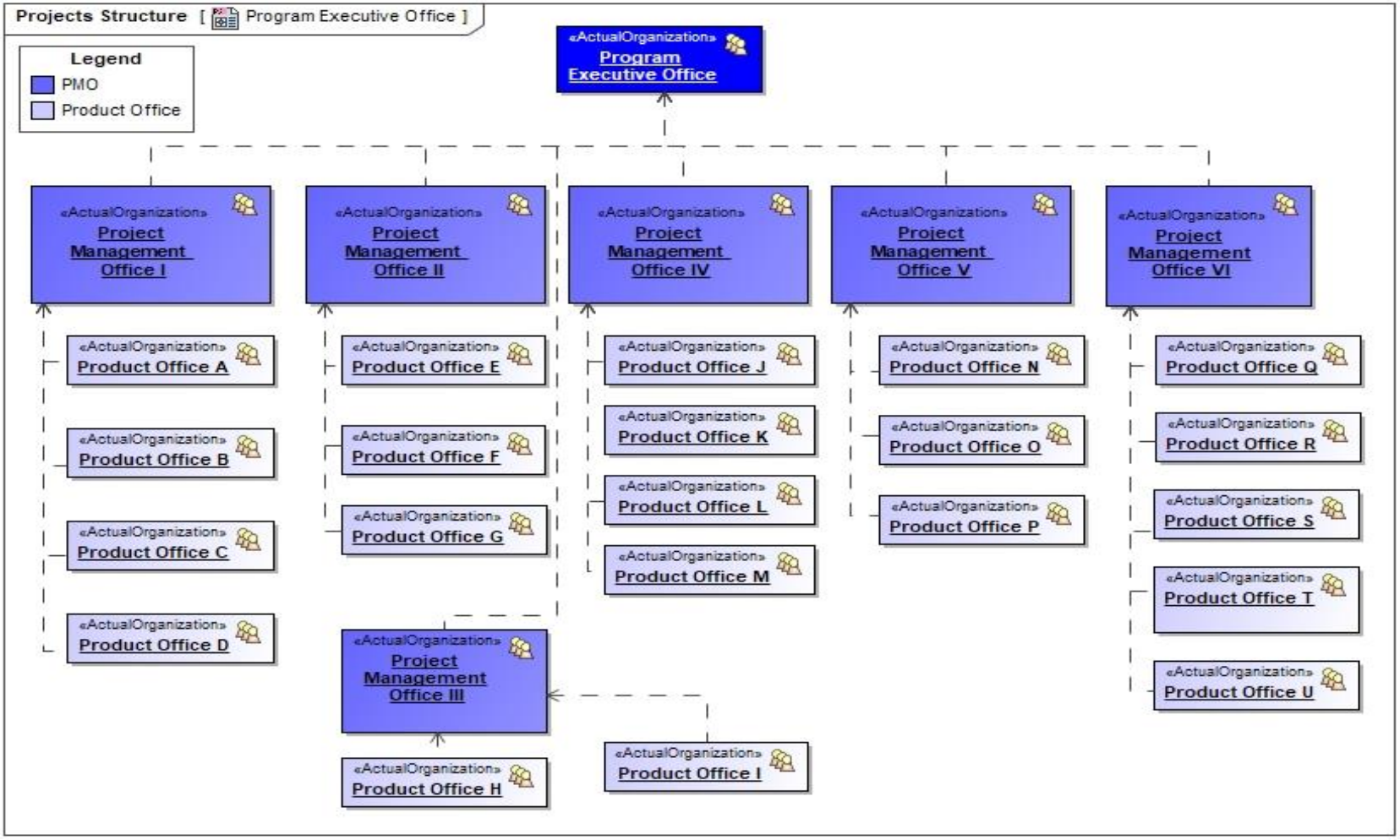
Background

- In the Joint Capabilities Integration and Development System (JCIDS) domain we rely on ISO/IEC/IEEE 15288, the JCIDS Manual and the Defense Acquisition Guidebook, which establish a common framework and a common process which defines acquisition requirements and evaluation criteria for future defense programs.

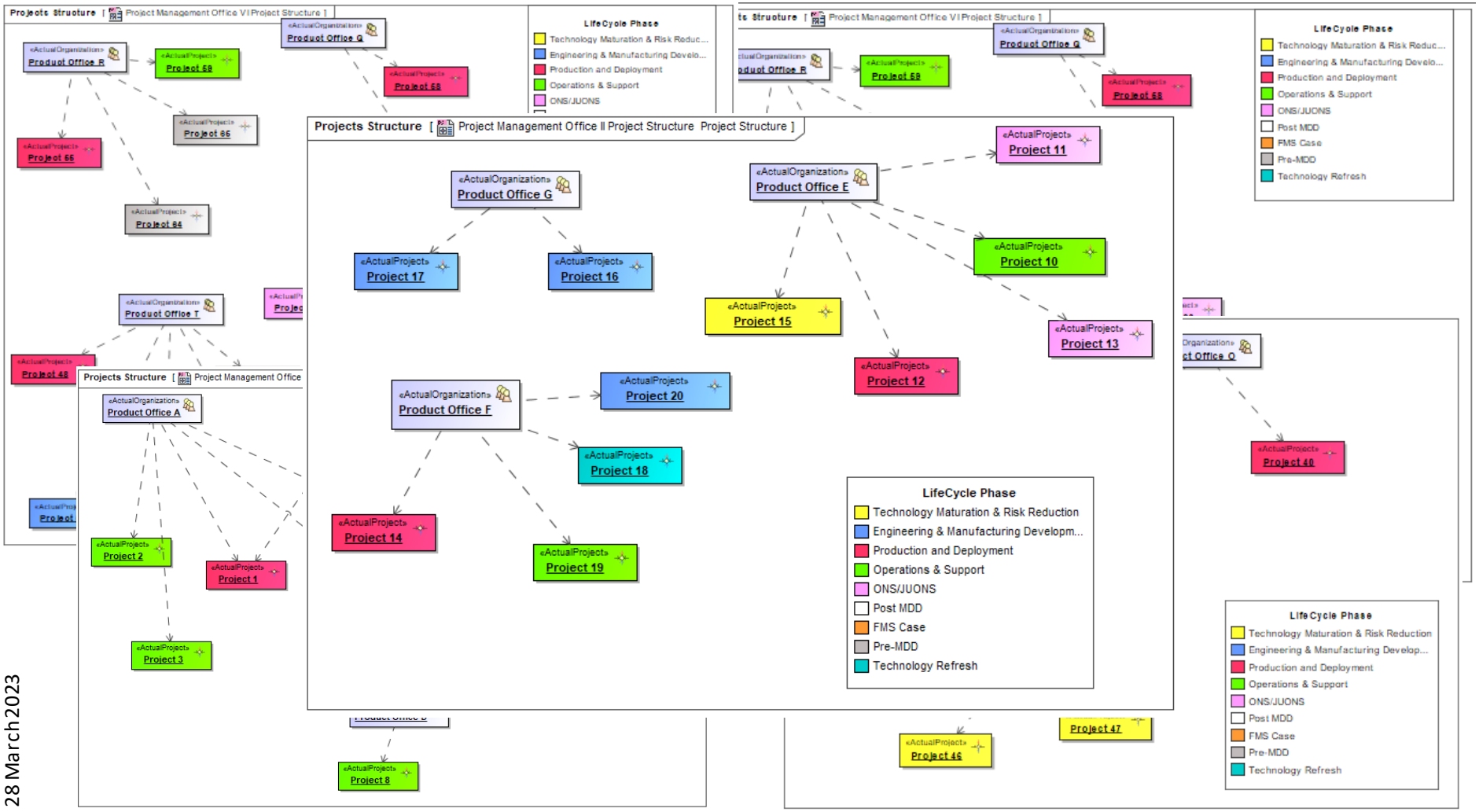
- Our challenge is to stake out a path to assist our Product Manager's (and DoD's) move toward the "Digital Enterprise."

- This presentation shares some of the lessons learned in the organization wide roll-out of MBSE across a Program Executive Office (PEO), describes some of the extensions to the UAFML standard that are necessary to support a PM in the pursuit of a successful program and shares a PMs perspective in the application of Mission Engineering to support his/her program.

Typical PEO Organization

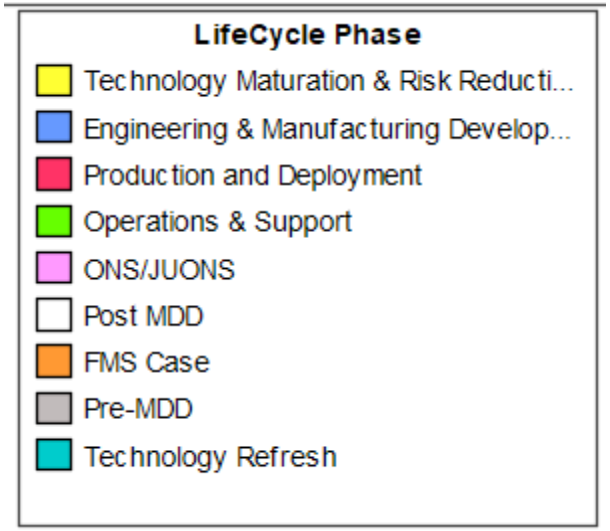


Multiple Product Offices and Projects



Systems by Lifecycle Phase

1	Project 47
2	Project 45
3	Project 15
4	Project 46
5	Project 29
6	Project 4
7	Project 17
8	Project 16
9	Project 20
10	Project 52
11	Project 57
12	Project 62
13	Project 14
14	Project 48
15	Project 49
16	Project 12
17	Project 40
18	Project 41
19	Project 55
20	Project 58
21	Project 38
22	Project 9
23	Project 61
24	Project 1
25	Project 32
26	Project 50
27	Project 51
28	Project 54
29	Project 60
30	Project 2
31	Project 10
32	Project 24
33	Project 3
34	Project 26
35	Project 42
36	Project 56
37	Project 8
38	Project 59
39	Project 43
40	Project 31
41	Project 37
42	Project 5
43	Project 6
44	Project 7
45	Project 19
46	Project 39
47	Project 36
48	Project 27
49	Project 63
50	Project 53
51	Project 11
52	Project 13
53	Project 25
54	Project 66
55	Project 35
56	Project 28
57	Project 33
58	Project 22
59	Project 65
60	Project 64
61	Project 30
62	Project 34
63	Project 21
64	Project 18
65	Project 67
66	Project 23



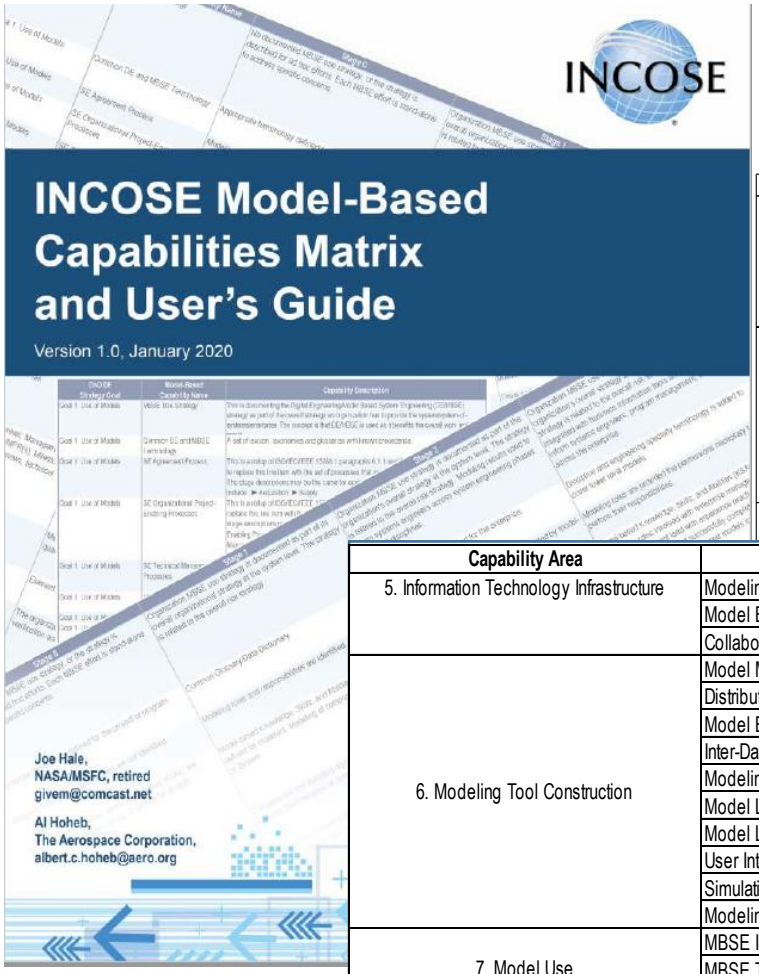
MBSE is a challenge to roll out to the entire enterprise – a phased approach is needed.

Contracts and resources keep us from moving faster

Lesson Learned

Product Offices Cannot Unilaterally Achieve MBCM Stage 3/4

MONTE PORTER ASSOCIATES LLC

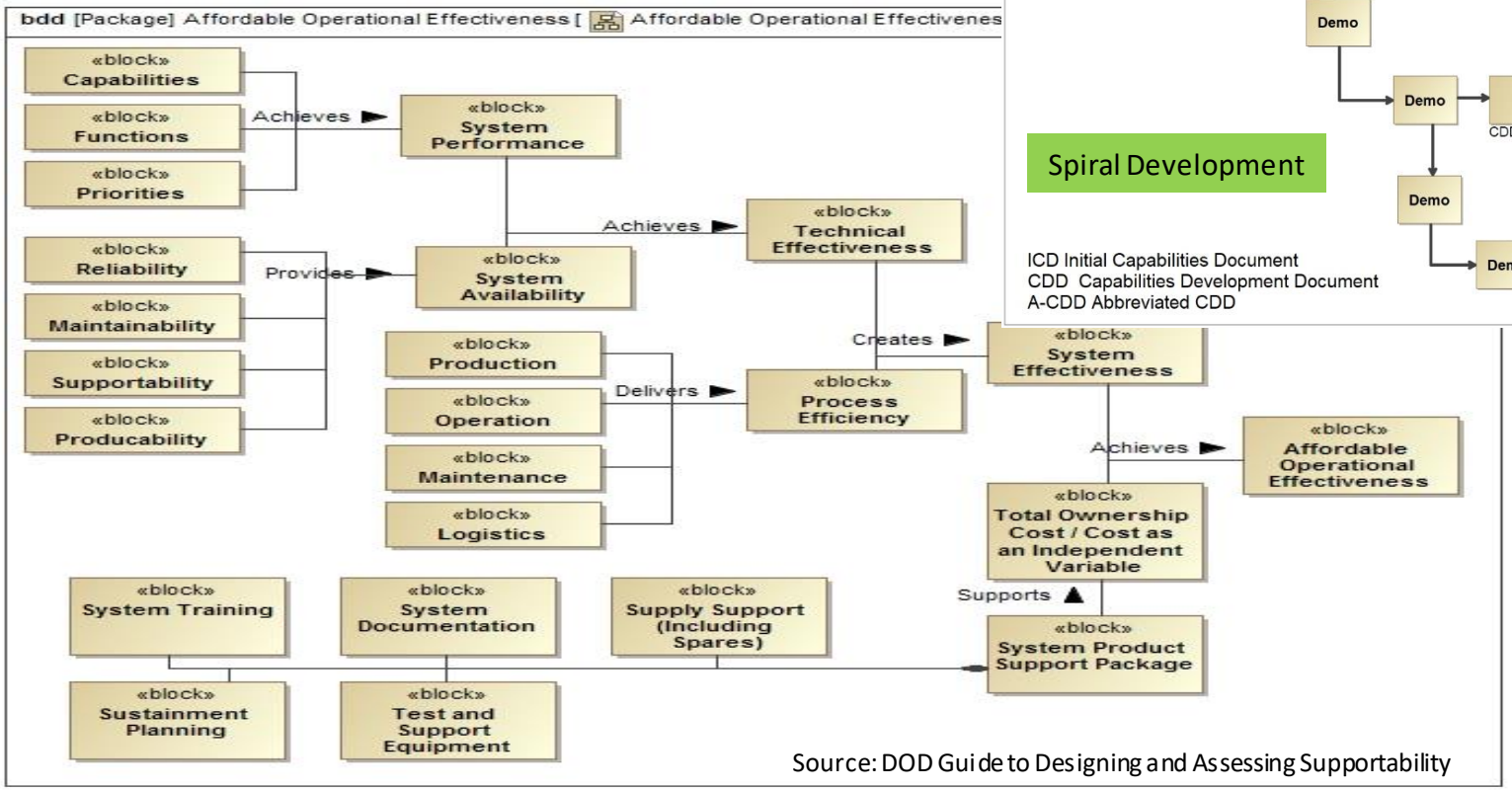


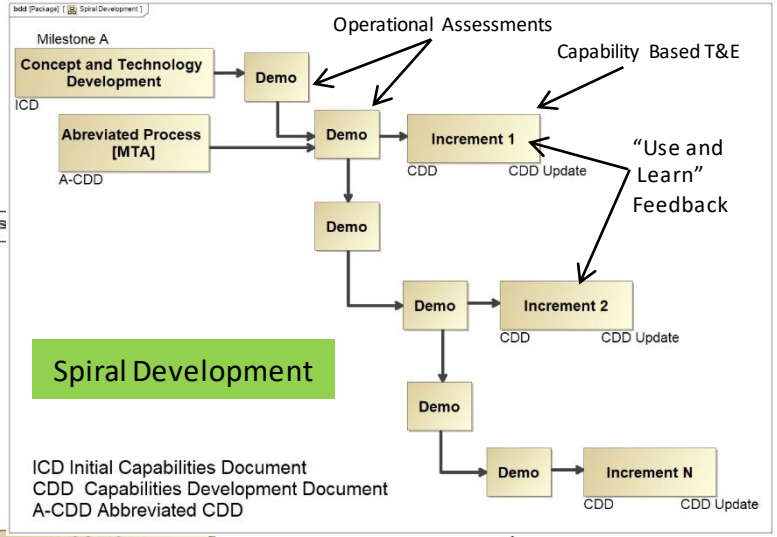
Product Office Domain
PMO Domain
PEO /and higher Domain

Capability Area	Capability Name	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
1. Workforce/ culture	MBSE Use Strategy					
	Common DE and MBSE Terminology					
	Modeling Roles and Responsibilities					
	Modeling Development Skills					
	Modeling Use skills					
	Modeling-related Training/KSA development					
2. SE Processes/ Methodology	SE Agreement Process					
	SE Organizational Project-Enabling Processes					
	SE Technical Management Processes					
	Model Configuration Management					
	Model Data Management					
	SE Technical Processes					
	Modeling Stakeholder Requirements					
	Model-Based Verification and Validation					
	SE-driven Model Plan					
3. Program/ Project Processes Methodology	Model Based Reviews: Management Program Reviews (MPR(s)					
5. Information Technology Infrastructure	Modeling Tool Access					
	Model Based Tool Licensing & Access					
	Collaboration capabilities					
6. Modeling Tool Construction	Model Management					
	Distributed Database/Tool interoperability					
	Model Based Data/Tool Independences					
	Inter-Database/Tool Data Item Associations					
	Modeling Methods					
	Model Languages					
	Model Libraries					
	User Interface (UI), Viewpoint/Views, and visualization					
	Simulation Capability					
	Modeling Process Quality					
7. Model Use	MBSE Institutional Adoption (e.g., agency, service, center, business					
	MBSE Technical Innovation Process					
	Enabling Technologies					
8. Modeling Policy	Intellectual Property (IP)					
	Tool Governance					

Product Manager Challenges

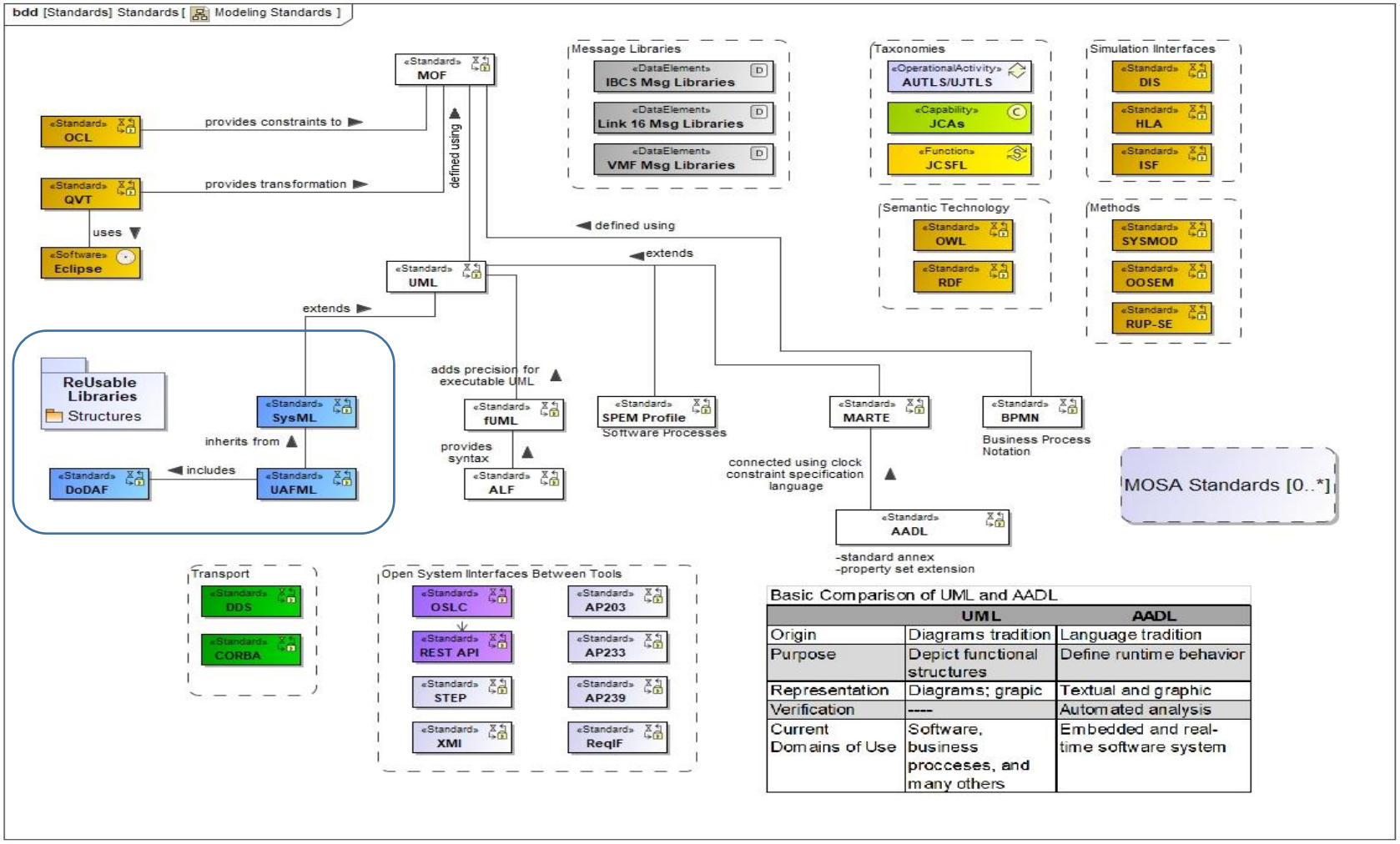
Total Life Cycle System Management





Source: DOD Guide to Designing and Assessing Supportability

Center of Gravity



Basic Comparison of UML and AADL

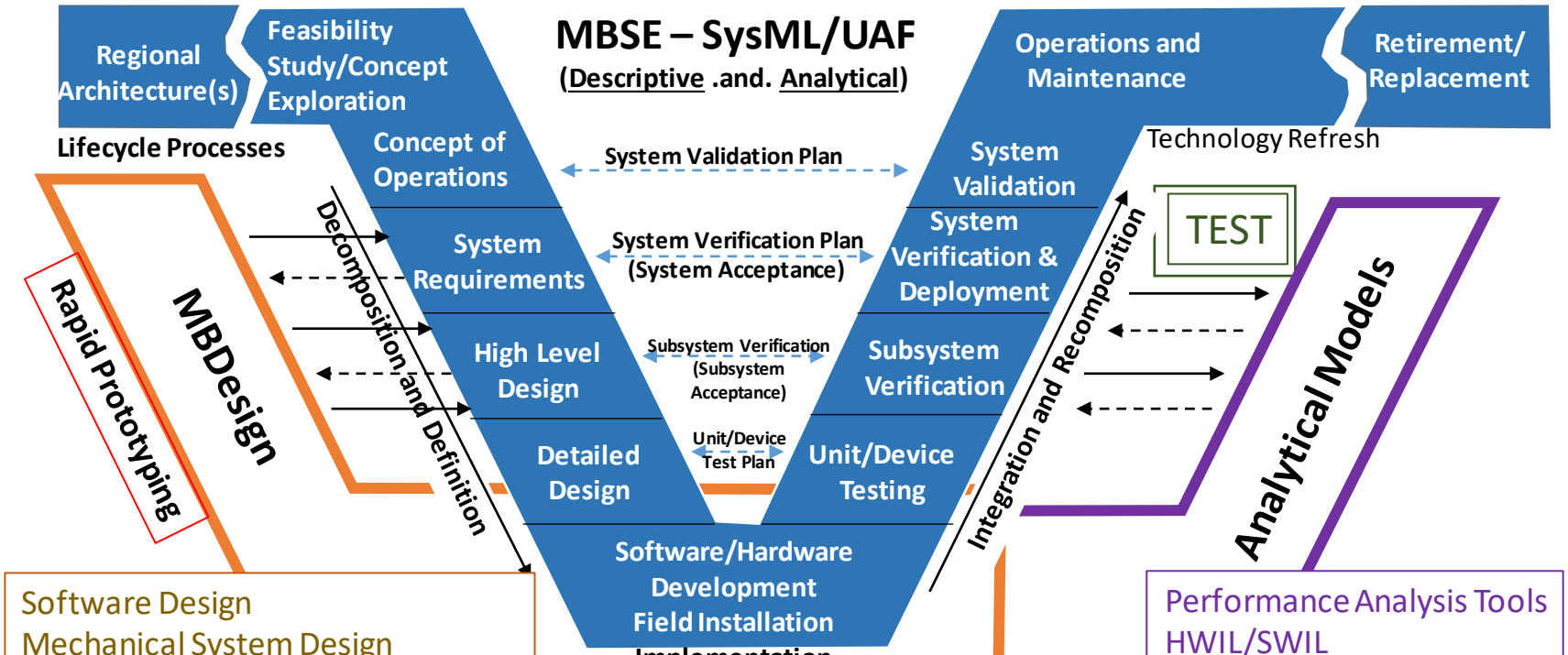
	UML	AADL
Origin	Diagrams tradition	Language tradition
Purpose	Depict functional structures	Define runtime behavior
Representation	Diagrams; grapic	Textual and graphic
Verification	----	Automated analysis
Current Domains of Use	Software, business procceses, and many others	Embedded and real-time software system

28 March2023

The "Model-Based" Acquisition Toolbox

Force-on-Force Simulations/
Few-on-Few Experiments (L/V)

MBSE Models should be informed by and inform other tools

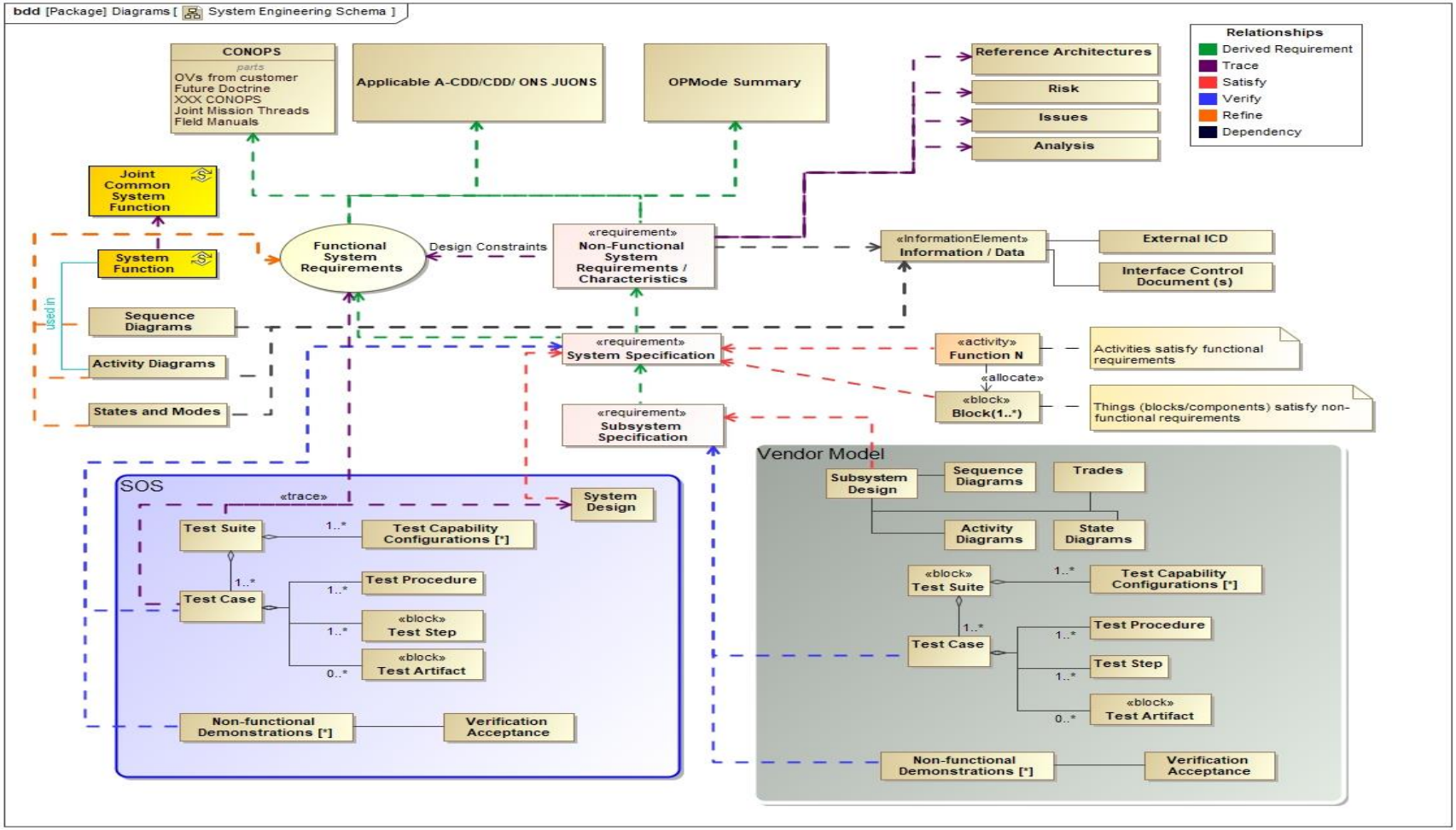


Software Design
Mechanical System Design
Electrical System Design
Electro-mechanical System Design
CAD/CAM

Performance Analysis Tools
HWIL/SWIL
Integration
Sim/Stim
Data Collection/Reduction

28 March 2023

Simplified System Engineering Schema for JCIDS



*

*Process, State and Interaction diagrams can be of type Operational, Services, Resources or Project

Requirements from the CDD

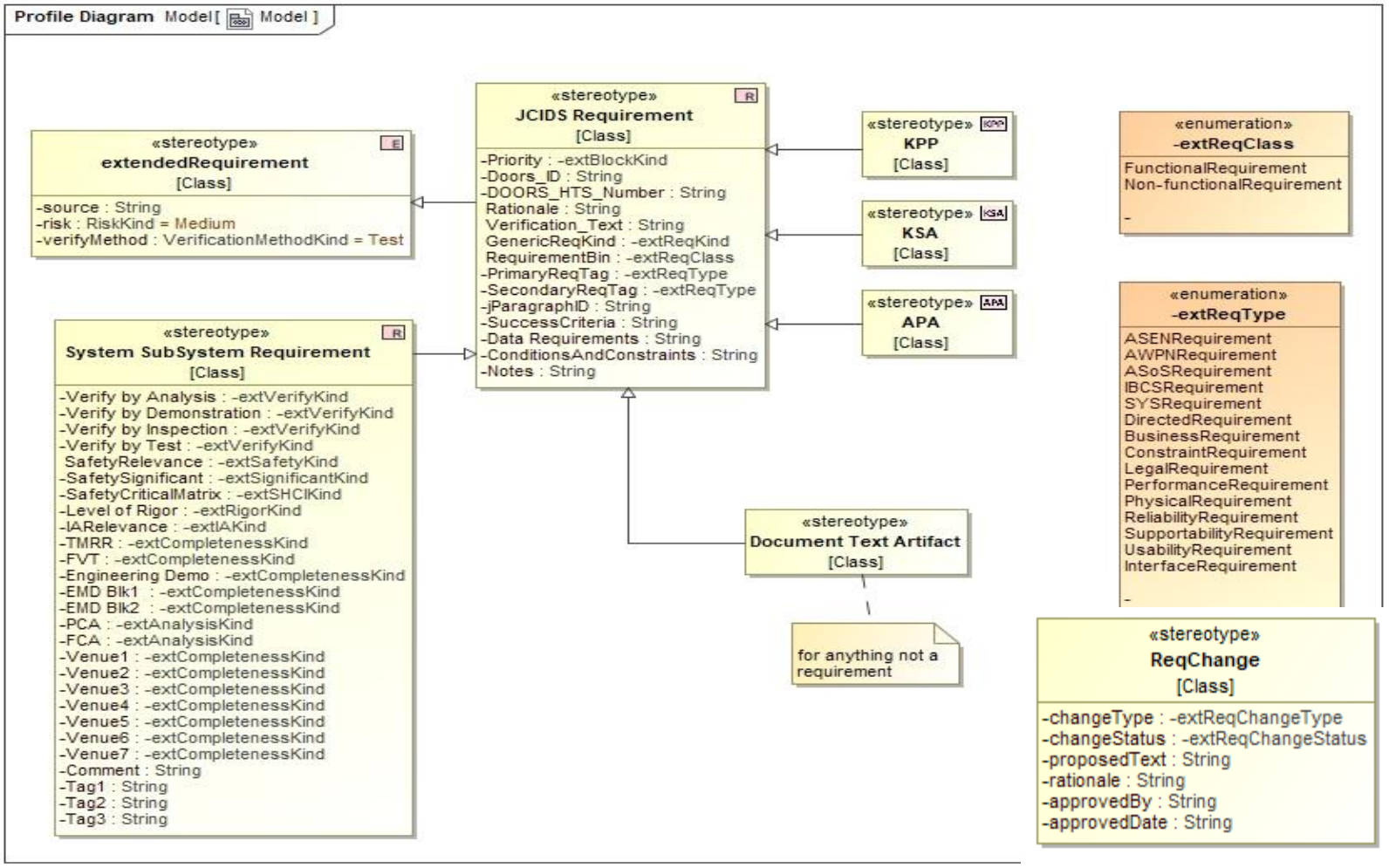
KPP Performance attributes of a system considered critical or essential to the development of an effective military capability. Failure of a system to meet a validated KPP threshold value triggers a review by the validation authority and evaluation of operational risk and/or military utility of the associated system(s).

KSA Performance attributes of a system considered important to achieving a balanced solution/approach to a system, but not critical enough to be designated a KPP.

APA Performance attributes of a system not important enough to be considered KPPs or KSAs, but still appropriate including in the CDD.

Source: 2021 JCIDS Manual

Requirement Meta-data



print any spec and any document directly from the model
And print the verification matrix at the same time

Number (almost) Everything

bdd [Model] Model [Model]

Activities (verb-noun)

- A1.1 Execute Operational Activity A
- A1.2 Execute Operational Activity B
- A1.3 Execute Operational Activity C
- A1.4 Execute Operational Activity E
- A1.5 Execute Operational Activity F

- S3.1 Do System Function S
- S3.2 Do System Function T
- S3.3 Do System Function U
- S3.4 Do System Function V
- S3.5 Do System Function W

- «activity» SS3.2.5.6.1 Perform Activity 1
- «activity» SS3.2.5.6.2 Perform Activity 2
- «activity» SS3.2.5.6.3 Perform Activity 3
- «activity» SS3.2.5.6.4 Perform Activity 4
- «activity» SS3.2.5.6.5 Perform Activity 5

Assign identifier to diagrams for easy retrieval

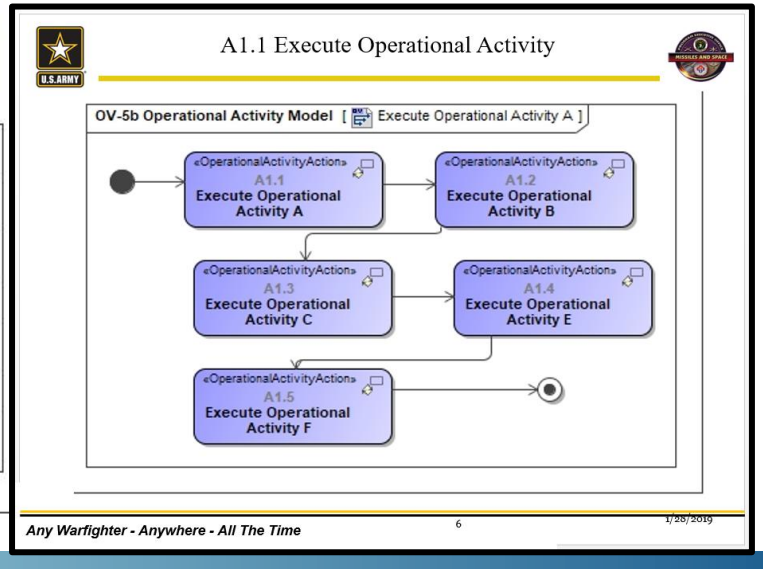
Sort by name or identifier

Transfer Activity IDs to activity type diagrams using a macro

«block» 1.4.5.1 Block 1
«block» 1.4.5.2 Block 2
«block» 1.4.5.3 Block 3
«block» 1.4.5.4 Block 4
«block» 1.4.5.5 Block 5
«block» 1.4.5.6 Block 6

WBS

#	Identifier	Name
1	1.4.5.1	Block 1
2	1.4.5.2	Block 2
3	1.4.5.3	Block 3
4	1.4.5.4	Block 4
5	1.4.5.5	Block 5
6	1.4.5.6	Block 6



Printing in Word and PowerPoint

#	Id	Doors_ ID	Name	Text	Primary Req Tag	Requirement Bin	Verify by Inspection	Verify by Analysis	Verify by Test	Safety Relevance
1	SS.1	KR_325	Buy Groceries	The system shall support acquisition of groceries		FunctionalRequirement			X	
2	SS.2	KR_23675	Kitchen Integration	The system shall integrate with all kitchen appliances and doodads	InterfaceRequirement	FunctionalRequirement			X	Critical
3	SS.3	KR_2343	Food Measurement	The system shall be able to measure exact amount of food preparation stuff	PerformanceRequirement	Non-functionalRequirement	X			
4	SS.4	KR_5093	Cooking Performanc	The system shall cook a full meal from start to finish within 20 minutes	PerformanceRequirement	FunctionalRequirement			X	
5	SS.5	KR_327	Table Places	Food prepared by the system shall fit on a standard plate and glass IAW MilStd 44499	UsabilityRequiremer					
6	SS.6	KR_326	Dining Efficiency	The system shall support both proper etiquette and woofing down methods of dining						

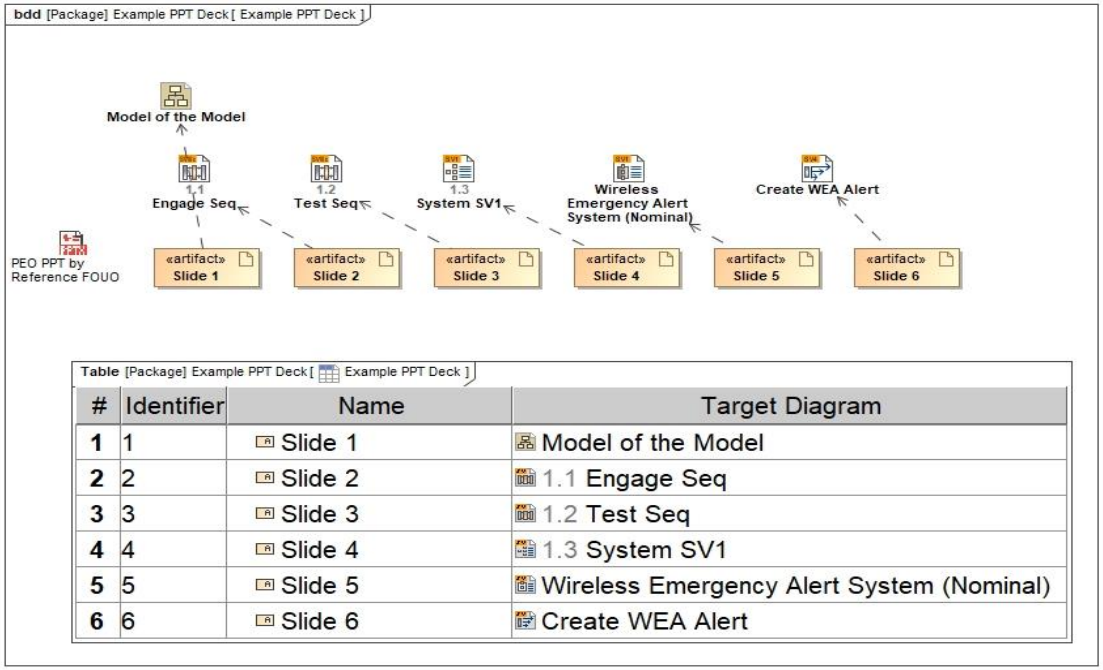
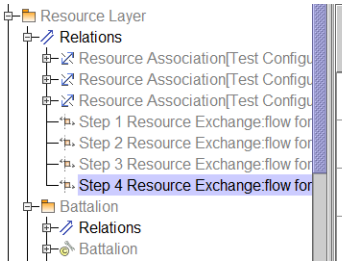


Table [Package] Example PPT Deck [Example PPT Deck]

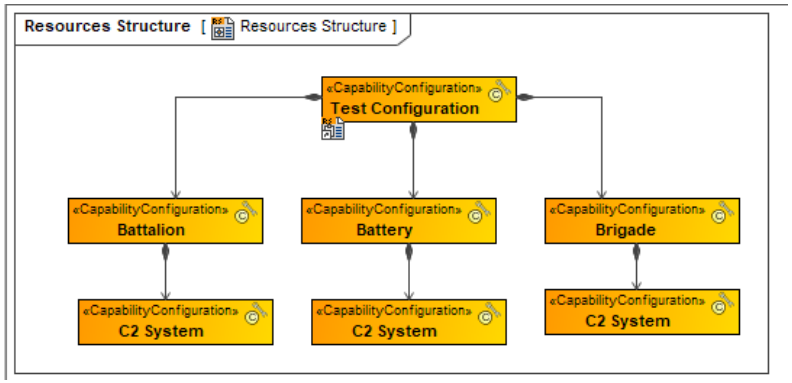
#	Identifier	Name	Target Diagram
1	1	Slide 1	Model of the Model
2	2	Slide 2	1.1 Engage Seq
3	3	Slide 3	1.2 Test Seq
4	4	Slide 4	1.3 System SV1
5	5	Slide 5	Wireless Emergency Alert System (Nominal)
6	6	Slide 6	Create WEA Alert

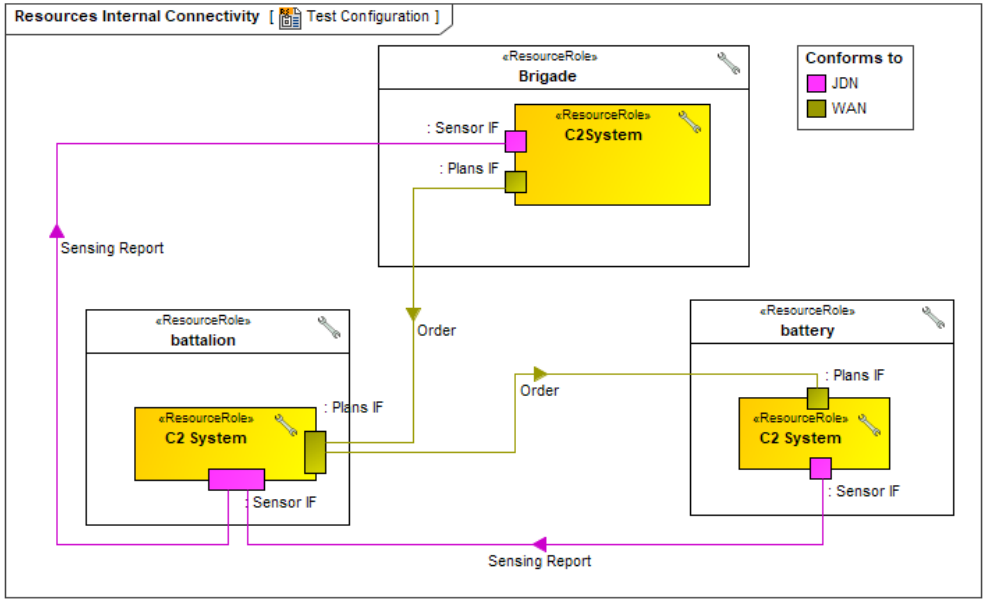
- Meaningful unique name for every requirement
- Avoid special characters e.g. ":" in the name
- Make sure you include meta-data
- Print the spec and the VCRM from the model (at the same time)
- Save the Velocity template with the model

A Small Quibble from My Testers



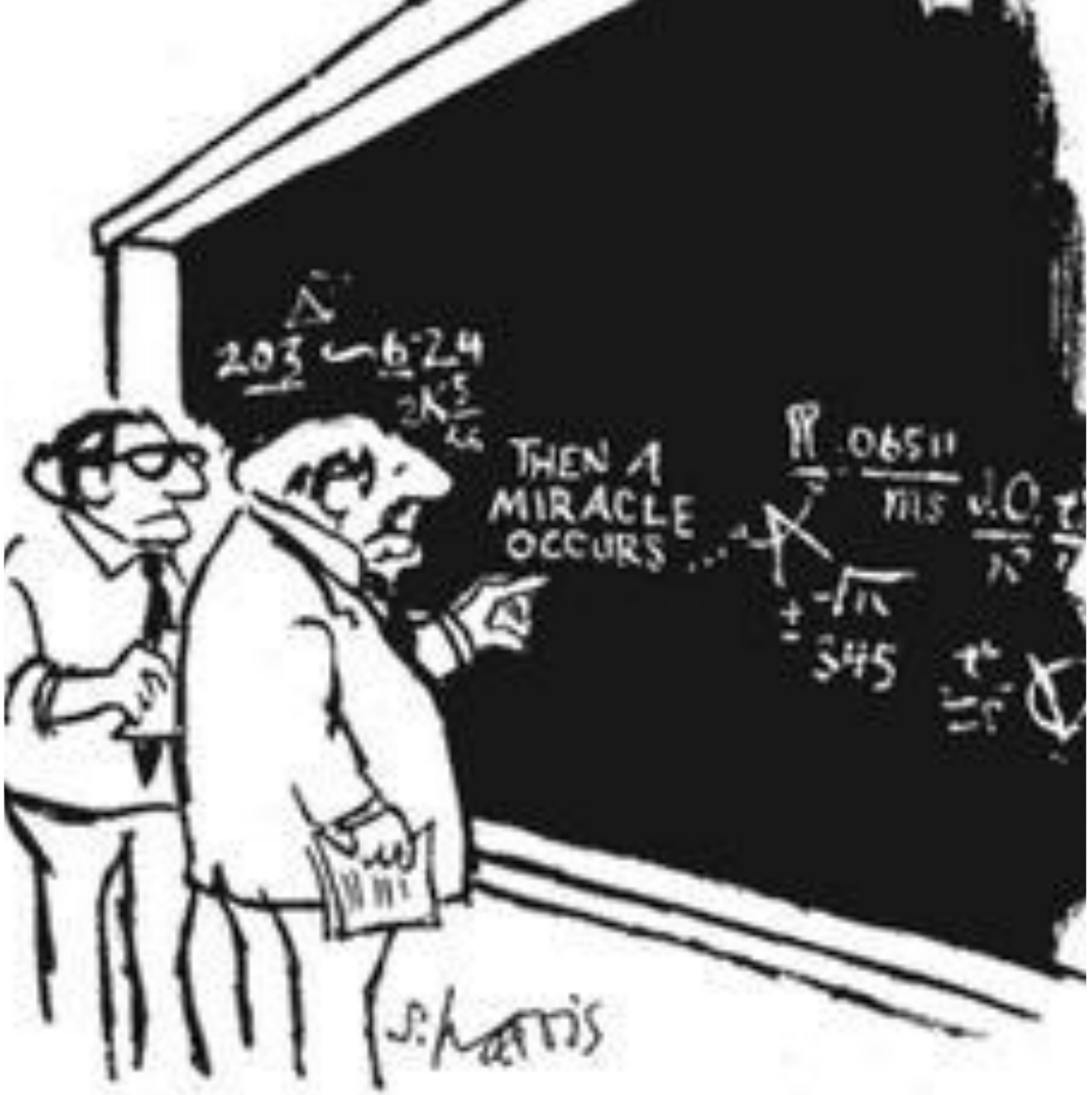
#	identifier	Activity	Producing Function	Resource Exchange Item	Info Format Type	COMMS / Waveform	C2 or SA	Sending Echelon	Sending CP Type	Sending Resource	Receiving Echelon	Receiving CP Type	Receiving Resource
1	Step 1	BDE publishes and disseminates OPORD	Publish Order	Order	: Plans : Plans	WAN	C2	Brigade	CP	C2 System	Battalion	CP	C2 System
2	Step 2	BN Forwards Order	Forward Order	Order	: Plans : Plans	WAN	C2	Battalion	CP	C2 System	Battery	CP	C2 System
3	Step 3	BTRY Sends Spot Report	Send Spot Rep	Sensing Report	: Sensings : Sensings	JDN	SA	Battery	CP	C2 System	Battalion	CP	C2 System
4	Step 4	BN Forwards Spot Report	Forward Spot R	Sensing Report	: Sensings : Sensings	JDN	SA	Battalion	CP	C2 System	Brigade	CP	C2 System





UAFML does a pretty good job of drilling down

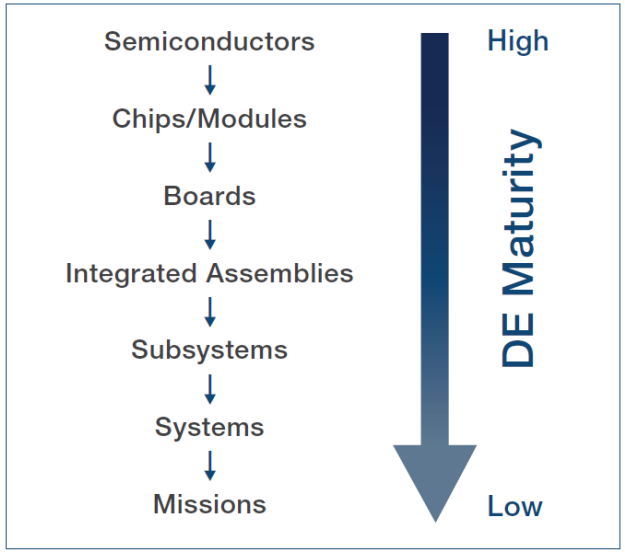
- Not so good referencing up from the resource exchange



"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

DE Challenge for DoD

Digital Engineering Maturity
(Electronic Systems Development)



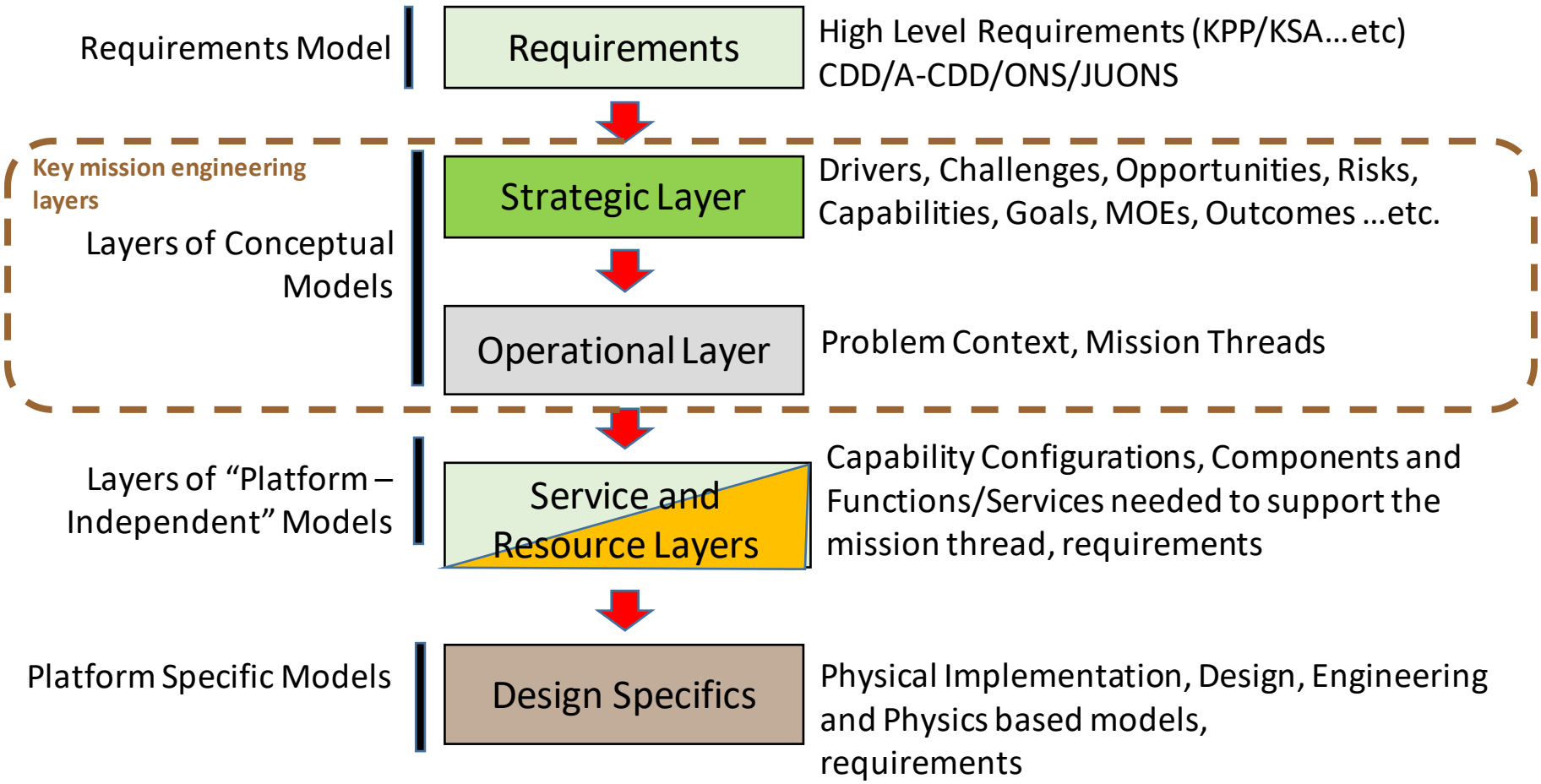
Above graphic suggests that the largest opportunity to mature the overall DE process is in the area of mission engineering

"The DE challenge for DoD is attaining knowledge-based integration of data sufficient to answer lifecycle questions, including:

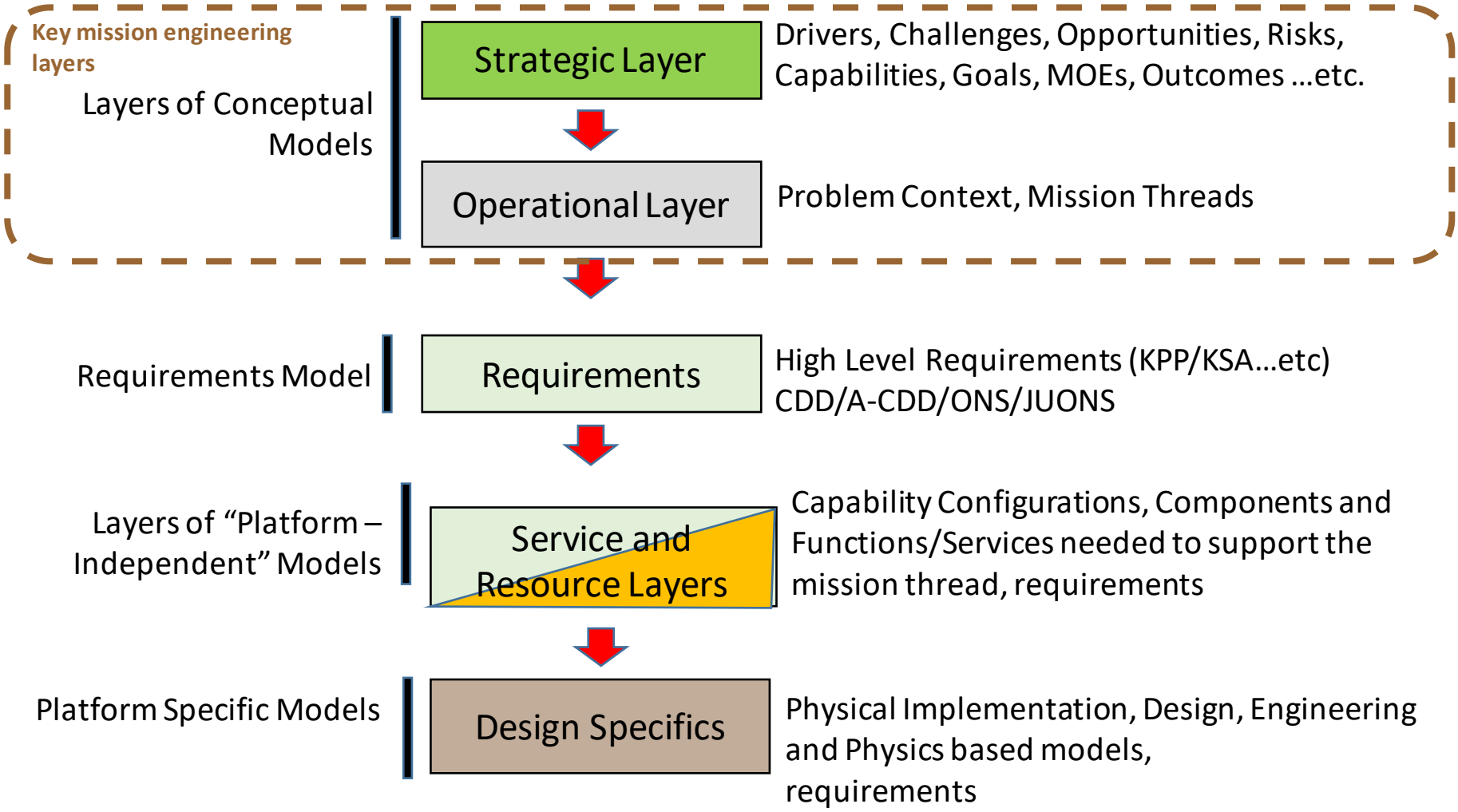
- How do the currently fielded systems or those under development support near-term missions?
- What is the performance and cost impact of replacing a subsystem in a legacy system?
- How do design decisions today impact system sustainment and operations availability?"

From the Emerging Technologies Institute Recommendations for the Department of Defense Mr. James A. Faist, ETI Brief Series November, 2021

Mission Engineering Supports a Robust Requirement Development Process



A Better Flow Would Look Like This



Mission Characterization

Best done in campaign/force on force models - Can be done tabletop

In lower level engineering models it is important to maintain context

Scenario = Overall campaign / operational context, conditions, & objectives

Derived From:

- **Conflict Setting**
  - Geo-political set-up
  - Conflict Timeframe
  - Strategic Mission Objective(s)
- **Mission Areas**
  - A grouping of like Campaign operations
  - Mission Areas allow categorization and configuration control
- **Multi-Service Force Deployment (MSFD) – i.e., Family of Scenarios**
  - The Joint Staff orchestrates the building of MSFD scenarios
  - Includes participation of Services, Agencies, Combatant Commanders.

ROE = Rules of Engagement
MOS = Measures of Success
MOE = Measures of Effectiveness

Vignettes = Subset of a scenario to focus the scope, details, and "Mission objective" to match the scope of the problem statement

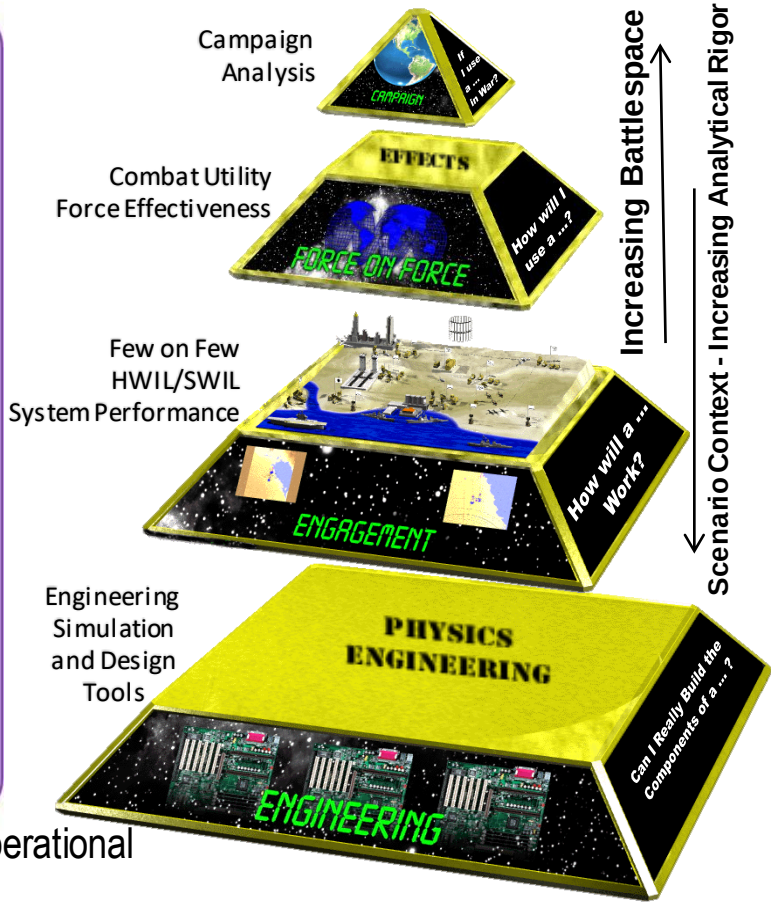
Set-Up
- Fragment of Theater Scenario
- Setting, Objective(s) & Commander's Intent
- Baseline forces; Threats/Intel; and order of battle
- Baseline framework of operational tasks
- Details of blue and red CONOPS; ROE
- Clutter (e.g. Neutrals) / Contested

Mission Assumptions & Constraints
- Size of force
- Resupply
- Pre-positioning
- Environment, Day/ Night, Weather

Mission Objective / Measures
- Desired End State
- Define Vignette Success / Best Value
- Measures of Success and Effectiveness (MOS/MOE)
- Define equation for Return on Investment

Many vignettes can be derived from a single Scenario

M&S Models
(Simulation System Representation)

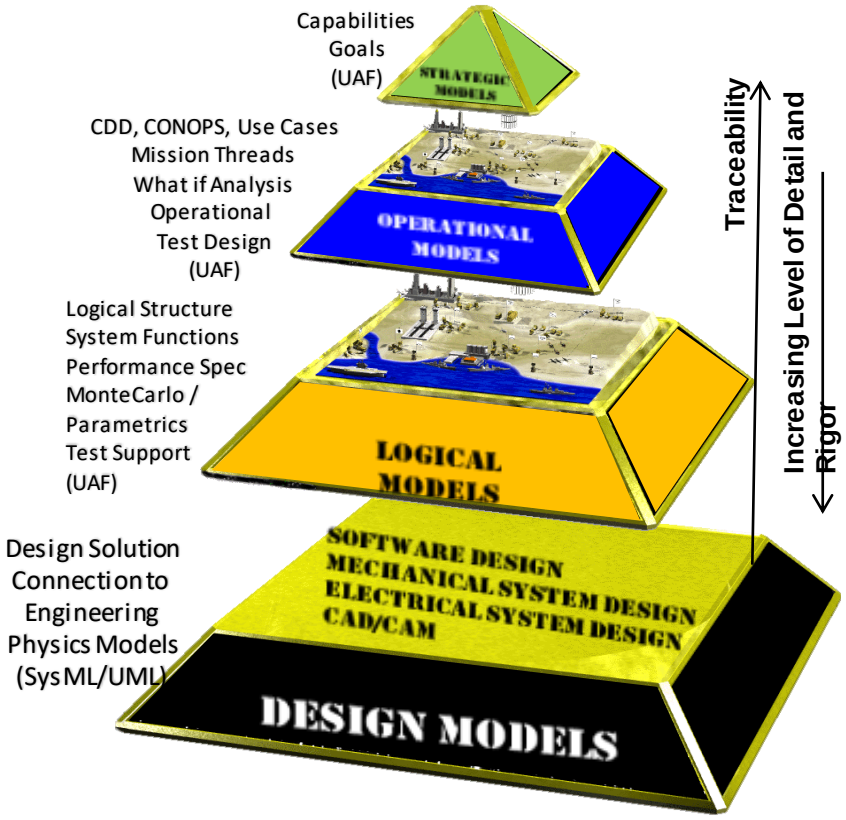


Addresses the mission, the operational environment and the operational assumptions/constraints

Mission Architecture

MONTE PORTER ASSOCIATES LLC

MBSE System Models
(Authoritative System Representation)

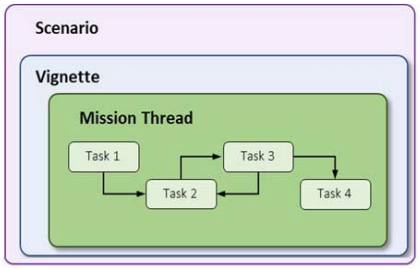


Mission Architecture - *conceptual modeling of concepts, approaches, and systems of systems that enables details of the process flow, timing, interactions, data, capabilities, and performance to be examined in relation to the other processes, entities, and systems that contribute to achieving the mission objective.*

Enables organized information sharing across the acquisition community.

Mission Thread - sub-element of mission architectures which comprises the documentation of end-to-end tasks or activities needed to accomplish a mission within a scenario or vignette.

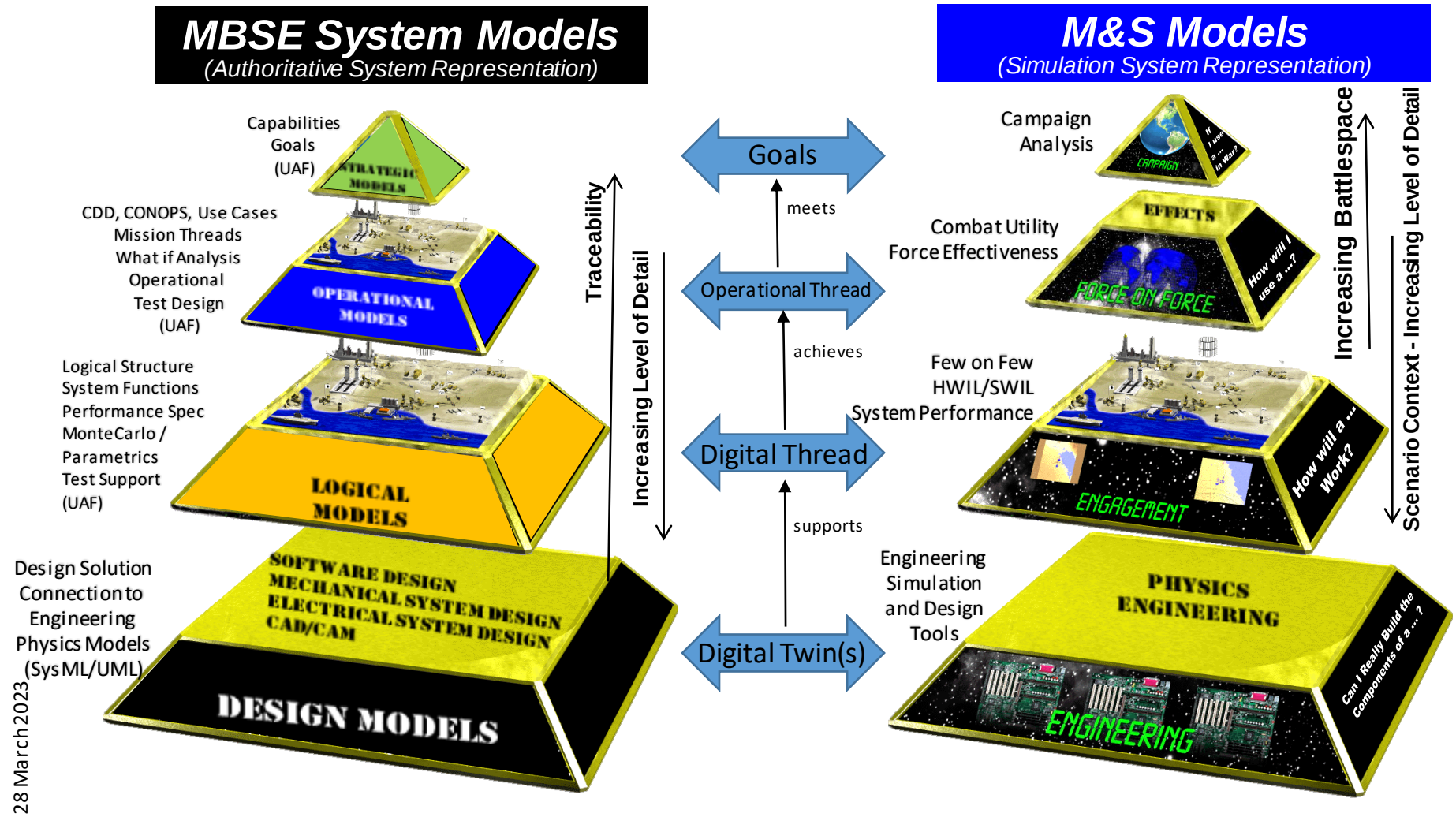
Multiple mission threads may be linked over time to execute missions with in a scenario or vignette



28 March 2023

MBSE Compliments M&S in the Digital Environment

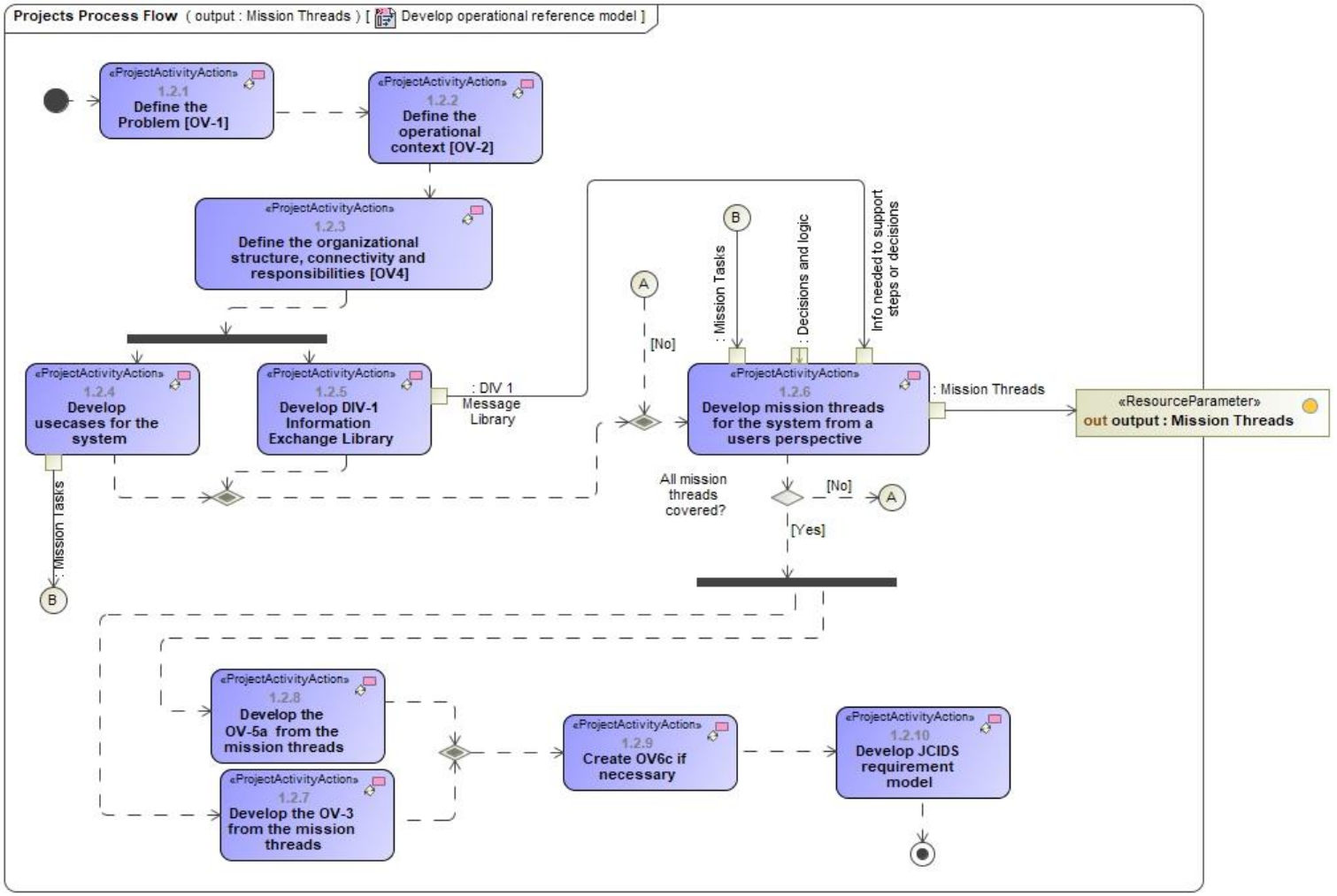
MONTE PORTER ASSOCIATES LLC



28 March 2023

Use the right tool to "think through" question being asked

Operational Model Process



UAFML Supports Test and Acquisition

MONTE PORTER ASSOCIATES LLC

JCIDS/Acquisition

Vision
Stakeholder Requirements
Capabilities
Operational Goals
Drivers, Challenges, Opportunities, Risks,
Capabilities, Goals, MOEs, Outcomes …etc.
Program Goals/Constraints
MOEs

«artifact» ICD/CDD/ONS/JUONS

CDD, CONOPS, Use Cases
Mission Threads
What if Analysis
Operational Test Design

«artifact» CONOPS

Logical Structure
System Functions
Performance Spec
MonteCarlo / Parametrics
Test Support
(UAF)

«artifact» Requirement Spec

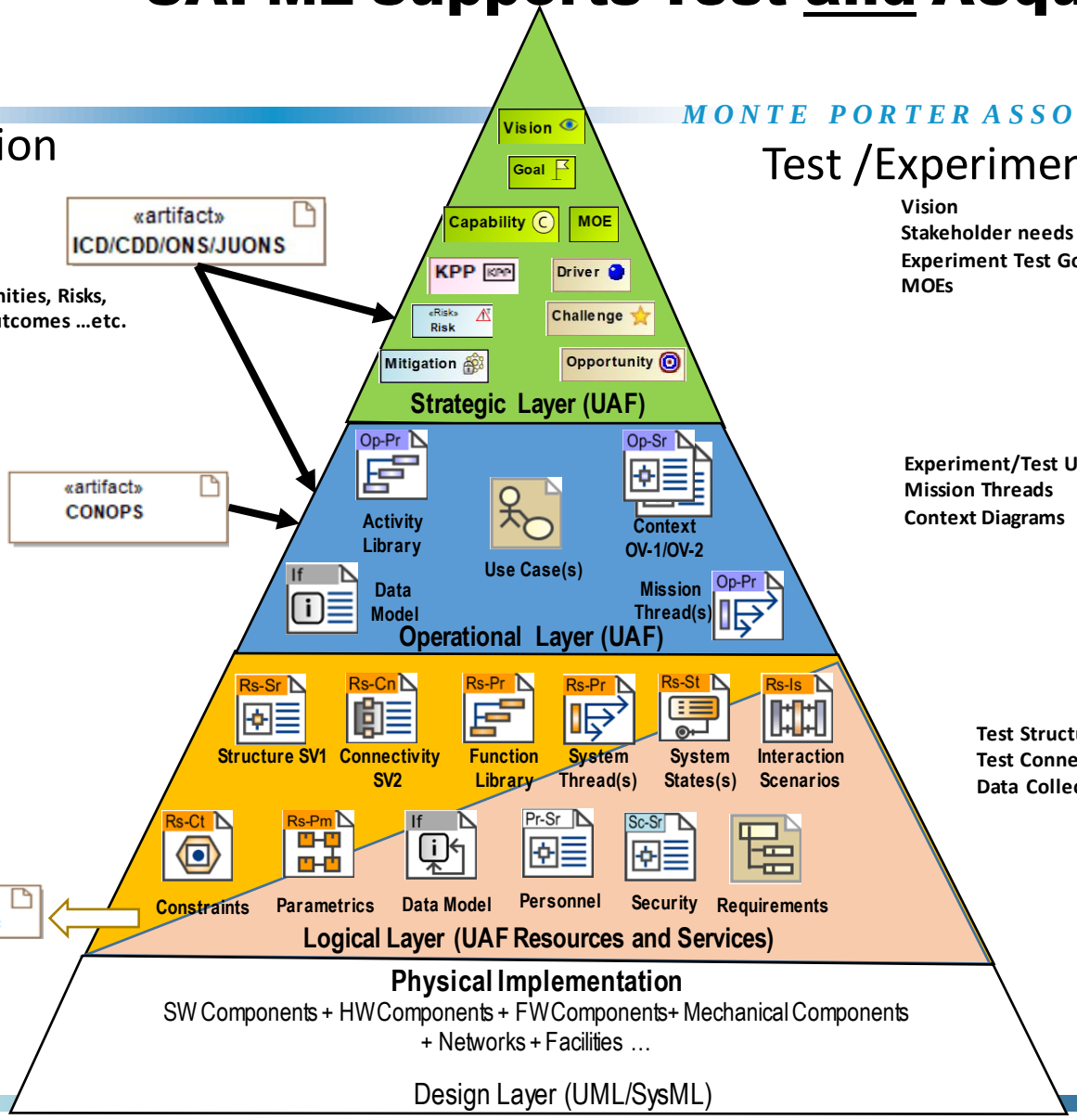
Design Solution Connection to Engineering Physics Models (UML/SysML)

Test /Experimentation

Vision
Stakeholder needs
Experiment Test Goals
MOEs

Experiment/Test Use Cases
Mission Threads
Context Diagrams

Test Structure
Test Connectivity
Data Collection/Reduction



Recommendations

UAFML is going the right direction – need to encourage folk to use UAFML .and. SysML – not an either/or proposition

Currently able to access all SysML functionality in UAFML – as we go to SysML 2.0 keep that capability

Need to consider requirement metadata

Consider the need to “drill up”


MBSE, JCIDS and the Digital Environment
Thank You!
SUPER!!
SWISH!
ZAW!
SMASH!
AHH!
POW!
BAM!
YELP!