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Digital Engineering Models of Complex Systems using MBSE from Enterprise Architecture to Systems of Systems Architectures & Systems Development Life Cycle

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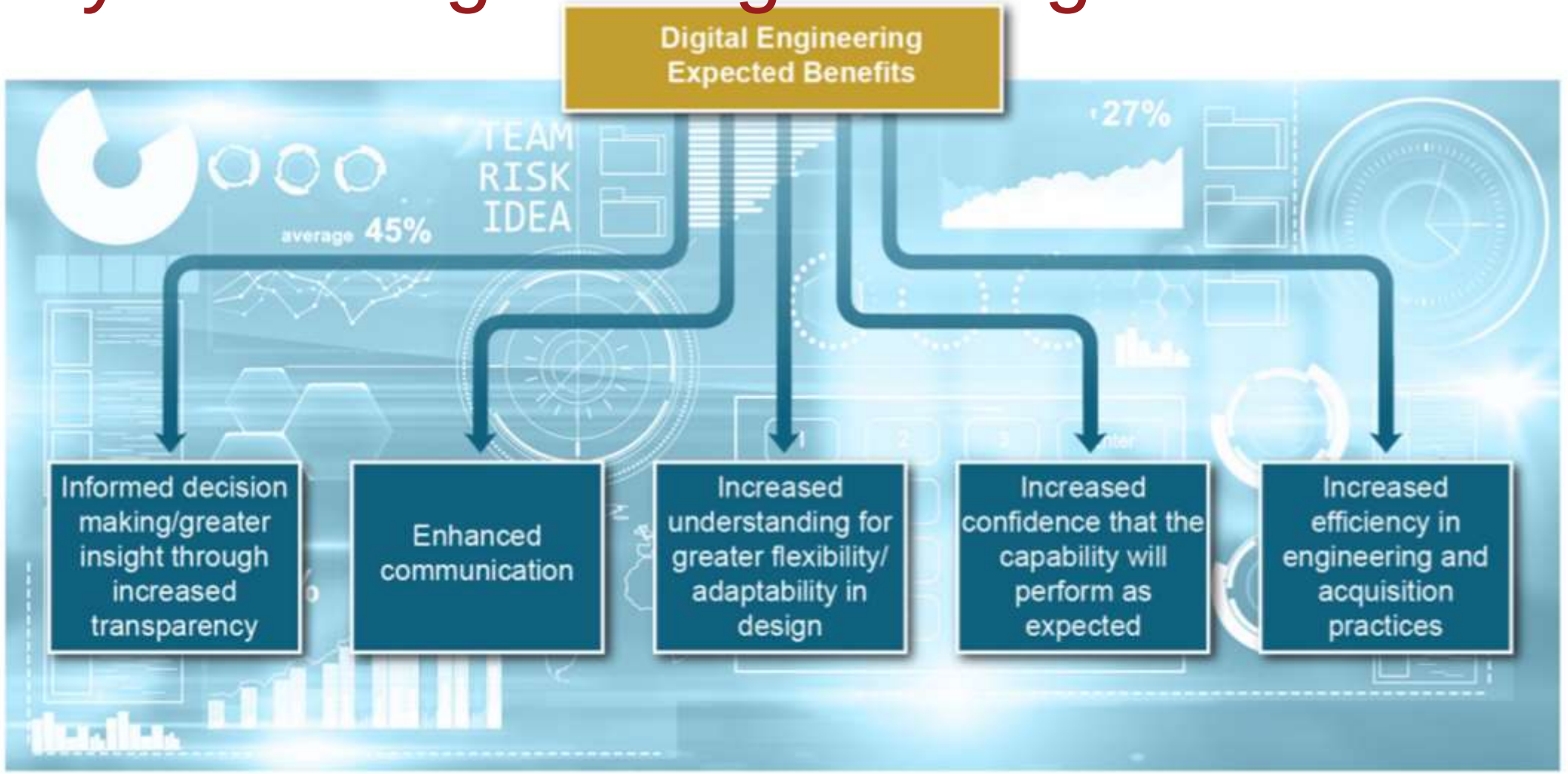
ENGILITY CORPORATION

www.incose.org/symp2018

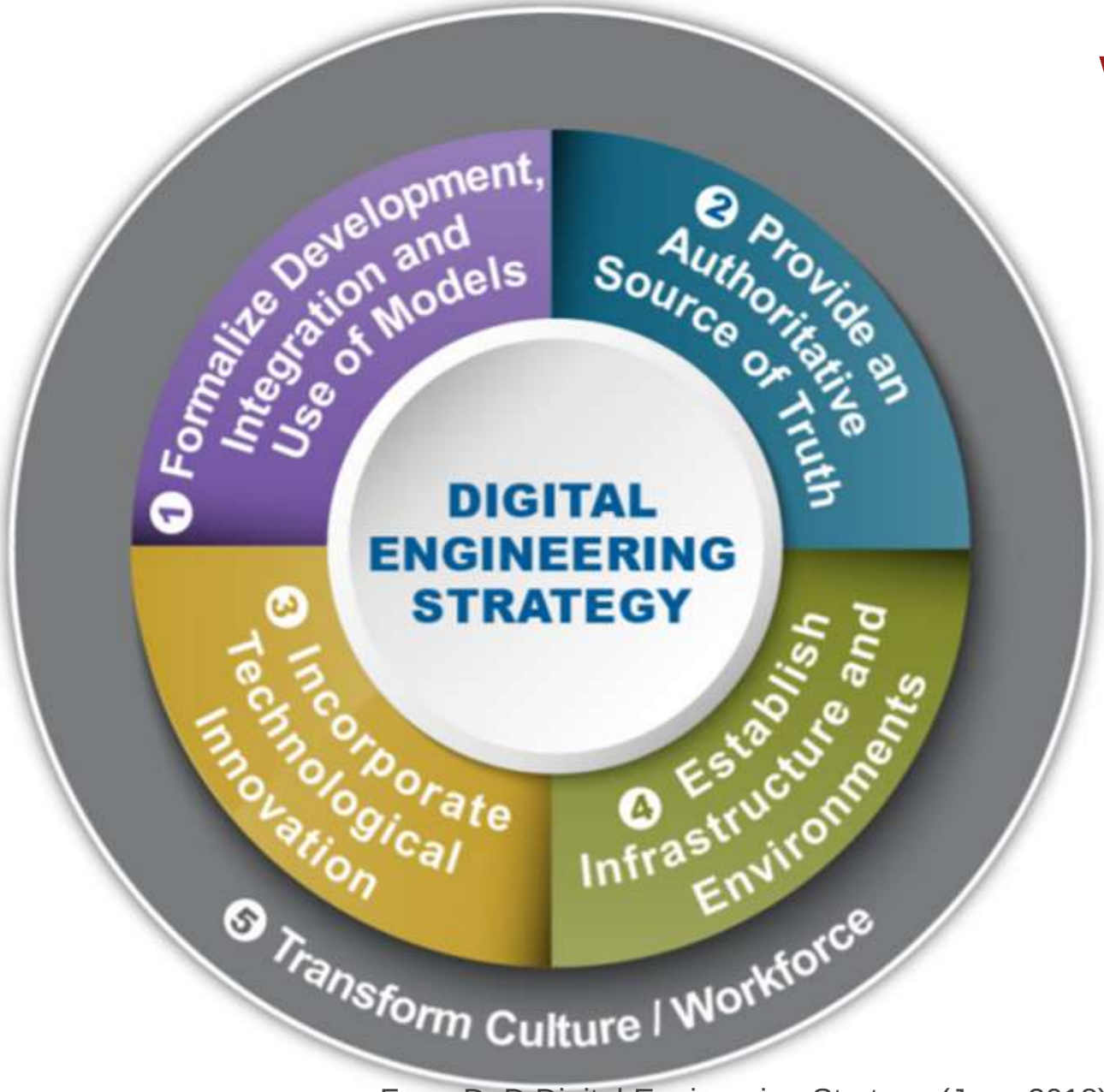
Agenda

- Digital Engineering Models
- Enterprise Architecture using DoDAF
- Systems of Systems Architectures & Systems Development Life Cycle using SysML
- Complex Systems using MBSE in SE Processes
- Mapping Enterprise Architecture with Systems of Systems Models in MBSE UPDM
- Object-Oriented Systems Engineering Methodology Practice
- Auto-generating Interface Control Documents
- Analyzing Performance Parametric

Why does Digital Engineering matter?



From DoD Digital Engineering Strategy (June 2018): https://www.acq.osd.mil/se/docs/2018-DES.pdf

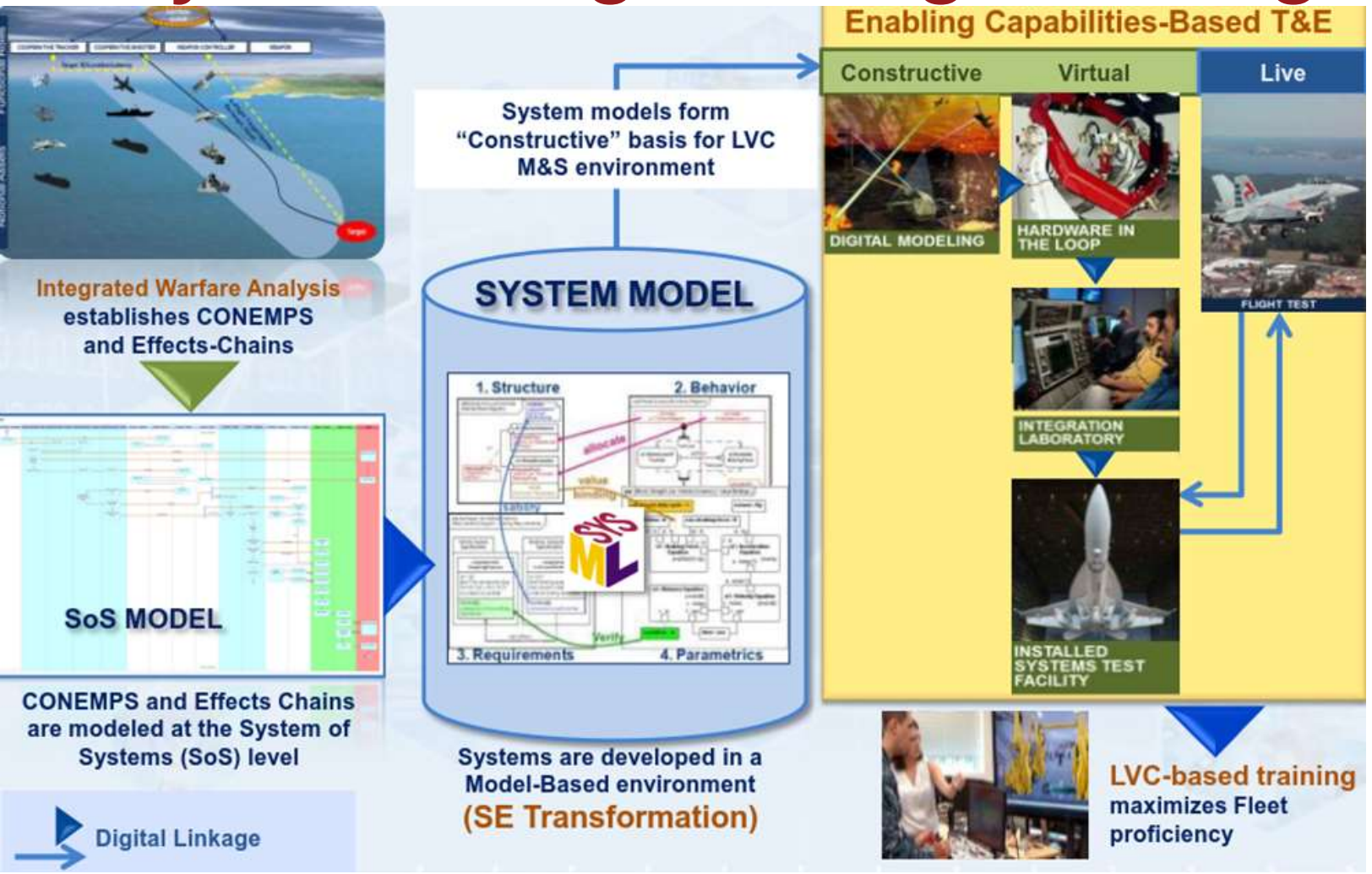


Why does Digital Engineering matter?

1. **Digital Engineering Models**
2. **Enterprise Architecture**
   Tracing Performance
   Parametric
3. **Object-Oriented Systems Engineering Methodology**
   Practice

From DoD Digital Engineering Strategy (June 2018): https://www.acq.osd.mil/se/docs/2018-DES.pdf

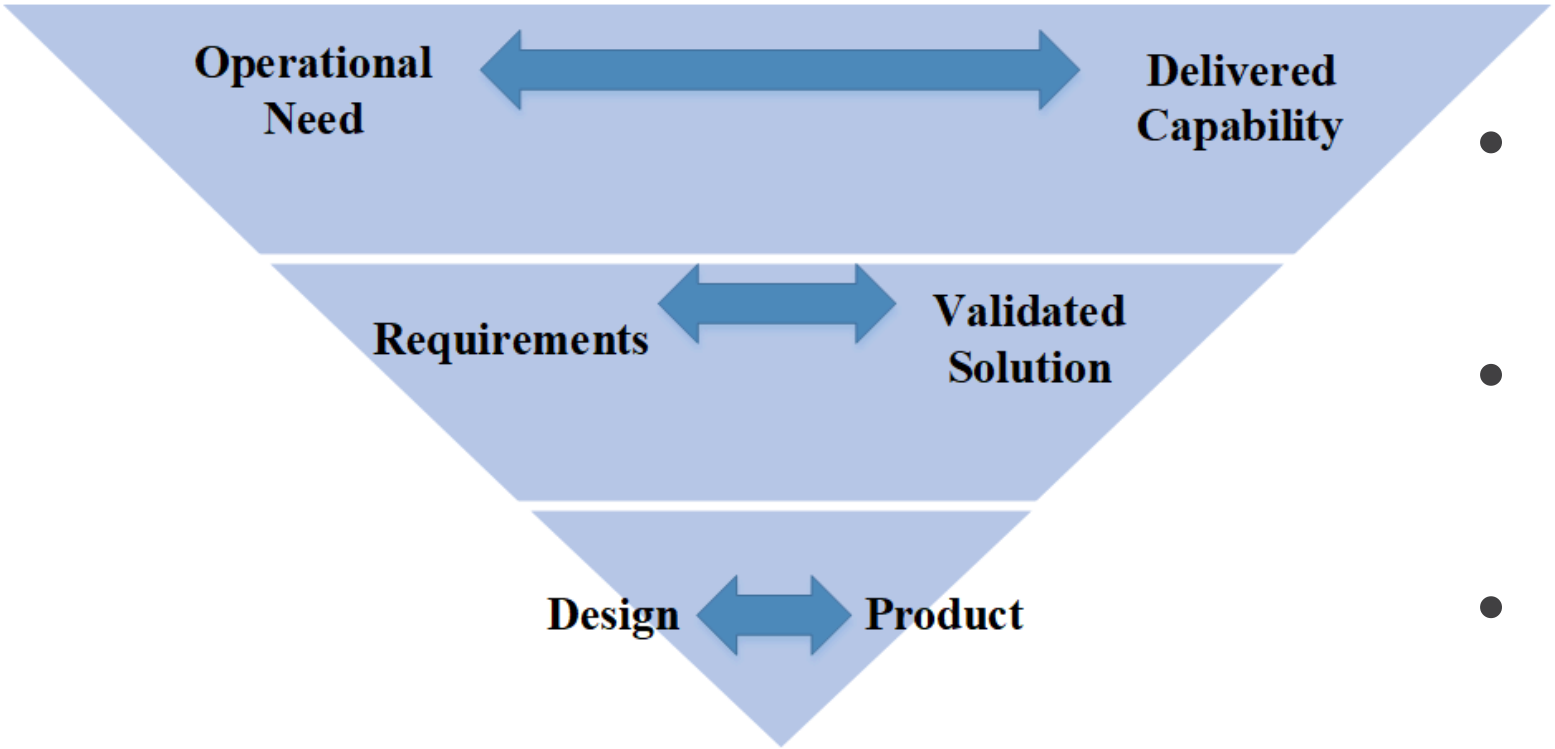
Why does Digital Engineering matter?



- Digital Engineering Models
- Enterprise Architecture Tracing Performance Parametric
- Object-Oriented Systems Engineering Methodology Practice

From NAVAIR Systems Engineering Transformation Industry Day (08MAR18): https://community.apan.org/cfs-file/__key/docpreview-s/00-00-05-00-16/SET_5F00_IndustryDayFinal-v3-_2800_2_2900_.pdf

MBSE Makes Systems Engineering Work



From Defense Acquisition Guide, (2014): https://www.dau.mil/acquipedia/Pages/ArticleDetails.aspx?aid=9c591ad6-8f69-49dd-a61d-4096e7b3086c

- Stop looking at the SE "Vee" model as linear
- Read Top to Bottom rather than Left to Right
- MBSE Effects a spiral approach toward SE

The proof in the pudding is in the eating!

- Not just Buzzword Bingo
- Tool-enabled Systems Engineering, not tools to replace Systems Engineering

Introduction

- The paper describes our digital modeling development to **collaborate and interface information exchanging between Enterprise Architecture (EA) and Systems of Systems (SoS)** on applying Systems Engineering (SE) concepts and employing MBSE methodology and tool.
- The **MBSE methods and techniques** are used to **create digitals models** that **change the ways SE is practiced proficiently** but still **correlates and bases with SE principles**.
- Utilizing the MBSE **centralized database & digital engineering models can accomplish complex systems designs efficiently** in integrating with today's high performance computing, networking technologies and digital infrastructure

MBSE Application Objective

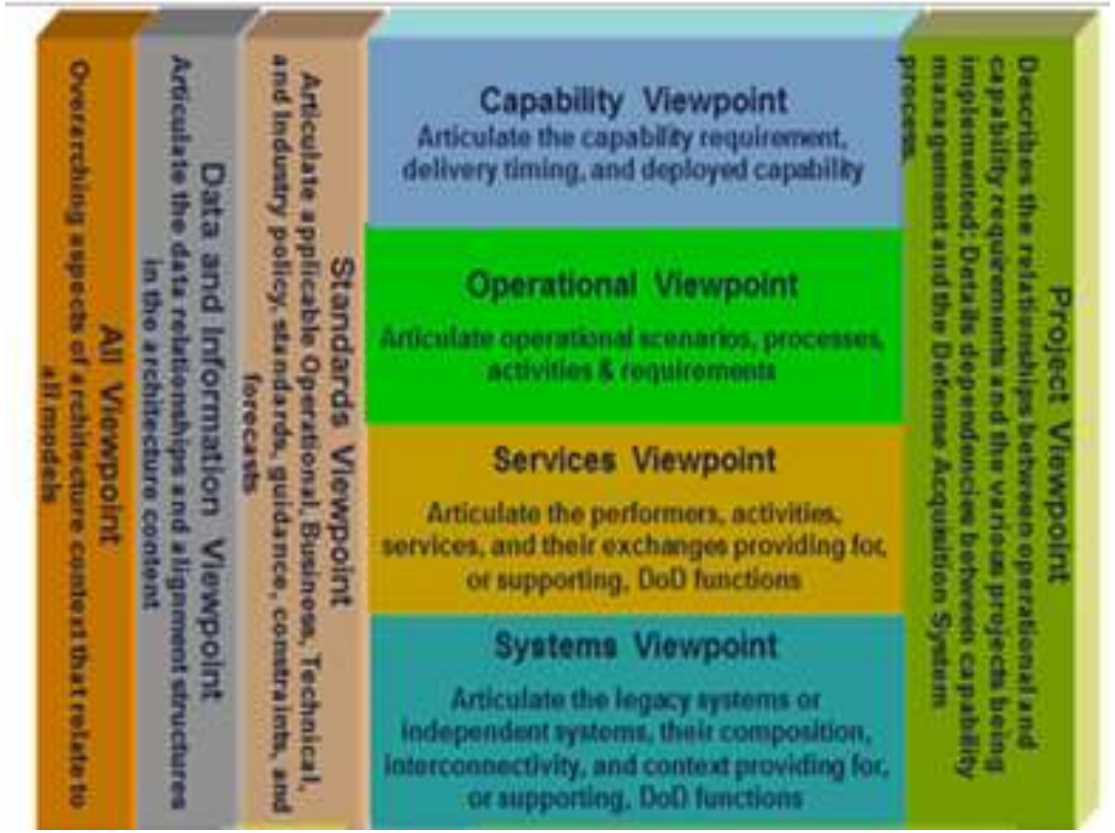
- We have an objective to transform
  - **from "As-Is" document-oriented** architecture and SE
  - **to "To-Be" MBSE to cope with trending Digital Infrastructure** Agile Development **from EA to SoS.**
- **The EA Framework uses the Department of Defense Architecture Framework (DoDAF)** with the Unified Profile for DoDAF / MODAF (UPDM) modeling standard and **SoS approach using the System Modeling Language (SysML)** for the Systems Development Life Cycle (SDLC) & integration.
- We apply this tactic to build modernized frigate warship equipped with SoS as **Cyber, Combat, Communications, Control, Computers, Command, Intelligence, Surveillance & Reconnaissance (C6ISR).**

Digital Engineering Models

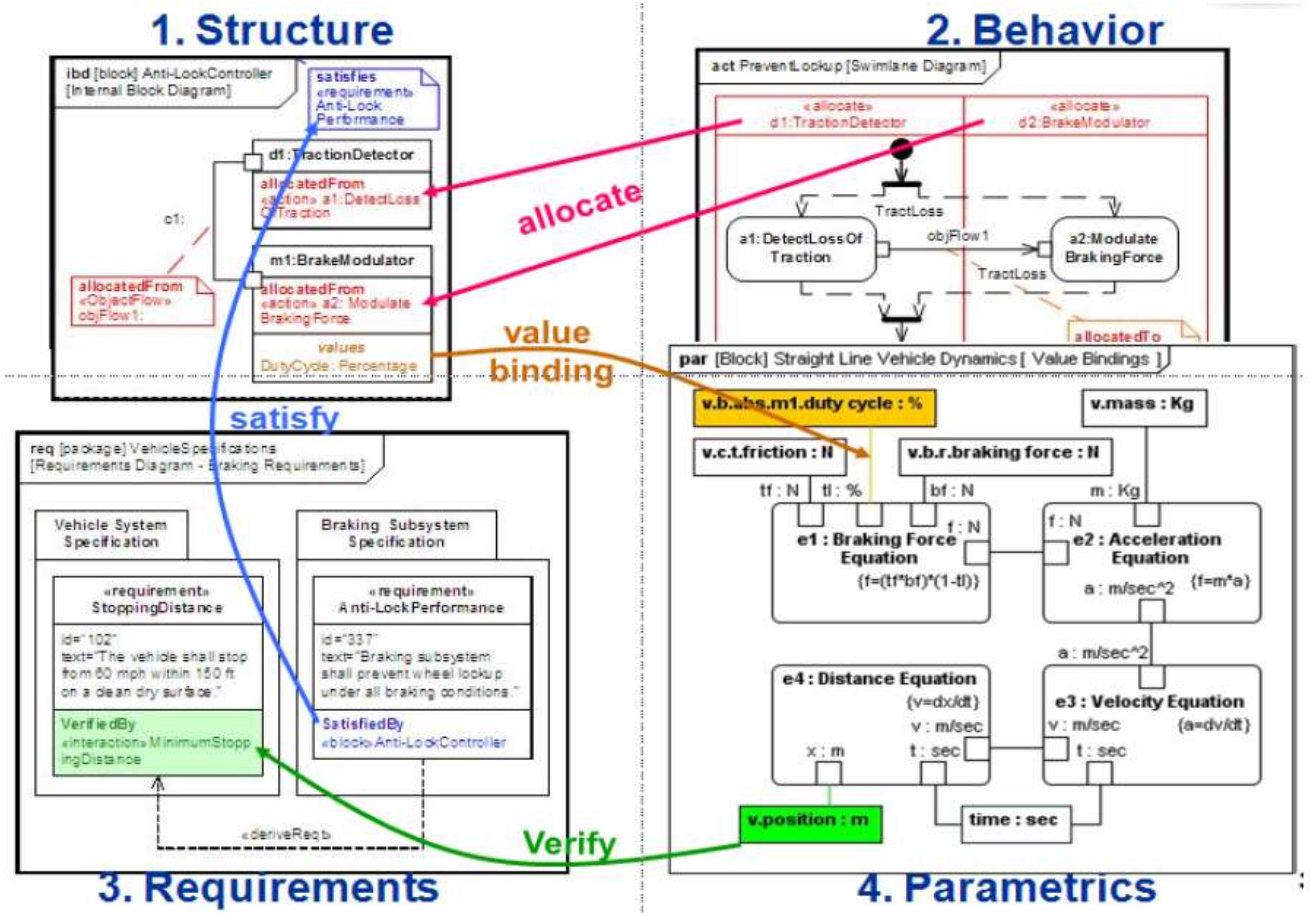
MBSE for EA UPDM and SoS SysML

EA UPDM Viewpoints/Views

DoDAF 2.0 (8 Viewpoints, 52 Views)



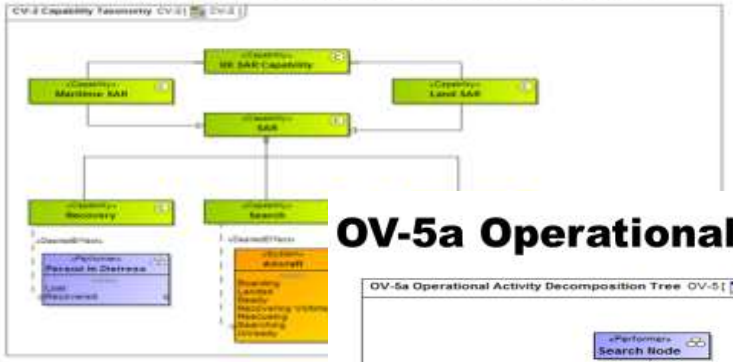
SoS SysML 4 -Pillars



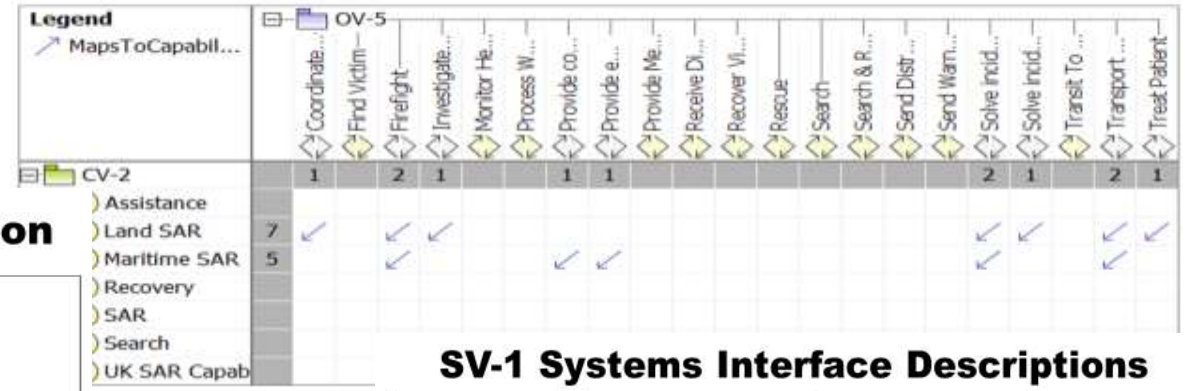
OMG Specification

DoD 2012 http://dodcio.defense.gov/Portals/0/Documents/DODAF/DoDAF_v2-02_web.pdf

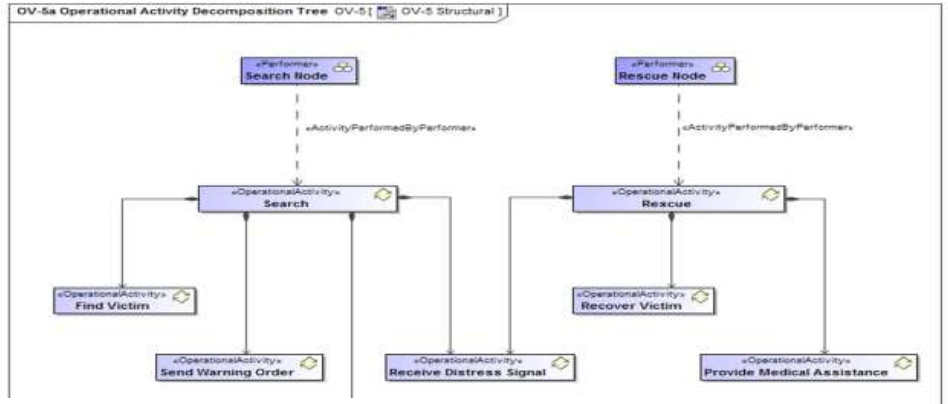
CV-2 Capability Taxonomies



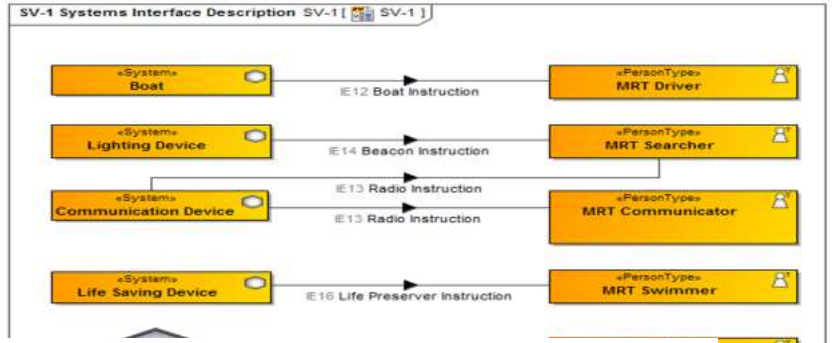
CV-6 Capability to Operational Activities Mappings



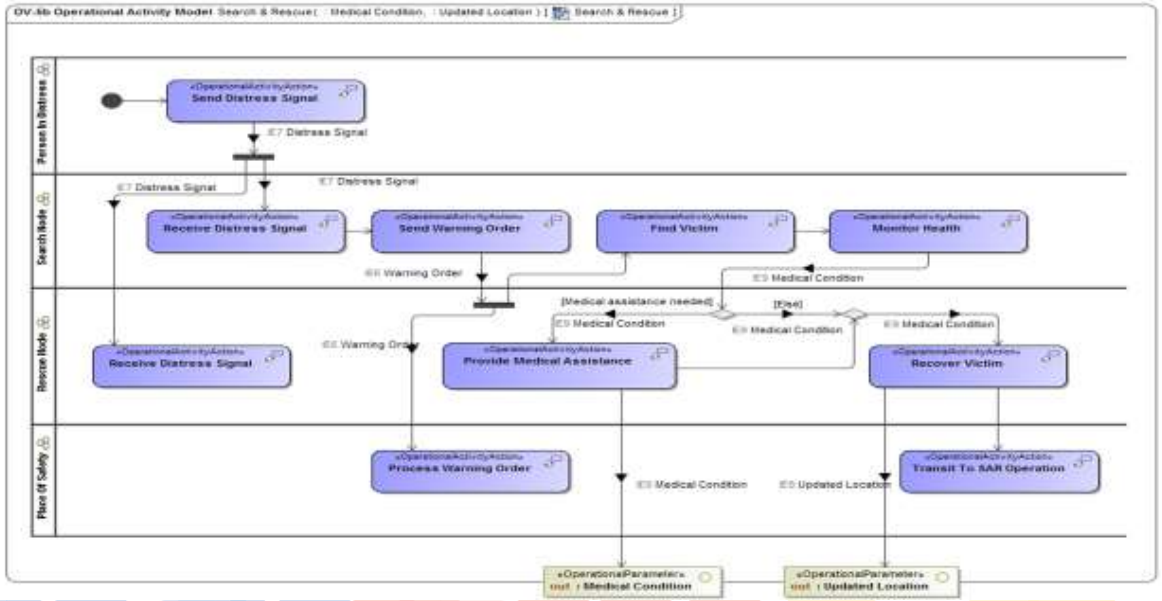
OV-5a Operational Activity Decomposition



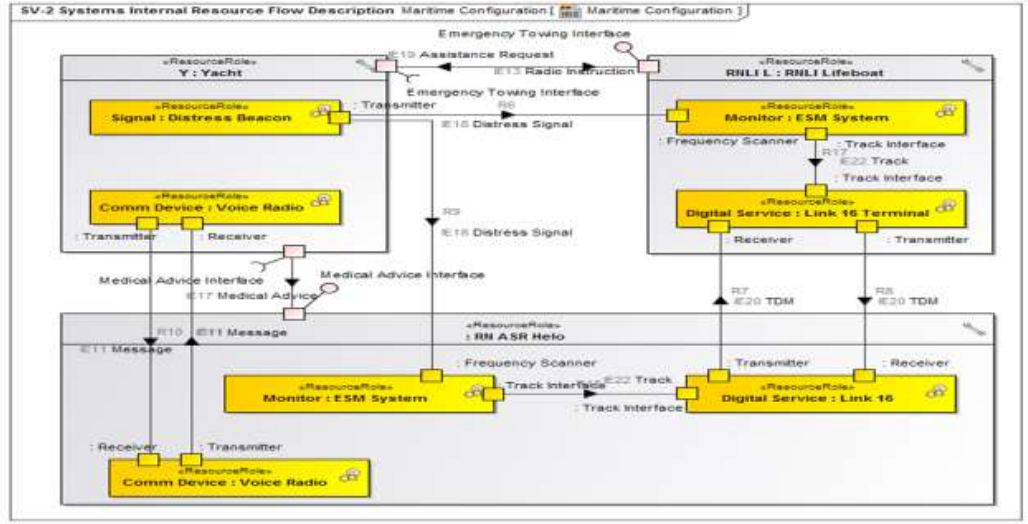
SV-1 Systems Interface Descriptions



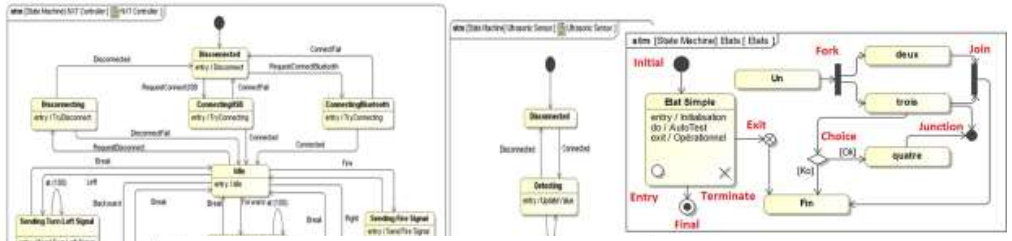
OV-5b Operational Activity Models



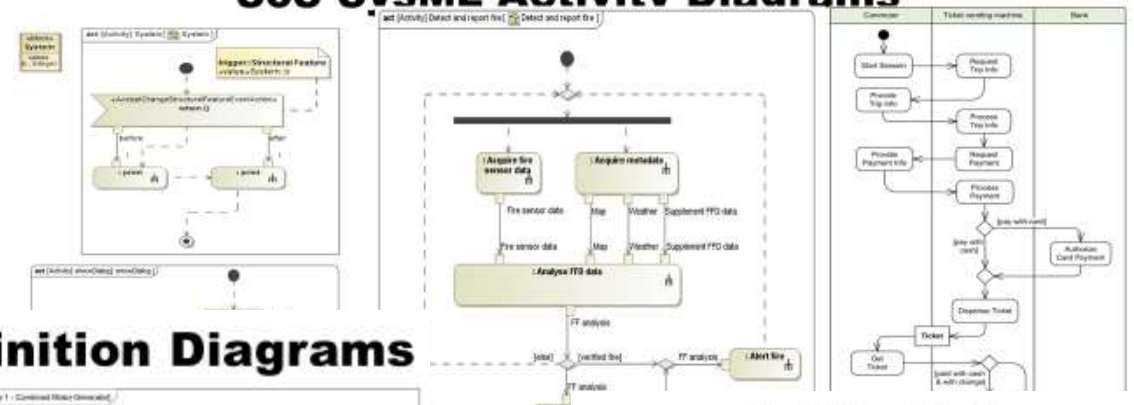
SV-2 Systems Internal Resource Flow Descriptions



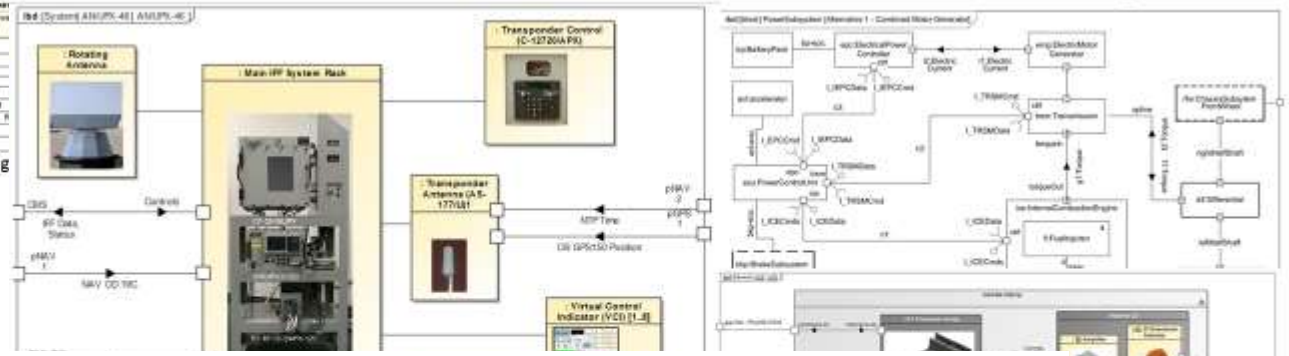
SoS SysML State Machine Diagram



SoS SysML Activity Diagrams

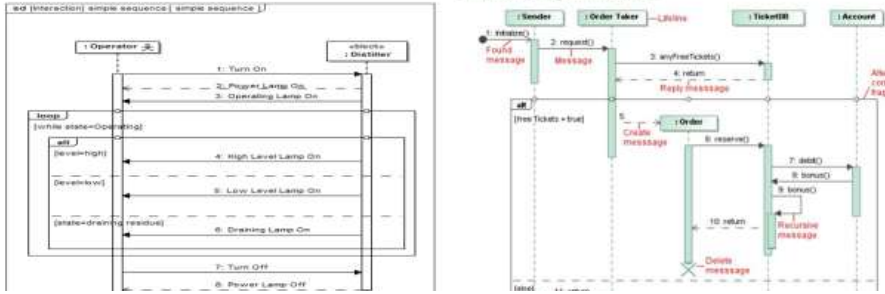


SoS SysML Internal Block Definition Diagrams

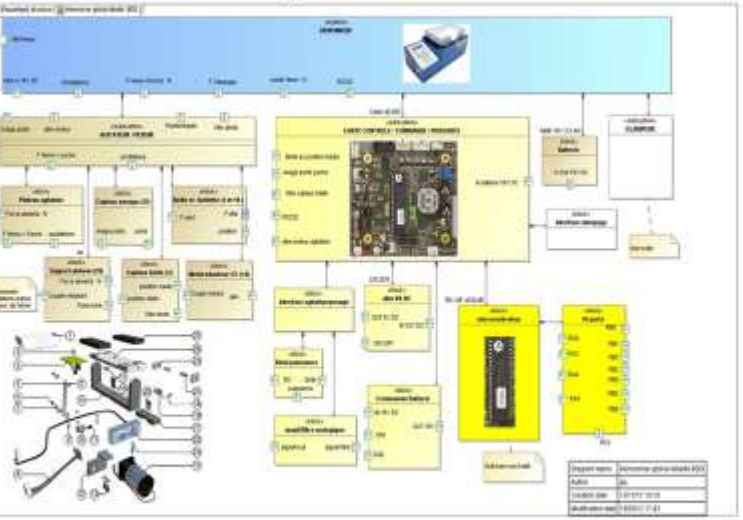


https://www.nomag

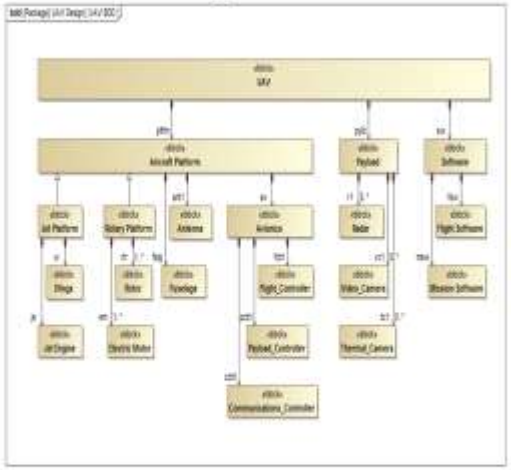
SoS SysML Sequence Diagram



SoS SysML Block Definition Diagram

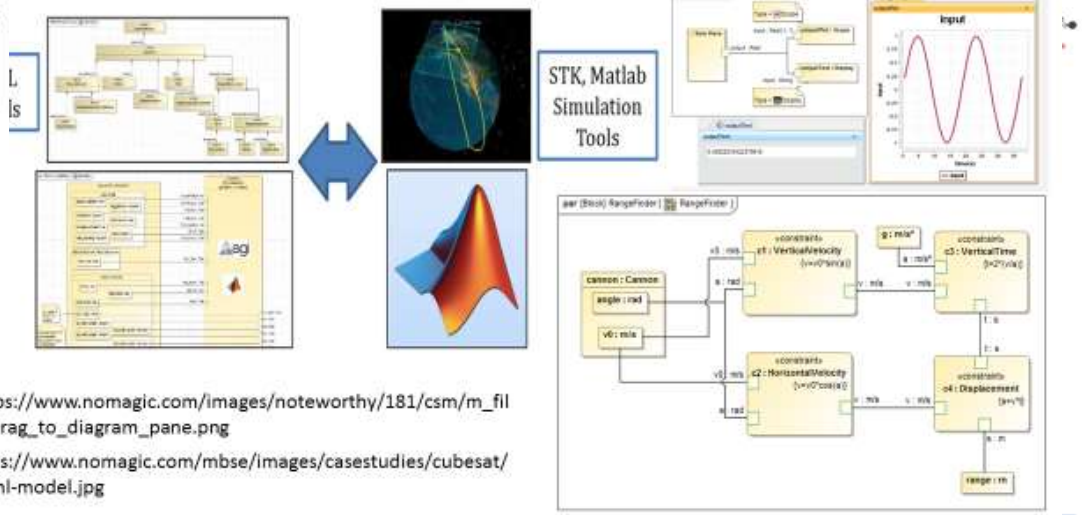


http://eduscol.education.fr/sti/system/files/images/ressources
/techniques/865/865-sysml-un-langage-modele-fig11.jpg



http://intercax.com/wp-content/uploads/2017/01/bdd-uav-sysml-mbse-model-based-engineering.png

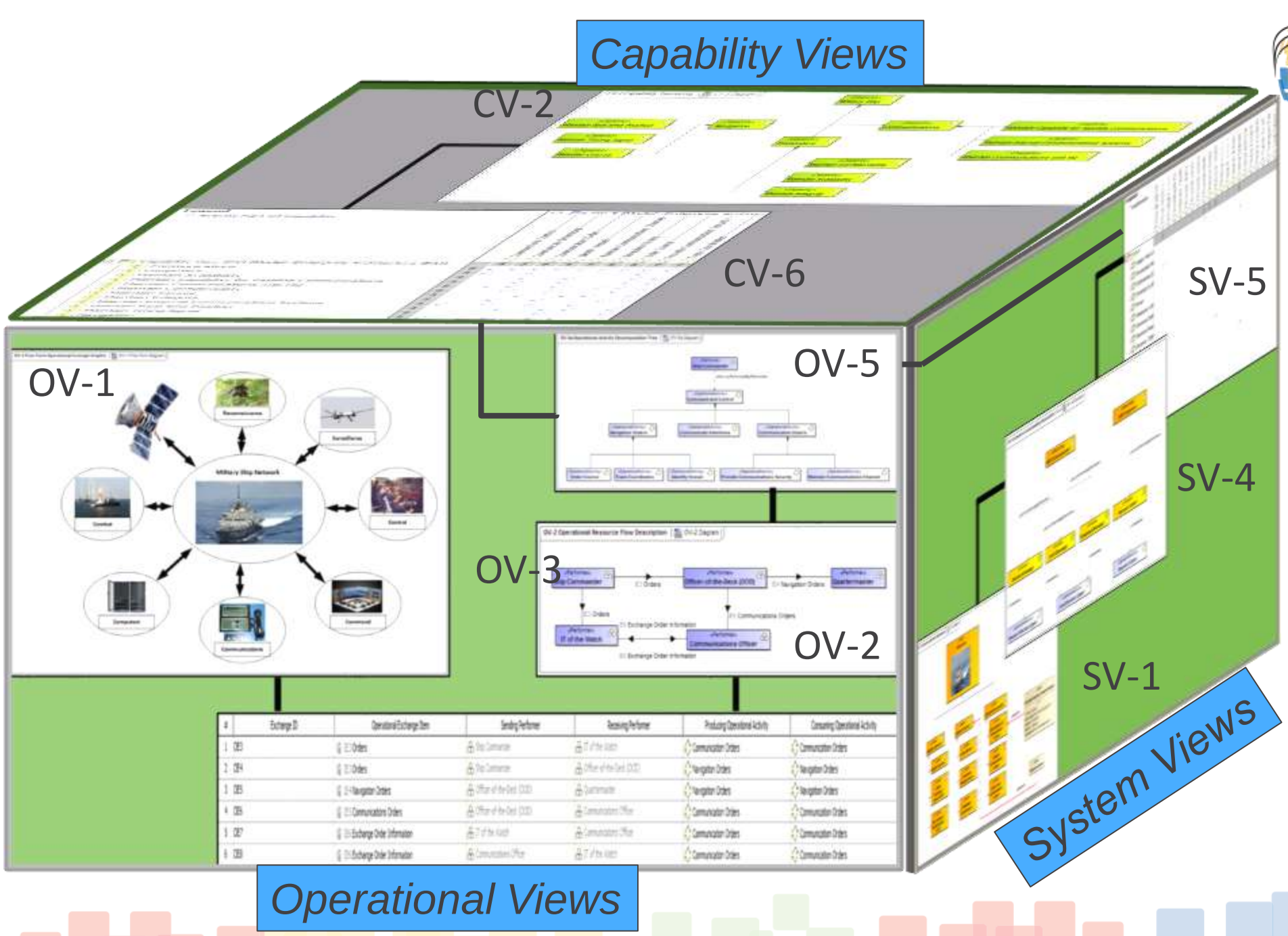
SoS SysML Parametric Diagram



https://www.nomagic.com/images/noteworthy/181/csm/m_file_drag_to_diagram_pane.png

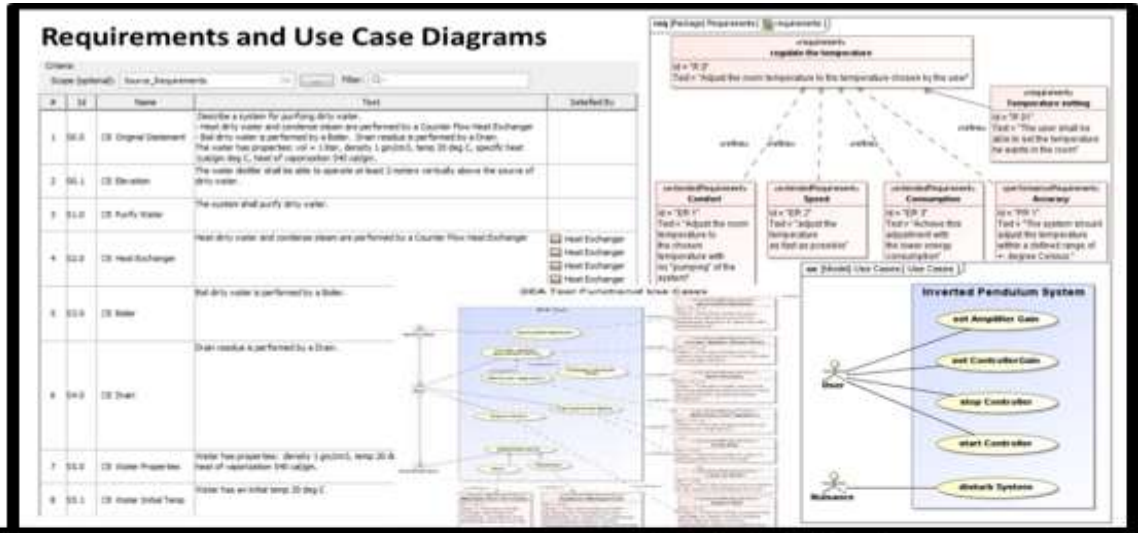
https://www.nomagic.com/mbse/images/casestudies/cubesat/sysml-model.jpg

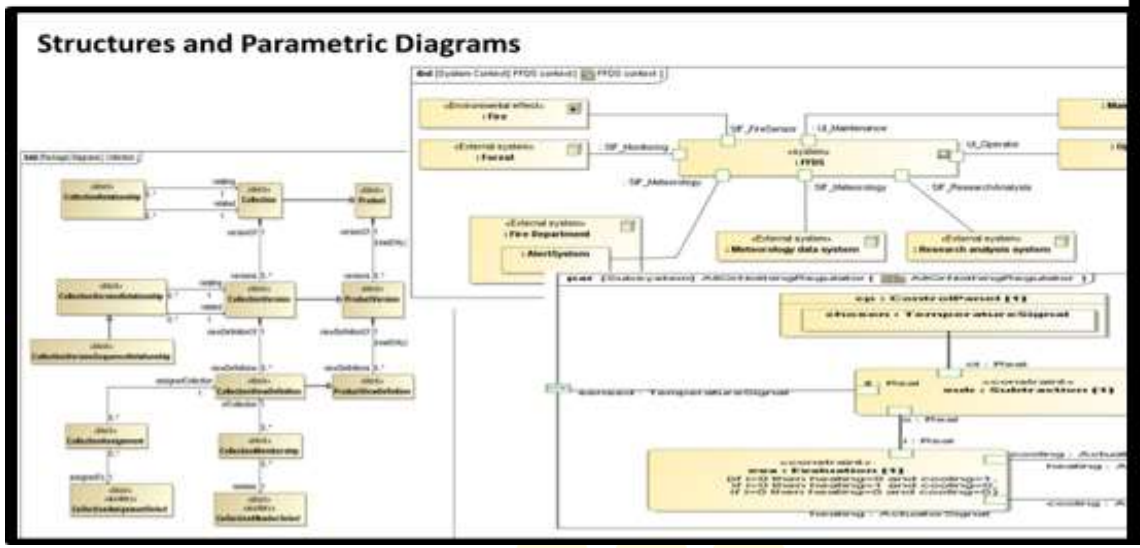
Enterprise Architecture

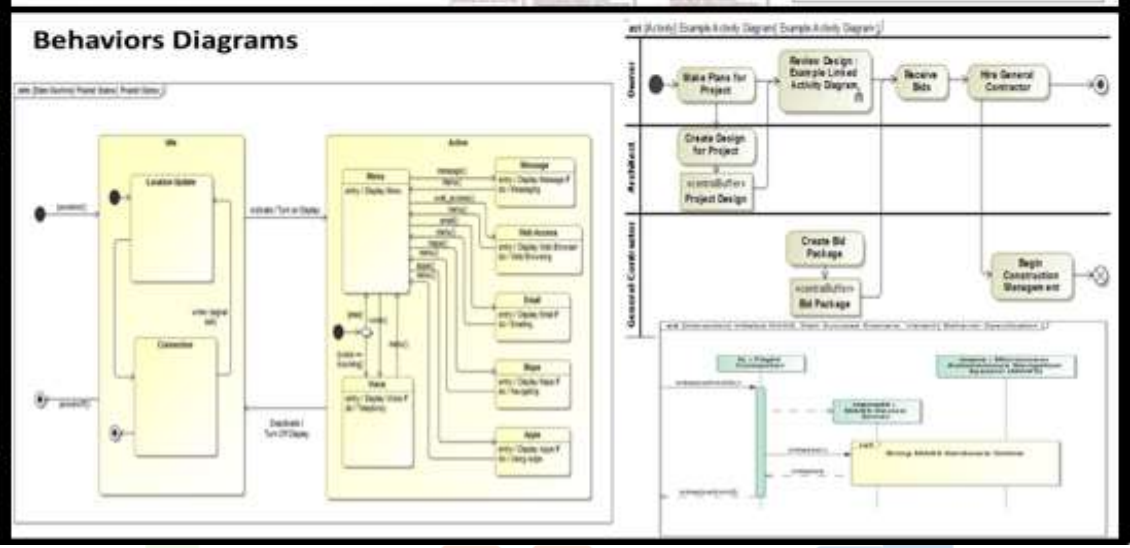

Capability Views
CV-2
CV-6
SV-5
OV-1
OV-5
SV-4
OV-3
OV-2
SV-1
System Views
Operational Views

Systems of Systems Architectures & Systems Development Life Cycle

Gathering MBSE SoS Domain Models

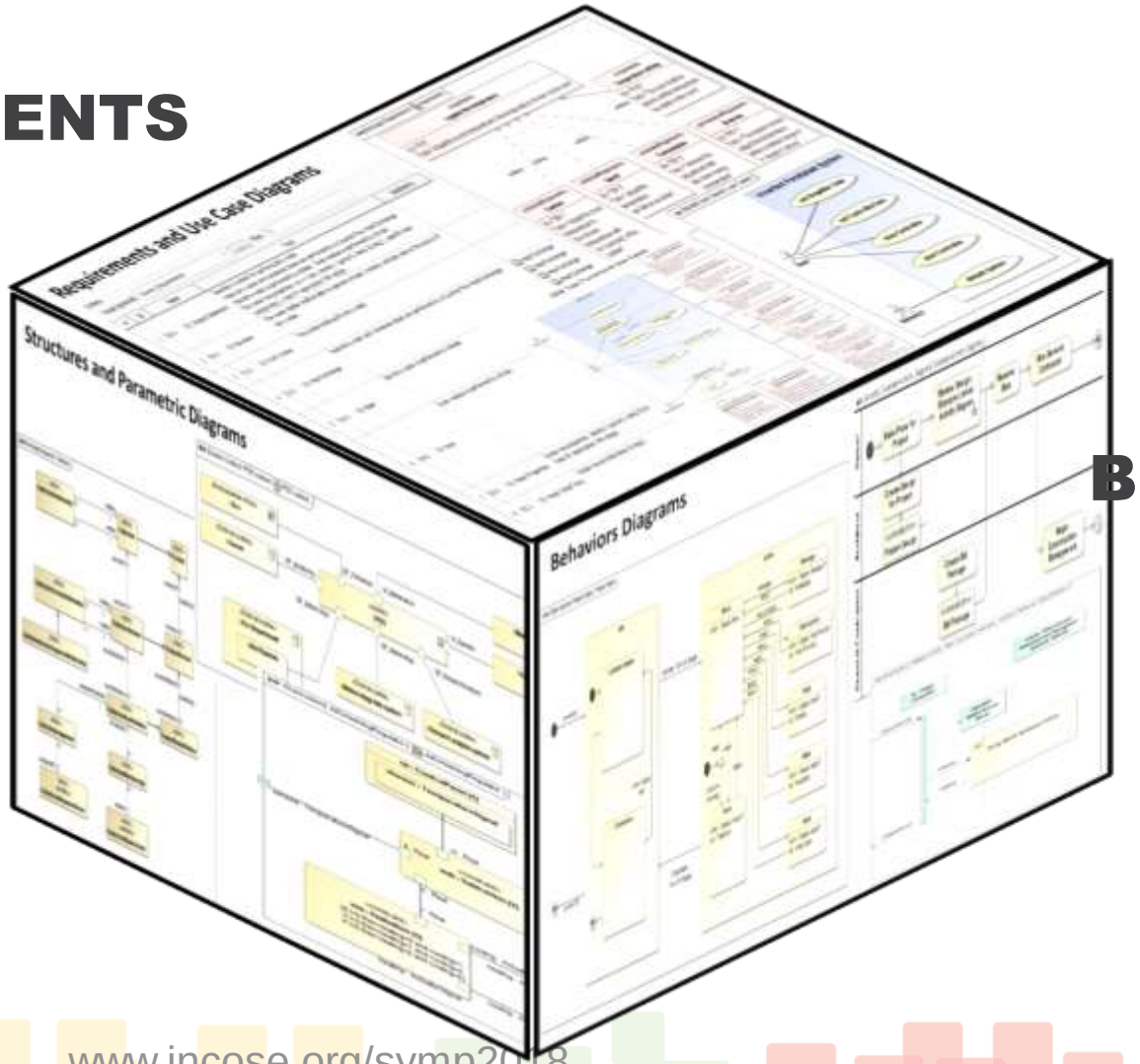






Integrating The Four Pillars Models in SysML

REQUIREMENTS



BEHAVIORS

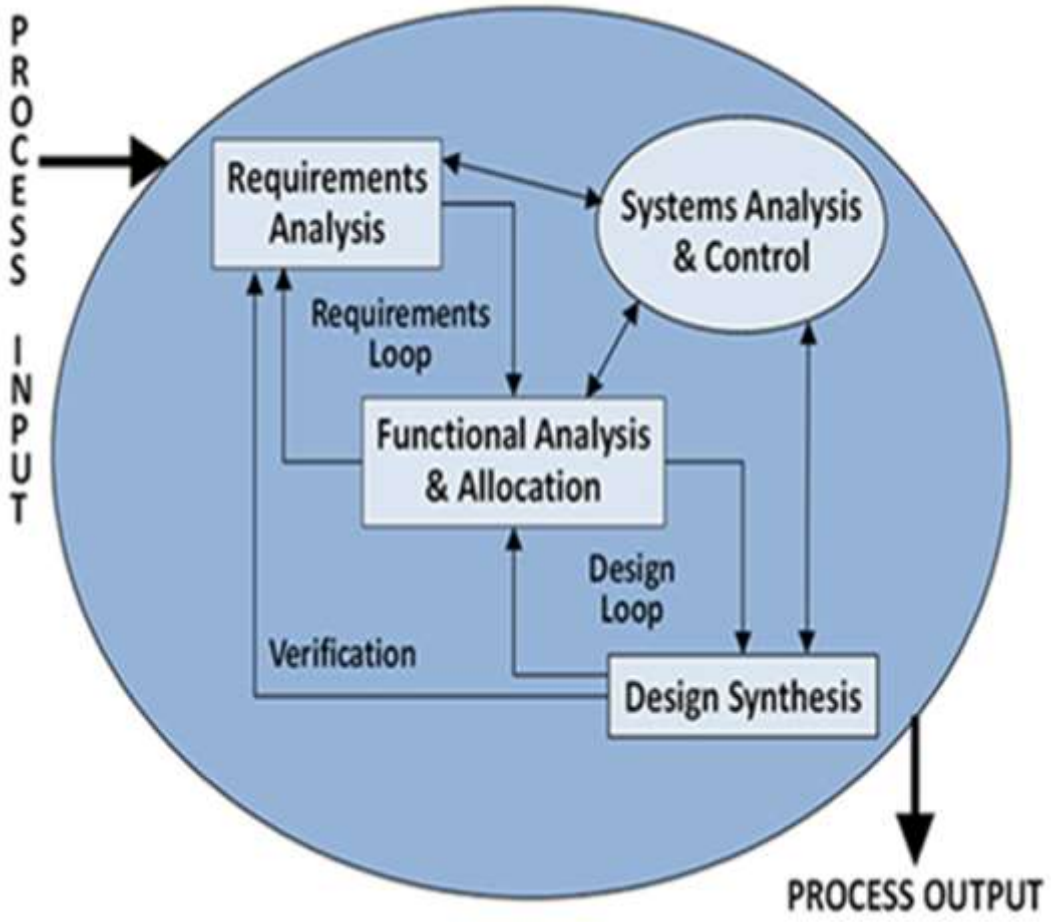
STRUCTURES – PARANETRICS

Complex Systems using MBSE in SE Processes

Engaging MBSE Methods in SE Process

The **MBSE methods and techniques** used to create artifacts changes

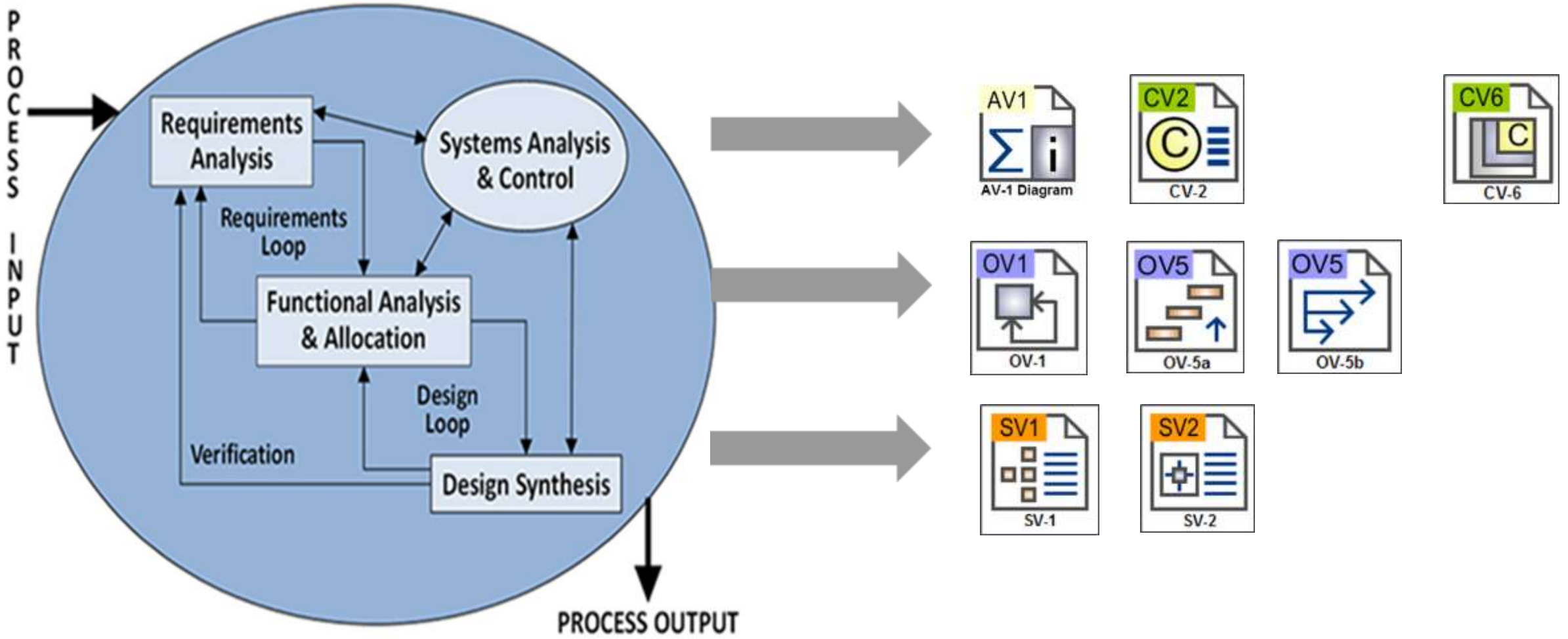
- the ways **SE is practiced** but
- still **correlates and bases** with **SE principles**



Applying SE Process with MBSE in EA

- To correlate SE processes: Stakeholder Needs, **Requirements Analysis, Functional Analysis and Synthesis**,
- The EA captures its
  - **requirement** baselines from **CV**, OV, SV & StdV;
  - **functional architecture** from **OV to SV** and
  - **physical architecture** from OV to **SV**

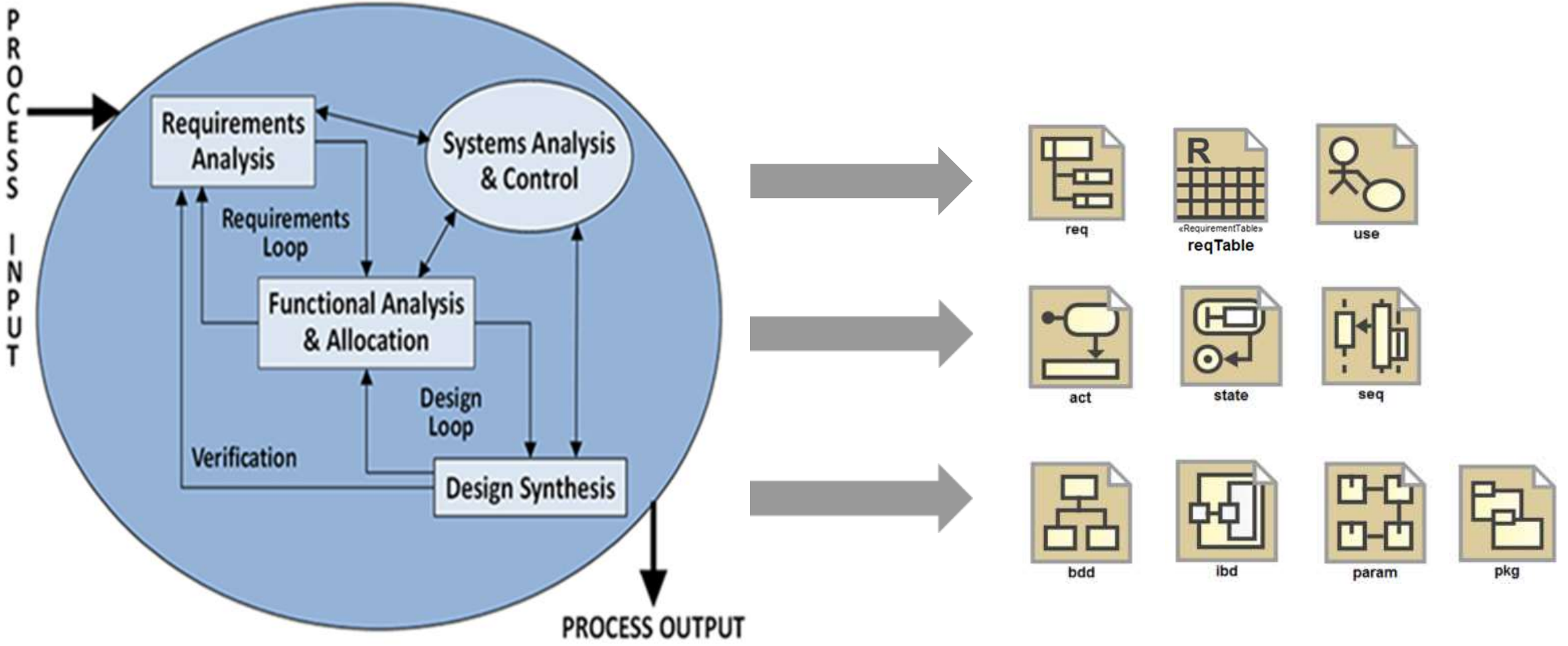
SE Process utilizing EA DoDAF view-models



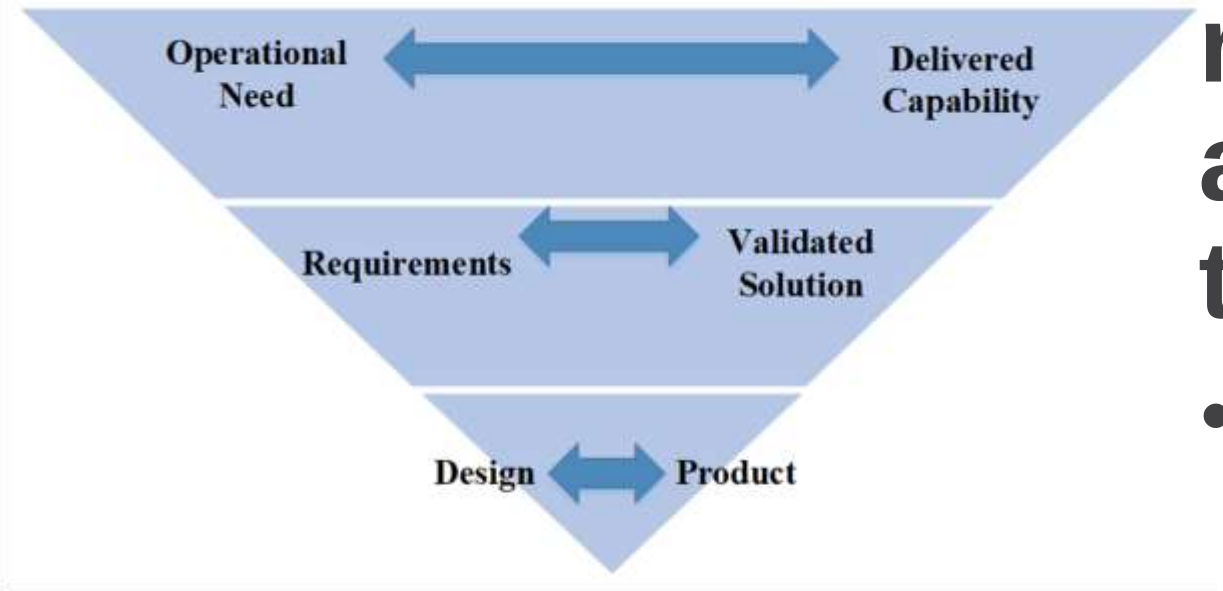
Applying SE Process with MBSE in SoS

- To correlate SE processes: SoS domain experts identify Needs via **Requirements Analysis, Functional Analysis and Synthesis**,
- The SoS captures its
  - **requirements** from **REQ,** UC and PKG
  - **functional architecture & engineering** from **ACT, STM & SEQ**
  - **physical architecture** from **BDD, IBD**, PAR & PKG

SE Process utilizing SoS SysML Models



Systems Engineering V-Model



From Defense Acquisition Guide, (2014)

SysML supports for **requirements, functional and structural allocation tables** facilitating

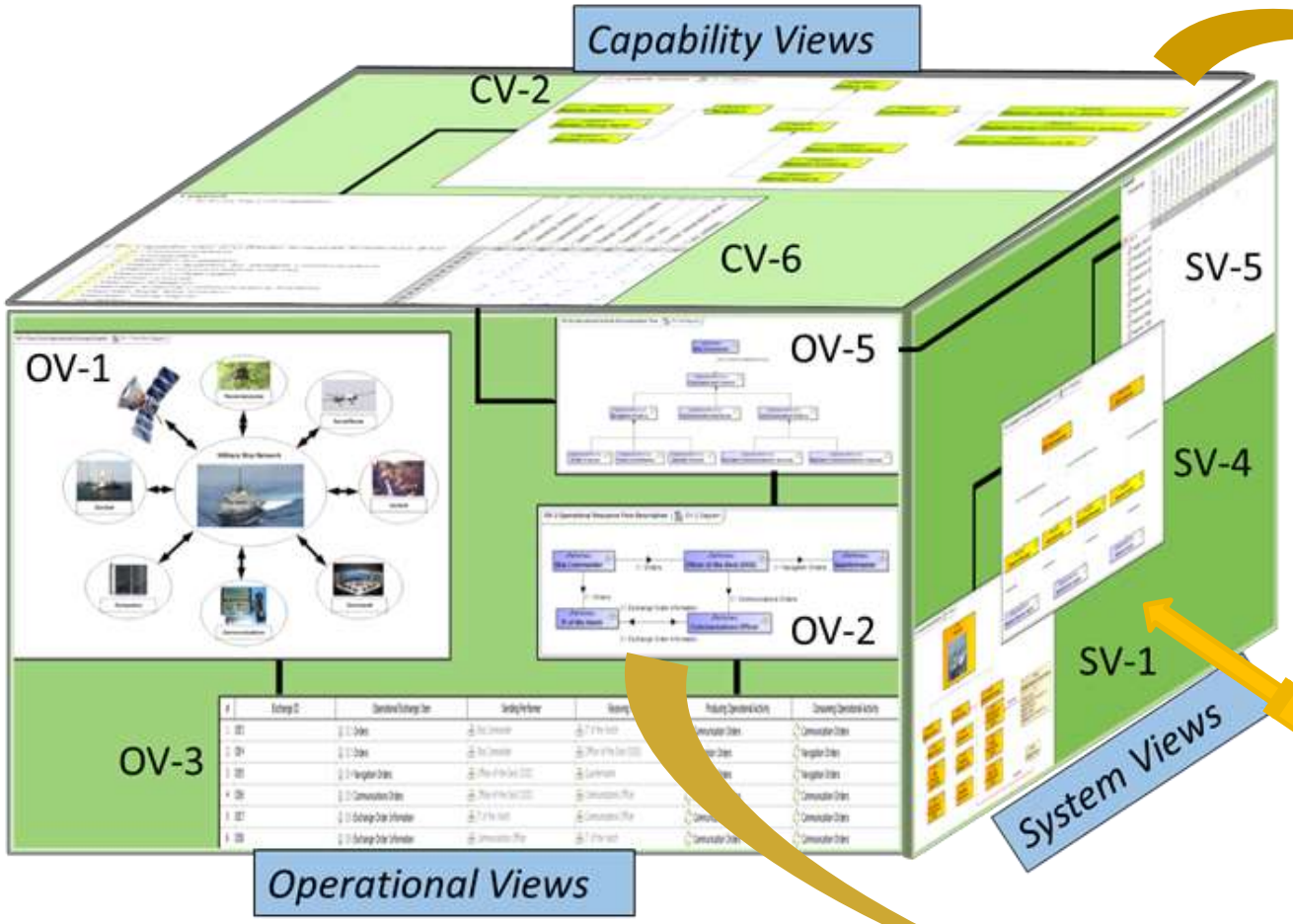
- automated **Verification and Validation** (V&V) and
- **Gap Analysis**

Mapping Enterprise Architecture with Systems of Systems Models

Mapping EA to SoS

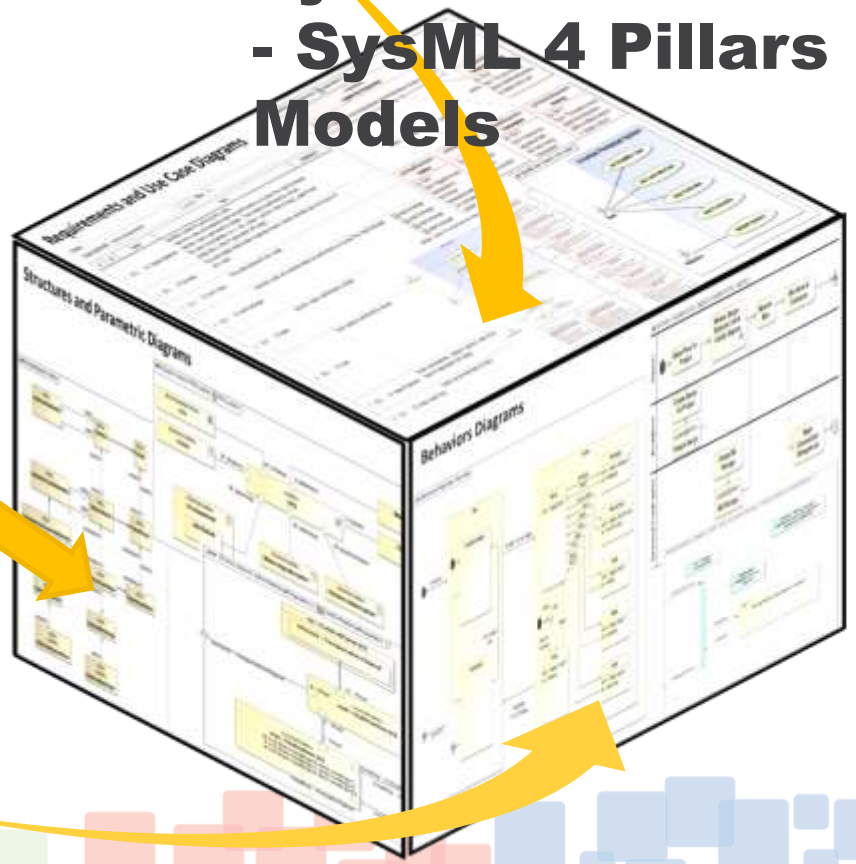
- The illustrations are the correlation on setting up the **EA and SoS in UPDM**
- We have used the mapping from
  - **EA CV with SoS Requirement Diagram**
  - **EA SV / SvcV with SoS Structural Diagram**
  - **EA OV to SoS Behavior Diagram**

Mapping MBSE EA-DoDAF with SoS-SysML

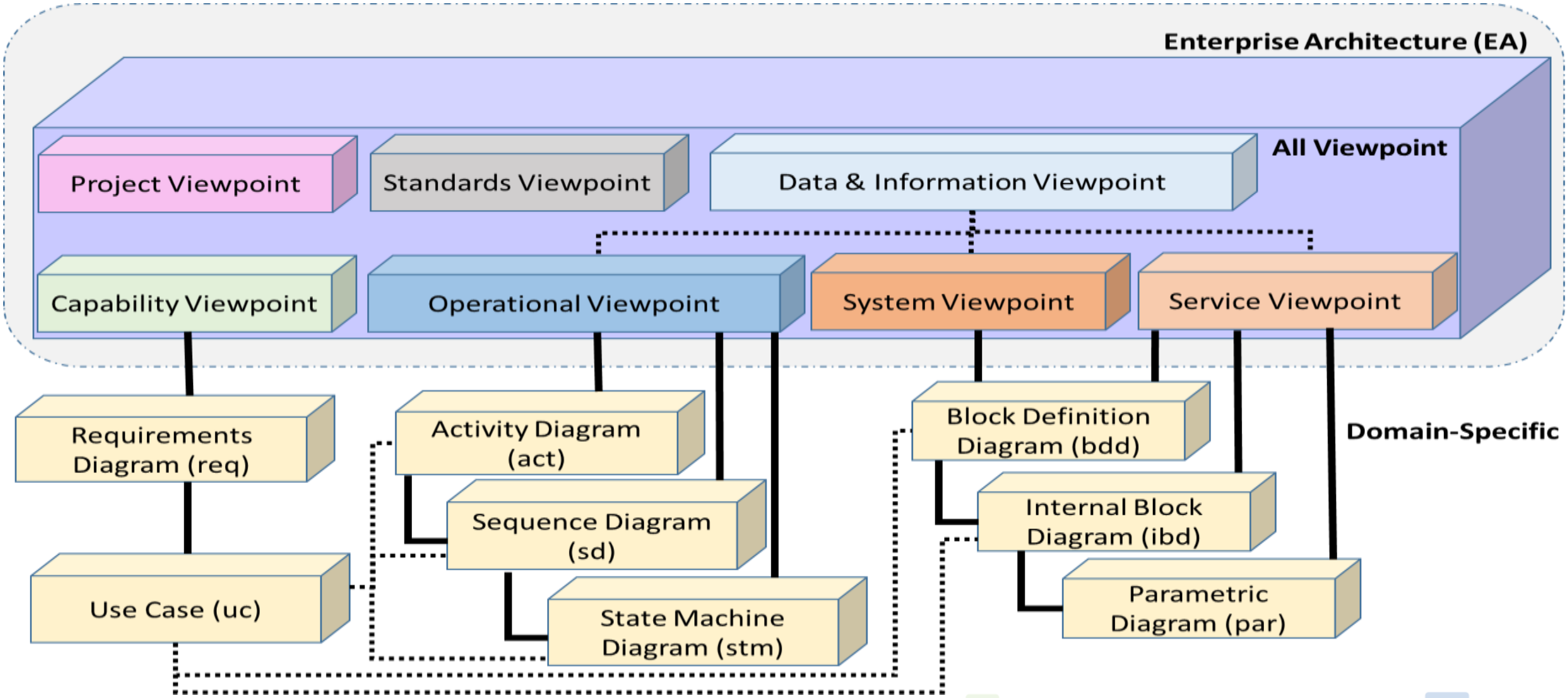


Enterprise Architecture – DoDAF View Models

Systems of Systems - SysML 4 Pillars Models



Respective EA-DoDAF mapping with SoS SysML



Customized Table: Needline-Operation Nodes vs Interface-System Nodes Table

Name	Qualified Name	Role	Part With Port	Role	Part With Port	Sync Element	Refines
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+ADNS 1	: ADNS EQUIPM...	+U PBD - CANES	: PLATFORM BOUNDARY DEFENSE (...	TCP/IP	
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+CANES UNCLASSIFIED	: UNCLASSIFIED ...	+BORDER - ADNS	: C4I PROVIDED BORDER NETWOR...	ETHERNET	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+CANES U	: UNCLASSIFIED ...	+CANES 5 CDS - CANES...	: CANES PROVIDED SECRET CROSS...	FIBER	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+ECDIS	: VMS 3	+AIS TRANSPONDER	: NAV SET TRANSPONDER UNIT 1	SERIAL	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+UNCLASSIFIED DATA CENTER RAC...	: UNCLASSIFIED ...	+UNCLASSIFIED EDGE S...	: UNCLASSIFIED EDGE SWITCH RA...	FIBER	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+NAV SET TRANSPONDER UNIT 1	: NAV SET TRAN...	+TERM BOX UNIT 5	: TERM BOX UNIT 5	WIRE CABLE	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+NAV SET TRANSPONDER UNIT 1	: NAV SET TRAN...	+AS-2809 UNIT 3 VHF ...	: AS-2809 UNIT 3 VHF ANTENNA	SERIAL	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+NAV SET TRANSPONDER UNIT 1	: NAV SET TRAN...	+GPA-017S UNIT 2 GPS...	: GPA-017S UNIT 2 GPS ANTENNA	SERIAL	GFE
...	Systems Viewpoint::SV-2::C4I (SECRET):...	+CANES 5 CDS - CANES U	: CANES PROVID...	+SECRET PRIMARY DAT...	: SECRET PRIMARY DATA CENTER ...	FIBER	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+UPBD 2	: PLATFORM BO...	+C4I U BORDER 2	: C4I PROVIDED BORDER NETWOR...	FIBER	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+UPBD 1 : TCP/IP	: PLATFORM BO...	+C4I U BORDER 1 : TCP...	: C4I PROVIDED BORDER NETWOR...	FIBER	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+UNCLASSIFIED EDGE SWITCH RACK...	: UNCLASSIFIED ...	+AIS DATA DISTRIBUTI...	: AIS DATA DISTRIBUTION LAPTO...	ETHERNET	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+AIS DATA DISTRIBUTION LAPTOP ...	: TERM BOX UNI...	+TERM BOX UNIT 5 PO...	: AIS DATA DISTRIBUTION LAPTO...	SERIAL	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+GPNTS 2	: GPNTS RACK 1 ...	+CANES U	: UNCLASSIFIED DATA CENTER RA...	COAXIAL	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+GPNTS 1	: GPNTS RACK 2 ...	+CANES U	: UNCLASSIFIED DATA CENTER RA...	COAXIAL	GFE
...	Systems Viewpoint::SV-2::C4I (UNCLASS...	+Border - ADNS 2	: C4I PROVIDED ...	+CANES UNCLASSIFIED 2	: UNCLASSIFIED DATA CENTER RA...	ETHERNET	GFE

Object-Oriented Systems Engineering Methodology (OOSEM)

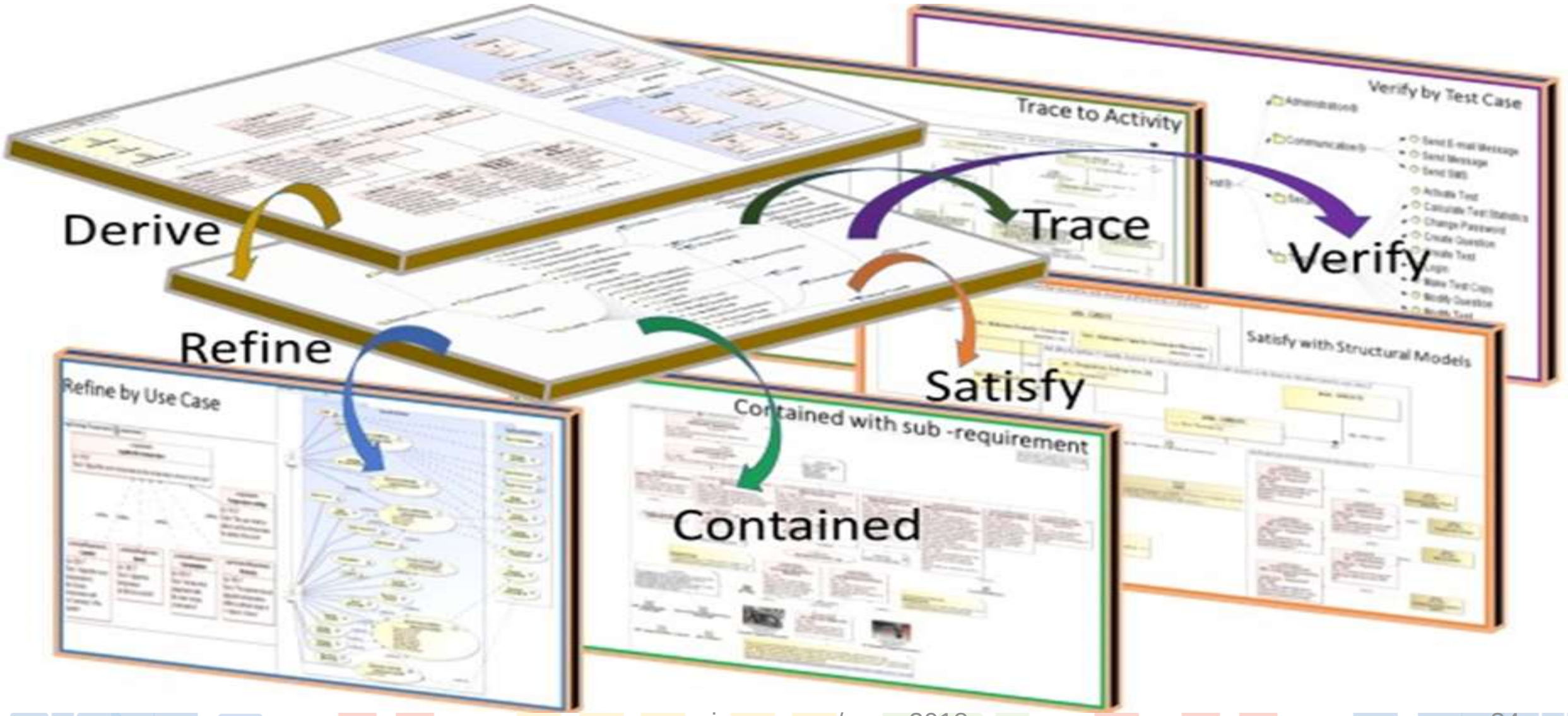
OOSEM Applying in our project

- We used MBSE tool utilizing automated relational database to keep all changes in **ONE single place minimizing complexities with Object-Oriented Systems Engineering Methodology (OOSEM)**
- **OOSEM employs SDLC activities** for stakeholder needs and
  - **system requirements analyses** then
  - result with **logical architectural definitions**
- On analyzing specifications, we can **derive, refine, satisfy, trace** and **verify** a set of concerned artifacts from the requirements that can be evidenced with OOSEM
- With the aid from **Use Case Diagram, we accomplished requirements traceability effectively**.

MBSE SoS REQ Relationships Development

SoS SysML Requirements Diagrams Relationships
Requirement is **contained** with Sub-Requirement
Requirement is **derived** from Super-Requirement
Requirement is **refined** by Use Case Diagram
Requirement is **satisfied** by Block / Activity
Requirement is **activated / responded** by Stakeholder
Requirement is **allocated** to Sub-System or Component
Requirement is **verified** by Test Case
Requirement is **traced** from LL(Algorithms or Codes – Activity / Blocks) to HL (Use Case) or vice versa
Requirement is ***conditioned by ASSUMPTION***
Requirement is ***associated with RISK***
Requirement is ***resulted from TRADE-OFF***
Requirement is ***supported by RATIONALE***

All MBSE SysML Requirements Relationships



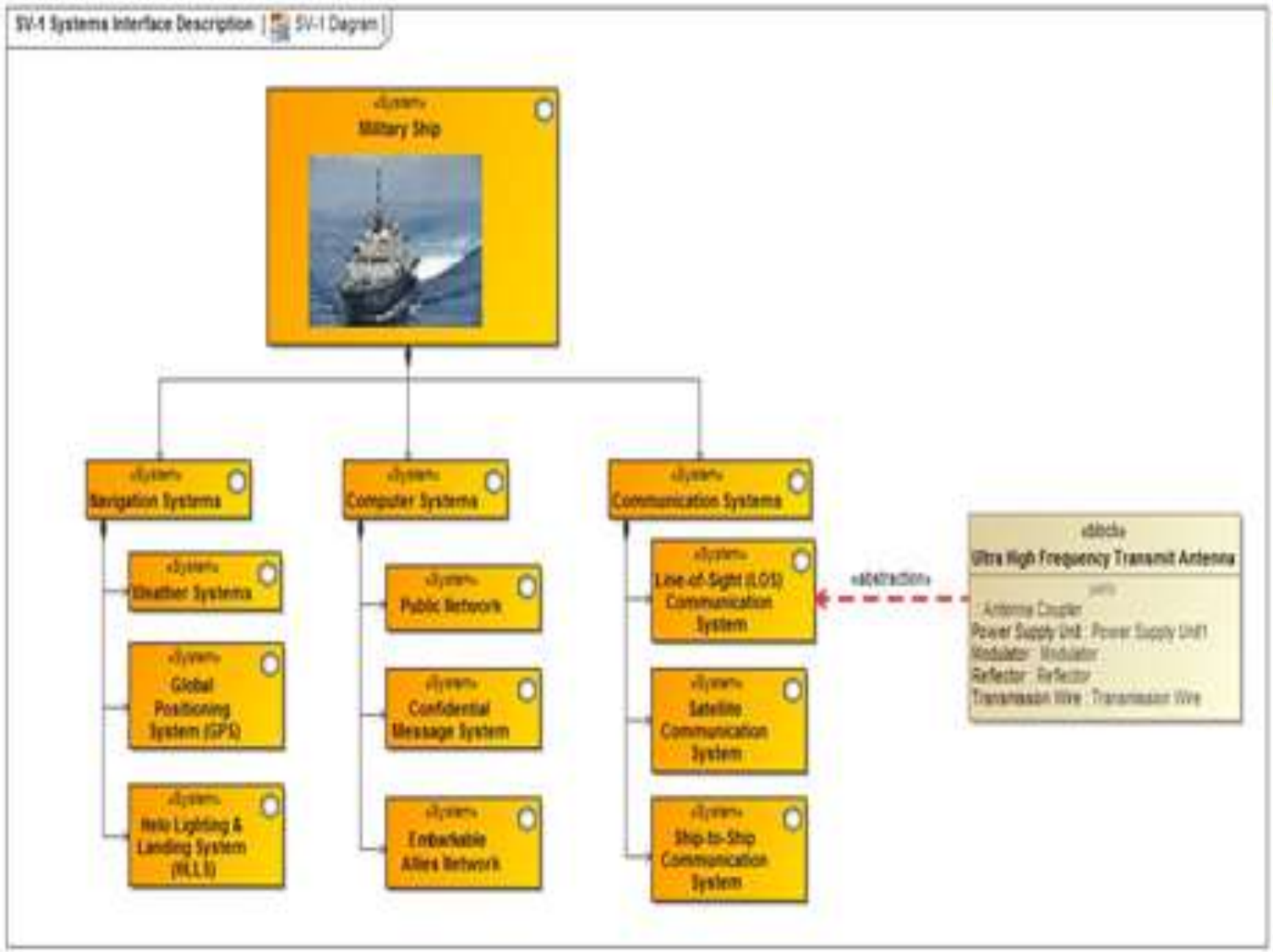
OOSEM Activities

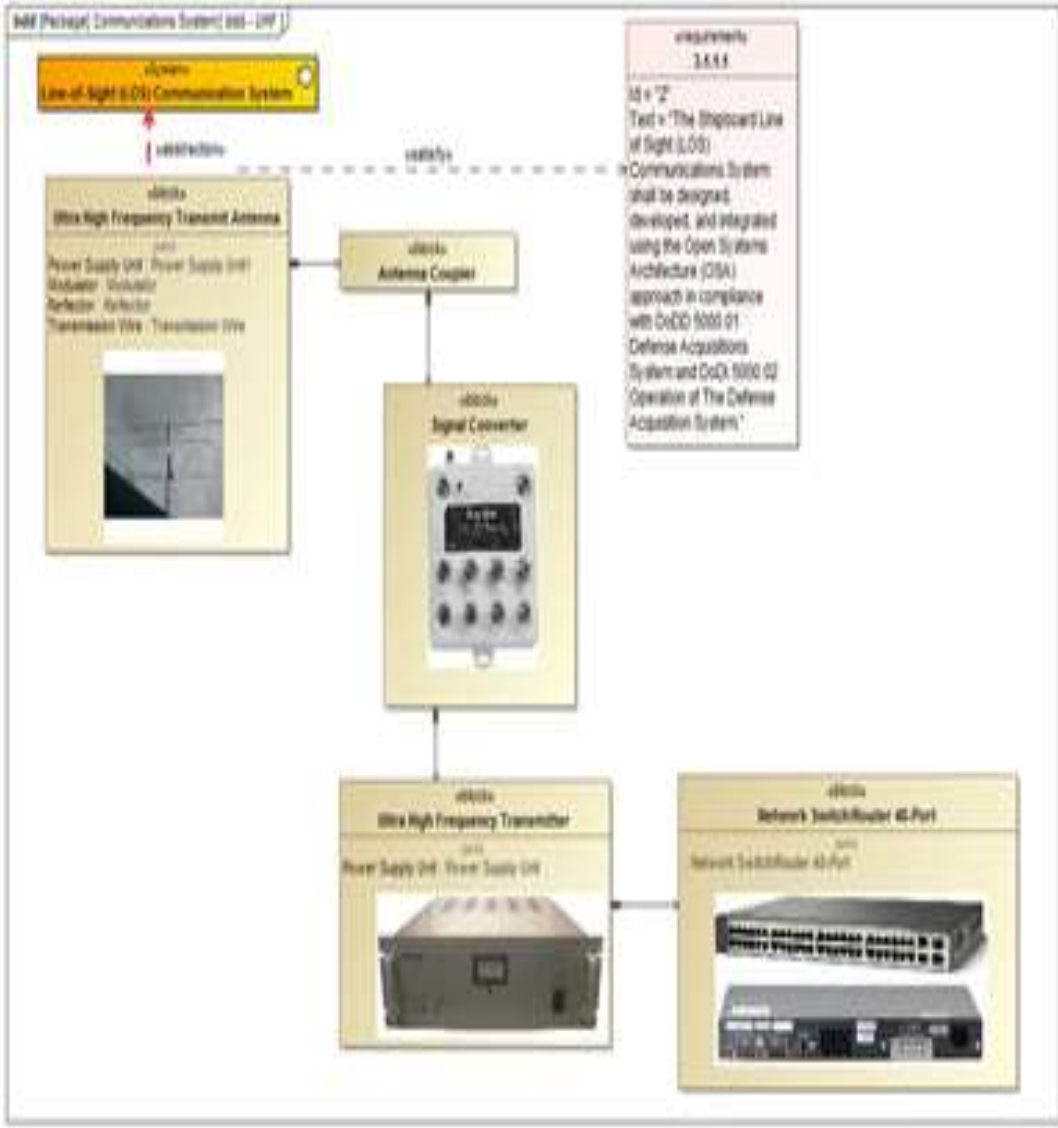
OOSEM Life Cycle Activities

	Analyze stakeholder needs	Analyze system requirements	Define logical architecture
Set up model : organize the model			
Identify project stakeholder	X		
Specify mission requirements	X		
Define enterprise use cases	X		
Define to-be-domain BDDs	X		
Define mission scenarios		X	
Capture critical system properties and constraints		X	
Define system context		X	
Specify black-box system requirements		X	
Define system state machine		X	
Define logical decomposition			X
Define interaction between logical components to realize each system action an / or operation			X
Define system logical IBD			X

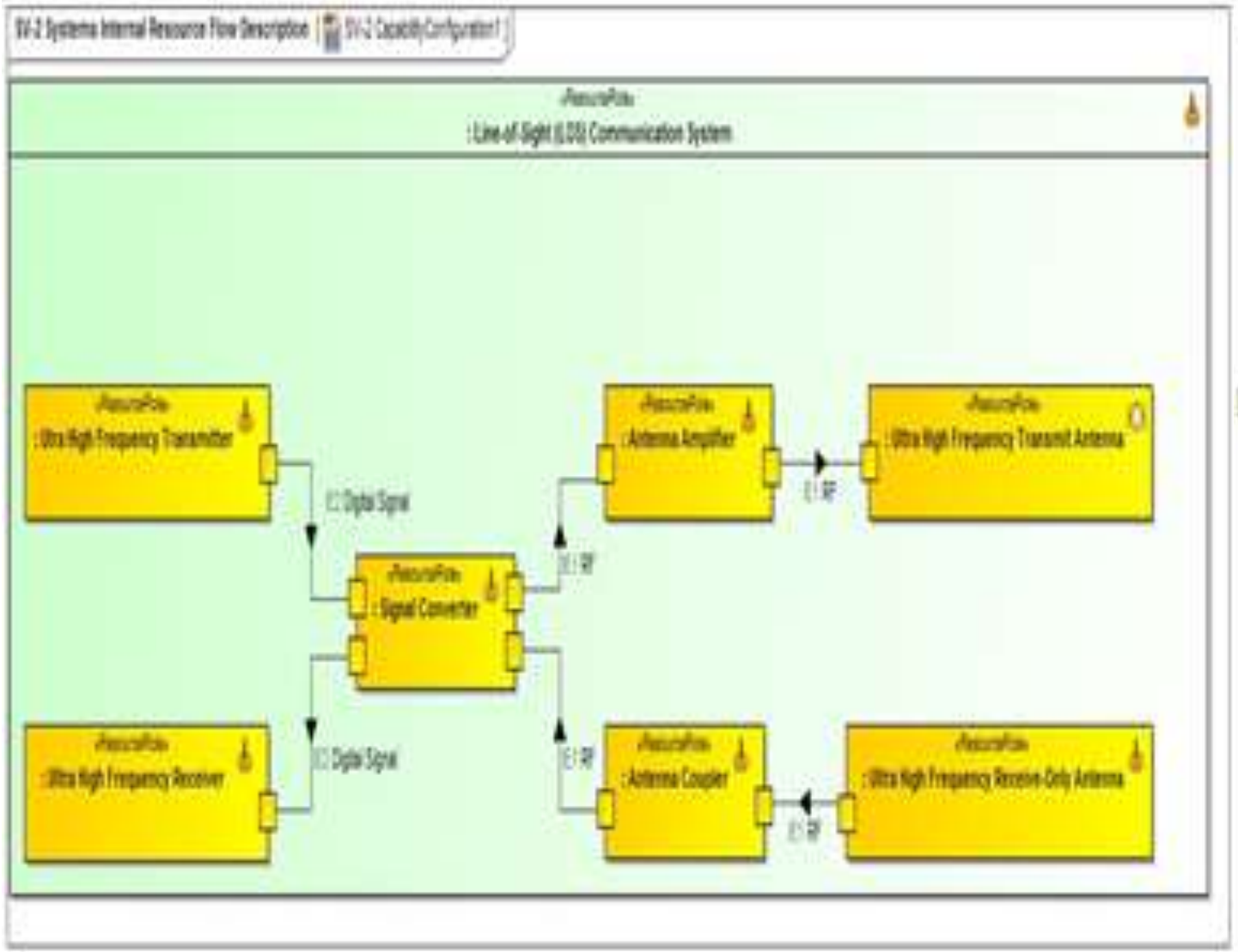
Auto-generating Interface Control Document (ICD)

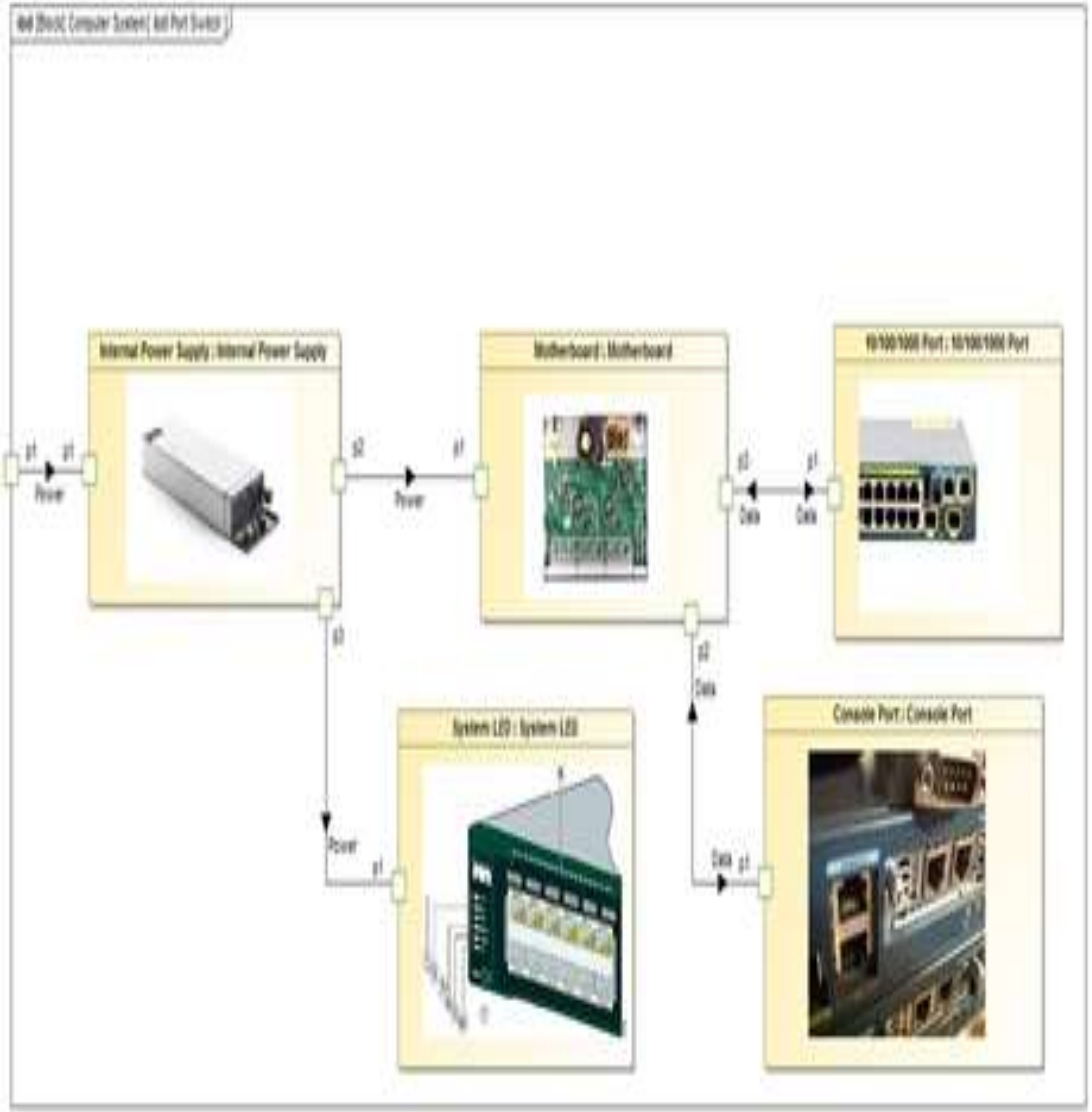
EA DoDAF SV-1 vs SoS SysML BDD





EA DoDAF SV-2 vs SoS SysML IBD





MBSE auto-generated ICD

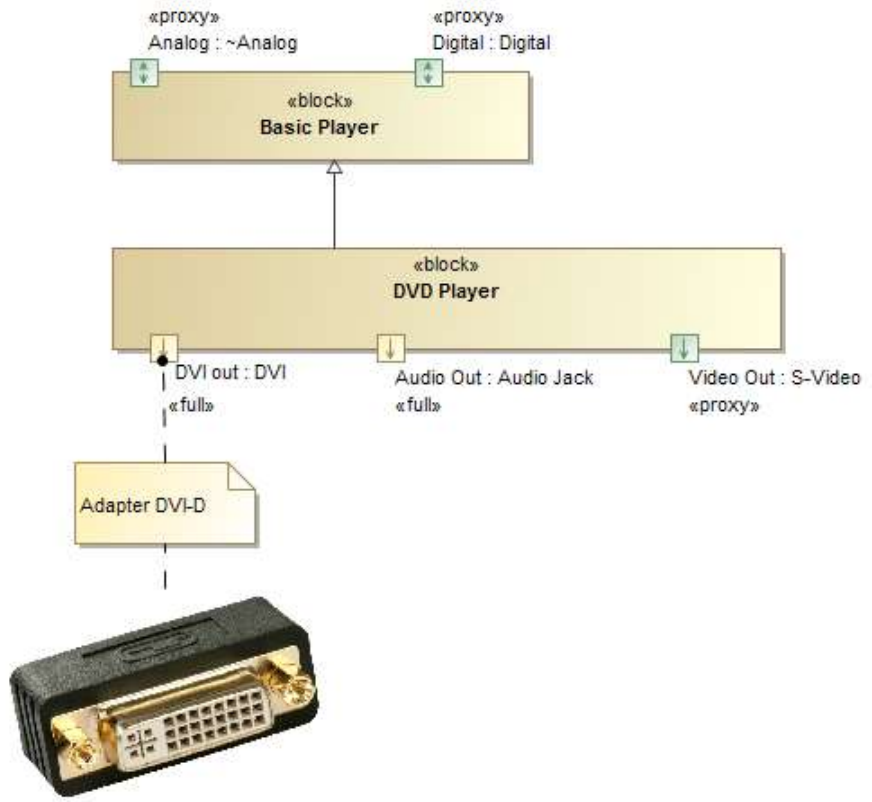
- The diagrams below are simulated MBSE Interface Control Document (ICD) that we have tried in our project to generate
  - a **Blackbox ICD table from BDD** and
  - **a Whitebox ICD table from IBD automatically** with MagicDraw CAMEO 14.5.
- Due to ITAR limitations, we can only use the MagicDraw samples to illustrate that we can complete an automatic ICD generation starting from EA SV-1 mapping with BDD and flow down to ICD of specific domain then complete the ICD.
- Actually, the BDD & ICD are structural models satisfied from the requirements, originated from EA CV-2

Blackbox ICD table from BDD

Criteria

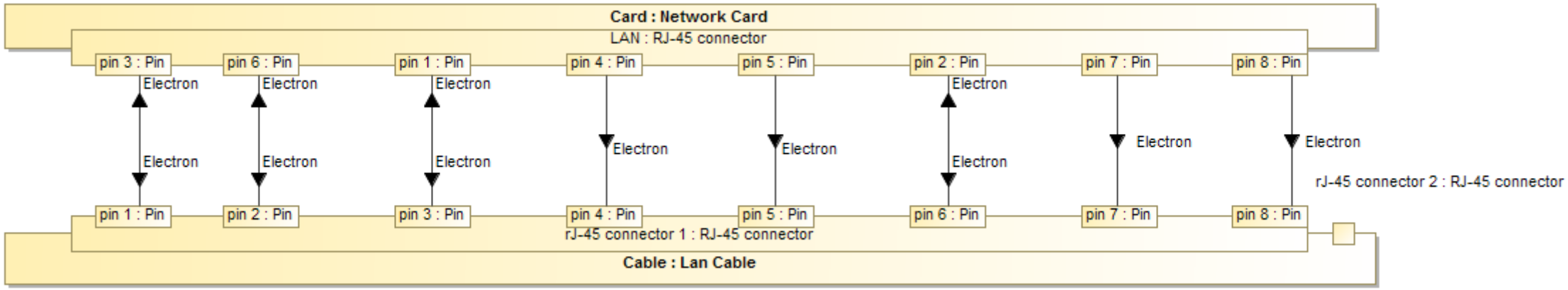
Element Type: Port ... Block: DVD Player

#	~ ^	Name	Type	Type Features	Direction	Documentation
1		Audio Out	Audio Jack	out Audio : Digital Audio Signal	out	
2		DVI out	DVI	out Video out : Digital Video Signal	out	
3		Video Out	S-Video	out Video : Analog Video Signal	out	
4	~ ^	Analog	Analog	inout Video	inout	
5	^	Digital	Digital	inout Video	inout	



https://blog.nomagic.com/model-based-interface-control-documents-icd/

Whitebox ICD Table from IBD



#	Part A	Port A	Flow item	Port B	Part B
1	LAN : RJ-45 connector	pin 1 : Pin	Electron	pin 3 : Pin	rJ-45 connector 1 : RJ-45 connector
2	LAN : RJ-45 connector	pin 2 : Pin	Electron	pin 6 : Pin	rJ-45 connector 1 : RJ-45 connector
3	LAN : RJ-45 connector	pin 3 : Pin	Electron	pin 1 : Pin	rJ-45 connector 1 : RJ-45 connector
4	LAN : RJ-45 connector	pin 4 : Pin	Electron	pin 4 : Pin	rJ-45 connector 1 : RJ-45 connector
5	LAN : RJ-45 connector	pin 5 : Pin	Electron	pin 5 : Pin	rJ-45 connector 1 : RJ-45 connector
6	LAN : RJ-45 connector	pin 6 : Pin	Electron	pin 2 : Pin	rJ-45 connector 1 : RJ-45 connector
7	LAN : RJ-45 connector	pin 7 : Pin	Electron	pin 7 : Pin	rJ-45 connector 1 : RJ-45 connector
8	LAN : RJ-45 connector	pin 8 : Pin	Electron	pin 8 : Pin	rJ-45 connector 1 : RJ-45 connector

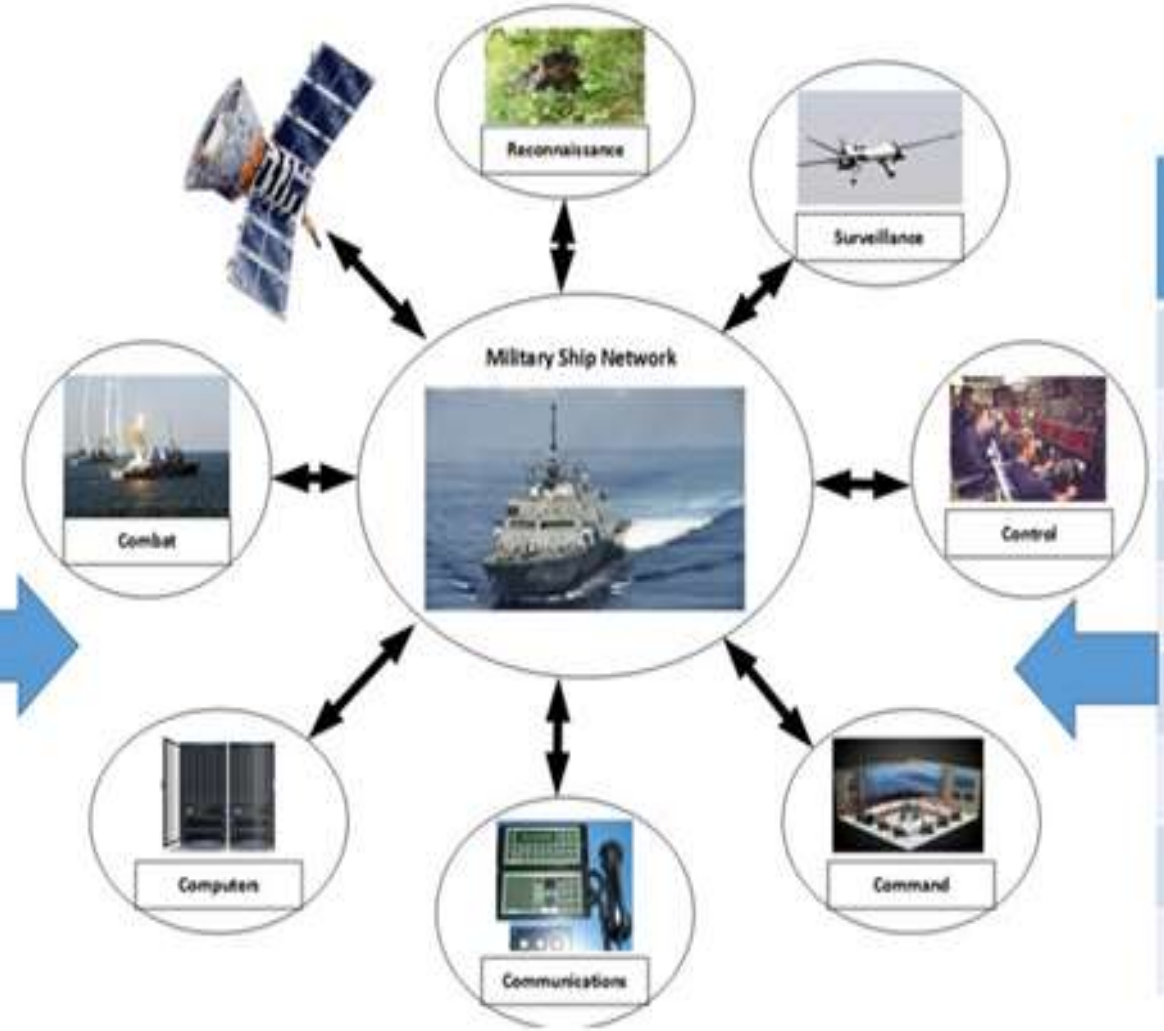
https://blog.nomagic.com/model-based-interface-control-documents-icd/

Analyzing Performance Parametric

Simulated-Simplified Frigate C6ISR Example

ICD

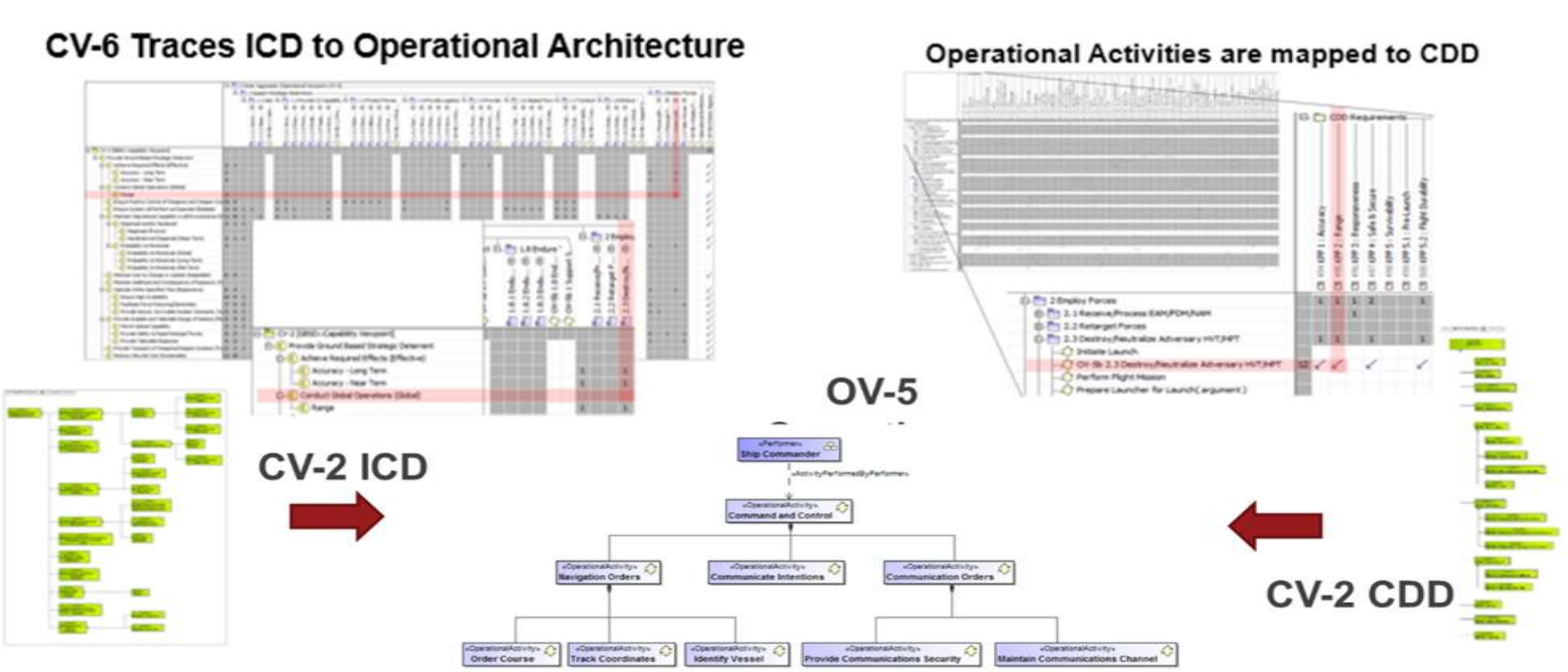
Capability	Initial Capability Description
Adaptable	Minimize Cost to Change or Update
Effective	Achieved Required Effects
Flexible	Provide Scalable and Tailorable Range of Options
Reliable	Ensure System will Perform as Expected
Responsive	Operate within Specified Time
Secure	Ensure Positive Control of Weapons and Weapon System
Survivable	Maintain Operational Capability in all Environments
Sustainable	Reduce Lifecycle Cost



CDD

KSA	KPP	Capability Development Document
KSA		Weapon Systems Reliability
KSA		Flexibility
KSA		Rapid Retargeting
KSA		Multiple Execution Plans
	KPP	Net Ready
	KPP	Survivability
	KPP	Responsiveness
	KPP	Accuracy

Correlate CV-2 with OV-5a to Generate CV-6



Lessons Learned

- **Data sharing** from EA to SoS that can be globally distributed from Data Information View (DIV): **DIV-1 Conceptual Model, DIV-2 Logical Model & DIV-3 Physical Model from DoDAF perspective in UPDM**
- The **integrity of any complex systems on exchanging information from EA to SoS can be mapped.**
- **Design Structure Matrix (DSM) and N2 chart** that can be analyzed in MBSE tool to determine coupling and cohesiveness between **components connectivity for modularity integration**.
- Regarding **model usage, impact, coverage and gap analysis, trade studies, behavioral simulations**, testing, code generation, and more can be performed for prototyping, live-virtual-constructive simulations, **performance optimizations for decision analysis**

Future Directions

- Based on the results of this project study, we can apply Systems Engineering Principles: SE Processes and V-Model to accomplish modeling any complex systems with MBSE methodologies and INCOSE-OMG compliant MBSE UPDM-SysML tools effectively from As-Is to To-Be and Future Digital Engineering: manufacturing integrated product, components and parts with digital twin, digital thread, Artificial Intelligence and Virtual Reality robotics.
- Cloud data storing and distributing with quantum computing worth for future infrastructure improvement consideration.
- The full spectrum of MBSE is model-centric to complete from Enterprise Architecture framework, via the Systems of Systems engineering life cycle, systems / network on-a-chip until product lifecycle management using Product Lifecycle Management (PLM).

Conclusions

- During this project, engaging **MBSE has provided proficient methodologies with less risk,** MBSE tool provides **dynamic relation maps, dependency matrices, generic tables and model metrics.**
- MBSE also generate **decision analysis output including model reviews, live document generation**, impact analysis, coverage analysis, automated requirements verifications, trade studies, behavioral simulations, testing, UI-Mock-ups as well as code generation.
- **Design decisions** are made by modelers based on iteratively changing management situations, tightening project status tracking, and meticulously ensuring specification completeness and **consistency helped to highlight defects** in early phases of product development.
- **In summary, digital engineering models of complex systems using MBSE tool and methodology allows EA structures to be treated as SoS architectures and SDLC models**
- **Our project is demonstrated to be an effective and cost efficient achievement without abandoning proven SE principles**

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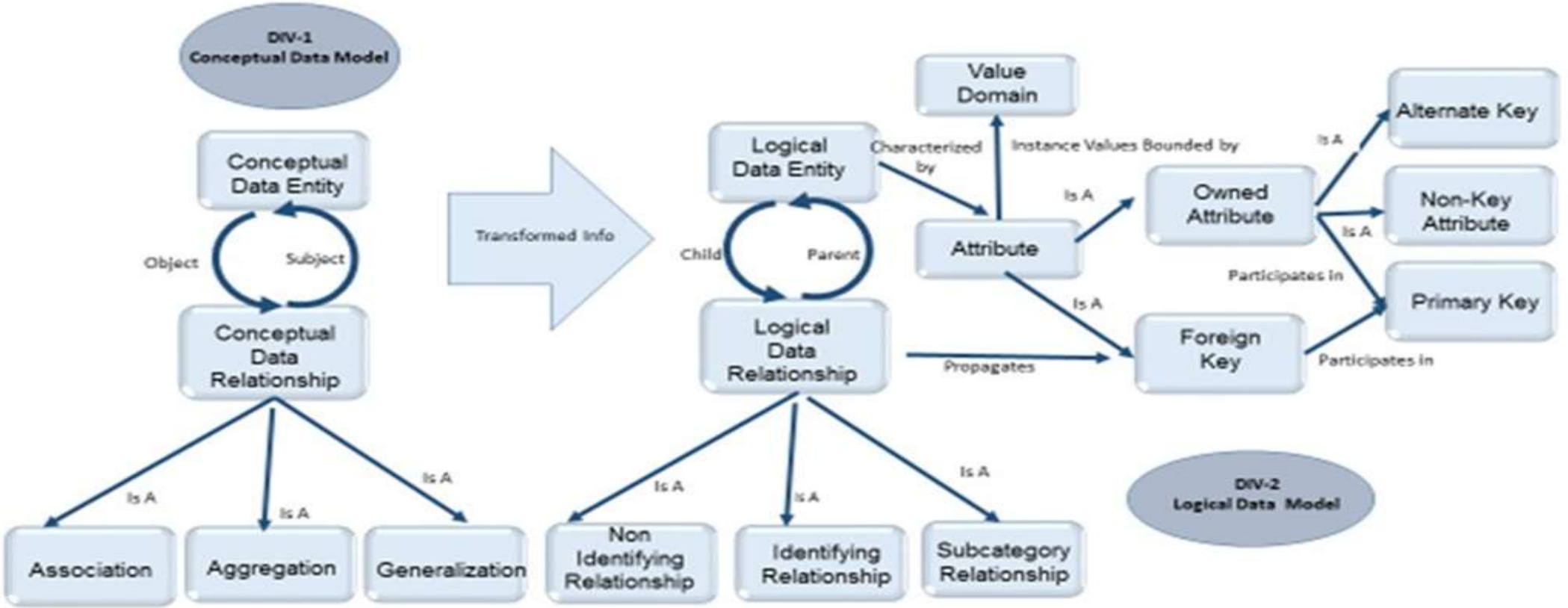
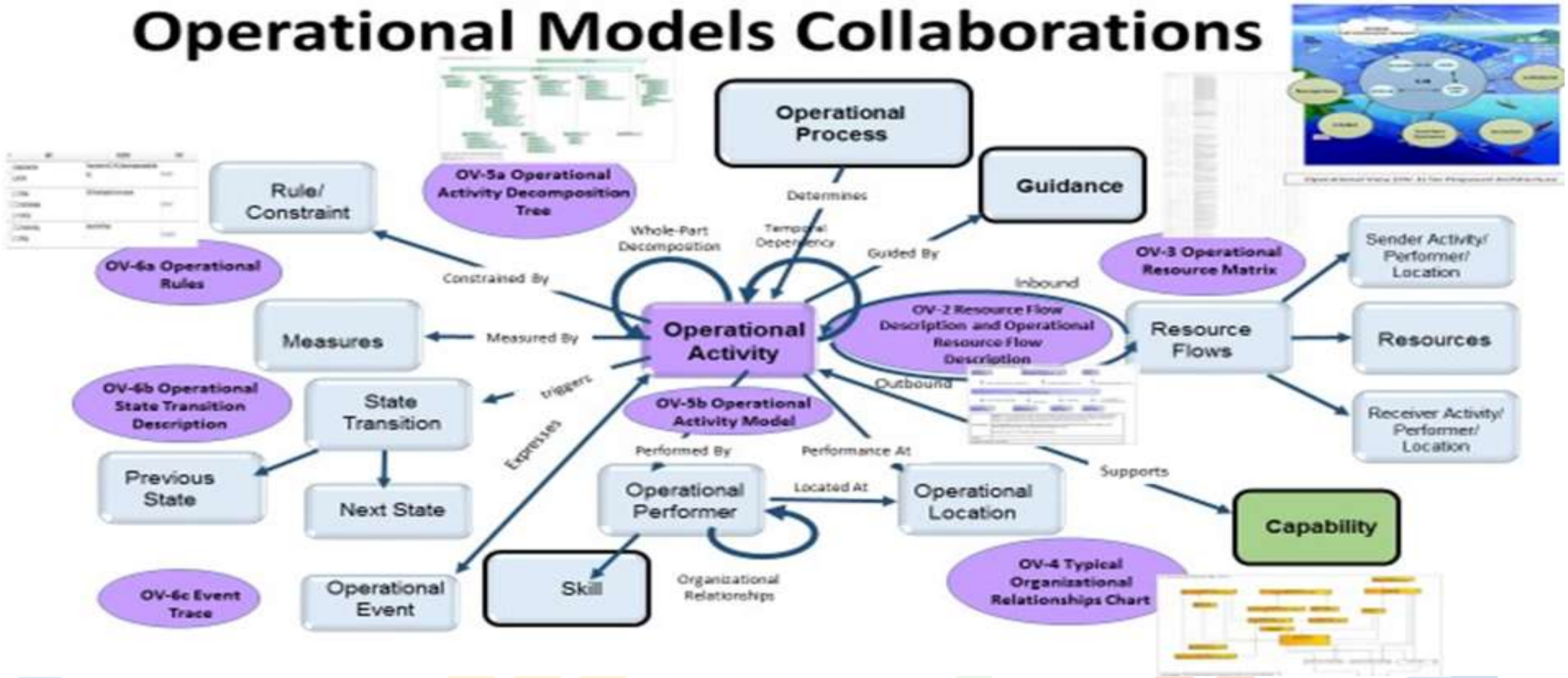
Back Ups

Data & Information Models Collaborations

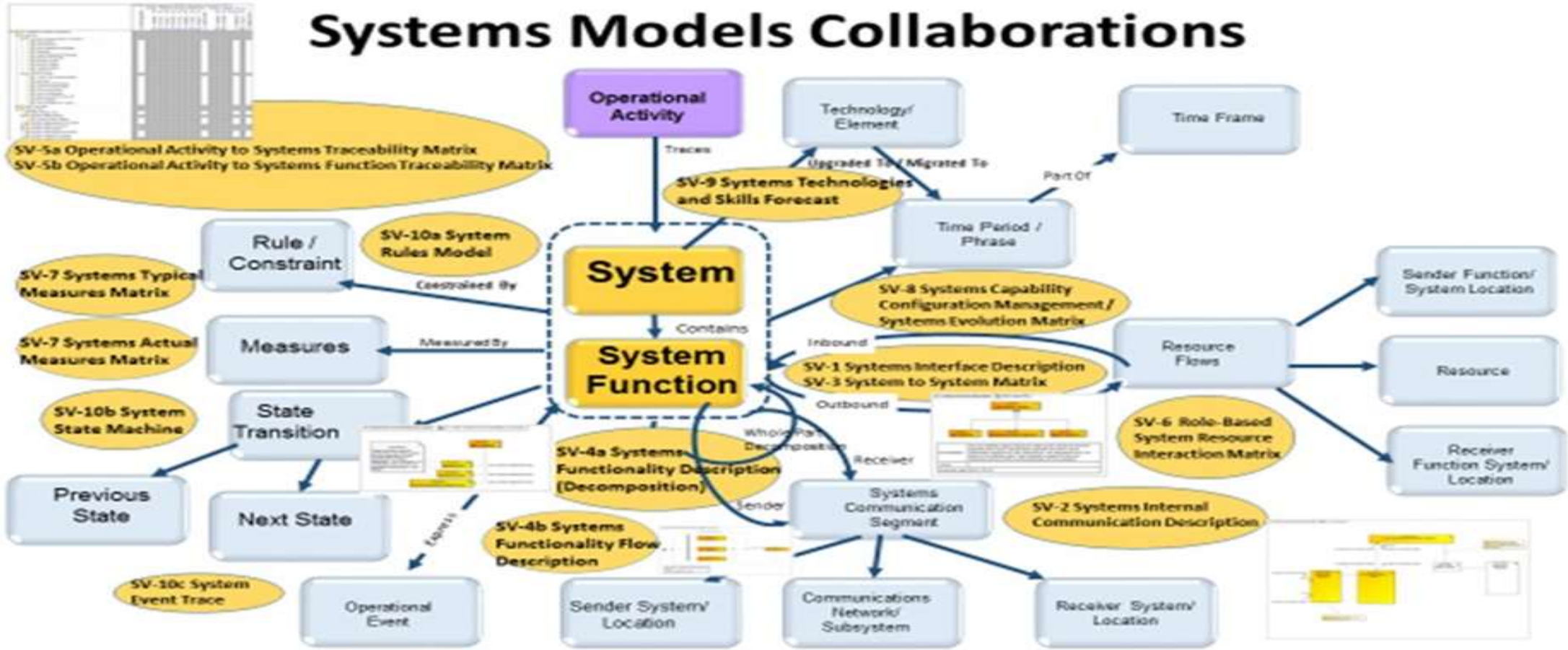


Capability Models Collaborations

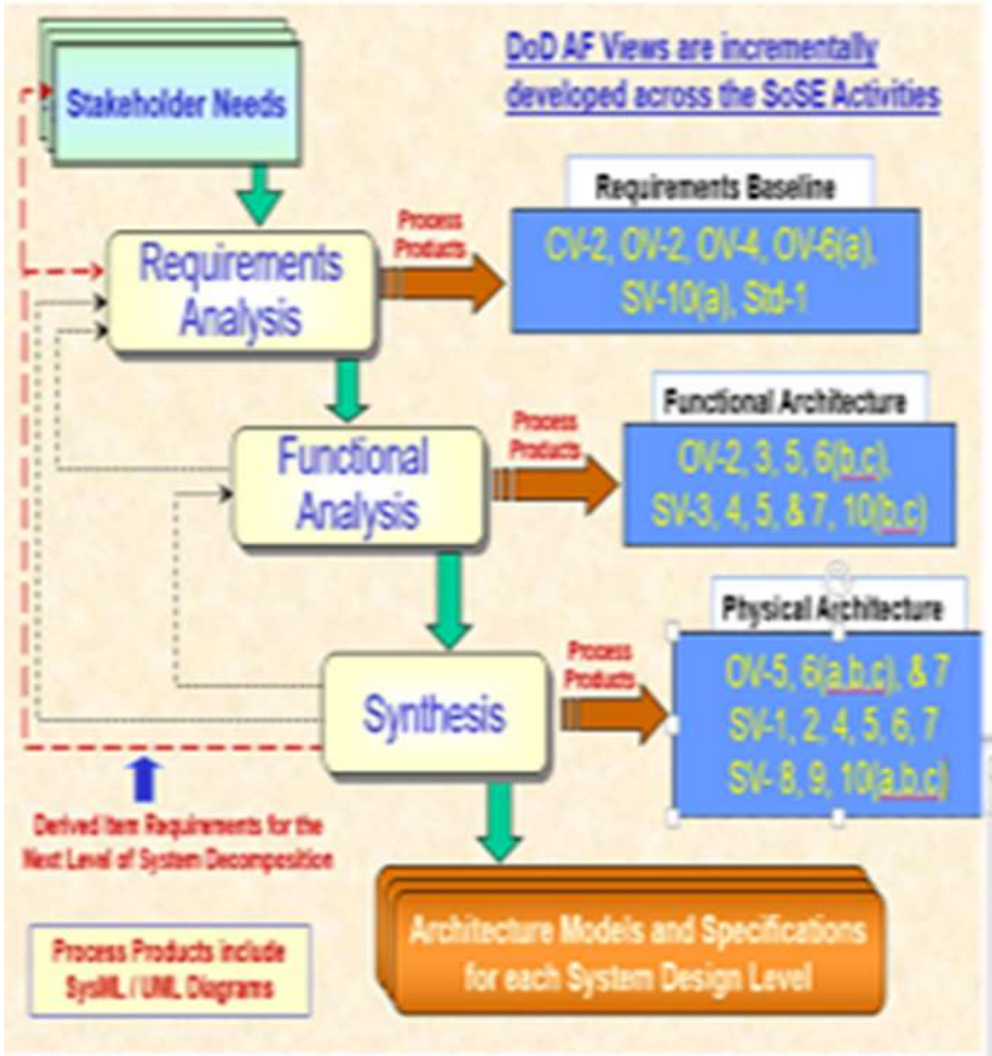
Operational Models Collaborations

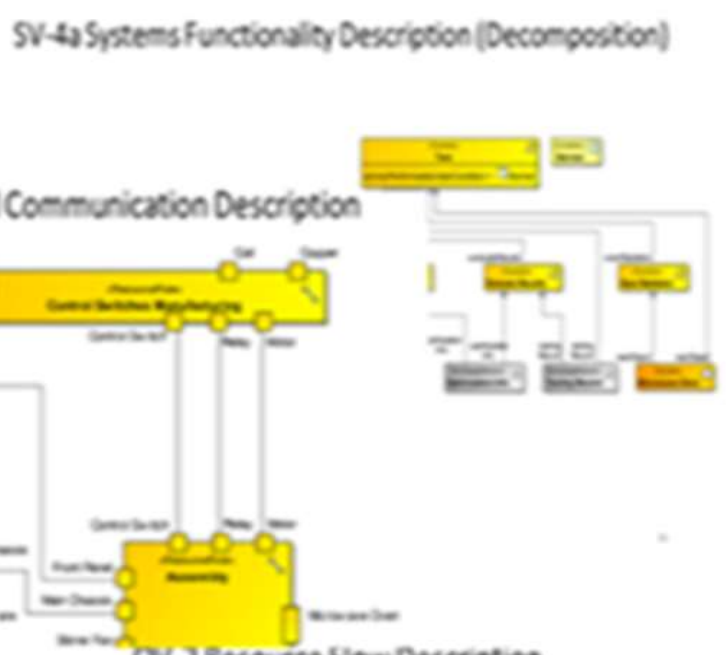


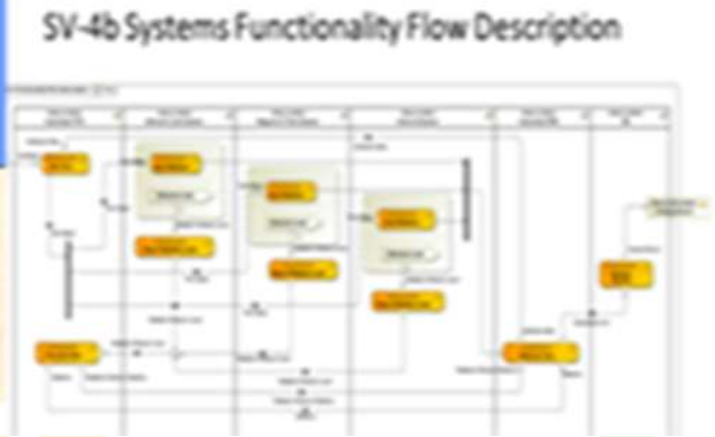
Systems Models Collaborations



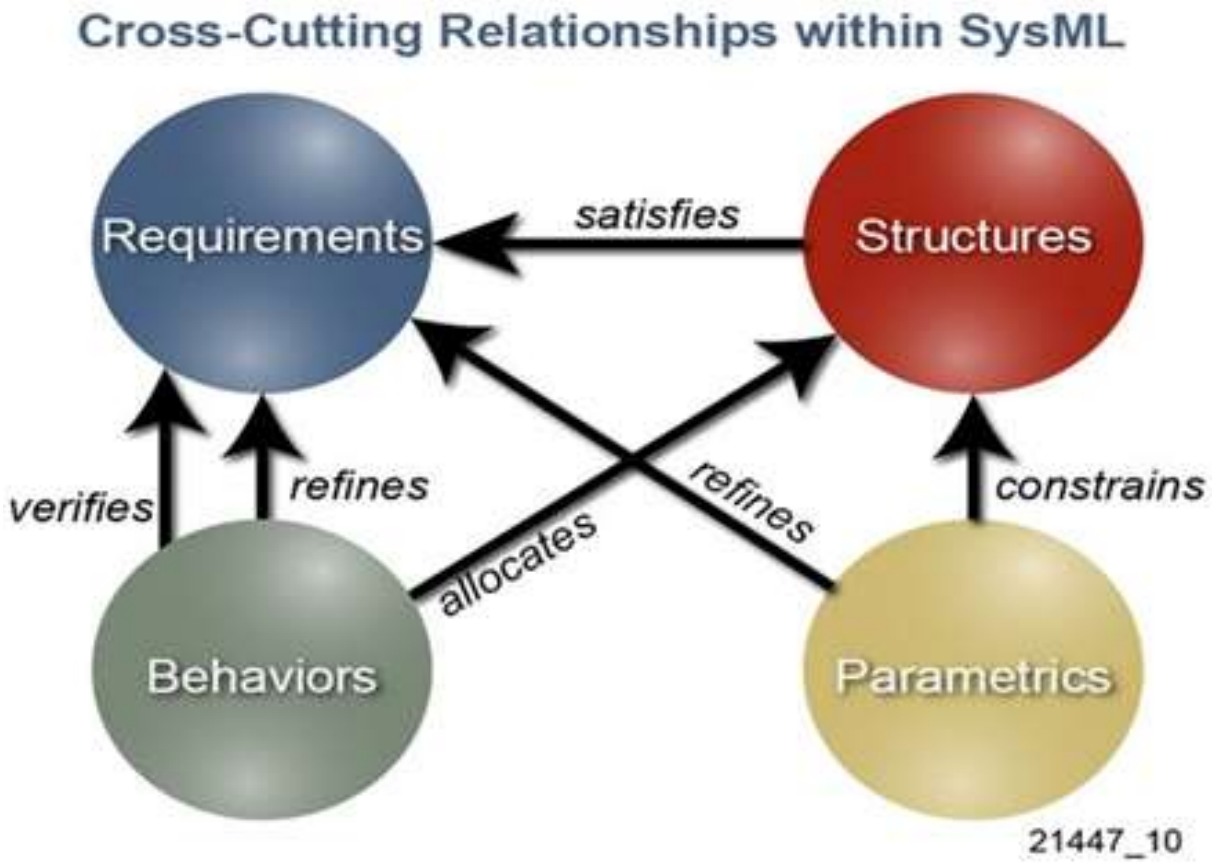
The System Development Process in MBSE EA – DoDAF views



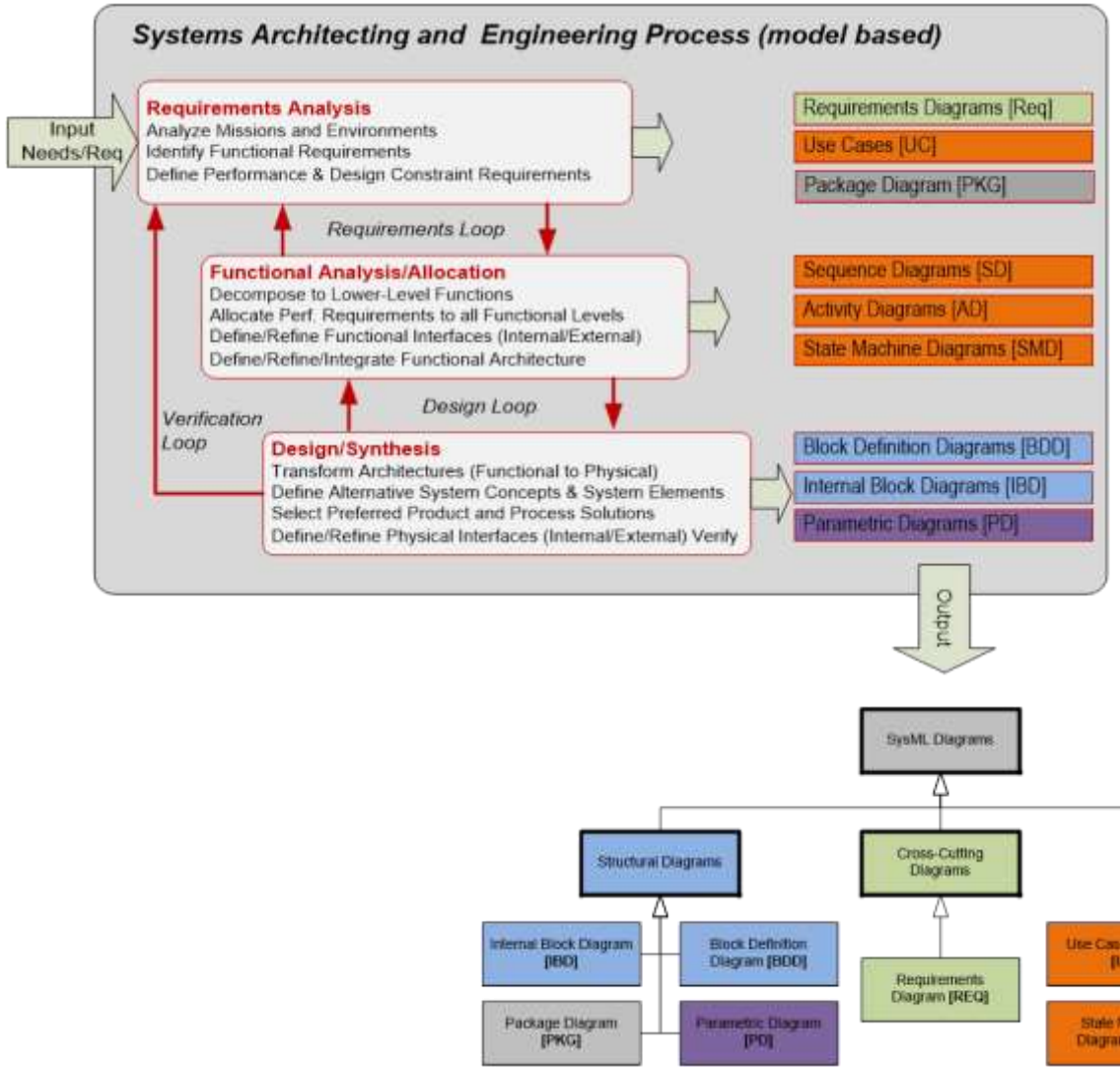


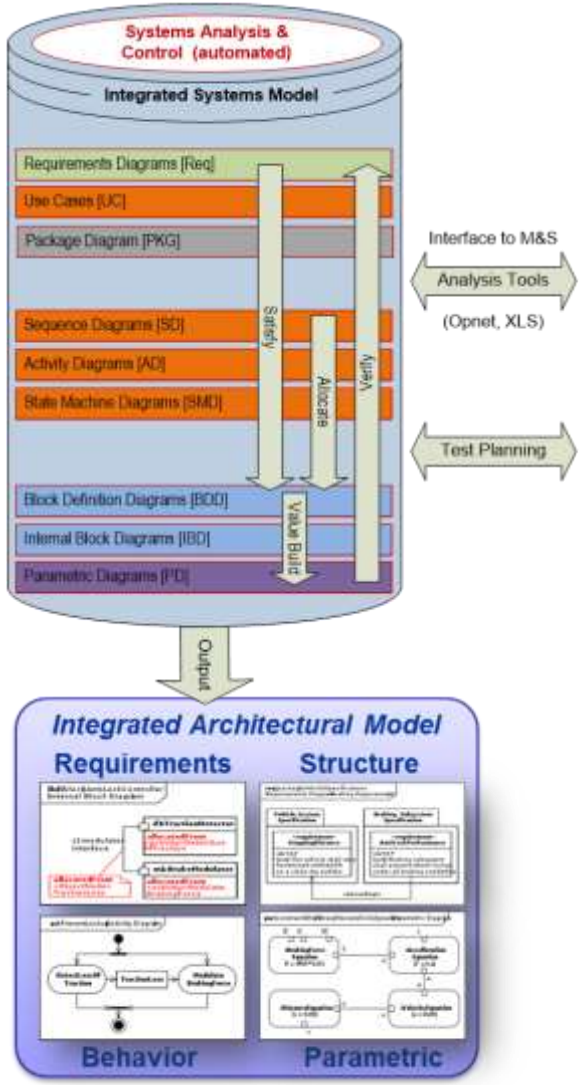


MBSE SoS – SysML



The System Development Process in MBSE SoS





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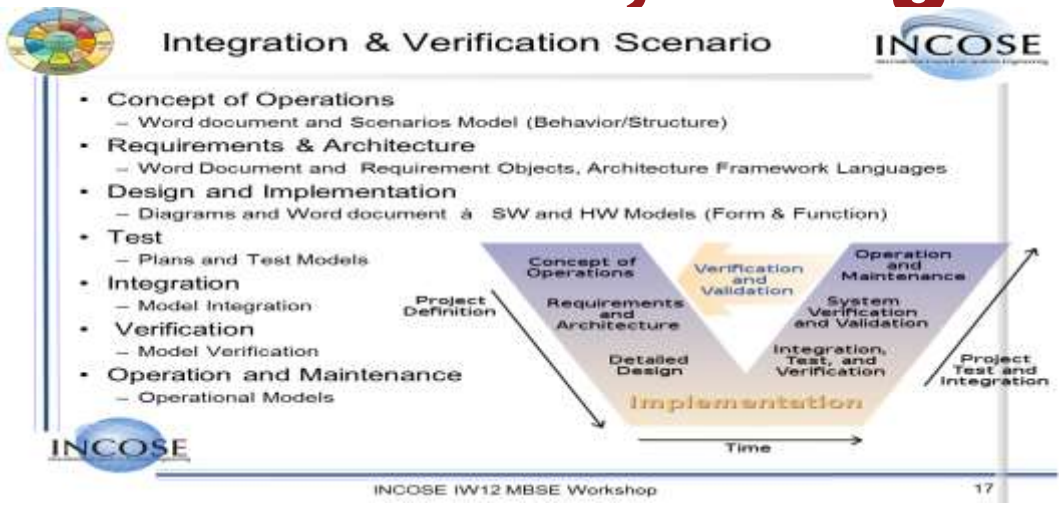

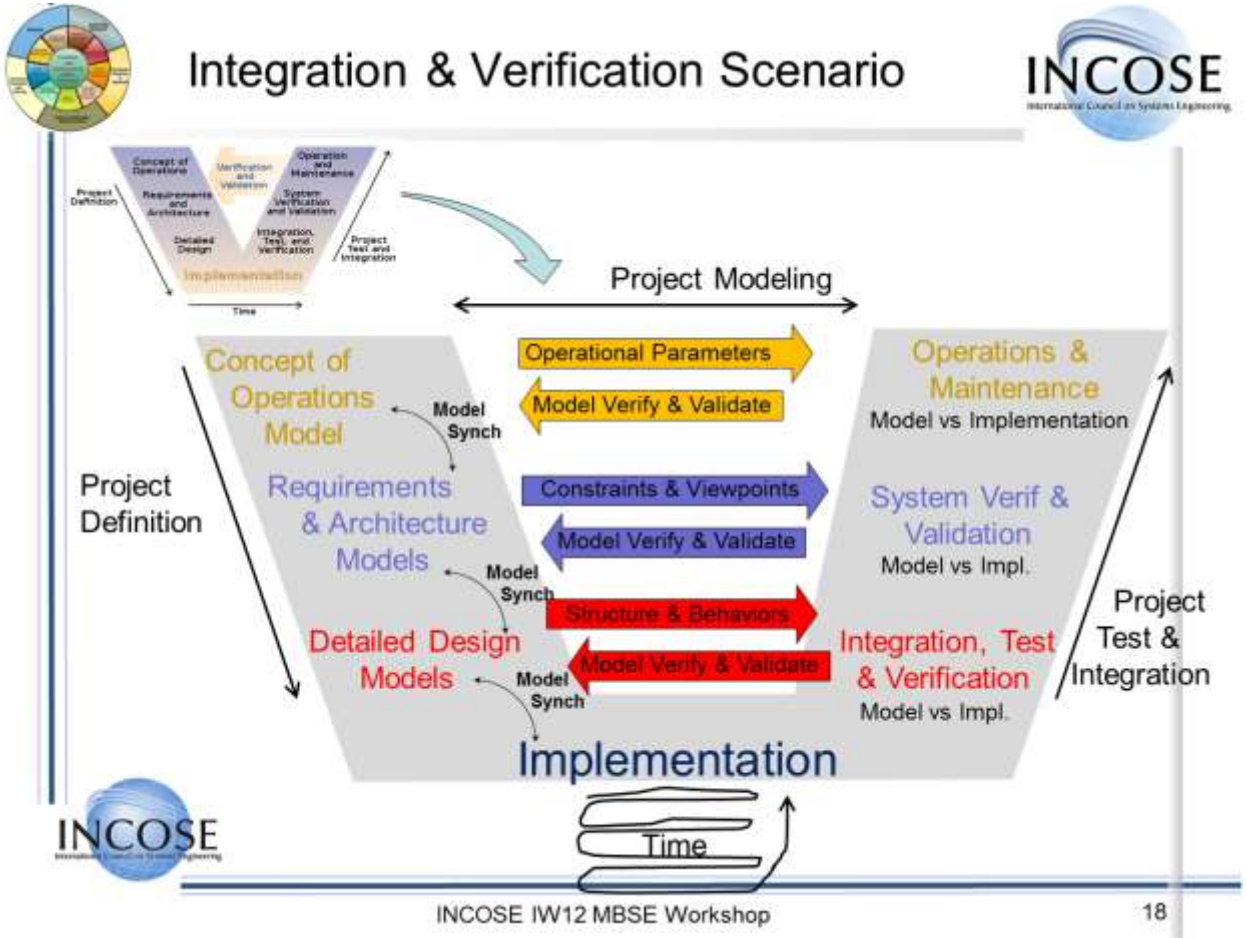

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The Zachman Framework for Enterprise Architecture™

The Enterprise Ontology™

Version 3.0

Classification Names / Audience Perspectives	What	How	Where	Who	When	Why	Classification Names / Model Names
Executive Perspective (Business Context Planners)	Inventory Identification List: Inventory Types	Process Identification List: Process Types	Distribution Identification List: Distribution Types	Responsibility Identification List: Responsibility Types	Timing Identification List: Timing Types	Motivation Identification List: Motivation Types	Scope Contexts (Scope Identification Lists)
Business Mgmt Perspective (Business Concept Owners)	Inventory Definition Business Entity Business Relationship	Process Definition Business Transform Business Input/Output	Distribution Definition Business Location Business Connection	Responsibility Definition Business Role Business Work Product	Timing Definition Business Interval Business Moment	Motivation Definition Business End Business Means	Business Concepts (Business Definition Models)
Architect Perspective (Business Logic Designers)	Inventory Representation System Entity System Relationship	Process Representation System Transform System Input /Output	Distribution Representation System Location System Connection	Responsibility Representation System Role System Work Product	Timing Representation System Interval System Moment	Motivation Representation System End System Means	System Logic (System Representation Models)
Engineer Perspective (Business Physics Builders)	Inventory Specification Technology Entity Technology Relationship	Process Specification Technology Transform Technology Input /Output	Distribution Specification Technology Location Technology Connection	Responsibility Specification Technology Role Technology Work Product	Timing Specification Technology Interval Technology Moment	Motivation Specification Technology End Technology Means	Technology Physics (Technology Specification Models)
Technician Perspective (Business Component Implementers)	Inventory Configuration Tool Entity Tool Relationship	Process Configuration Tool Transform Tool Input /Output	Distribution Configuration Tool Location Tool Connection	Responsibility Configuration Tool Role Tool Work Product	Timing Configuration Tool Interval Tool Moment	Motivation Configuration Tool End Tool Means	Tool Components (Tool Configuration Models)
Enterprise Perspective (Users) The Enterprise	Inventory Instantiations Operations Entities Operations Relationships	Process Instantiations Operations Transforms Operations In/Outputs	Distribution Instantiations Operations Locations Operations Connections	Responsibility Instantiations Operations Roles Operations Work Products	Timing Instantiations Operations Intervals Operations Moments	Motivation Instantiations Operations Ends Operations Means	Operations Instances (Implementations) The Enterprise
Audience Perspectives / Enterprise Names	Inventory Sets	Process Flows	Distribution Networks	Responsibility Assignments	Timing Cycles	Motivation Intentions	

Composite Integrations ⟶ ⟵ Alignment ⟶ ⟵ Composite Integrations

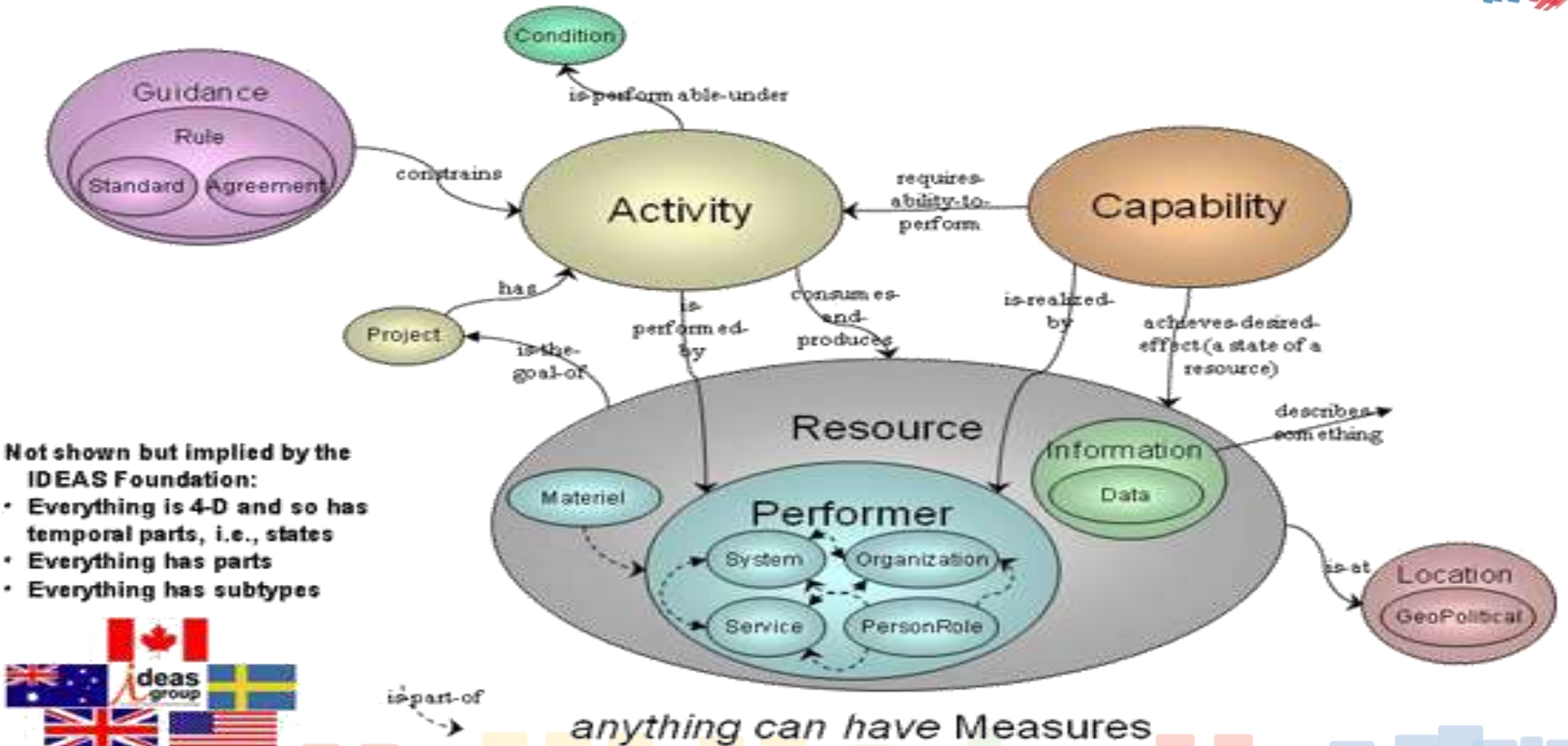
Attribute Transformations

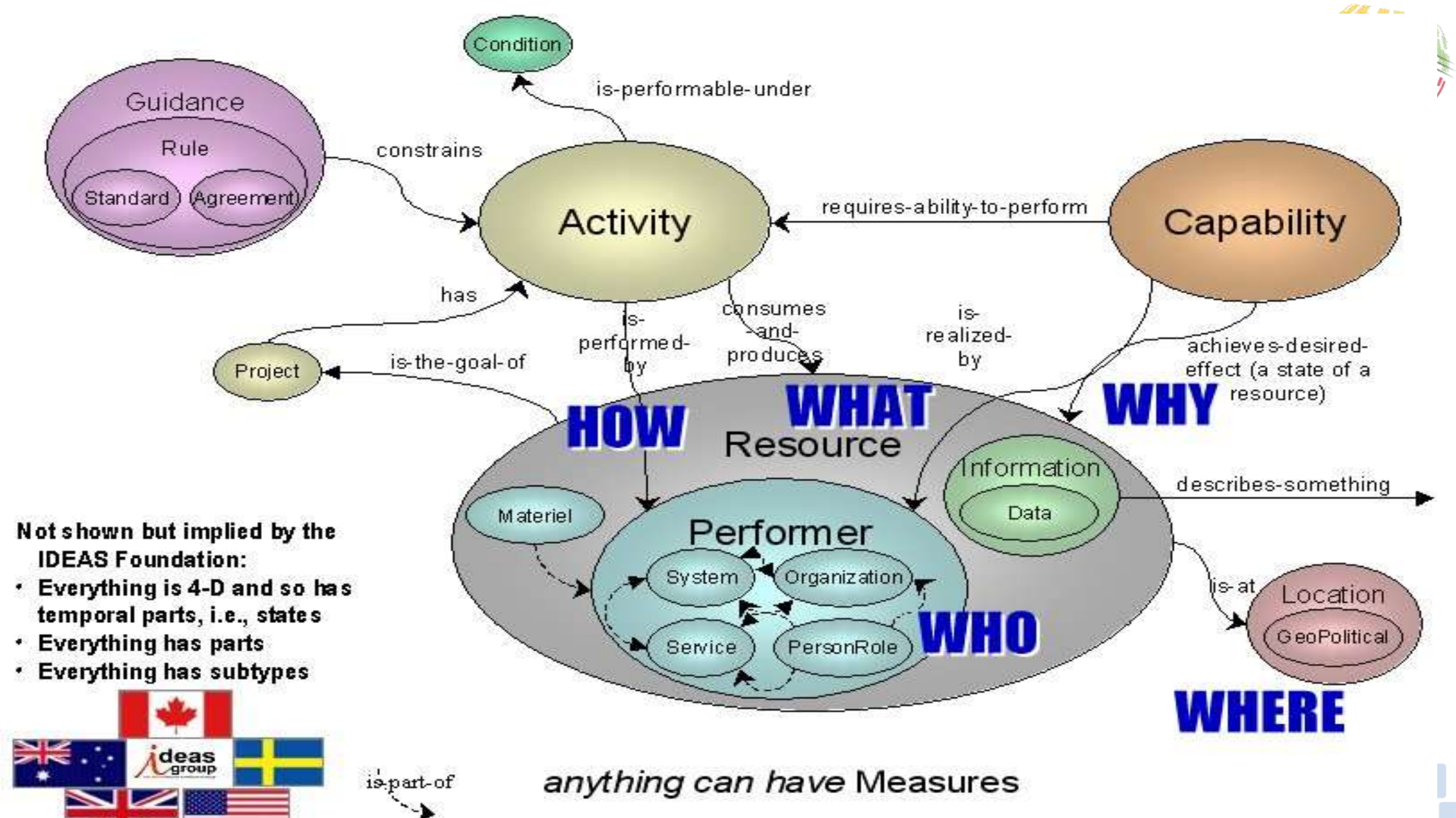
*Horizontal integrations lines are shown for example purposes only and are not a complete set. Composite integrations relationships connecting every cell horizontally potentially exist.

EA using DoDAF

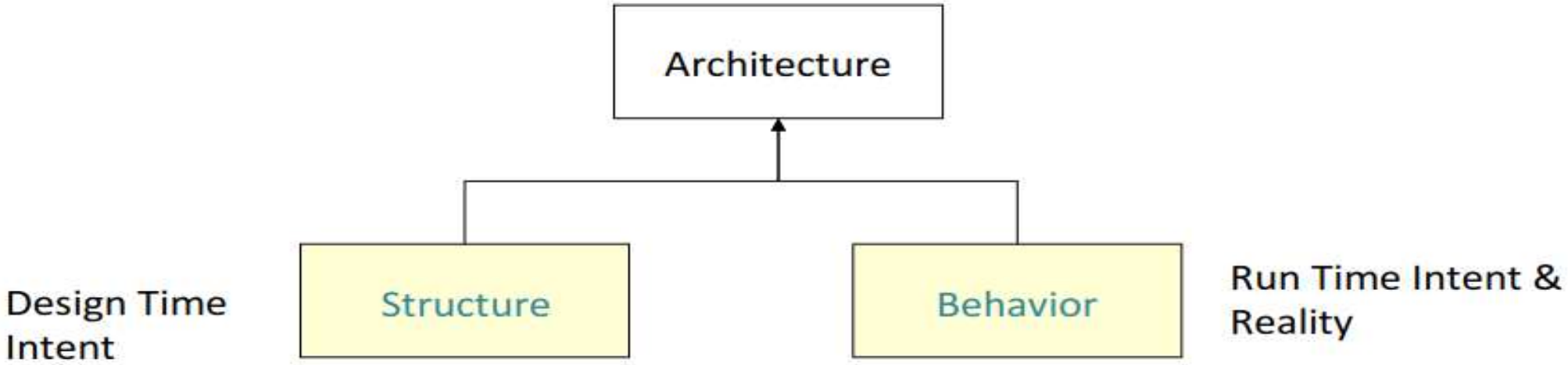
	What (Date)	How (Function)	Where (Network)	Who (People)	When (Time)	Why (Motivation)
Viewpoint	AV, DIV	OV, SV, SvcV	OV, SV, SvcV	OV	CV, OV, PV, SV, SvcV	AV, CV, OV, StdV, SV, SvcV
DoDAF-described Models	AV-2, DIV-1, DIV-2, DIV-3	OV-5a, OV-5b, OV-6a, b, c, SV-4, SV-10a, b, c, SvcV-10a, b, c	OV-2, SV-2, SvcV-2	OV-2, OV-4	CV-2, CV-4, OV-6c, PV-2, SV-8, SvcV-8, Sv-10c, SvcV-10c	AV-1, CV-1, OV-6a, StdV-1, StdV-2, SV-10a, SvcV-10a
Meta-model group	Information and Data, Project	Activity, Capability, Service, Measures	Location	Performer	All	Rules, Goals

MBSE SoS/Enterprise Meta Model




Condition
is-performable-under
Guidance
Rule
Standard
Agreement
constrains
Activity
requires-ability-to-perform
Capability
has
Project
is-the-goal-of
is-performed-by
consumes-and-produces
is-realized-by
achieves-desired-effect (a state of a resource)
HOW
WHAT
WHY
Resource
Information
Data
describes-something
Materiel
Performer
System
Organization
Service
PersonRole
WHO
is-at
Location
GeoPolitical
WHERE
Not shown but implied by the IDEAS Foundation:
• Everything is 4-D and so has temporal parts, i.e., states
• Everything has parts
• Everything has subtypes
ideas group
is-part-of
anything can have Measures

Architecture Meta Model

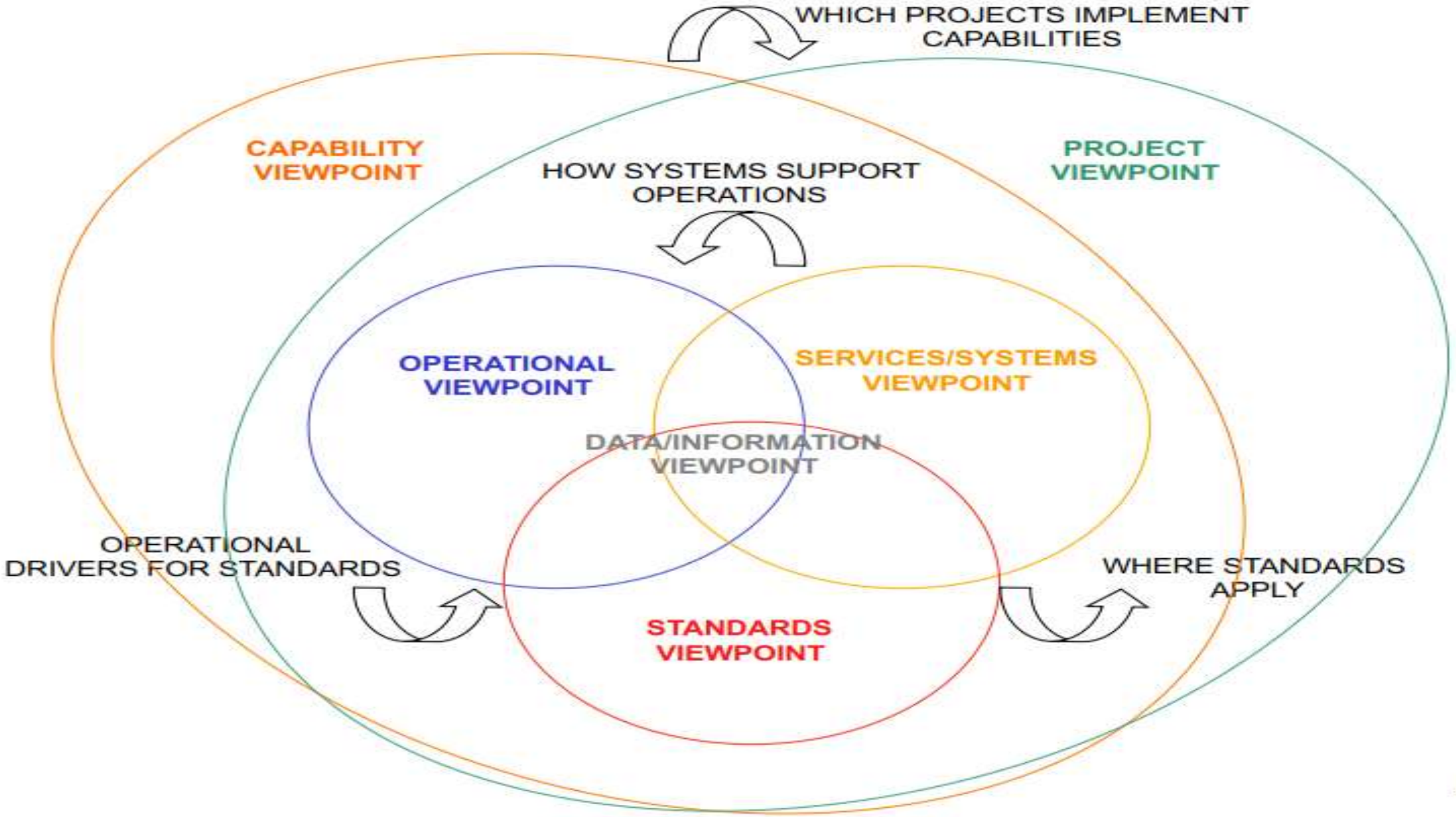


Defined by Components
Defined by Topology
Defined by Structural Rules

Defined by a response to:
- Actions
- Events

Constrained by Behavior Rules
Constrained by Intent

Viewpoint Relationships



DoDAF CORE Model Originality

- Essential Part of an Integrated Architecture originally prescribed by DoDAF
  - Essential **dynamic dimension**:
    - **Capability,**
    - **Activity,**
    - **Event,**
    - **System,**
    - **Service**
  - **Drives other dimensions**: **data**
- Exact list of models depends on the **scope and purpose of architecting**
  - **Enterprise Level**
  - **Segment / Capability Level**
  - **Solutions Level**

Architectural Elements in CORE Models

Certain Types of Models represent key problem and solution dimensions

- Activities
  - Business Functions
  - Processes
  - Tasks
  - Actions
- Locations
  - Countries
  - Areas of Responsibility/Theaters
  - Facilities, Installations
- Performers
  - Organizations
  - Organization Types
  - Person Types
- Systems
  - Automated Information Systems
  - GOTS/COTS Solution Systems
  - FoS/SoS Composition
- Services
  - Business Services
  - Software Services
- Standards
- Capabilities and Desired Effects
- Projects/Initiatives/Programs
- Vision and Goals

Baseline Core Model Required Viewpoints

- AV-1 Overview and Summary
  - To provide a context for your architecture
- AV-2 Integrated Dictionary
  - To provide the meaning of the architecture elements and to resolve integration issues
- OV-1 Concept Graphic
  - To provide a concept of operations in a graphical way for your audience
- OV-2 Operational Resource Flow Description
  - To describe the internal and external key operational Performers and abstract Inkages that connect resource flows (information flows) between them
- OV-3 Resource Exchange Matrix
  - Detailed Resource Exchanges to elaborate on the OV-2
- OV-5a Activity Node Tree
  - To sketch out the decomposition activities
- OV-5b Activity Model
  - To provide a context as well as detail on the activity orchestration
- SV-1 Systems Interface Description
  - To provide an overview of the external and internal Systems that are in scope
- SvcV-1 Services Description
  - To provide an overview of the external and internal business/software services that are in scope
- StdV-1 Standards Profile
  - To enumerate the standards that are in scope

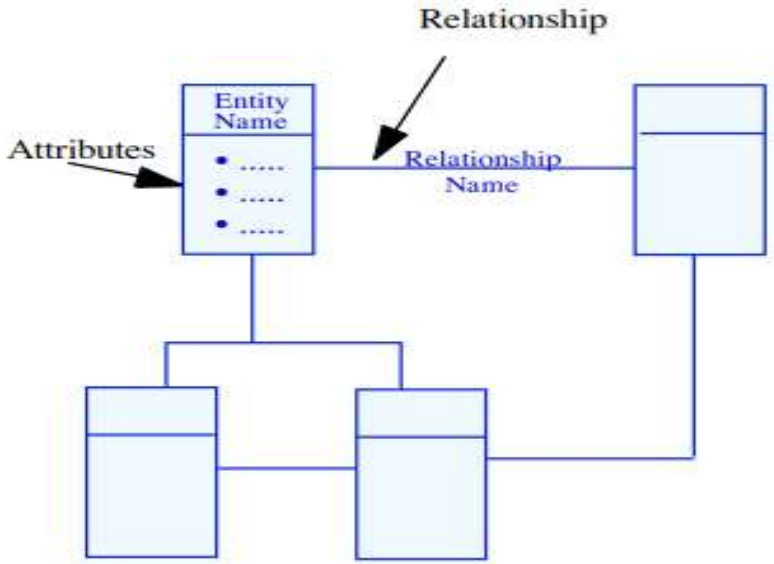
Supporting Views Categories

- **Sequence & Timing Models:**
  - OV-6a, b, c
  - SV-10a, b, c
  - SvcV-10a, b, c
- **Data Models:**
  - DIV-1
  - DIV-2
  - DIV-3
- **Other:**
  - OV-4
  - SV-2, SvcV-2
  - SV-4, SvcV-4
  - CV-1, CV-2, CV-4
- **Planning Views:**
  - SV-7, SvcV-7
  - SV-8, SvcV-8, CV-3,
  - PV-2
  - SV-9, SvcV-9, StdV-2
- **Matrix Views:**
  - SV-3, SvcV-3a, b
  - SV-5a, b, SvcV-5
  - CV-5,
  - CV-6,
  - CV-7
  - PV-1, PV-3
  - SV-6, SvcV-6

Data Models

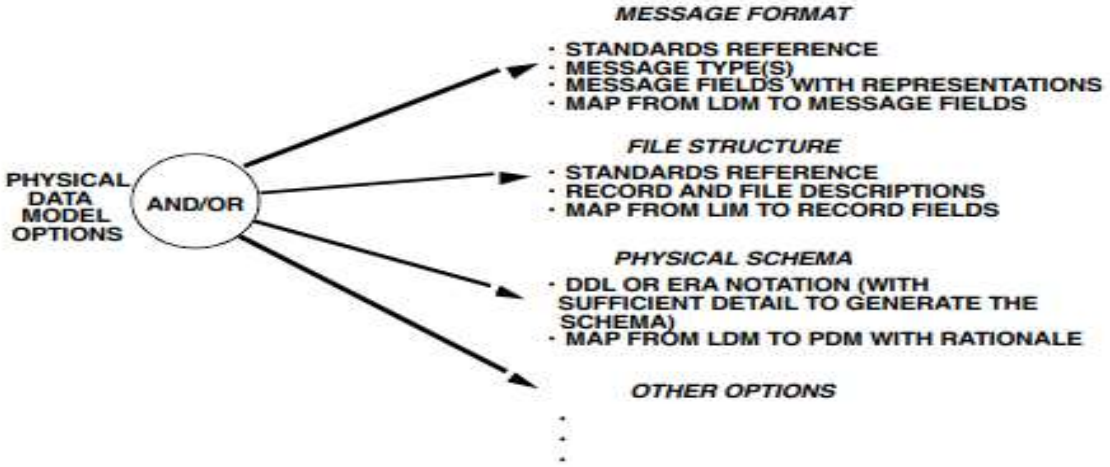
Conceptual & Logical Data Model

DIV -1, DIV-2



Physical Data Model

DIV -3



Data/Information Viewpoint views model shared structured enterprise concepts and data. Architect must document what data is being modeled.

All Viewpoint

Models	Descriptions
AV-1 Overview and Summary Information	Describes a Project's Visions, Goals, Objectives, Plans, Activities, Events, Conditions, Measures, Effects (Outcomes), and produced objects.
AV-2 Integrated Dictionary	An architectural data repository with definitions of all terms used throughout the architectural data and presentations.

Capability Viewpoint

Model	Description
CV-1: Vision	The overall vision for transformational endeavors, which provides a strategic context for the capabilities described and a high-level scope.
CV-2: Capability Taxonomy	A hierarchy of capabilities which specifies all the capabilities that are referenced throughout one or more Architectural Descriptions.
CV-3: Capability Phasing	The planned achievement of capability at different points in time or during specific periods of time. The CV-3 shows the capability phasing in terms of the activities, conditions, desired effects, rules complied with, resource consumption and production, and measures, without regard to the performer and location solutions
CV-4: Capability Dependencies	The dependencies between planned capabilities and the definition of logical groupings of capabilities.
CV-5: Capability to Organizational Development Mapping	The fulfillment of capability requirements shows the planned capability deployment and interconnection for a particular Capability Phase. The CV-5 shows the planned solution for the phase in terms of performers and locations and their associated concepts.
CV-6: Capability to Operational Activities Mapping	A mapping between the capabilities required and the operational activities that those capabilities support.
CV-7: Capability to Services Mapping	A mapping between the capabilities and the services that these capabilities enable.

Project Viewpoint

Models	Descriptions
PV-1: Project Portfolio Relationships	It describes the dependency relationships between the organizations and projects and the organizational structures needed to manage a portfolio of projects.
PV-2: Project Timelines	A timeline perspective on programs or projects, with the key milestones and interdependencies.
PV-3: Project to Capability Mapping	A mapping of programs and projects to capabilities to show how the specific projects and program elements help to achieve a capability.

Data and Information Viewpoint

Models	Descriptions
DIV-1: Conceptual Data Model	The required high-level data concepts and their relationships.
DIV-2: Logical Data Model	The documentation of the data requirements and structural business process (activity) rules. In DoDAF V1.5, this was the OV-7.
DIV-3: Physical Data Model	The physical implementation format of the Logical Data Model entities, e.g., message formats, file structures, physical schema. In DoDAF V1.5, this was the SV-11.

Operational Viewpoint

Model	Description
OV-1: High-Level Operational Concept Graphic	The high-level graphical/textual description of the operational concept.
OV-2: Operational Resource Flow Description	A description of the Resource Flows exchanged between operational activities.
OV-3: Operational Resource Flow Matrix	A description of the resources exchanged and the relevant attributes of the exchanges.
OV-4: Organizational Relationships Chart	The organizational context, role or other relationships among organizations.
OV-5a: Operational Activity Decomposition Tree	The capabilities and activities (operational activities) organized in a hierarchal structure.
OV-5b: Operational Activity Model	The context of capabilities and activities (operational activities) and their relationships among activities, inputs, and outputs; Additional data can show cost, performers or other pertinent information.
OV-6a: Operational Rules Model	One of three models used to describe activity (operational activity). It identifies business rules that constrain operations.

System Viewpoint

Models	Descriptions
SV-1 Systems Interface Description	The identification of systems, system items, and their interconnections.
SV-2 Systems Resource Flow Description	A description of Resource Flows exchanged between systems.
SV-3 Systems-Systems Matrix	The relationships among systems in a given Architectural Description. It can be designed to show relationships of interest, (e.g., system-type interfaces, planned vs. existing interfaces).
SV-4 Systems Functionality Description	The functions (activities) performed by systems and the system data flows among system functions (activities).
SV-5a Operational Activity to Systems Function Traceability Matrix	A mapping of system functions (activities) back to operational activities (activities).
SV-5b Operational Activity to Systems Traceability Matrix	A mapping of systems back to capabilities or operational activities (activities).
SV-6 Systems Resource Flow Matrix	Provides details of system resource flow elements being exchanged between systems and the attributes of that exchange.
SV-7 Systems Measures Matrix	The measures (metrics) of Systems Model elements for the appropriate timeframe(s).
SV-8 Systems Evolution Description	The planned incremental steps toward migrating a suite of systems to a more efficient suite, or toward evolving a current system to a future implementation.
SV-9 Systems Technology & Skills Forecast	The emerging technologies, software/hardware products, and skills that are expected to be available in a given set of time frames and that will affect future system development.
SV-10a Systems Rules Model	One of three models used to describe system functionality. It identifies constraints that are imposed on systems functionality due to some aspect of system design or implementation.

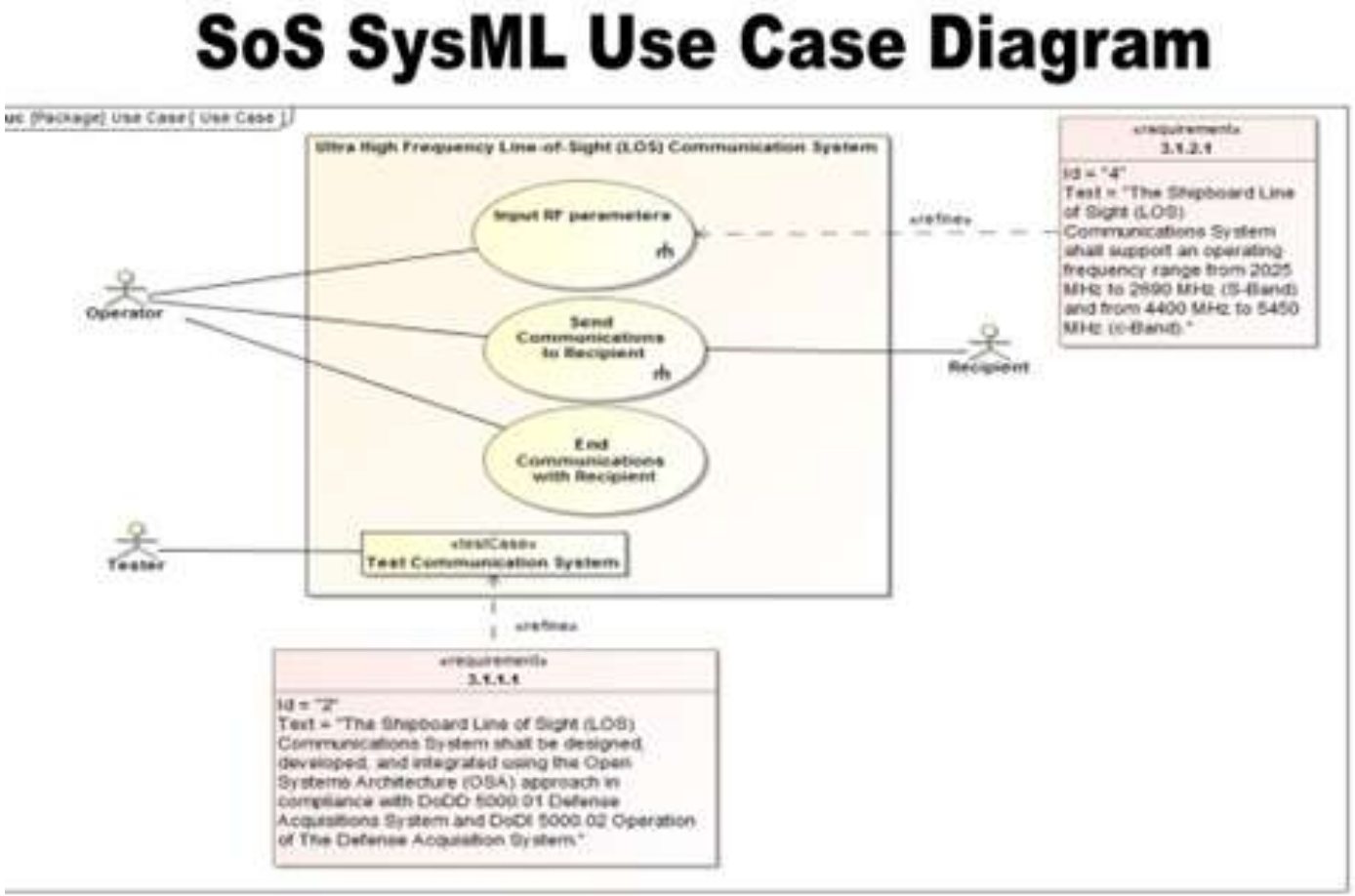
Services Viewpoint

Models	Descriptions
SvcV-1 Services Context Description	The identification of services, service items, and their interconnections.
SvcV-2 Services Resource Flow Description	A description of Resource Flows exchanged between services.
SvcV-3a Systems-Services Matrix	The relationships among or between systems and services in a given Architectural Description.
SvcV-3b Services-Services Matrix	The relationships among services in a given Architectural Description. It can be designed to show relationships of interest, (e.g., service-type interfaces, planned vs. existing interfaces).
SvcV-4 Services Functionality Description	The functions performed by services and the service data flows among service functions (activities).
SvcV-5 Operational Activity to Services Traceability Matrix	A mapping of services (activities) back to operational activities (activities).
SvcV-6 Services Resource Flow Matrix	It provides details of service Resource Flow elements being exchanged between services and the attributes of that exchange.
SvcV-7 Services Measures Matrix	The measures (metrics) of Services Model elements for the appropriate timeframe(s).
SvcV-8 Services Evolution Description	The planned incremental steps toward migrating a suite of services to a more efficient suite or toward evolving current services to a future implementation.

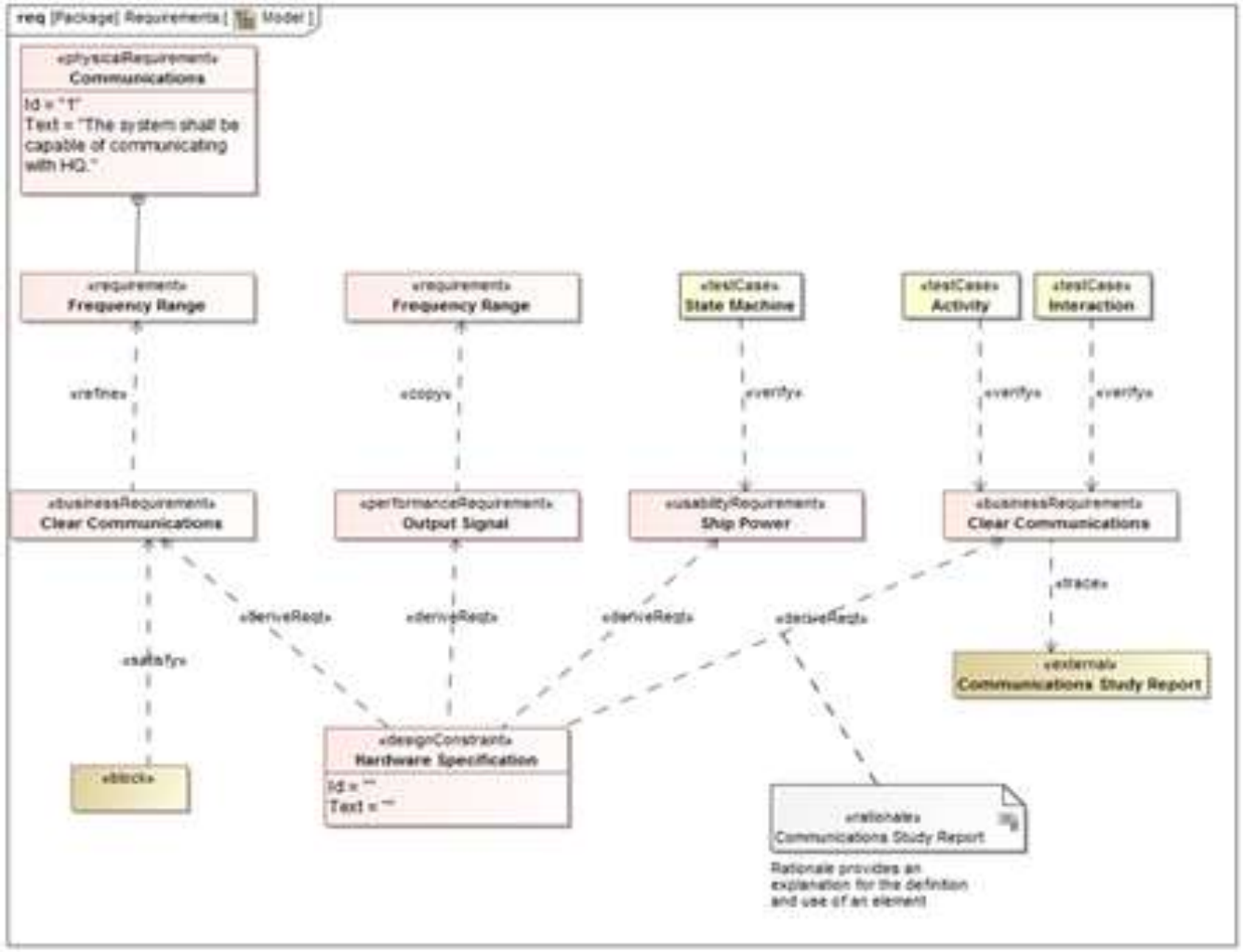
Standards Viewpoint

Models	Descriptions
StdV-1 Standards Profile	The listing of standards that apply to solution elements.
StdV-2 Standards Forecast	The description of emerging standards and potential impact on current solution elements, within a set of time frames.

OOSEM – Use Case

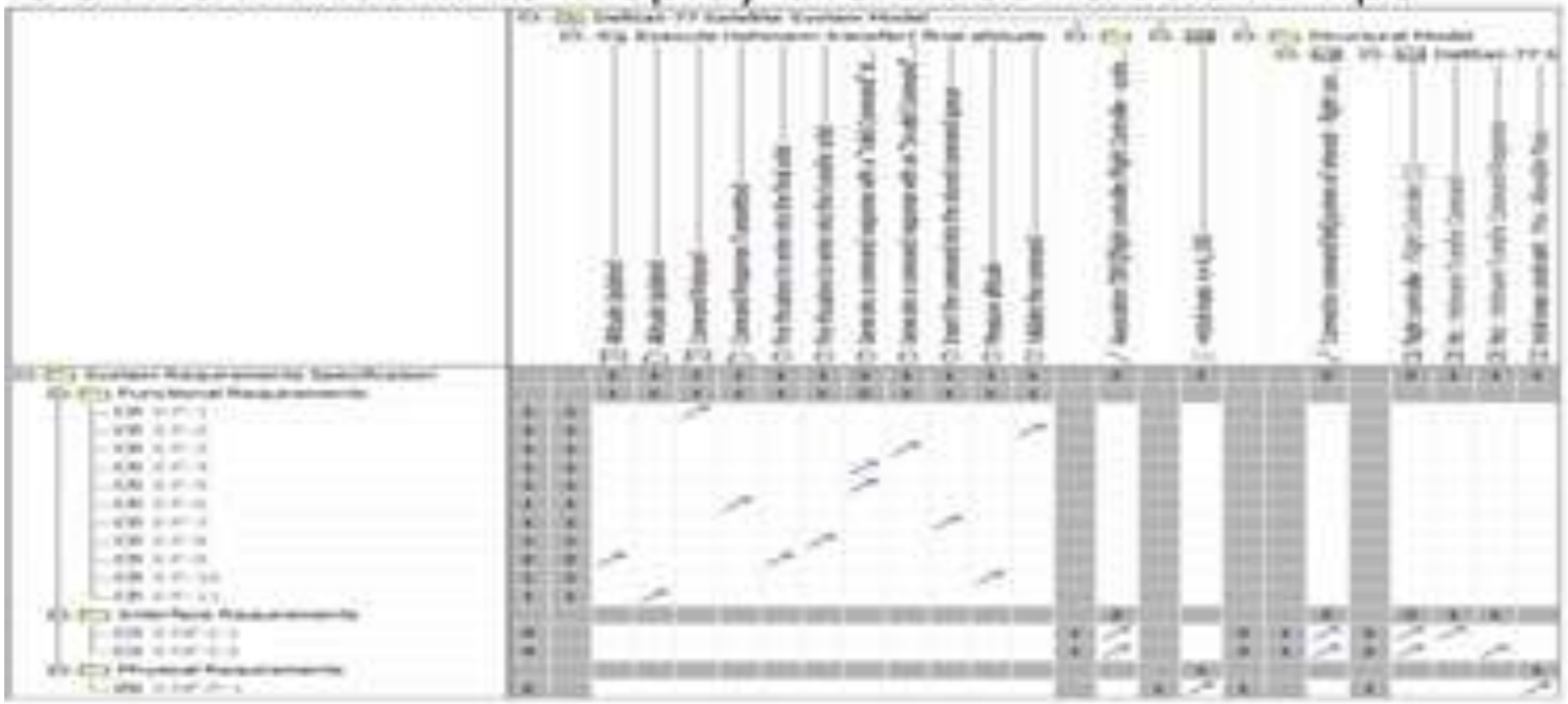


OOSEM – Requirements

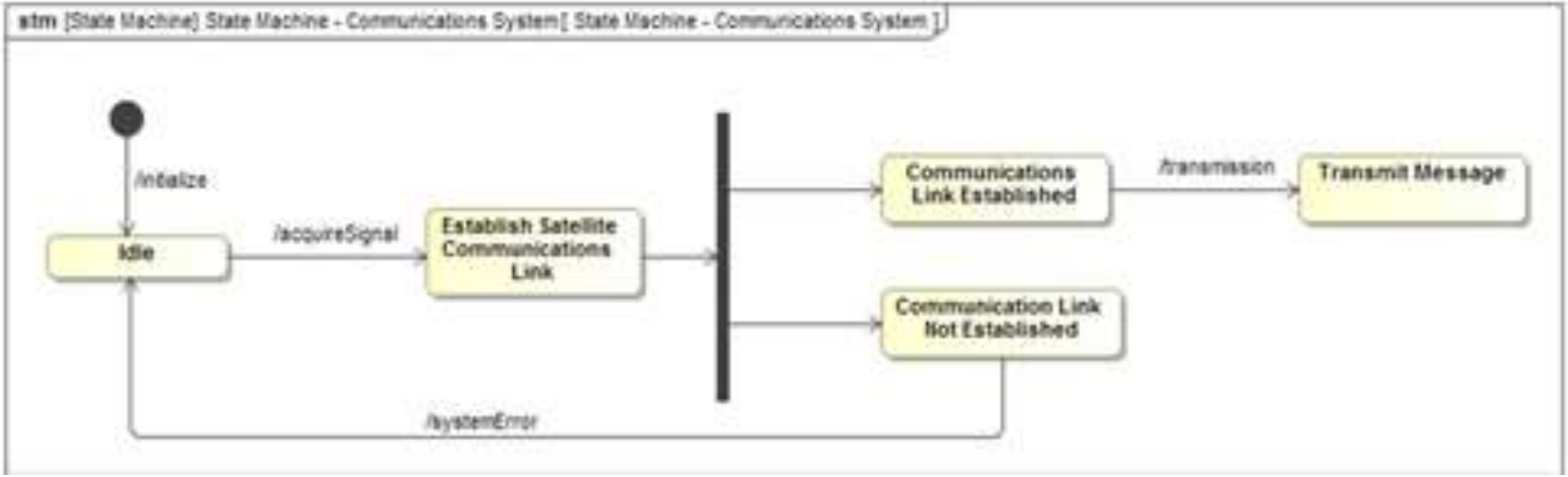


OOSEM – Trace Req

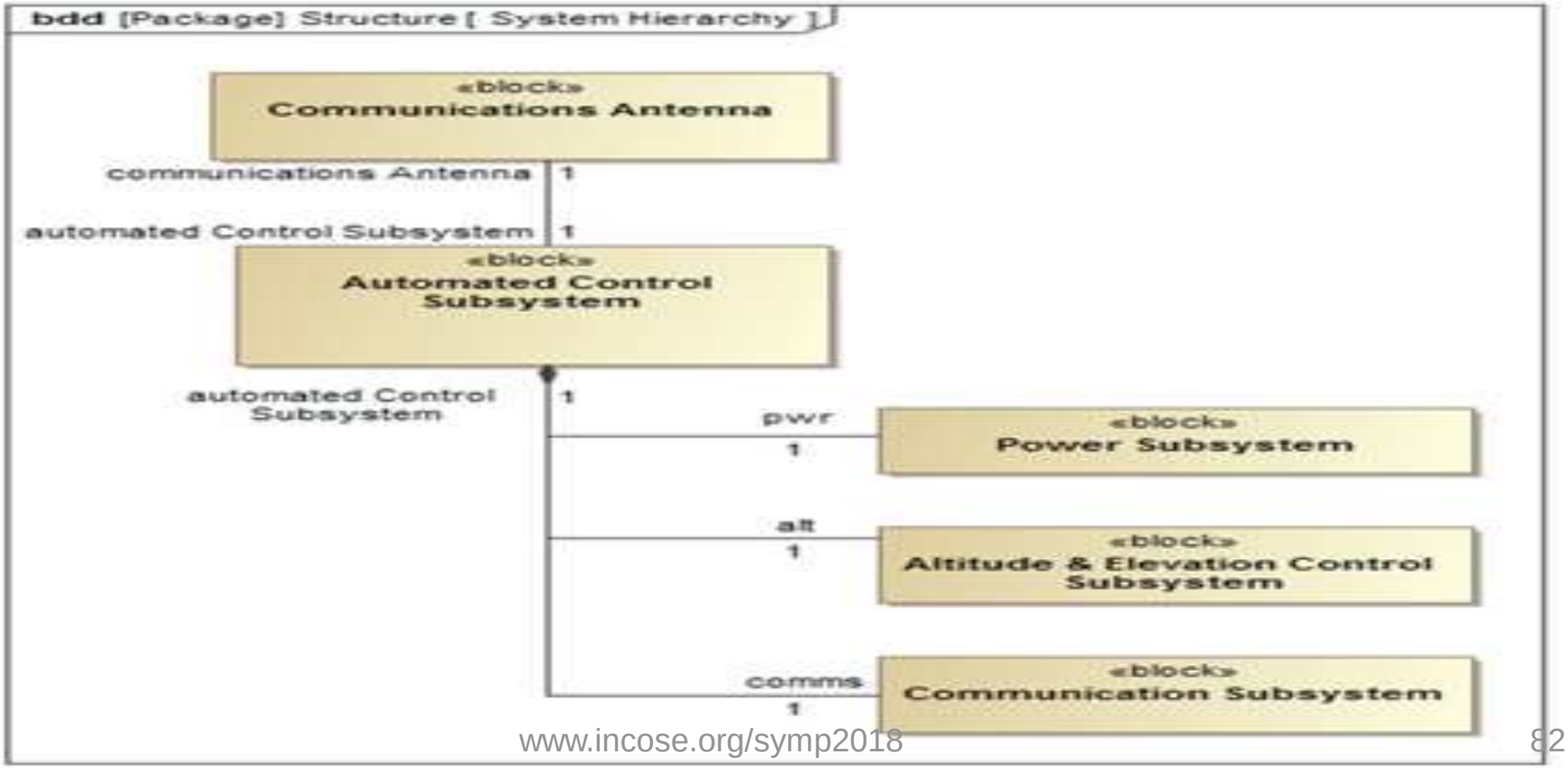
OUTPUT: Matrix to display the trace relationships



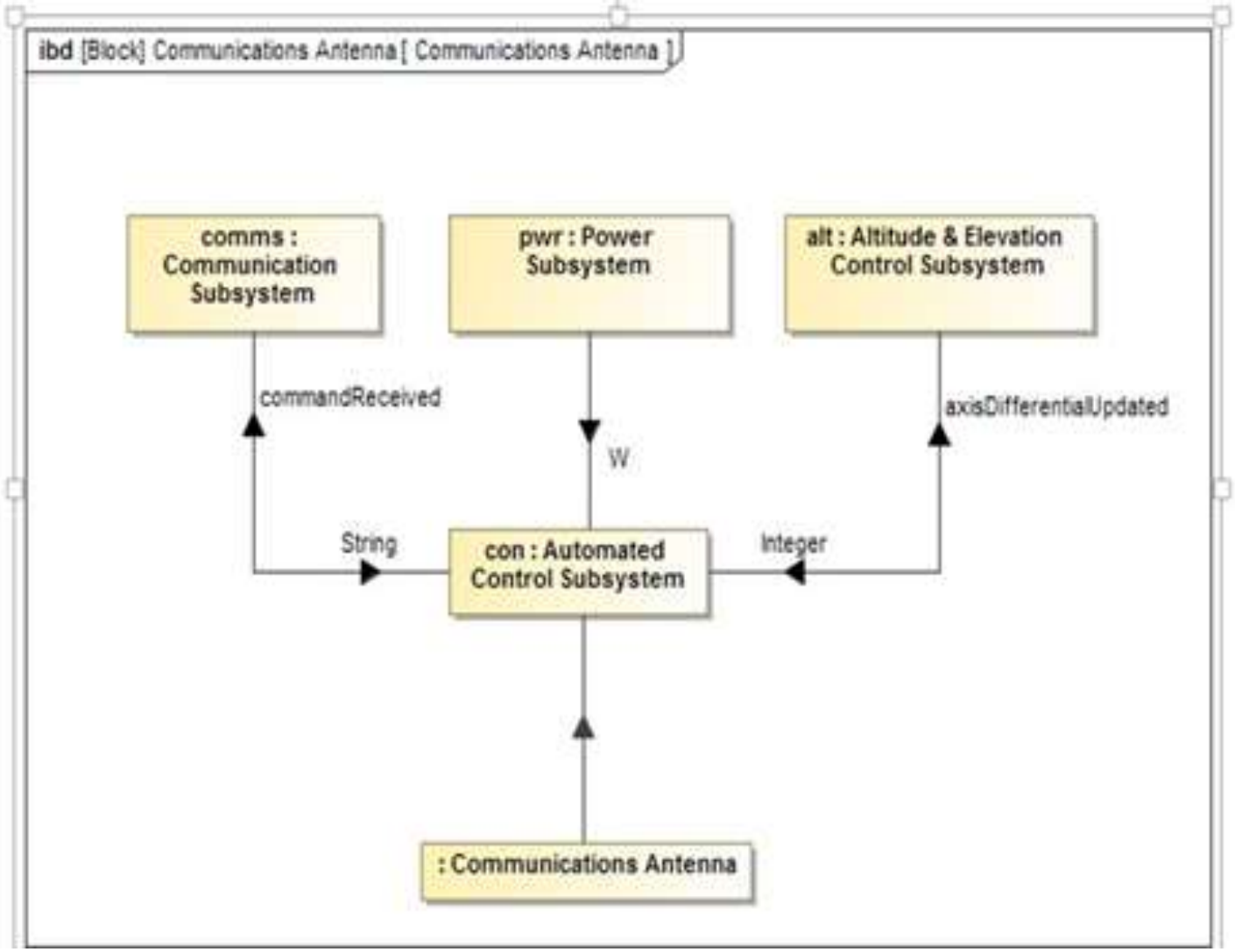
OOSEM – State Machine



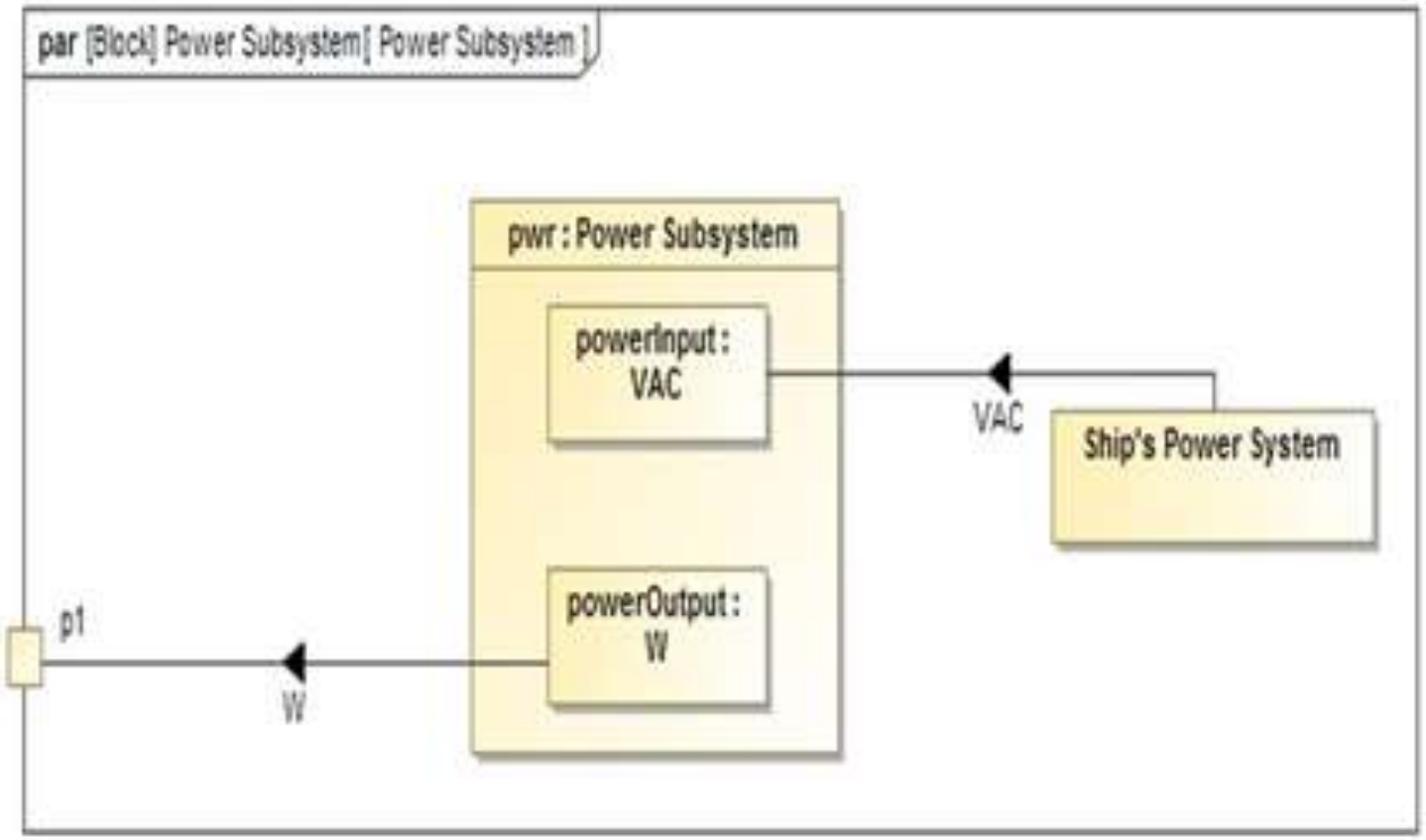
OOSEM – Structure in BDD



OOSEM – Structure in IBD

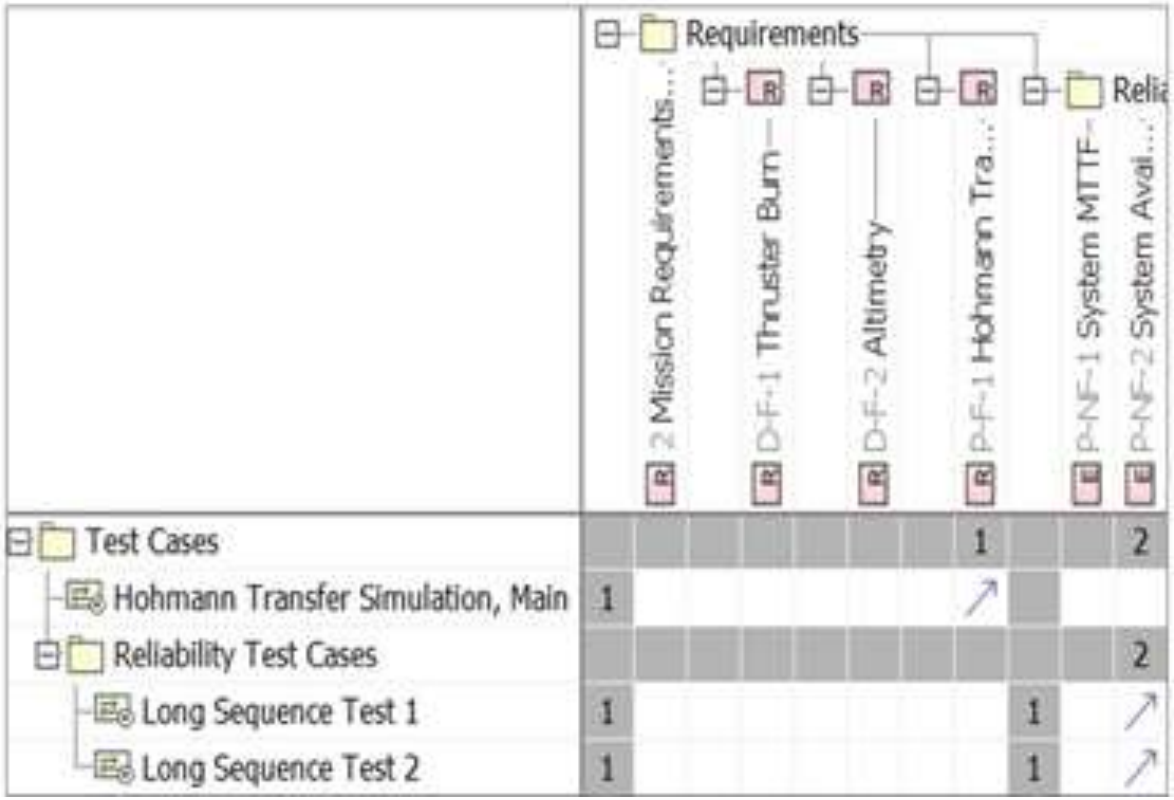


OOSEM – Parametrc



OOSEM – Test Cases

Test Cases Matrices to Verify Requirements

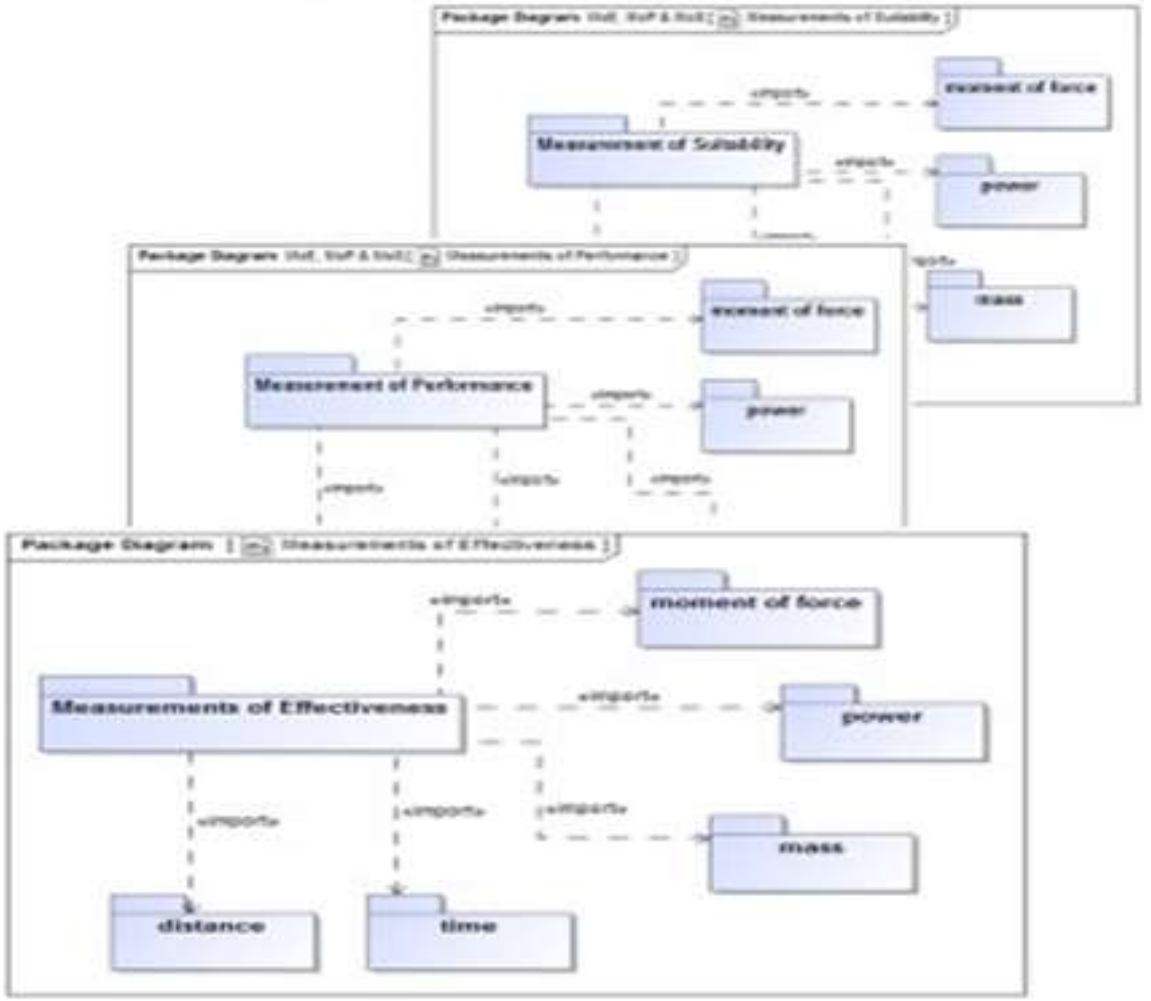


Tracing EA KPP, KSA with SoS MOE, MOP

EA KPP & KSA tracing with SoS MOE, MOP & MOS

Parameter or Attribute	Description	Performance Objective	Performance Threshold	Current Performance Status (if Post MS B)	Source Document
KSA	Panel Indicators	Printer indicators shall be clearly labeled and display the following status: Power, Print Ready, and Paper Low	Same as Objective	Meets Objective	Printer Spec S-133-32105 3.2.1.5.4 3.2.4.3
KSA	Data Commands	At a minimum, the Printer shall respond to the following ASCII control codes: LF, CR, FF, EOT, and ENQ. Printer shall respond to unused control codes by inserting a space.	Same as Objective	Meets Objective	Printer Spec S-133-32105 3.2.1.12
KSA	Human Performance	Burrs, Edges and Corners	Exposed or protruding burrs, edges, and corners shall be rounded or otherwise treated to preclude injury to personnel or damage to the printer.	Meets Objective	Printer Spec S-133-3210[illegible] 3.3.7.1
KSA	Human Performance	Painted Surface Colors	The printer painted surface color shall be gray, FED-STD-595 Color Number 26492	Meets Objective	Printer Spec S-133-3210[illegible] 3.3.7.1

Parameter or Attribute	Description	Performance Objective	Performance Threshold	Current Performance Status (if Post MS B)	Source Document
KPP	Maintainability	Provide organizational level fault detection	95% of all faults detectable faults shall be detectable and observable by faulty operation or an operational indicator	Meets Objective	Printer Spec S-133-32105 3.2.4.3
KPP	Environmental	Fungus Inert	Shall inert materials in accordance with MIL-STD-454 shall be used for all materials not hermetically sealed	Meets Objective	Printer Spec S-133-32105 3.3.1.4
KPP	Electromagnetic Radiation	Operate through Electromagnetic Radiation, Emissions and Susceptibility	AC loads, Switching Transients, power lead susceptibility (continuous wave injection, spike injection), radiated emissions (Narrowband, Broadband), Radiated Susceptibility (Spike Injection, Power Injection, Field Impingement), power lead emissions (Red Line/Black Line of NAVSEAM 5100)	Meets Objective	Printer Spec S-133-32105 3.3.2
KPP	Maintainability	Preventative Maintenance	Preventive maintenance shall not be required at an interval of less than 365 days.	Meets Objective	Printer Spec S-133-32105 3.2.4.6



CAMEO UPDM 2 DODAF 2.0 Content