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Unified Architecture Framework (UAF) for System of Systems Modeling

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Agenda

- What is the UAF?
- System of Systems Modeling
- Coverage requirements for SoS
- Conclusion
- Questions?

Why Model Based Systems Engineering (MBSE)?

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- Pictures paint a thousand words
  - Visio is good at this
  - Language is not controlled
- Modeling languages add semantics and constraints
  - Control what is being said and how it is said
- MBSE is enabled by SysML*, which is a common language of expression that captures:
  - Structure
  - Behavior
  - Requirements
    - Functional
    - Non Functional
- Models can be quantifiable and executable

*** Systems Modeling Language (OMG SysML™)**

What is UPDM?

- UPDM is the *Unified Profile for DoDAF and MODAF* (+ NAF + DNDAF)
- UPDM is NOT a new Architectural Framework
- UPDM is NOT a methodology or a process
- UPDM is a graphical enterprise modeling language
- UPDM was developed by members of the OMG with help from industry and government domain experts

• DOD (US) • MOD (UK) • SWAF (Swedish Armed Forces) • DND (Canada)	• MITRE • Raytheon • Lockheed Martin • General Dynamics • L3	• PTC • IBM • No Magic • Sparx • Mega

MBSE and Engineering Analysis

Why is UPDM so popular with practitioners of MBSE?

- –No standardized frameworks for MBSE exist
- –Integration with existing OMG standards, e.g. SysML, UML
- –Tool vendors support: Implemented in most popular modeling tools:
  IBM Rhapsody, No Magic MagicDraw, PTC Integrity Modeler
- –Defense and Industry driven

Common repository (Integrated Architecture Repository)

- – Application of engineering analysis methods
  - Impact Analysis
  - Coverage Analysis
  - Trade-off Analysis
  - Behavioral execution
  - Requirements compliance analysis
  - Model-based testing
- – Interoperability

Why a Unified Architecture Framework (UAF)?

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- Proliferation of frameworks that UPDM was being asked to support
- Need to support industry and federal usage as well as military
  - Commercialization, whilst still supporting architect needs
- Ability to support other frameworks
  - By Extension
  - By Mapping

Why a Unified Architecture Framework Profile (UAFP)*?

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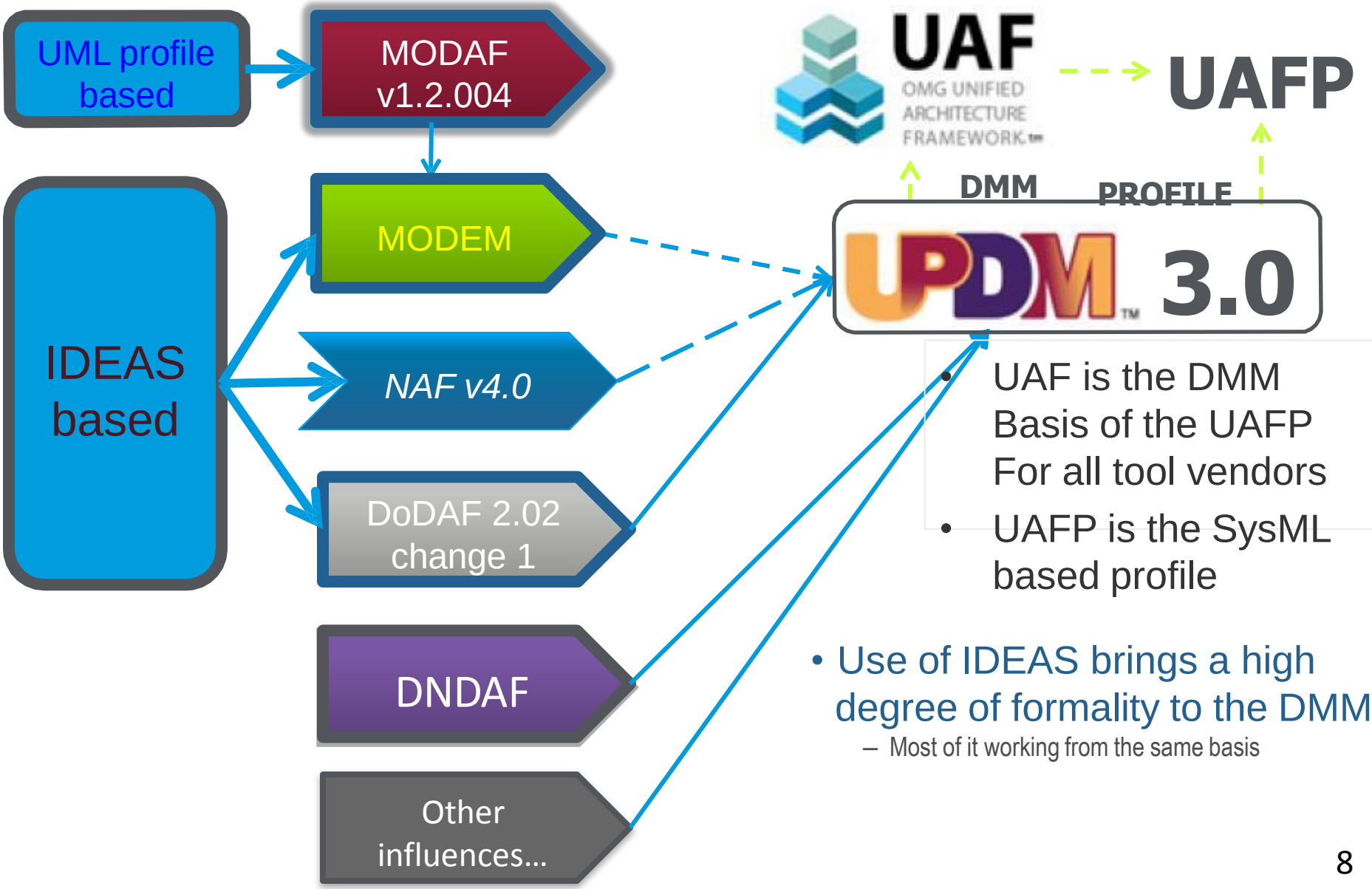
- *An MBSE approach to a layered "model of models" (MOM)*
- IDEAS* based format for a Domain MetaModel (DMM) that allows implementation by non-SysML based tools
  - Same format as DoDAF, MODAF and NAF
- *UAF enables the development of integrated model layers (e.g., outcomes model layer and a component layer)*

*UAFP is the planned OMG update to the UPDM standard
*IDEAS: **I**nternational **D**efence **E**nterprise **A**rchitecture **S**pecification, http://www.ideasgroup.org/

UPDM version 3/UAFP



- UAF is the DMM Basis of the UAFP For all tool vendors
- UAFP is the SysML based profile

- Use of IDEAS brings a high degree of formality to the DMM
  - Most of it working from the same basis

UPDM 3 (UAF) Requirements

- UPDM RFP requirement: ” The UPDM V3.0 domain metamodel shall be derived from MODEM and DM2, both of which are based upon the International Defence Enterprise Architecture Specification Foundation [IDEAS].”
  - Mandatory requirements (excerpt):
    - Provide Domain Metamodel derived from MODEM and DM2
    - An Architecture Framework Profile Using SysML
    - Supports BPMN 2.0
    - Use of SysML Requirements Elements and Diagrams
    - Use of SysML Parametrics Elements and Diagrams Mapped to Measurements
    - Traceability Matrix to Supported Frameworks
  - Non mandatory features (excerpt):
    - UML Profile for NIEM
    - Information Exchange Packaging Policy Vocabulary (IEPPV)
    - Viewpoints in Support of SoS Life Cycle Processes and Analyses
    - Support for Additional Viewpoints beyond those defined in DoDAF, MODAF/ MODEM, NAF, and the Security Viewpoint from DNDAF.
    - Human Systems Integration (HSI)

Grid Approach for NATO Architecture Framework (NAF 4)

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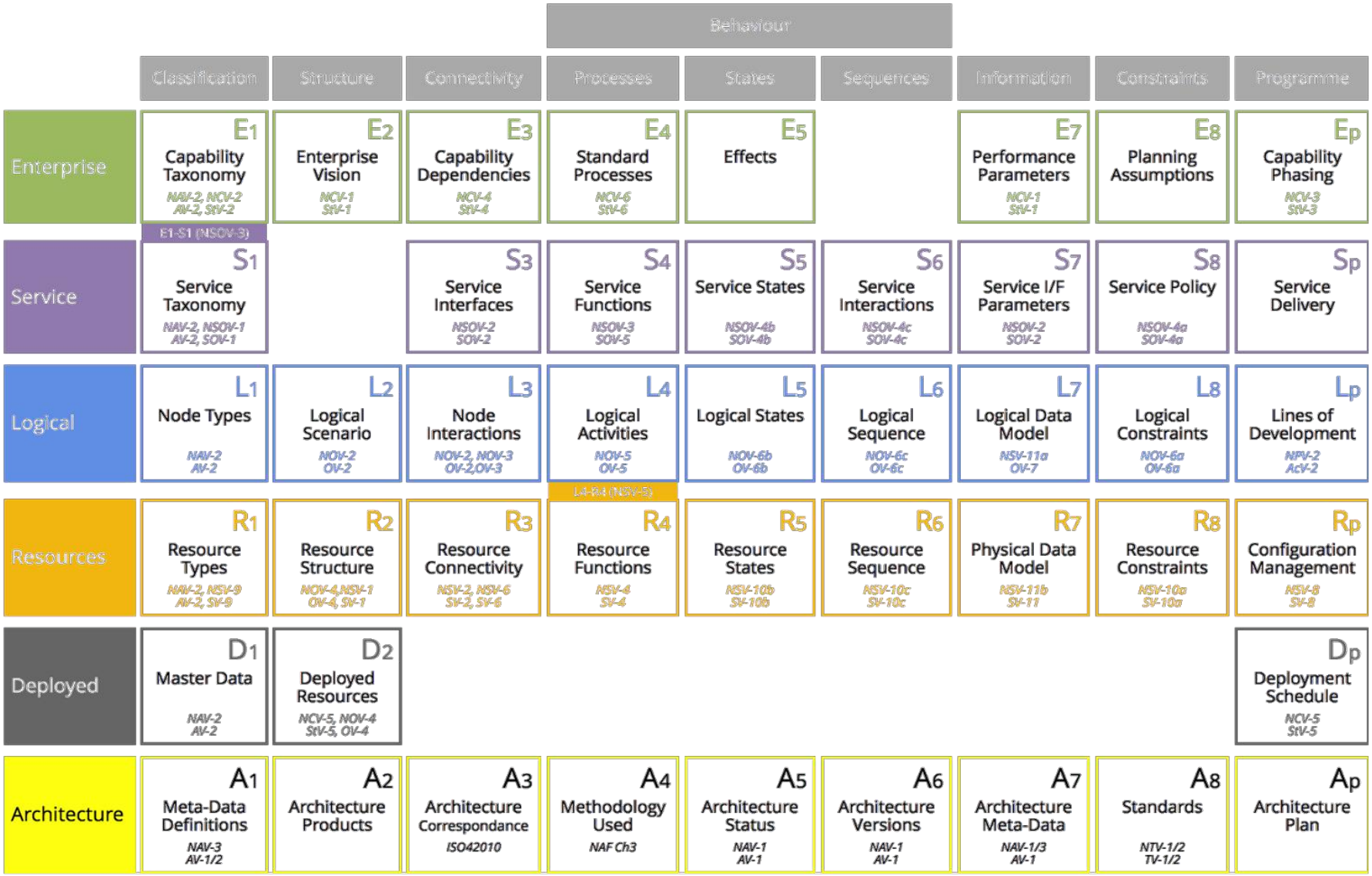

Why the Grid ?

- Very hard to manage the views with so many contributing frameworks
  - Leads to very complex mapping tables
  - Unwieldy descriptions
- Provides an abstraction layer so it is possible to map many other frameworks onto the DMM
  - HSI views and SoS Lifecycle views
- Commercializes the UAF while supporting architect needs
  - Still the same underlying architectural data structures and view constructs that support base frameworks
  - Same data model, different presentation layer

	Taxonomy Tx	Structure Sr	Connectivity Cn	Processes Pr	States St	Interaction Scenarios Is	Information If	Parameters Pm	Constraints Ct	Roadmap Rm	Traceability Tr
Metadata Md	Metadata Taxonomy Md-Tx	Architecture Viewpoints Md-Sr	Metadata Connectivity Md-Cn	Metadata Processes [a] Md-Pr	-	-			Metadata Constraints Md-Ct		Metadata Traceability Md-Tr
Strategic St	Strategic Taxonomy St-Tx	Strategic Structure St-Sr	Strategic Connectivity St-Cn	-	Strategic States St-St	-			Strategic Constraints St-Ct	Strategic Deployment, St-Rm Strategic Phasing St-Rm	Strategic Traceability St-Tr
Operational 0p	Operational Taxonomy Op-Tx	Operational Structure Op-Sr	Operational Connectivity Op-Cn	Operational Processes Op-Pr	Operational States Op-St	Operational Interaction Scenarios Op-Is			Operational Constraints Op-Ct	-	Operational Traceability Op-Tr
Services Sv	Service Taxonomy Sv-Tx	Service Structure Sv-Sr	Service Connectivity Sv-Cn	Service Processes Sv-Pr	Service States Sv-St	Service Interaction Scenarios Sv-Is	Conceptual Data Model,	Environment Pm-En	Service Constraints Sv-Ct	Service Roadmap Sv-Rm	Service Traceability Sv-Tr
Personnel Pr	Personnel Taxonomy Pr-Tx	Personnel Structure Pr-Sr	Personnel Connectivity Pr-Cn	Personnel Processes Pr-Pr	Personnel States Pr-St	Personnel Interaction Scenarios Pr-Is	Logical Data Model,		Competence, Drivers, Performance Pr-Ct	Personnel Availability, Personnel Evolution, Personnel Forecast Pr-Rm	Personnel Traceability Pr-Tr
Resources Rs	Resource Taxonomy Rs-Tx	Resource Structure Rs-Sr	Resource Connectivity Rs-Cn	Resource Processes Rs-Pr	Resource States Rs-St	Resource Interaction Scenarios Rs-Is	Physical schema, real world results	Measurements Pm-Me	Resource Constraints Rs-Ct	Resource evolution, Resource forecast Rs-Rm	Resource Traceability Rs-Tr
Security Sc	Security Taxonomy Sc-Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr	-	-			Security Constraints Sc-Ct	-	Security Traceability Sc-Tr
Projects Pj	Project Taxonomy Pj-Tx	Project Structure Pj-Sr	Project Connectivity Pj-Cn	Project Process PJ-Pr-	-	-			-	Project Roadmap Pj-Rm	Project Traceability Pj-Tr
Standards Sd	Standard Taxonomy Sd-Tx	Standards Structure Sd-Sr	-	-	-	-			-	Standards Roadmap Sd-Rm	Standards Traceability Sd-Tr
Actuals Resources Ar		Actual Resources Structure, Ar-Sr	Actual Resources Connectivity, Ar-Cn	Simulation					Parametric Execution/ Evaluation [b]	-	-

Dictionary Dc Summary &

Overview Sm-Ov

Requirements Req

	Taxonomy Tx	Structure Sr	Connectivity Cn	Processes Pr	States St	Interaction Scenarios Is	Information[c] If	Parameters[d] Pm	Constraints Ct	Roadmap Rm	Traceability Tr
Metadata Md	Metadata Taxonomy[ff] Md-Tx	Architecture Viewpoints [a] Md-Sr	Metadata Connectivity Md-Cn	Metadata Processes [a] Md-Pr	-	-			Metadata Constraints [a] Md-Ct		Metadata Traceability Md-Tr
Strategic St	**CV-1 CV-2**	**CV-1**	**CV-4**	-	Strategic States St-St	-			Measurable Properties	**CV-5 CV-3**	**CV-6**
Operational Op	**OV-2**	**OV-1a OV-2**	**OV-3/ OV-6**	**OV-5**	**OV-6b**	**OV-6c**			**OV-6a**	-	Operational Traceability Op-Tr
Services Sv	**ScV-1**	**ScV-1 ScV-2**	**ScV-3 ScV-6**	**ScV-4**	**ScV-10b**	**ScV-10c**	**DIV-1**	**Environment Pm-En**	**ScV-10a**	**ScV 8 ScV-9**	**ScV-5, CV-7**
Personnel Pr	**OV-4**	**OV-4**	**OV-4 SV-6**	**SV-4**	**SV-10b**	**SV-10c**	**DIV-2**	**ScV-7**	**OV-4 Typical**	**PV-2 SV-8**	**SV-5**
Resources Rs	**SV-1, SV-2**	**SV-1, SV-2**	**SV-3, SV-6**	**SV-4**	**SV-10b**	**SV-10c**	**DIV-3**	**SV-7**	**SV-10a**	**SV-9 SV-8 SV-9**	**SV-5**
Security Sc	Security Taxonomy Sc-Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr	-	-		**Measurements Pm-Me**	Security Constraints Sc-Ct	-	Security Traceability Sc-Tr
Projects Pj	**PV-1**	**PV-1**	**PV-2**	-	-	-			-	**PV-2**	Project Traceability Pj-Tr
Standards Sd	**StdV-1**	**StdV-1**	-	-	-	-			-	**StdV-2**	**StdV-1**
Actuals Resources Ar		**OV-4**	**OV-4 SV-1 & SV-2**	Simulation [b]					Parametric Execution/Evaluation [b]	-	-

Dictionary * Dc (AV-2)

Summary & Overview SmOv (AV-1, OV-1 graphic)

Requirements Rq

SoS Modeling Requirements

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- An analysis of information needed to develop a useful SoS model using UAF showed that most SoS model elements are already covered by the UAF DMM
- Some aspects of SoS management processes are out of scope of UAF modeling and need to be covered with other modeling tools and techniques
  - SoS Program Management (tools such as MS Project)
  - SoS Cost analysis and budgeting (financial analysis tools)
  - SoS Risk analysis and mitigation plans (analysis tools)
- However, for all processes listed above, UAF defines elements, constraints or relationships that are needed to link UAF model elements as inputs to external tools
  - The linking will be supported by tool vendors through an industry exchange standards such as OSLC.
- Following table provides a subset of identified model elements/concepts from the review (see paper) and their mapping to elements in UAF
  - Full table to be published in UAF specification for OMG at Sept. 2015 technical meeting

UPDM coverage for SOS M&S

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Element	Definition	Mapping to UAF
Agreement (among system owners and SoS PMO)	Focus is on managing relationships among multiple organizations. Agreements support SoS evolution including specific commitments to execute SoS increment development. [21]	Agreement, element of RuleKind: an enumeration list. A constraint that applies to stakeholders, organizations, systems and processes.
Asset/ Resource: System info (constituent system and service architecture models)	Resource/System — A functionally, physically, and/or behaviorally related group of regularly interacting or interdependent elements; that group of elements forming a unified whole. [24]	Resource: Abstract element placeholder to indicate that resources can be exchanged in Operational and Systems views.
Capability Objectives (Vision, goal, objective)	The ability to perform a function, task, or action [25]	Enterprise Goal: A specific, required objective of the enterprise that the architecture represents.

UPDM coverage for SOS M&S

Element	Definition	Mapping to UAF
CONOPS	Concept of operations —A verbal or graphic statement that clearly and concisely expresses what the joint force commander intends to accomplish and how it will be done using available resources. Also called CONOPS. [26]	CONOPS: A high level operational concept related to one or more missions. The Diagram describes a mission, class of mission, or scenario; and highlights the main operational elements and interesting or unique aspects of operations.
Integrated Master Schedule (IMS)	Set of SoS SE activities and milestones plus key single system activities and milestones that are driving SoS critical path. Focus is on key synchronization points among SoS constituents and pointers to development schedules of constituent systems for the current SoS increment. [21]	Project: A time-limited endeavor to create a specific set of products or services. UAF elements: Project and Project Milestone
Technical Plan(s)	Focus is on planning the implementation and test of changes to constituent systems to execute a SoS increment. [21]	A technical plan in UAF may be modeled as a specialization of SysML Test case, associated with a model layer (structure, behavior, and parametrics)

UPDM coverage for SOS M&S

	Definition	Mapping to UAF
Outcomes: Desired Result	Effect — 1. The physical or behavioral state of a system that results from an action, a set of actions, or another effect. 2. The result, outcome, or consequence of an action. 3. A change to a condition, behavior, or degree of freedom. [24]	DesiredEffect: A desired state of a Resource.
Performance Measures (metrics) **Performance data**	Measures of performance are defined in an enterprise's Business Motivation Model as objectives. They may be based on risks and potential rewards identified in assessments. Key Performance Indicators (KPI) / Critical Success Factors (CSF) are not especially distinguished in the model; enterprises can make the distinction if they choose to. [22]	Measurement: MeasurableProperty: A property of something in the physical world, expressed in amounts of a unit of measure. The property may have a required value - either specified by the defaultValue

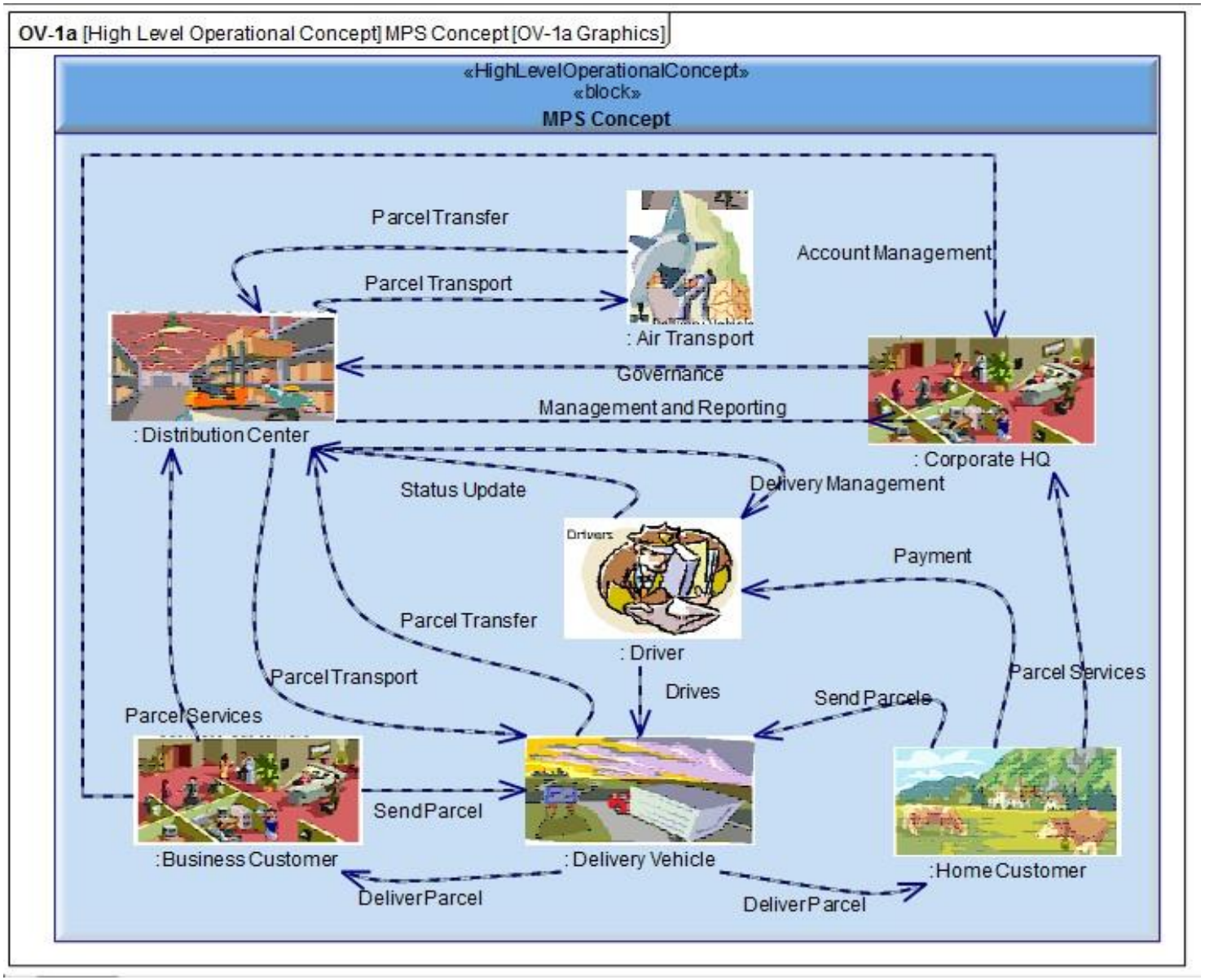
UPDM coverage for SOS M&S

Element	Definition	Mapping to UAF
Requirement	A statement that identifies a system, product or process' characteristic or constraint, which is unambiguous, clear, unique, consistent, stand-alone (not grouped), and verifiable, and is deemed necessary for stakeholder acceptability. [27]	SysML: A requirement specifies a capability or condition that must (or should) be satisfied. A requirement may specify a function that a system must perform or a performance condition that a system must satisfy. Requirements are used to establish a contract between the customer (or other stakeholder) and those responsible for designing and implementing the system.
Systems Information	Focus is on system-level information that affects SoS level capability objectives. Extends beyond technical issues to include operational, fiscal, organizational, and planning issues. [21]	Systems (solutions) model layer elements and relationships, fiscal info can be modeled as attributes (or measurement element) of model elements.

Example SoS: Marvelous Parcel Service (MPS)

- MPS CONOPS consists of Corporate Headquarters carrying out standard business functions, Regional Distribution Centers responsible for warehousing, fleet management, tracking and transfer, Delivery Vehicle Fleet composed of the vehicles that make deliveries for a particular distribution center, Storefronts and Drop Boxes, and Customers - business and residential.

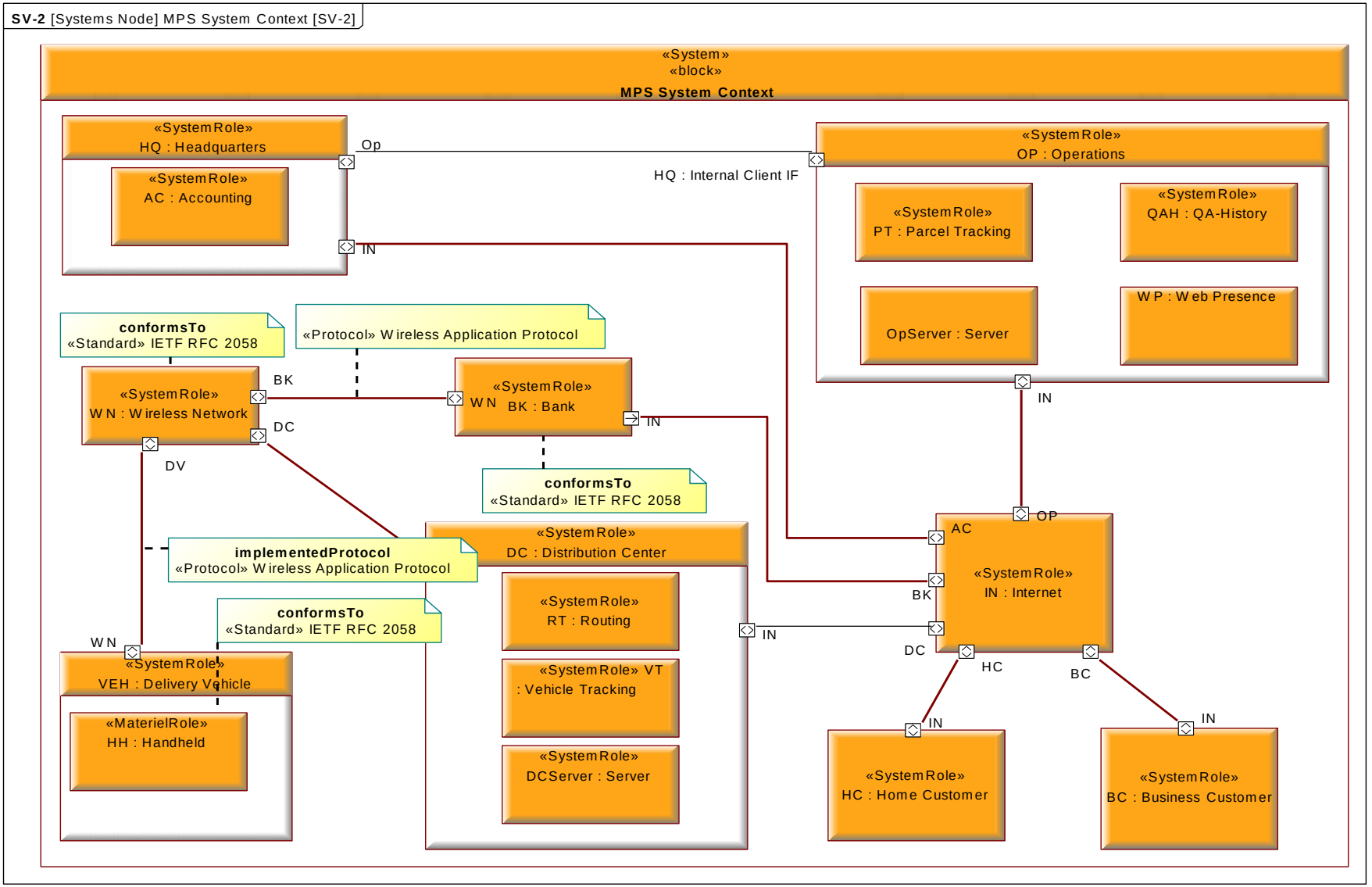
Concept of Operations



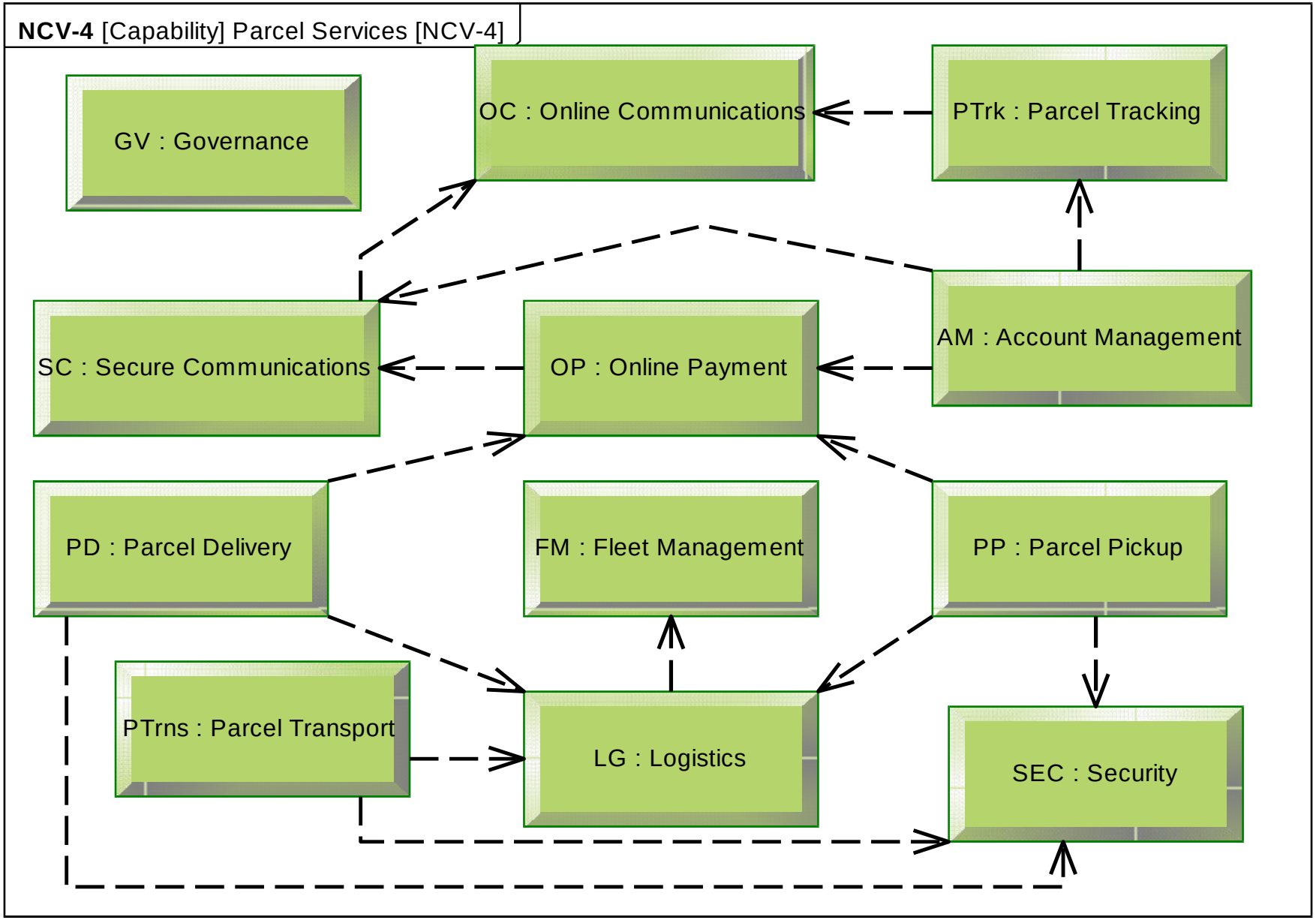
Systems View for MPS

- SoS model for MPS. It identifies system nodes (e.g., platforms, units, facilities, locations) and key interfaces, details about connections and data traffic. The major systems of Headquarters, Delivery Vehicles, Distribution Center, Operations and business and residential customers are shown. Implemented protocols and communications networks are identified

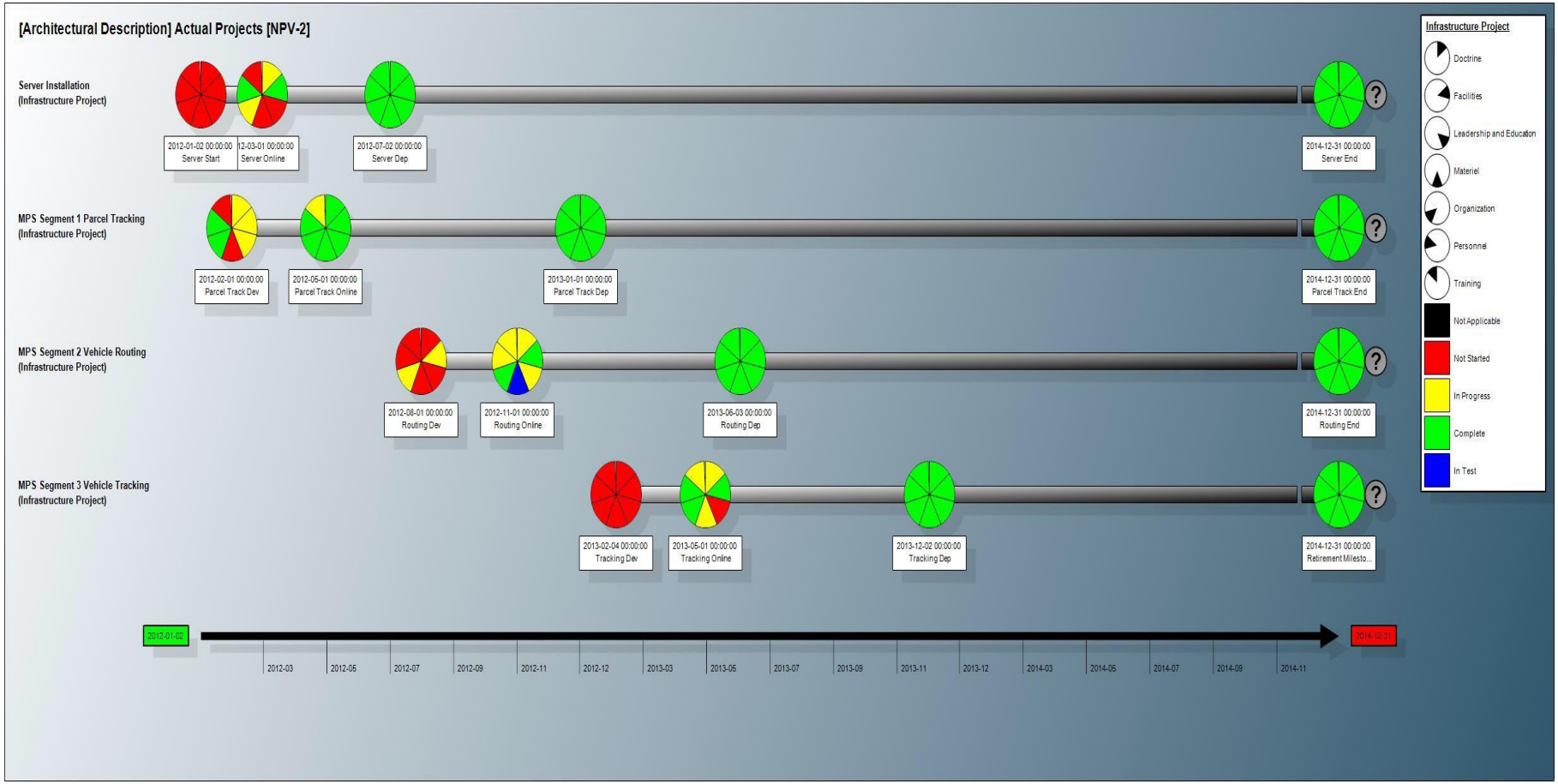
Systems Connectivity View



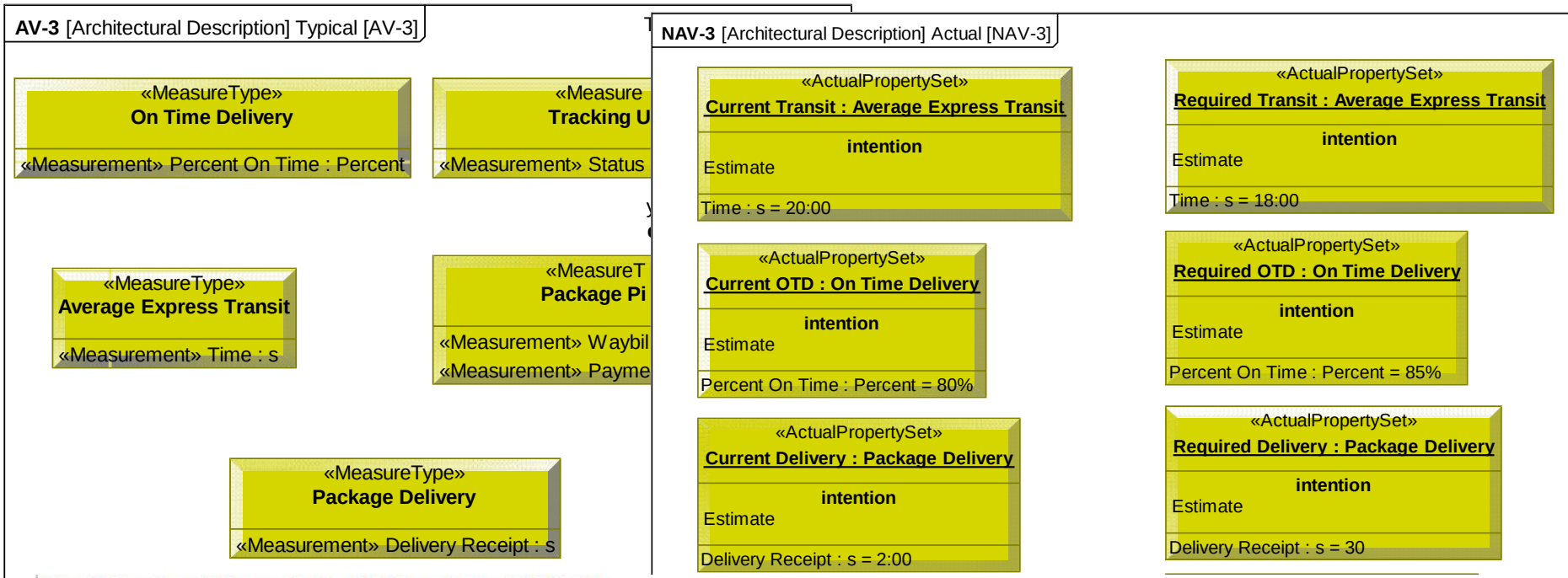
Capabilities



Integrated Development Schedule



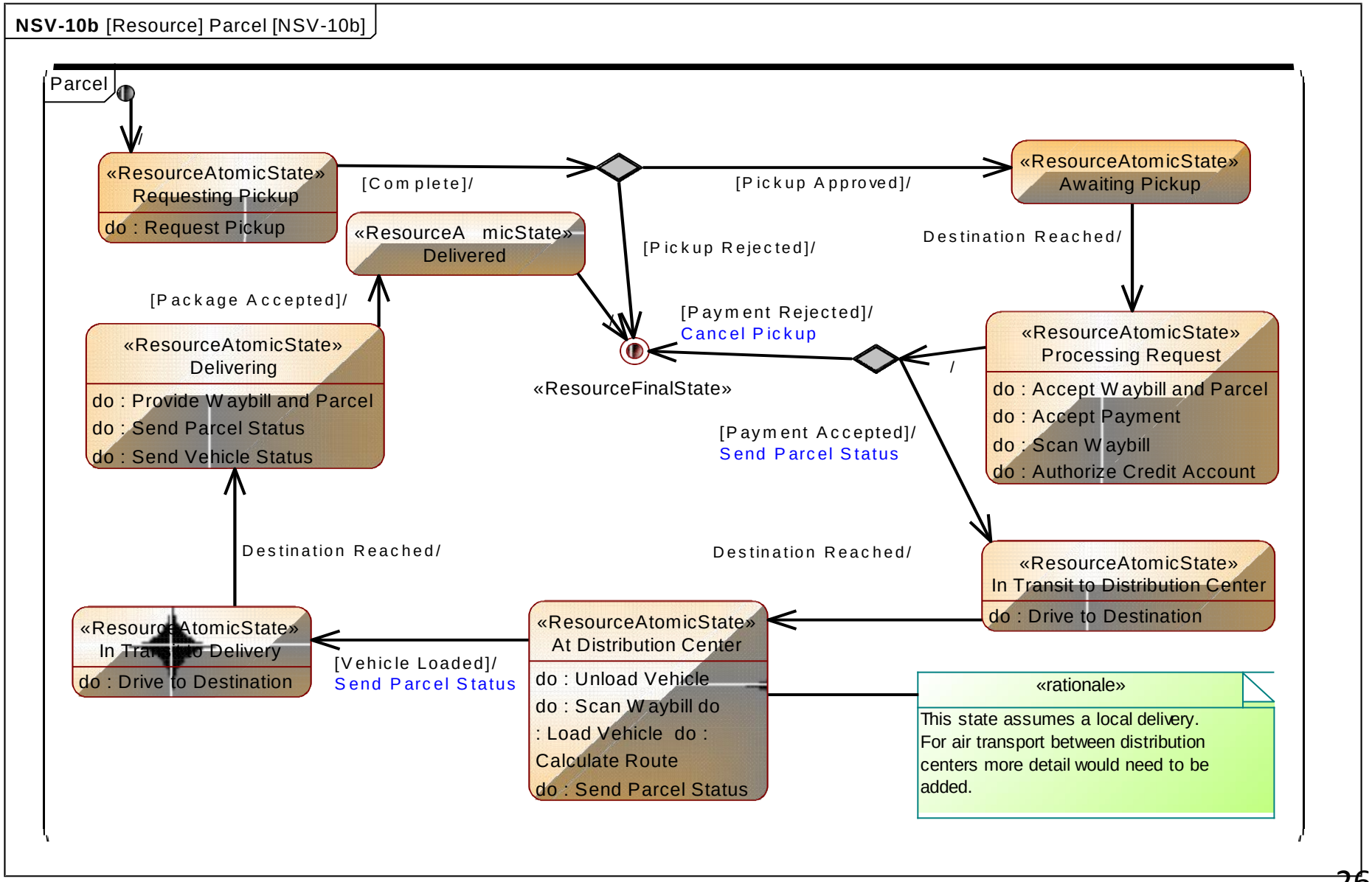
Performance Measures



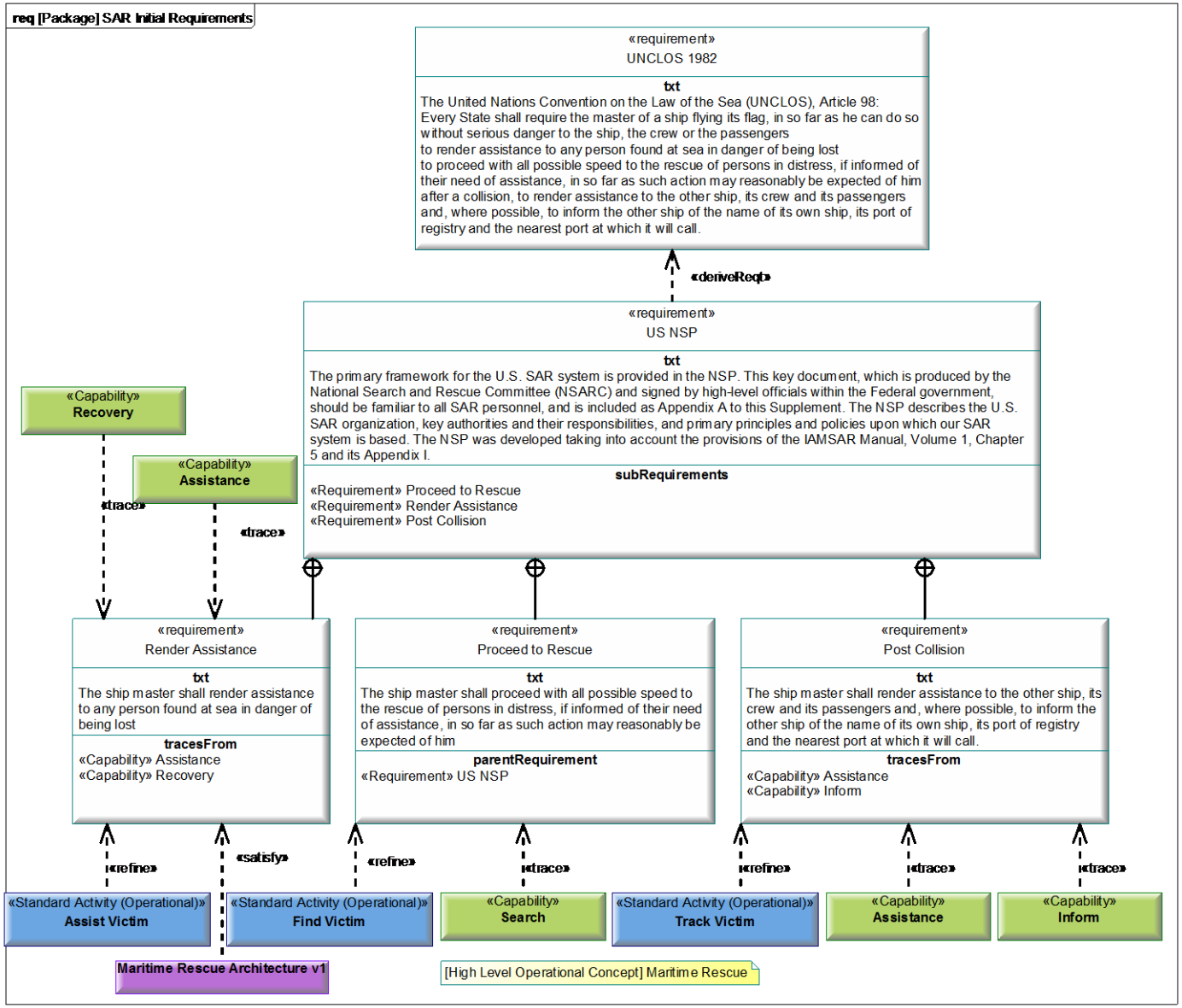
[Architectural Description] Structure [NSV-7]

System Resource		Actual Property Set							
Type	Name	Name	Intention	Property	Minimum Value	Actual Value	Maximum Value	Unit	Quantity Kind
«Resource Artifact»	Delivery Vehicle	Current Transit	Estimate	Time	15:00	20:00	25:00:00	Second	Time
		Required Transit	Estimate	Time	15:00	18:00	25:00:00	Second	Time
		Current OTD	Estimate	Percent On Time	75	80%	90	Percentage	
		Current Pickup	Estimate	Payment Processing	0:30	5:00	5:00	Second	Time
				Waybill Processing	0:30	2:00	5:00	Second	Time
		Required Delivery	Estimate	Delivery Receipt	1:00	30	5:00	Second	Time
		Required OTD	Estimate	Percent On Time	75	85%	90	Percentage	
		Required Pickup	Estimate	Payment Processing	0:30	5:00	5:00	Second	Time
				Waybill Processing	0:30	0:30	5:00	Second	Time
«Resource Artifact»	Flat Panel LED Monitor								
«Resource Artifact»	Flat Screen Plasma Monitor								
«Resource Artifact»	Handheld	Current Update	Estimate	Status Change Update	0:30	20:00	20:00	Second	Time
		Required Update	Estimate	Status Change Update	0:30	0:15	20:00	Second	Time
«Resource Artifact»	Web Presence	Current Update	Estimate	Status Change Update	0:30	20:00	20:00	Second	Time
		Required Update	Estimate	Status Change Update	0:30	0:15	20:00	Second	Time
«Service Access»	Distribution Center								

Desired Outcome (System States and Metrics)



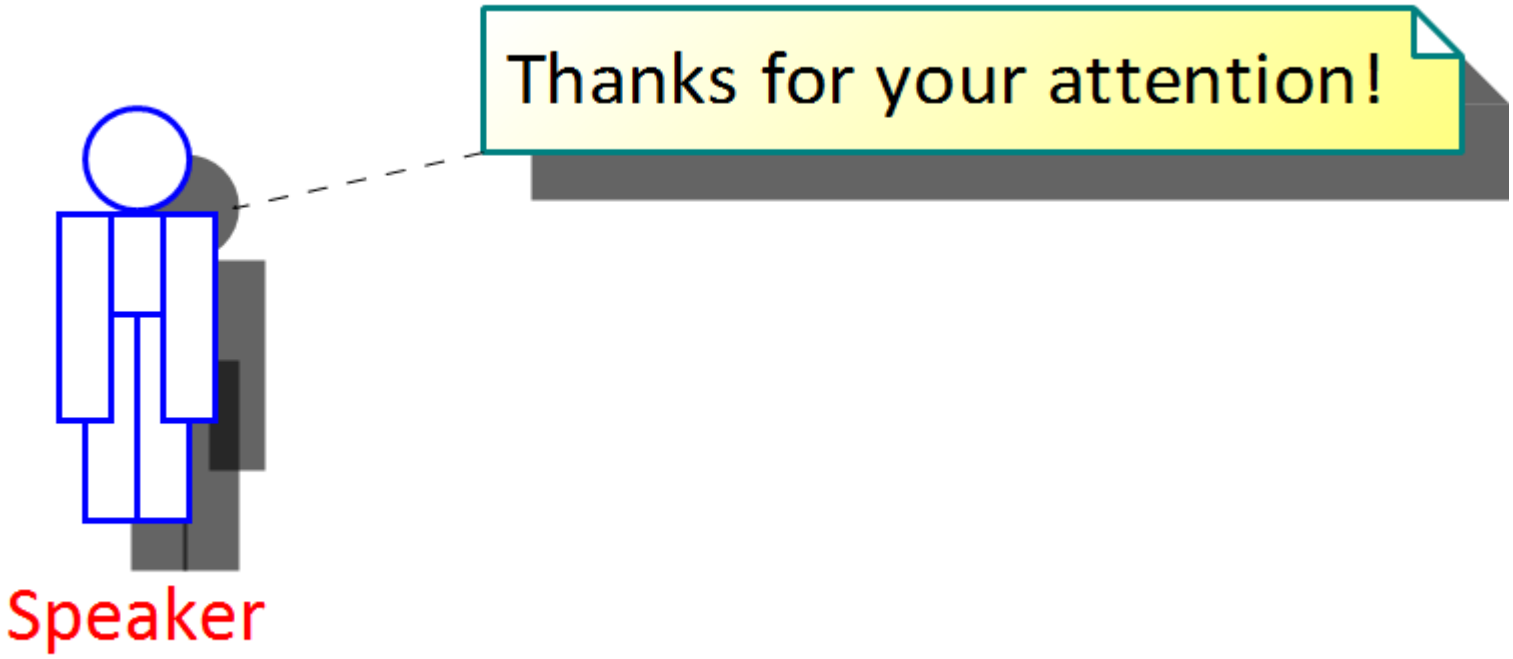
System Requirements (Showing Traceability)



Conclusions

- The UAF is a Model-Based Systems Engineering (MBSE) approach to a layered "model of models" (MOM)
- UAFP can be used with integrated SysML modeling and simulation tools to assemble complex SoS models
  - Provide built-in analysis techniques
- New technologies can and will be applied to extend the use of UAF architectures to enable
  - Architecture Federation
  - Tool Federation
  - Improved interoperability
- Improves the discovery and reuse of architectural artifacts
- Supports Systems of Systems

Questions and Answers



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