

INCOSE (MBSE) Model Based System Engineering (SoS) System of Systems Activity Introduction

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INCOSE IW11 MBSE Workshop







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- Conclusions / Recommendations
- References and Related Initiatives
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Introduction MBSE System of Systems



- System of Systems (SoS)...one of many definitions/characterizations
 - A class of problems that have unique characteristics, distinguishing them for "classic" systems.
 - For example, unbounded context and usage, potentially emergent behaviors, large number of complex interactions, costly to fully verify and validate a priori,...
 - These unique characteristics have lead the SE and Architecting community to investigate new languages and frameworks to help better define these key SoS characteristics
- SoS Engineering
 - Best Practices in Analysis, Architecture, Design, Development, Integration, Testing, Deployment and Maintenance
 - Modeling is increasingly critical to understanding, managing and validating
 - SoS modeling (e.g. SysML, MARTE, Modelica, eXtend, SimuLink, ...)
- SoS Architecting
 - Architecture Frameworks (DoDAF, MODAF, FEAF, Zachman, TOGAF,....)
 - Model Based Frameworks (e.g. UPDM Unified Profile for DoDAF/MODAF)





Introduction SoS Engineering Key Concepts



	Traditional Systems Engineering	System-of-Systems Engineering	CoC Engineering Key
Purpose	Development of single system to meet stakeholder requirements and defined performance	Evolving new system-of-systems capability by leveraging synergies of legacy systems	 SoS Engineering Key Concepts Legacy Systems Legacy Systems
System Architecture	System architecture established early in lifecycle and remains relatively stable	Dynamic reconfiguration of architecture as needs change; use of service oriented architecture approach as enabler	 Dynamic Reconfiguration of Architecture Service Oriented Architecture Enabler
System Interoperability	Defines and implements specific interface requirements to integrate components in system	Component systems can operate independently of SoS in a useful manner Protocols and standards essential to enable interoperable systems	 Protocols and Standards to Enable Interoperable Systems Added "ilities" or Quality Attributes
System "ilities"	Reliability, Maintainability, Availability are typical ilities	Added "ilities" such as Flexibility, Adaptability, Composeability	 Federated Acquisition Independent Systems Concept of Operations Critical
Acquisition and Management	Centralized acquisition and management of the system	Component systems separately acquired and continue to be managed as independent systems	 Ongoing Experimentation Converging Spirals
Anticipation of Needs	Concept phase activity to determine system needs	Intense concept phase analysis followed by continuous anticipation, aided by ongoing experimentation	SoS Modeling
Saunders, T. of-Systems E	et al, "United States Air Force Scientifi Engineering for Air Force Capability Dev	c Advisory Board Report on System- velopment," SAB-TR-05-04, July 2005	Implications \rightarrow



IntroductionSoS MBSE Implications



Legacy Systems	$\left \rightarrow \right $	Models for behavior, interfaces, requirements, performance, e.g. SysML, Modelica, MARTE
Dynamic Reconfiguration of Architecture	→	Dynamic Reconfigurable models of architecture, e.g. UPDM with UML/SysML model version management
Service Oriented Architecture Enabler	>	SOA modeling language, e.g. SoaML, SOA Patterns
Protocols and Standards to Enable Interoperable Systems	\rightarrow	Models for protocols, standards, interoperability, e.g. UPDM, DoDAF 2 MetaModel
Added "ilities" or Quality Attributes	→	Specialty Engineering models, e.g assurance
Federated Acquisition	$\left \rightarrow \right $	Models for acquisition project synergy, e.g. UPDM, MODAF, DoDAF 2 MetaModel
Independent Systems	\rightarrow	Models for independence in system functionality, e.g. Agent Based, federated models
Concept of Operations Critical	→	Models for CONOPs including Mission, Objectives, Courses of Action, etc. e.g. UPDM Operational Viewpoint, BPMN Business Processes
Ongoing Experimentation	$\left \rightarrow \right $	Analysis of Alternatives models for all viewpoints and model versioning



MBSE SoS Conceptual Model (partial) Specifies View Multiplicity default: 0..*



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Some MBSE SoS Challenges



- Core Concepts have a wide range of interpretations and definitions across modeling languages
 - Duality: System of Systems and Model of Models
 - OMG Initiative: "Ecosystem" of Languages/Models
- Methodology / Discipline differences expand into SoS Engineering
 - Object Oriented vs Structured/Functional
 - Enterprise vs SoS vs System
 - Business vs Engineering Models (BPMN vs UML vs SoaML vs SysML)
 - Enterprise, Business and Technical Architecture Models (pick your favorite Architecture Frameworks)
- Example Concepts with several interpretations
 - Capability
 - Function
 - Activity
 - Requirement
 - View
 - Viewpoint
- Example Languages with overlap
 - BPMN and UML (SysML, UPDM)

They remain separate standards			
BPMN is a UML profile with notation			
Create a unified model encompassing both			
Semantic models with UML and BPMN viewpoints			
BPMN replaces UML activity diagrams			
BPMN grows to make UML not required			
BPMN and UML are separate models, mapped with QVT			
There are ways to make links between them			

UML/BPMN Integration Straw Poll (source OMG)



Systems Language Models for SoS



SysML Core Concepts

- Structure, Behavior, Requirements, Parametrics
 - View, Viewpoint, Block, Part, Role, Connector, Interface, Item, ItemFlow, Activity, State, Transition, Requirement, Constraint Block,...
- SoS Core Concepts
 - View, Viewpoint, Enterprise, Mission, Projects, Milestone, Vision, Goal, Policy, Capability, Node, Configuration, Resource, System, Information, Data, Technology, Standard, Organization, Task, Activity, Measures of Effectiveness, Key Performance Parameters, "ilities", Scenario, Workflow...

SysML/SoS Mapping Example (one of several approaches)

- Structure (Block,...)
 - Enterprise, Capability, Configuration, Resource, Systems, Information, Data, Technology, Organization, Milestone, Vision, Goal, Node, ...
- Behavior (Activity, State,...)
 - Function, Task, Activity, Scenario, Workflow,
- Requirement
 - Policy, Constraint, Standard,...
- Parametrics
 - MoE's, KPP's, "ilities"...

See UPDM and DoDAF Meta model References for mapping standards efforts





Architecture Framework (AF) Models for SoS



- Zachman Framework
 - Perspectives, Interrogatives, Checklist
- TOGAF 9 (The Open Group AF)
 - Architecture Development Model
- FEAF (Federal Enterprise AF)
 - Reference Models (Business, Technical, Information, ...)
- DoDAF 2 / MODAF / NATO AF /...
 - Viewpoints, Products for Capability, Operational, System, Service, Technology Standards, Information, ... Views
- ...and many additional variants of various combinations of the above frameworks





MBSE SoS Case Studies



- Architecture Eco-System Efforts
 - Special Interest Group at OMG
 - Co-Chairs:
 - Jim Amsden (IBM)
 - Cory Casanave (Model Driven Solutions)
- UPDM and DoDAF 2.0
 - UPDM 1.0 official OMG standard
 - Co-Chairs
 - Jim Rice, NoMagic
 - Graham Bleakley, IBM
 - Matthew Hause, Atego
 - DoD
 - Walt Okon, OSD
 - Len Levine, DISA

