A SYSTEMS ENGINEERING TOOLS ECOSYSTEM

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October, 2018

ptc

AGENDA

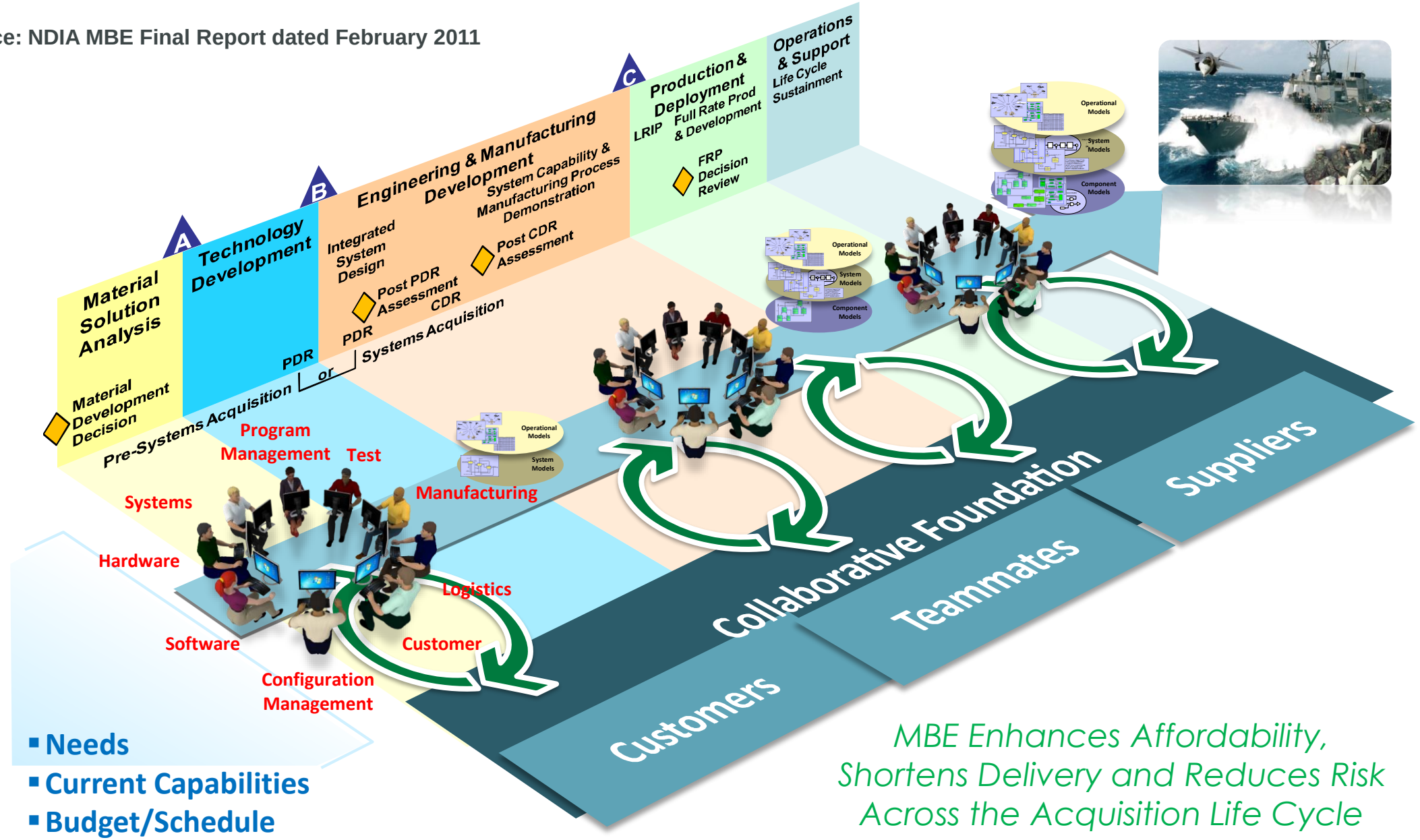
- Introduction
- The INCOSE 2020 Vision
- MBSE
- SysML 2.0
- Data Architectures
- Conclusions
- Questions and Answers?

MODEL-BASED SYSTEMS ENGINEERING (MBSE)

- The NDIA defines Model-Based Systems Engineering (MBSE) as "an approach to engineering that uses models as an integral part of the technical baseline that includes the requirements, analysis, design, implementation, and verification of a capability, system, and/or product throughout the acquisition life cycle."
  - MBSE is much more than JUST SysML
  - There are a variety of methods in use
  - Some are standards based and others are proprietary
  - Supported by hundreds of tools

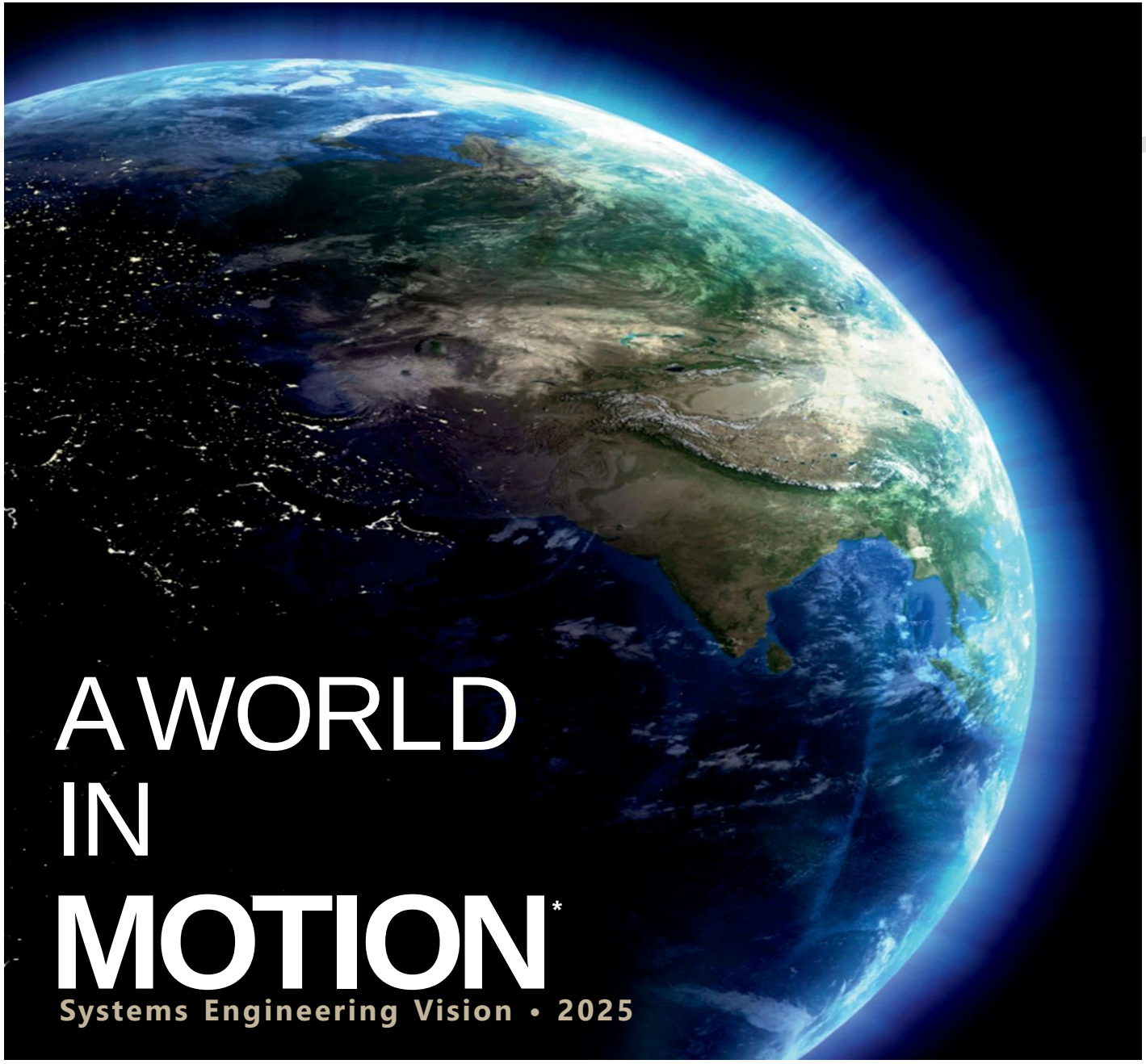
MBE TO BE STATE

Source: NDIA MBE Final Report dated February 2011



- Needs
- Current Capabilities
- Budget/Schedule

MBE Enhances Affordability, Shortens Delivery and Reduces Risk Across the Acquisition Life Cycle



INCOSE
International Council on Systems Engineering

Model-based Systems Engineering (MBSE) Initiative Overview

Sanford Friedenthal

Mark Sampson

INCOSE
International Council on Systems Engineering

MBSE Initiative Charter

- Supports MBSE Component of the SE Vision 2020
- Promote, advance, and institutionalize the practice of MBSE through broad industry/academic involvement
  - Research
  - Standards
  - Processes, Practices, & Methods
  - Tools & Technology
  - Outreach, Training & Education
- MBSE Wiki
  - http://www.omgwiki.org/MBSE/doku.php

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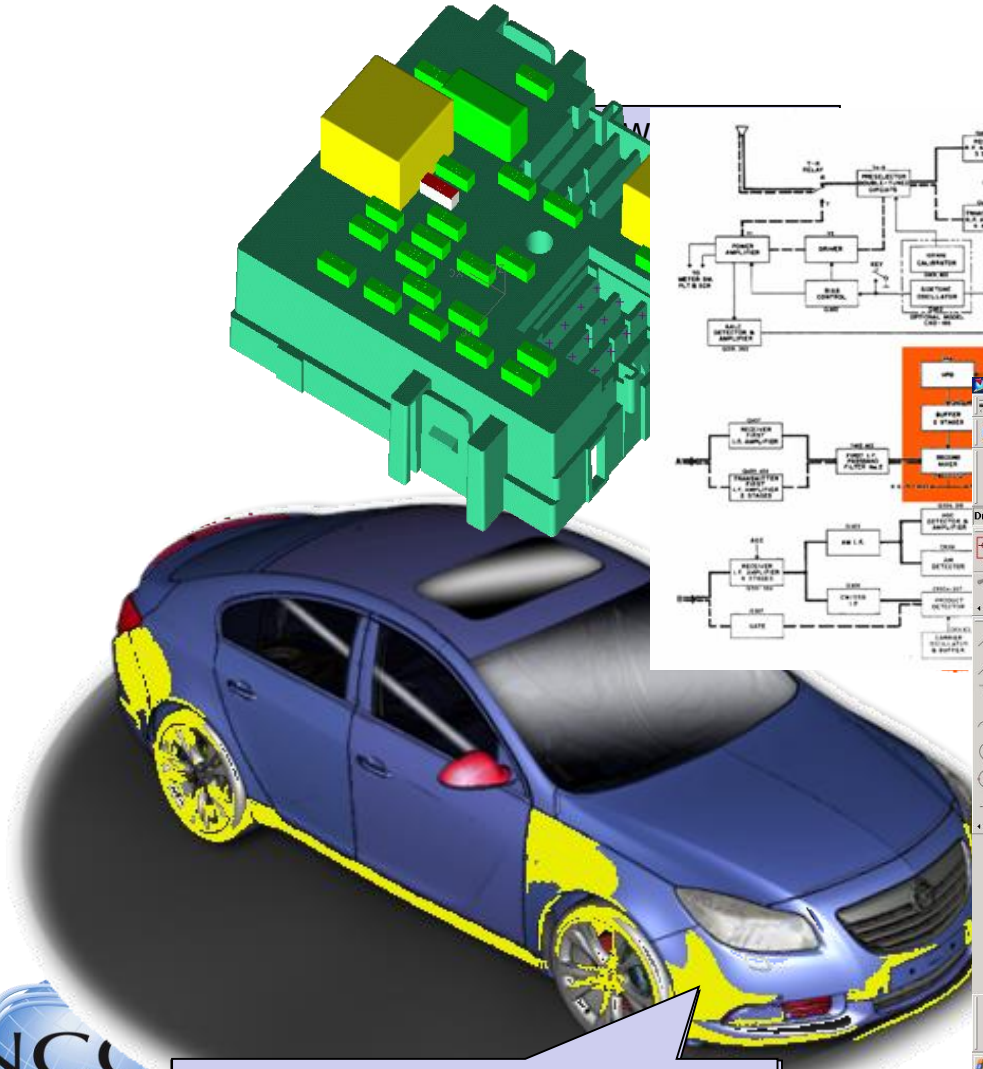
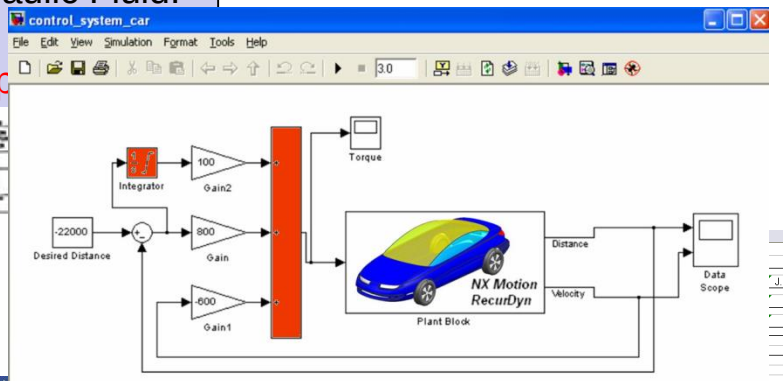
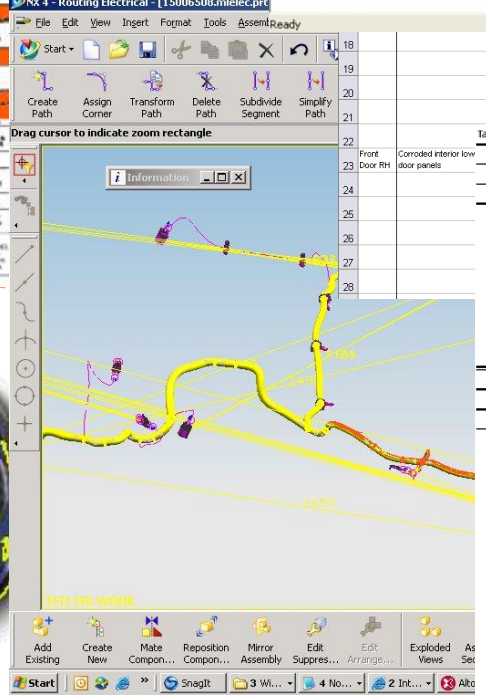
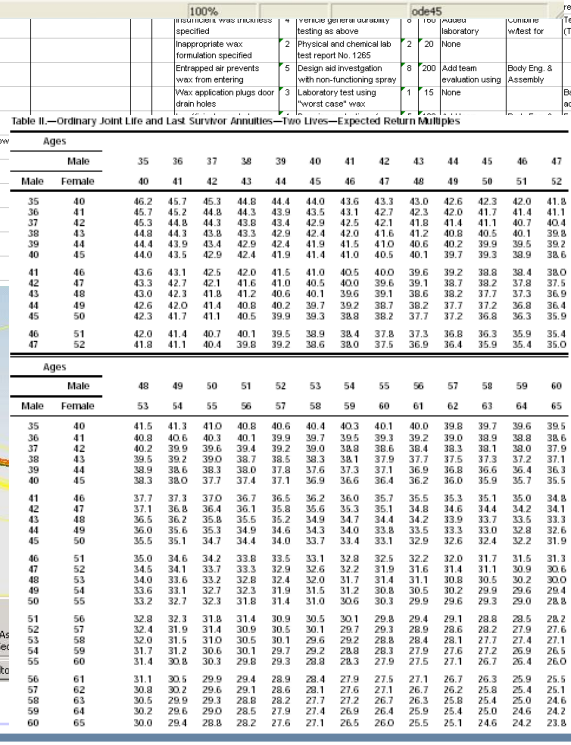
Integrated Systems Engineering Vision

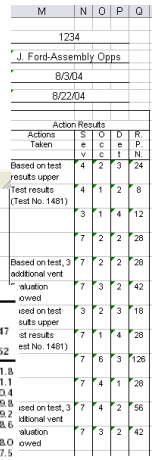
Hydraulic Fluid:
SAE
comp

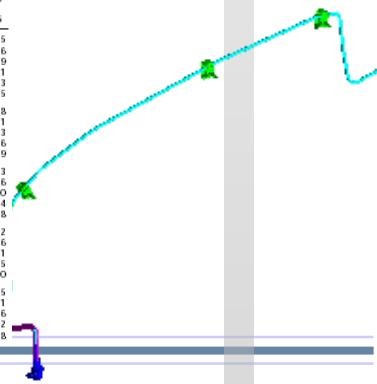












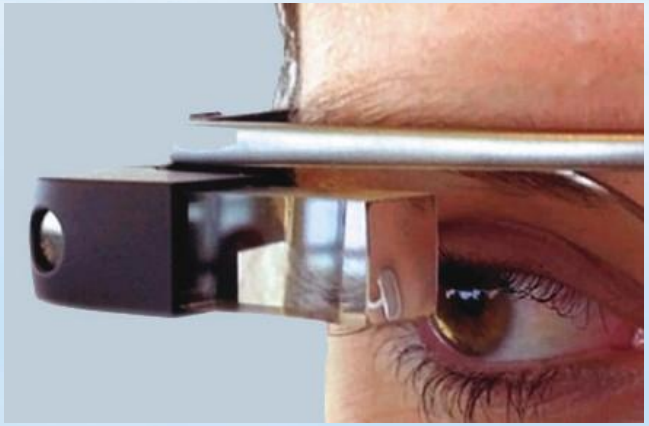
Minimum Turn Radius: 24 ft.
Dry Pavement Braking Distance
at 60 MPH : ~~110~~ ft. 90 ft

TECHNOLOGY DRIVEN SYSTEMS ENGINEERING TOOLS

Cloud-based high performance computing supports high fidelity system simulations

Advanced search query, and analytical methods support reasoning about systems

Immersive technologies support data visualization



Net-enabled tools support collaboration

Leveraging Technology for Systems Engineering Tools

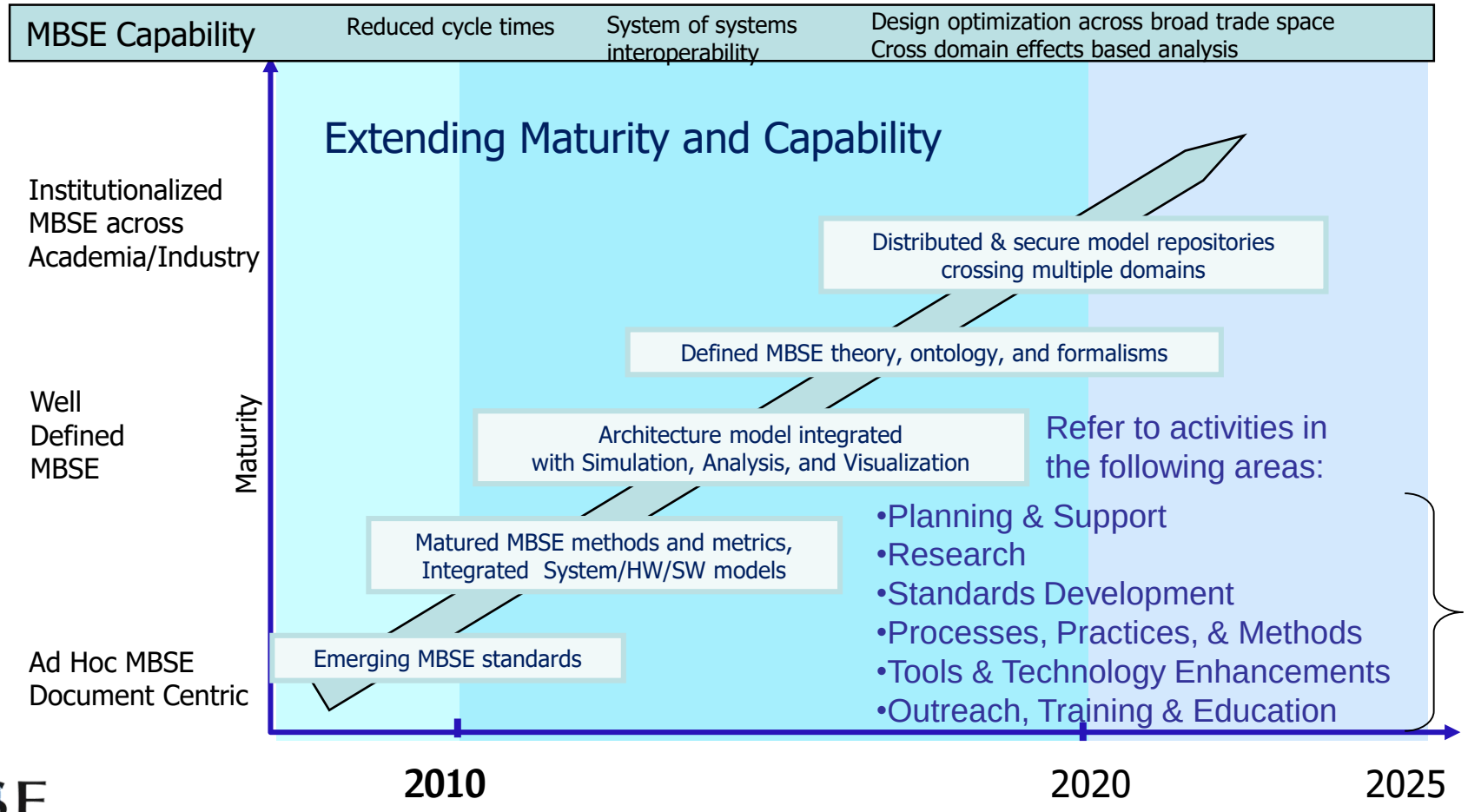
FROM

Current systems engineering tools leverage computing and information technologies to some degree, and make heavy use of office applications for documenting system designs. The tools have limited integration with other engineering tools.

TO

The systems engineering tools of 2025 will facilitate systems engineering practices as part of a fully integrated engineering environment. Systems engineering tools will support high fidelity simulation, immersive technologies to support data visualization, semantic web technologies to support data integration, search, and reasoning, and communication technologies to support collaboration. Systems engineering tools will benefit from internet-based connectivity and knowledge representation to readily exchange information with related fields. Systems engineering tools will integrate with CAD/CAE/PLM environments, project management and workflow tools as part of a broader computer-aided engineering and enterprise management environment. The systems engineer of the future will be highly skilled in the use of IT-enabled engineering tools.

INCOSE MBSE Roadmap



INCOSE
International Council on Systems Engineering

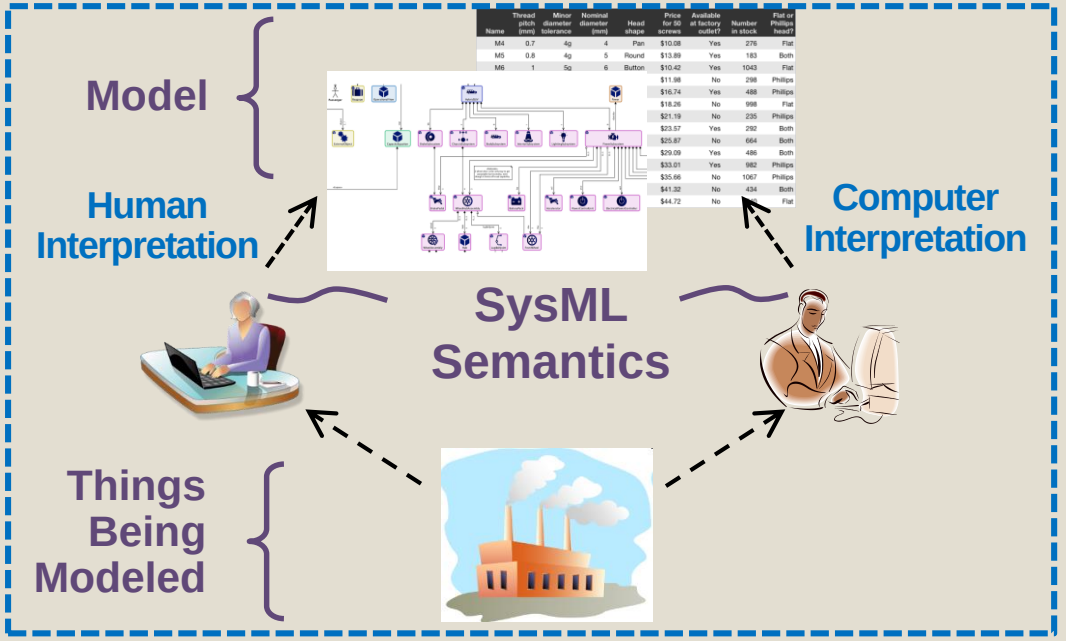
The Systems Modeling language (SysML)

- Diagrams for system requirements, behavior, structure and parametric relationships.
  - Used to define high-level abstract systems down to detailed physical systems.
- Developed by the Object Management Group (OMG) and INCOSE.
  - Organizations from industry, academia, government, standards organizations, etc.
  - Many books on its basic notation and how to use SysML in large complex systems.
  - More than 10 commercial implementations of SysML tools are available, as well as freeware and shareware.
- Integrations between SysML tools and other SE tools such as analysis tools, requirements engineering tools, PLM tools, process tools, etc.
  - Open System Lifecycle Collaboration (OSLC) has provided a standardized means of connecting tools that do not require point to point integrations.
  - Mandated for the development of many different military systems.

INCOSE
International Council on Systems Engineering

SysML v2
Next Generation Systems Modeling Language

- SysML v1 adopted in 2006 and facilitated MBSE awareness and adoption
- SysML v2 to enhance MBSE effectiveness:
  - Precision & expressiveness
  - Interoperability with other engineering models and tools
  - Usability by model developers and consumers



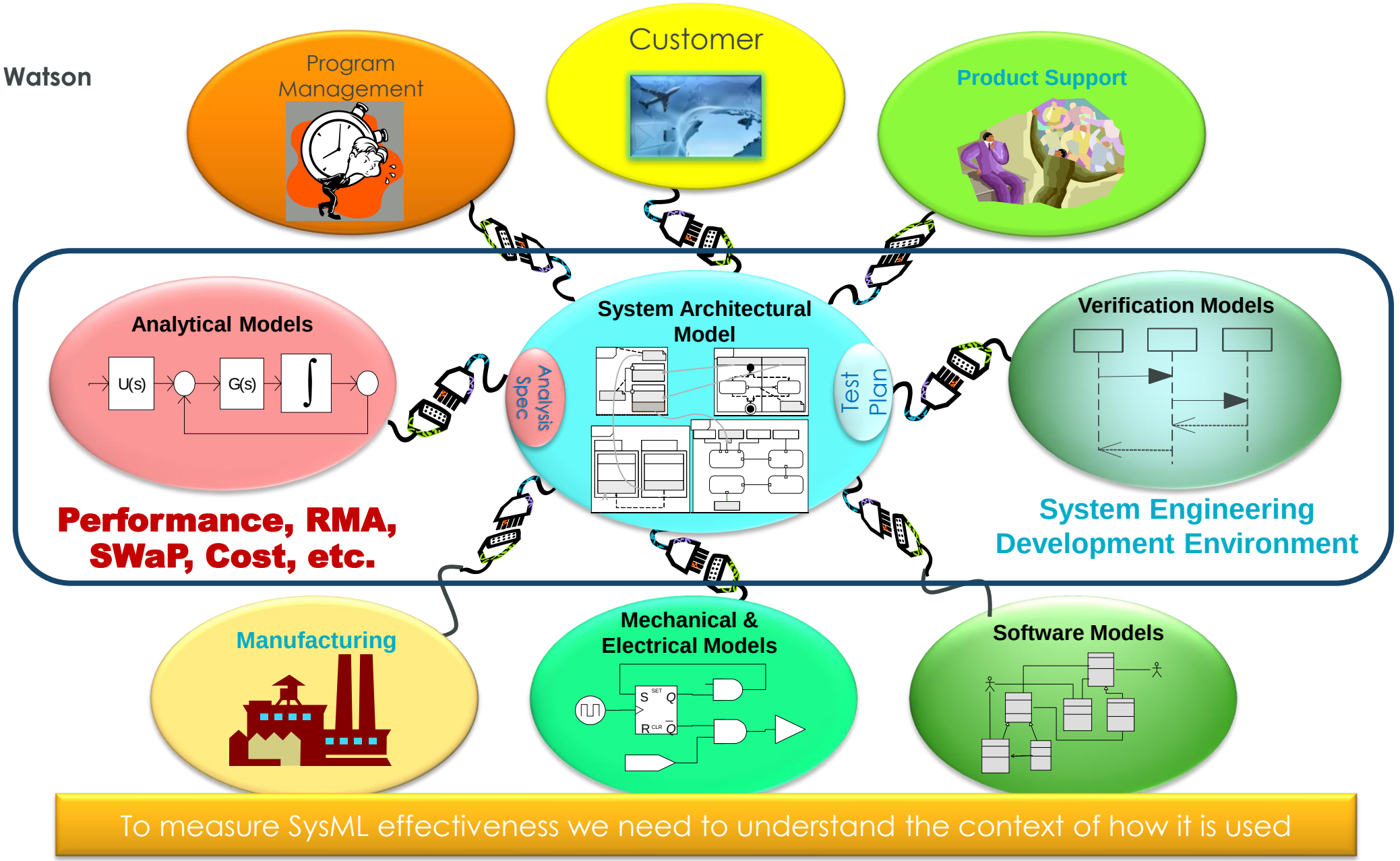
SST Objectives & Approach

- Deliver a SysML v2 Specification compliant with the SysML v2 RFP and SysML v2 API and Services RFP
  - On the RFP schedule
  - Validated by the user community
  - With a demonstrable pilot implementation
  - That provides a smooth migration path for SysML v1 users and models
- Driven by RFP requirements and user needs
  - Incremental deliveries on a monthly cadence
  - Incremental pilot implementation to support user feedback
- By a broad team of end users, vendors, academia, and government liaisons
  - Currently ~80 members from 56 organizations
- Organized into 6 tracks
  - PM track serves as integration role

SE TOOL ARCHITECTURE

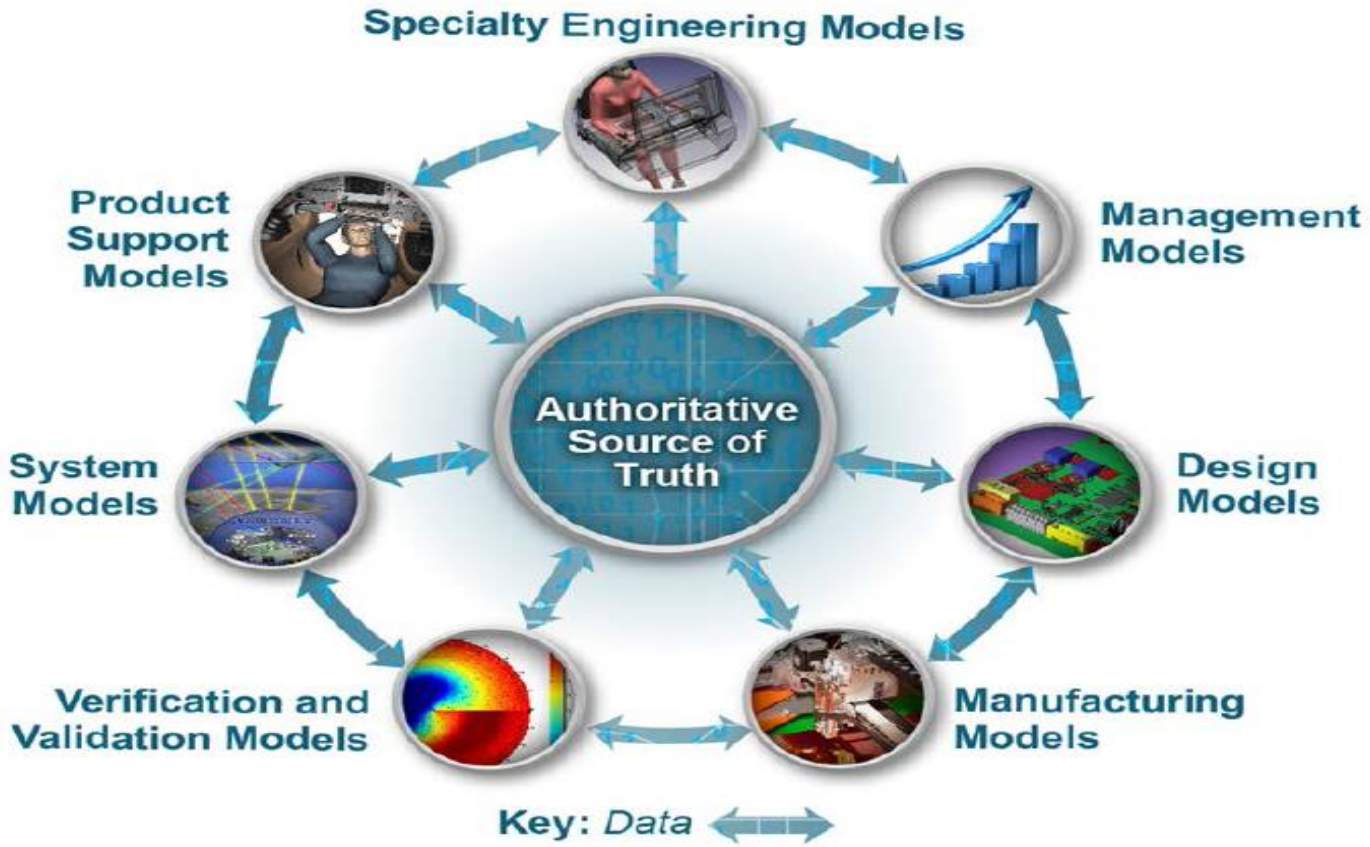
EVOLVING MBSE USE CASES: SYSML AT THE CENTER

Source; John Watson



To measure SysML effectiveness we need to understand the context of how it is used

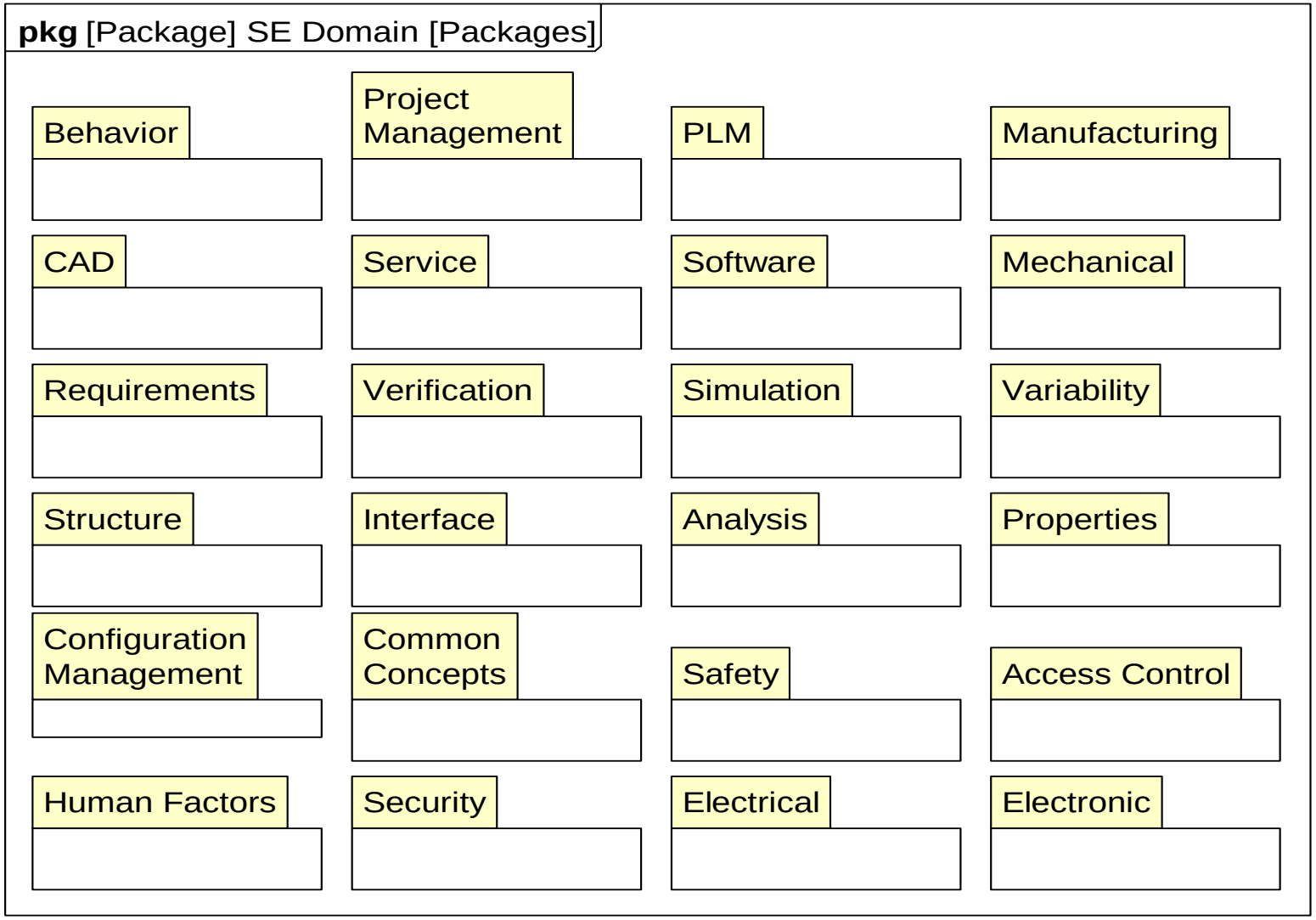
Goal #1: Formalize Development, Integration & Use of Models



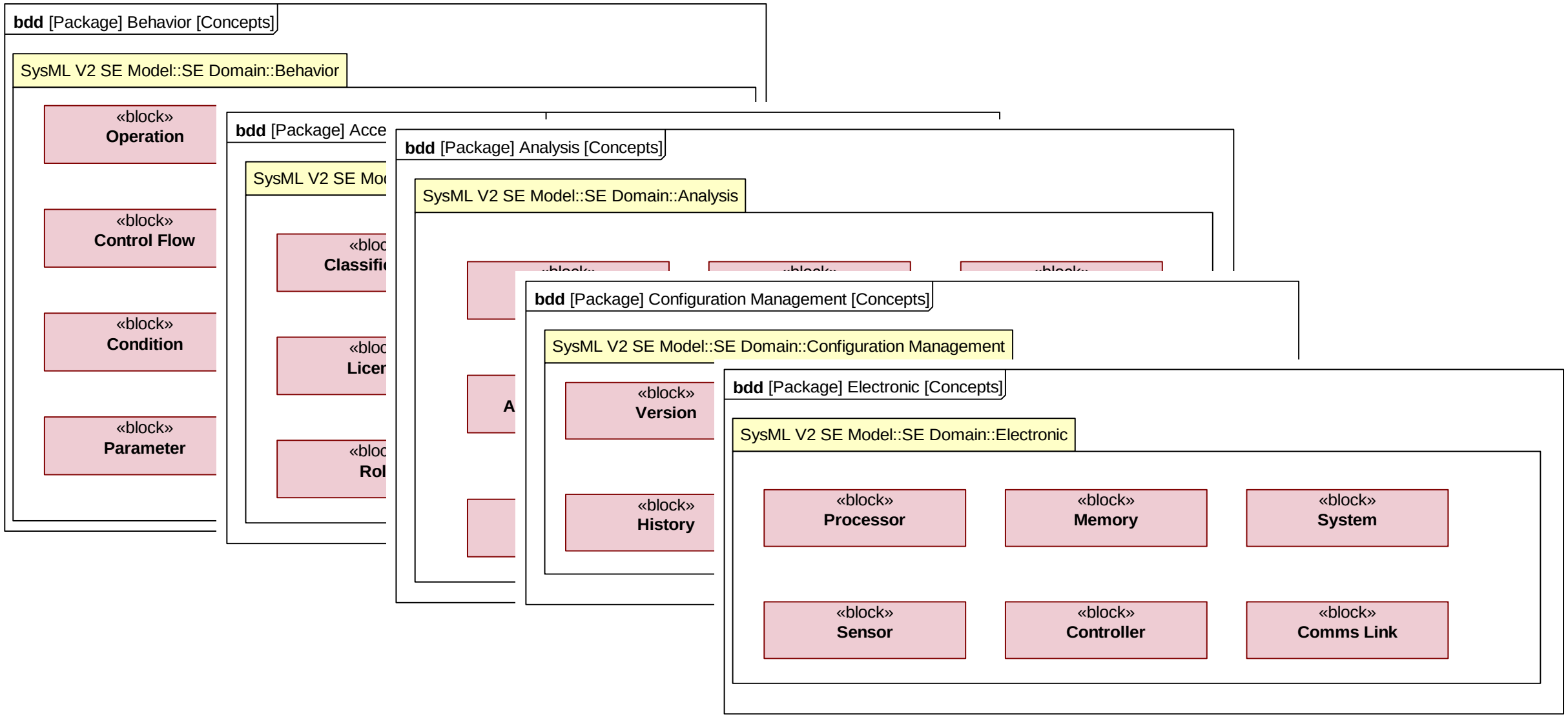
Models as the cohesive element across a system's lifecycle

SE DOMAINS

- Areas of interest for systems engineers
- Each is a separate data source
- Traceability/exchange is required between these

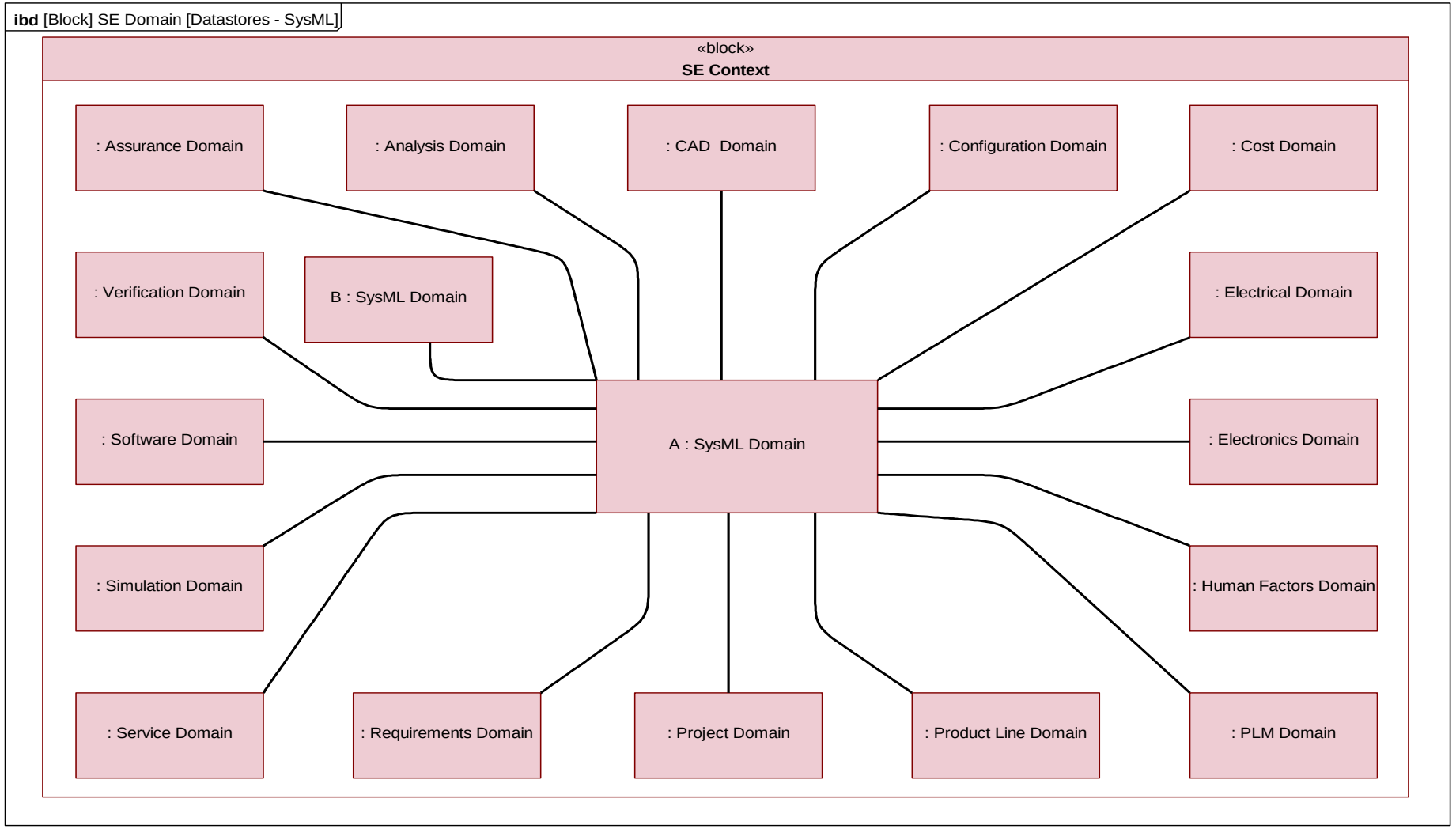


CONCEPTS WITHIN EACH DOMAIN (PARTIAL)



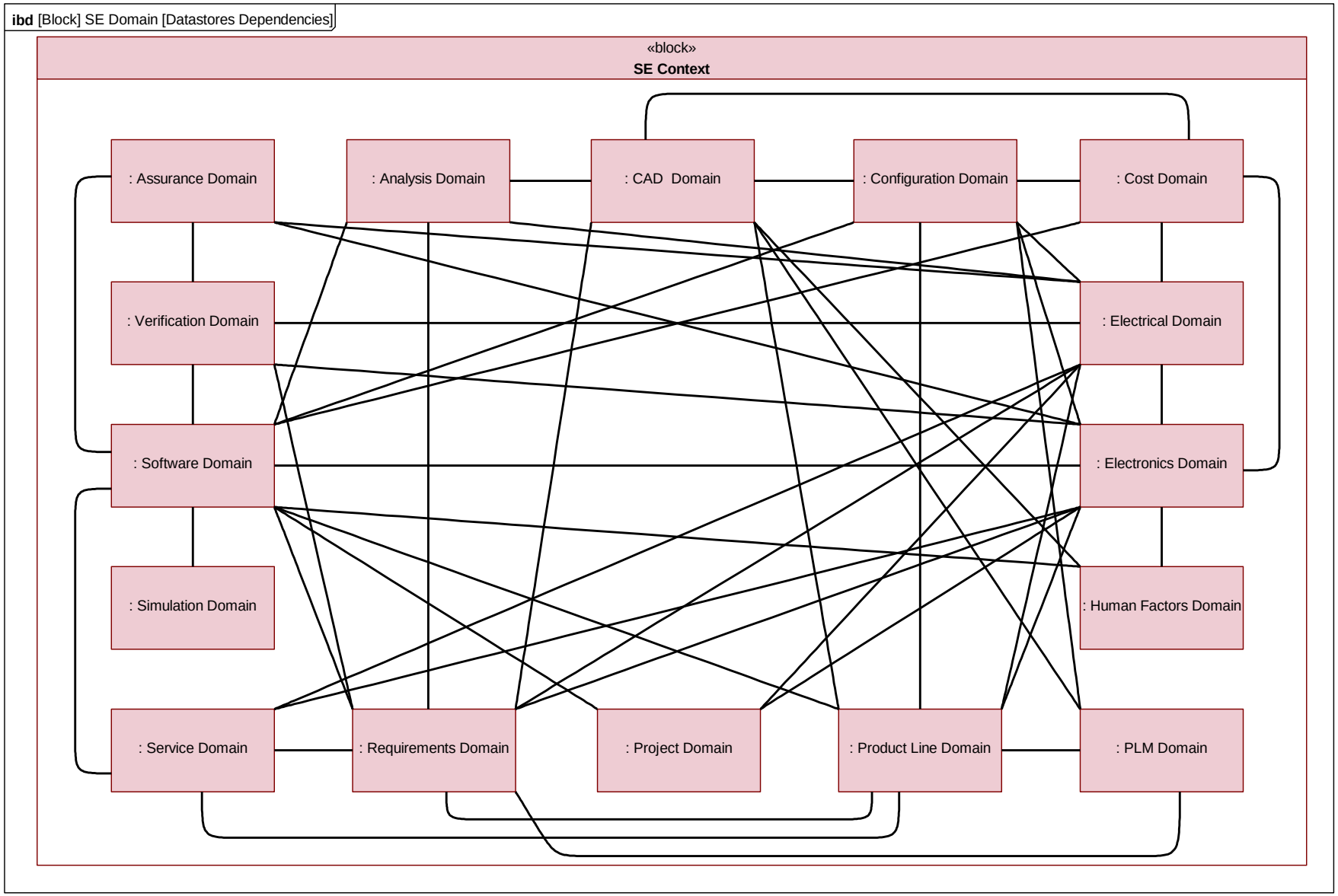
FEDERATED DATA ARCHITECTURE

- The System Model at the center of the development effort



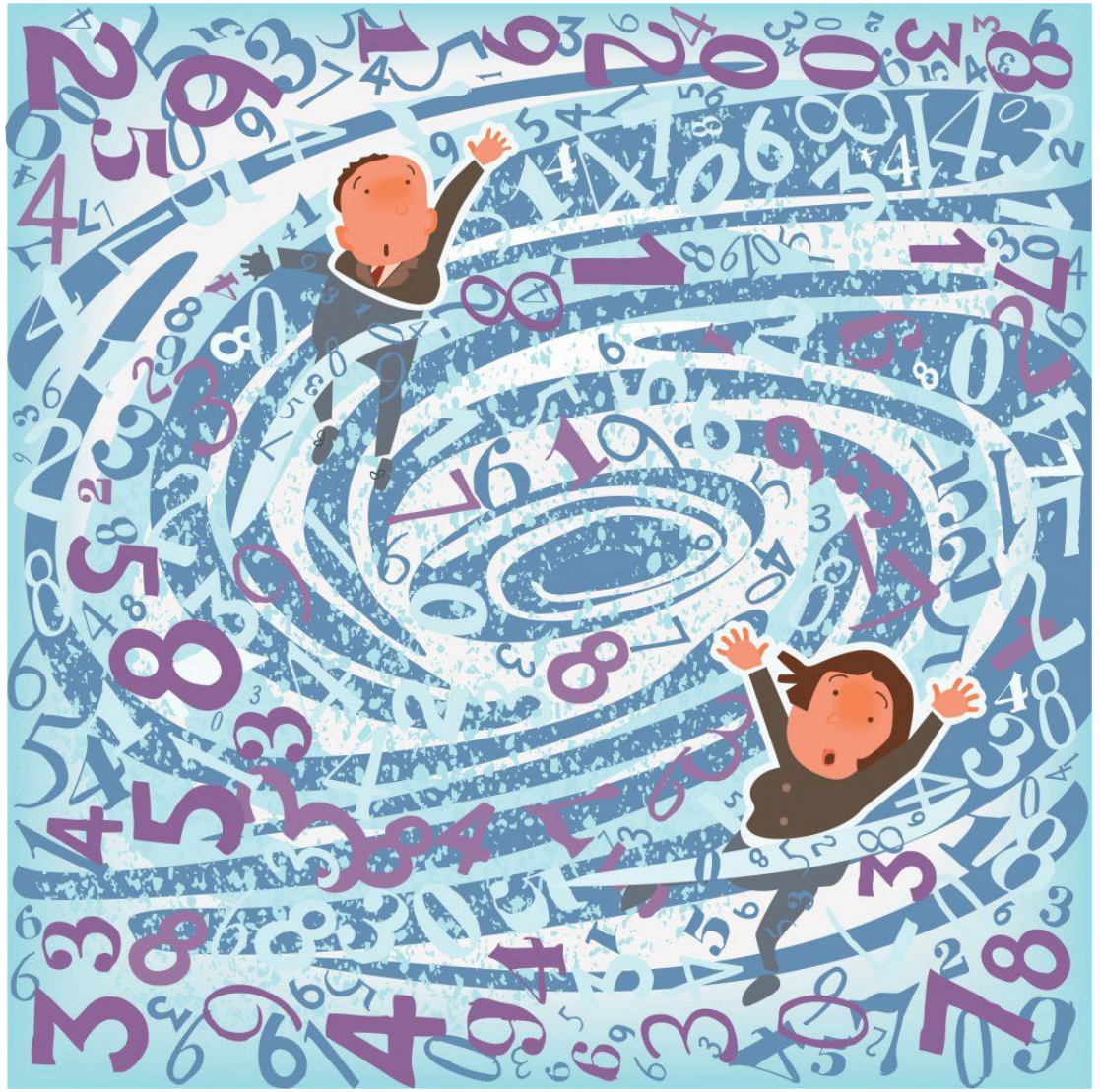
NETWORK BASED ARCHITECTURE

- It looks awful and chaotic, but is closer to reality
- Development is more of a network rather than a hierarchy.
- Point to point interfaces would be impossible to create and maintain



SOURCE(S) OF TRUTH

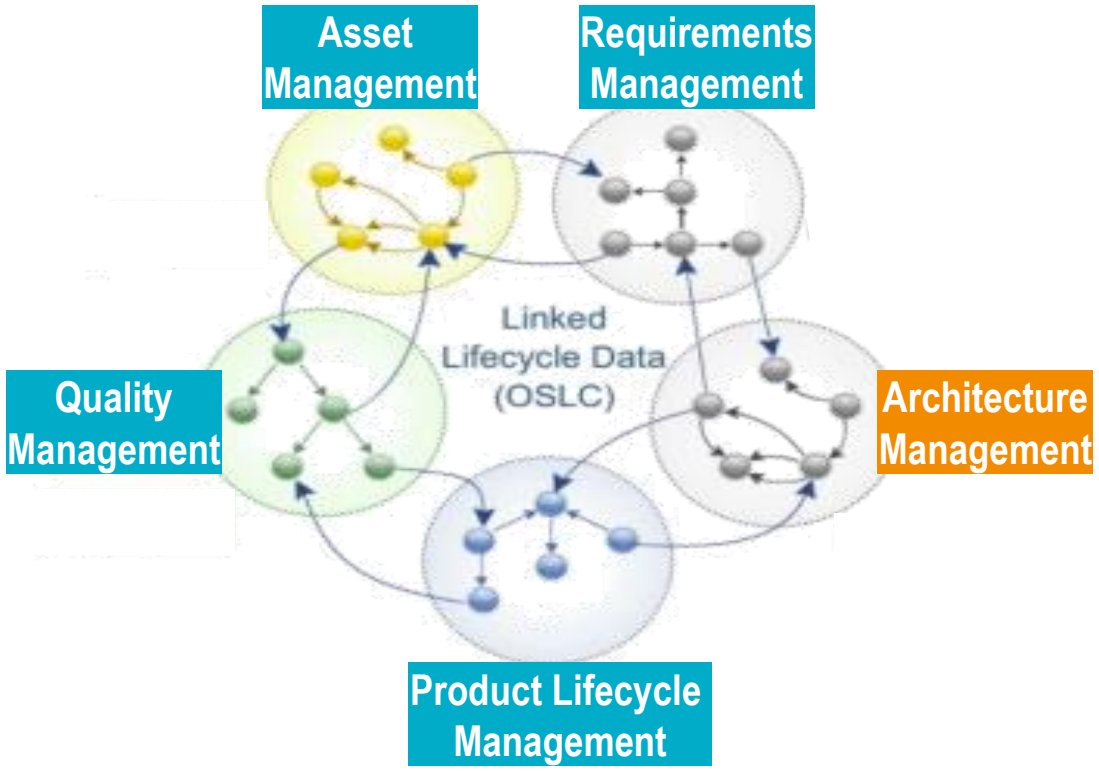
- Single source of truth does not mean all data is stored in a single database
- DEWG group and others preferred term is “Authoritative Source of Truth”
- Data is owned and can be accessed in multiple locations, NOT in a single database.
- Constant transfer of large amounts of data between locations ensures:
  - Duplication of data
  - Old and irrelevant data
  - Data chaos
- Interoperability NOT Interchange



OPEN SERVICES FOR LIFECYCLE COLLABORATION

OSLC is being used as a foundational layer to satisfy key customer use cases – extended as needed to deliver more robust interoperability.

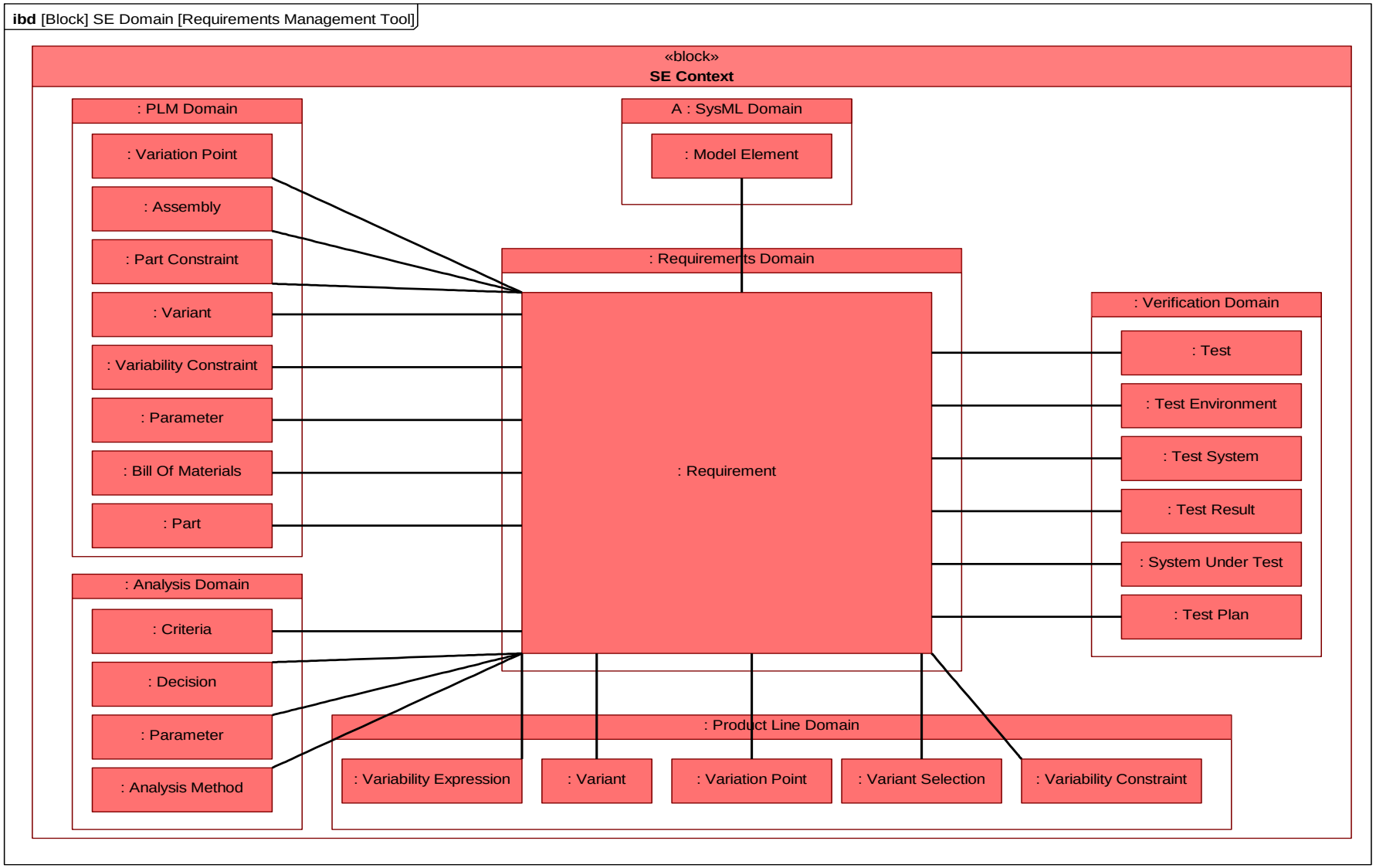
- Standards-based
  - Extends the value of ALM investments
  - RESTful Web Services architecture
- Designed for maintainability
  - Source application owns both data and UX
  - No data transformations, replication or synchronization
- Open / extensible
  - Enables use cases for cross-vendor interoperability
  - Supports N:N relationships – ideal for selective data sharing across supply chain



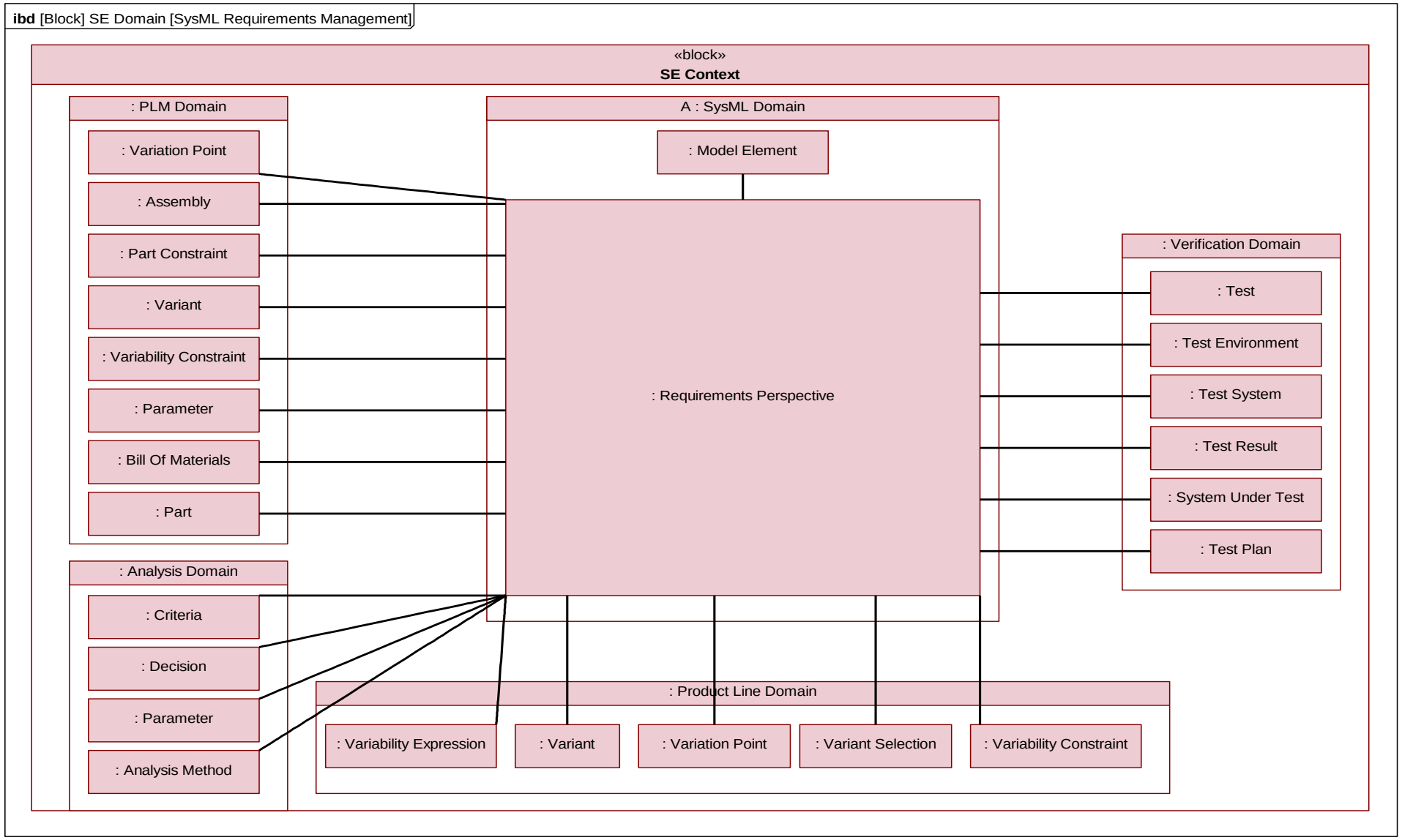
OSLC GROUPS

- ALM-PLM Interoperability (2nd edition)
  - Define Industrial relevant scenarios for interoperability of ALM and PLM engineering.
- Lifecycle Integration Patterns
  - A user group focused on finding and sharing of solutions to common lifecycle integration problems.
- Linked Data Platform
  - Writing a W3C specification for HTTP-based (RESTful) application integration patterns using read/write Linked Data.
- RDF Data Shapes
  - Writing a W3C Recommendation for describing structural constraints and validate RDF instance data against those
- Automation
  - Reducing manual interactions in all phases of software development and operations
- Change and Configuration Management
  - Tasks, defects, assets, and configurations at OASIS
- PROMCODE TC
  - Exchanging project management information across organizational boundaries
- Core
  - Common problems with finding, creating, and updating resources
- Architecture Management
  - Modeling, diagrams, and use cases for software development
- Automation
  - Plans, requests, and results for builds and deployments
- Change Management
  - Defects, enhancements, changes, and tasks
- Performance Monitoring
  - Watching availability, performance, and capacity
- Quality Management
  - Plans, cases, and results for ongoing testing
- Requirements Management
  - Define stakeholder needs and how to meet them
- Embedded Systems
  - Integrating dedicated components
- Mobile
  - Mobile-specific needs
- Asset Management
  - Reusable components, documentation, and representations
- Configuration Management
  - Snapshots, baselines, and versions
- Estimation and Measurement
  - Size, quality, time, and effort for making software

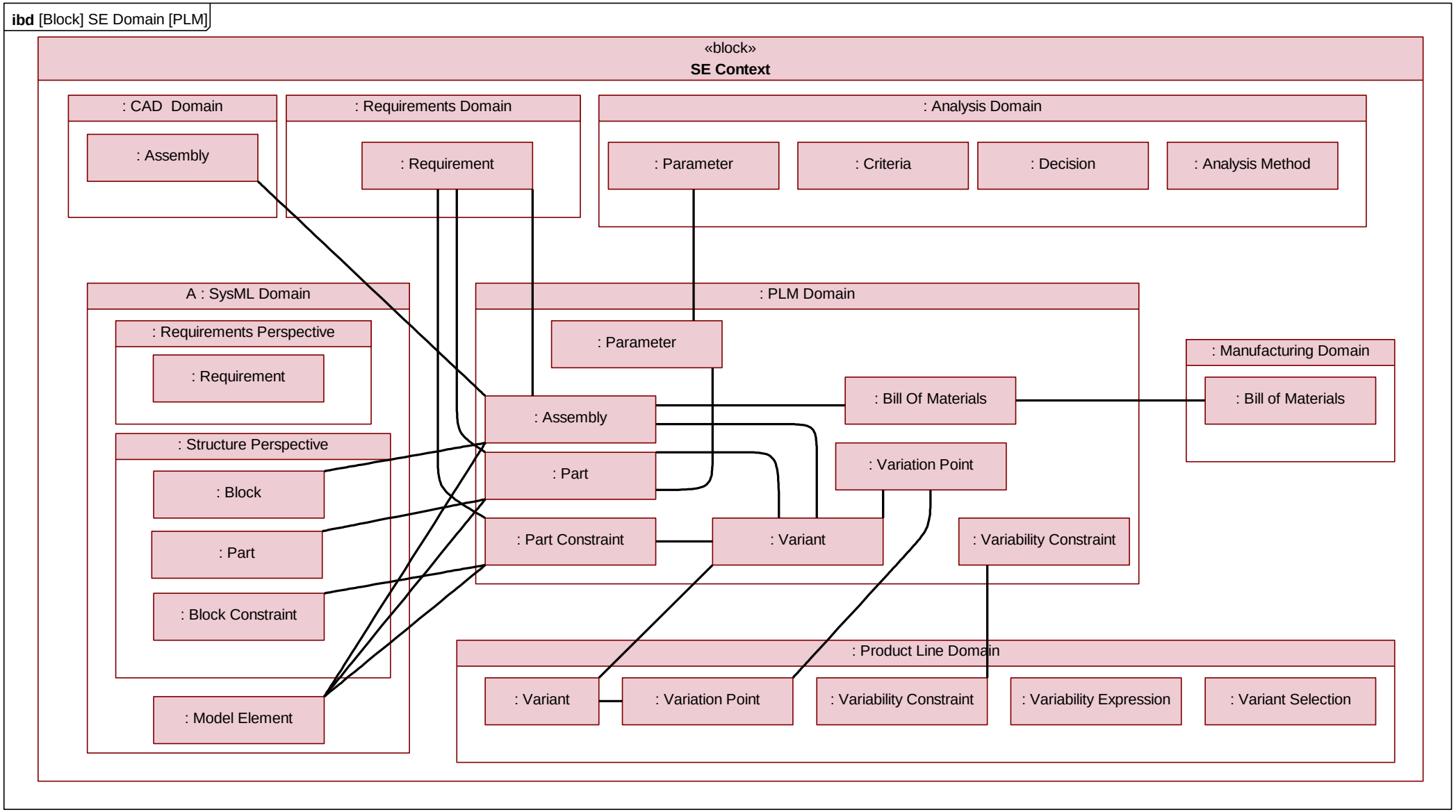
REQUIREMENTS MANAGEMENT TRACEABILITY



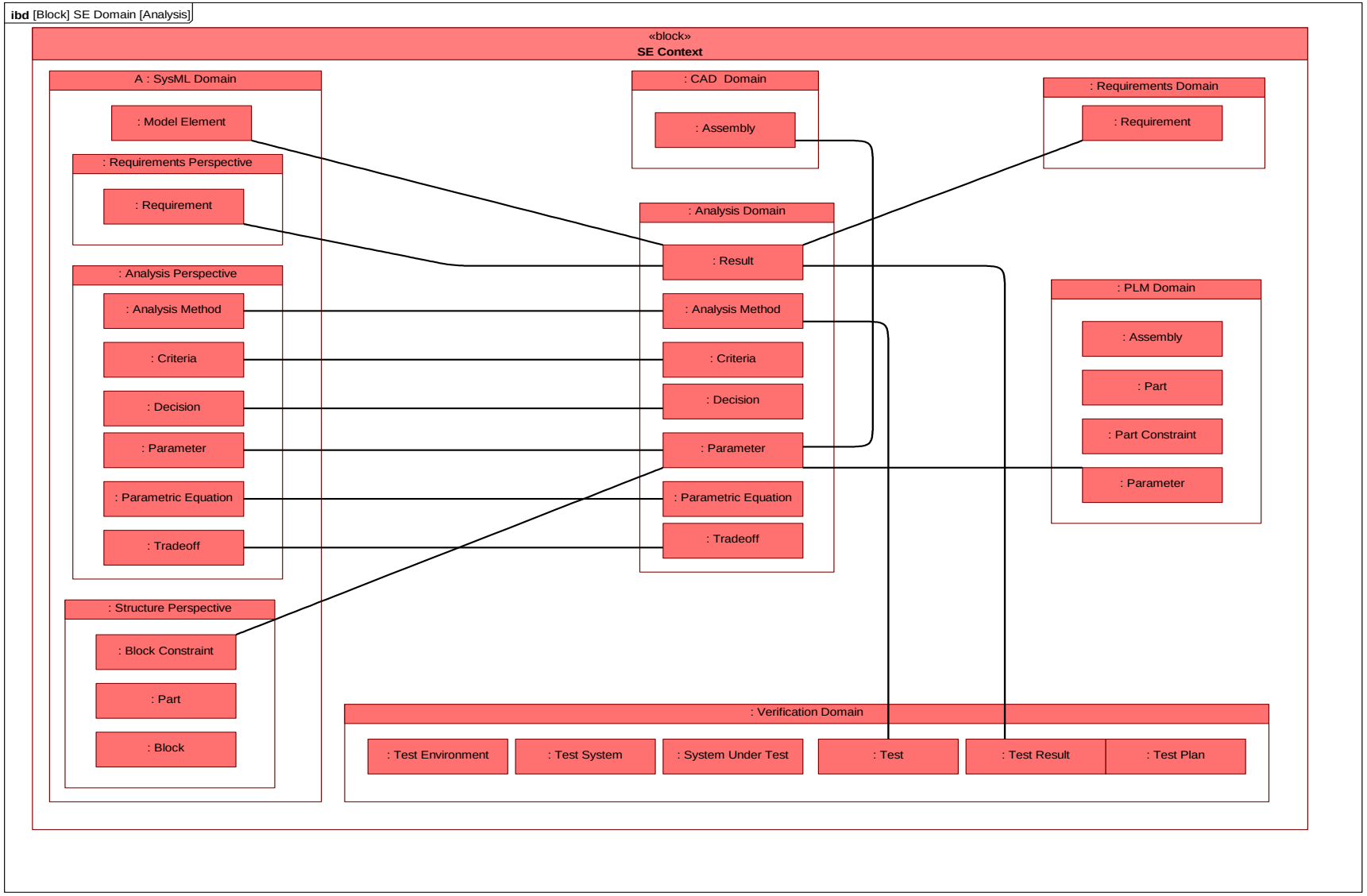
SYSML REQUIREMENTS TRACEABILITY



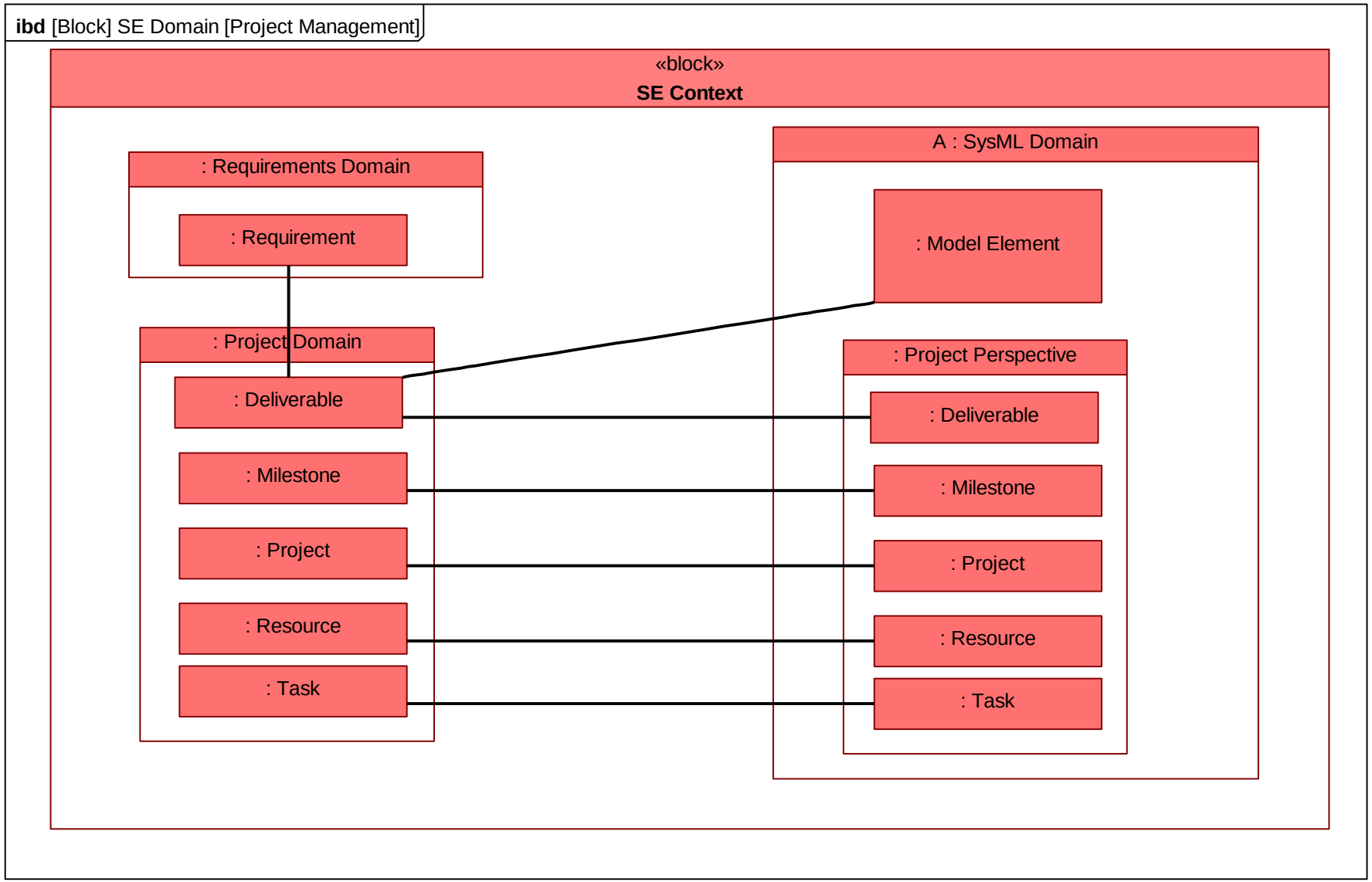
PLM DOMAIN TRACEABILITY



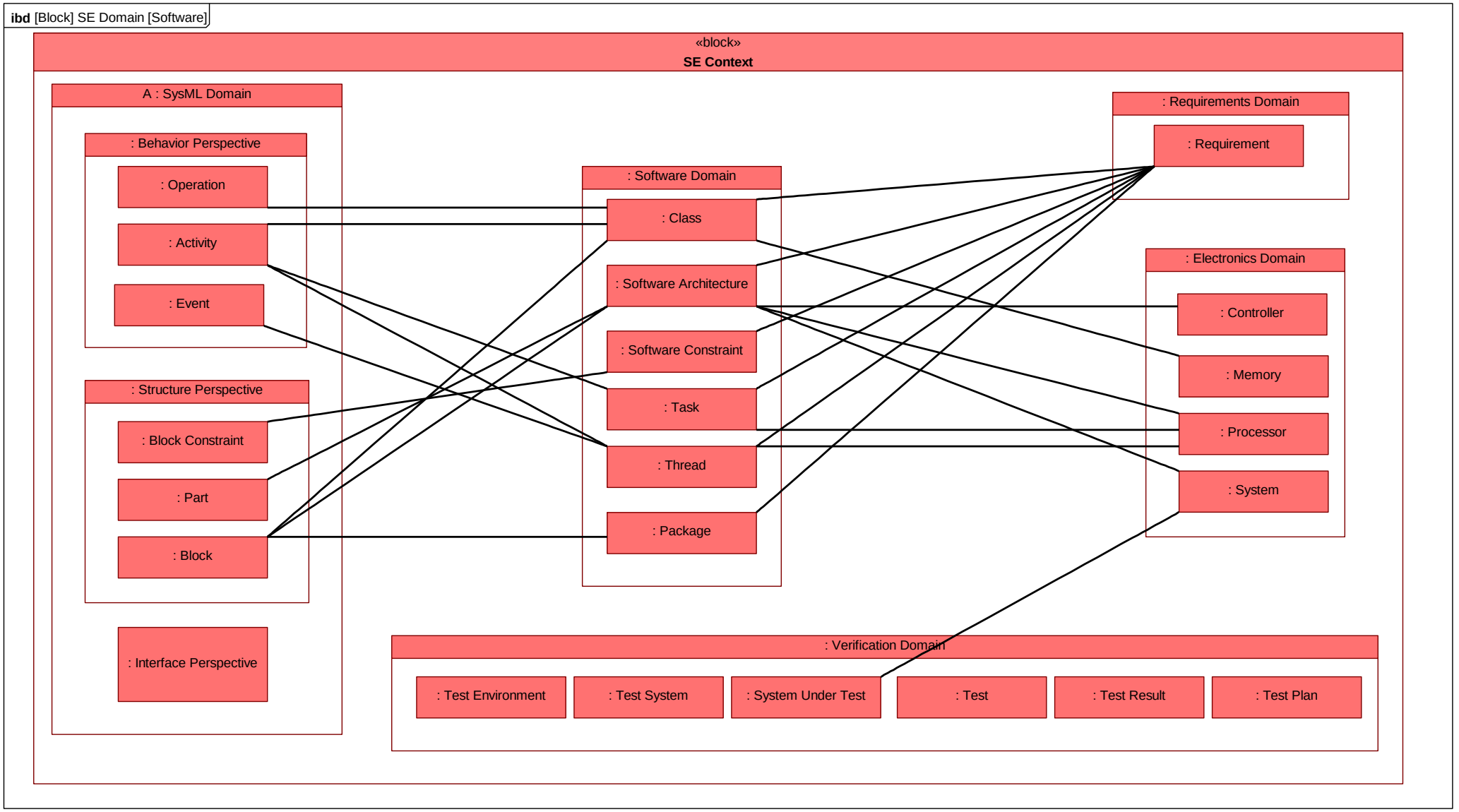
ANALYSIS DOMAIN



PROJECT MANAGEMENT TRACEABILITY



SOFTWARE DOMAIN TRACEABILITY



Systems of Engagement

ThingWorx

Role Based Business & Engineering Apps

navigate

AR/VR

mashup

Crosscutting Workflow Orchestration - Symphony

integrity lifecycle manager

integrity modeler

integrity lifecycle manager

windchill

Others...

integrity lifecycle manager

Crosscutting Link & Context - OSLC/REST

Thing Library

integrity lifecycle manager

Requirements

integrity modeler

Functions

integrity modeler

Logical Structure

windchill pdmlink windchill bom management
windchill platform structures

eBOM mBOM sBOM

Options & Choices

Product Structure

integrity lifecycle manager SCM

Software Structure

3rd Party...

integrity lifecycle manager
integrity modeler sysim

Tests Results Simulation

Validation

Physical

Digital

Systems of Record

Authoring & Sourcing = Data Authority

SST

SysML v2 Submission Team (SST)
Track Lead Telecon

Track 5

API and Services

OMG Ottawa

Tue, Sep 25, 2018

Manas Bajaj / Intercax
manas.bajaj@intercax.com

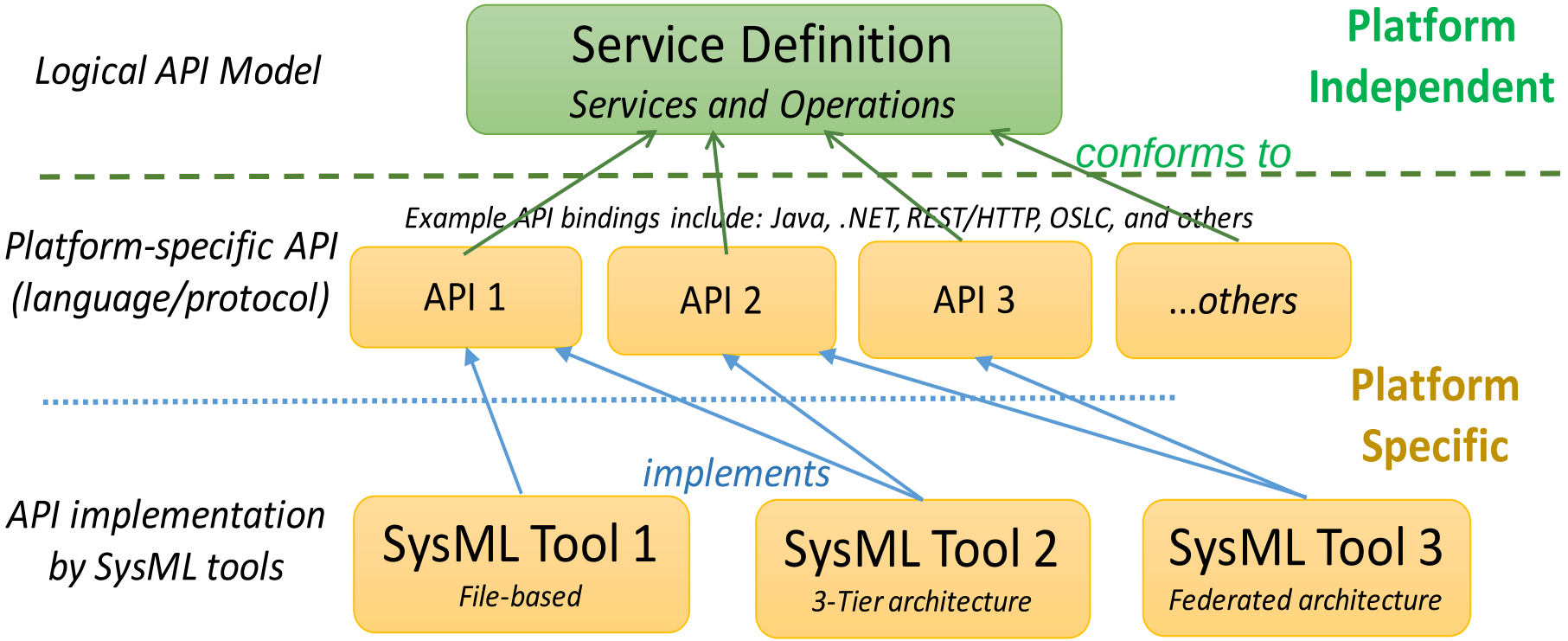
Progress

SST

- SysML v2 API & Services RFP issued at OMG Boston (Jul'18)
- Defining API services (PIM level)
- POC implementation (REST/HTTP PSM) + Infrastructure
  - Play framework (web-services) + Cassandra (database)
  - GET and POST endpoints for model, elements, and relationships (any type)
  - Expanding infrastructure for reference implementation
- Validation tests
  - Reviewing validation test scenarios (Track 2)
  - Using test models created using concrete textual syntax (Track 6)
  - Test models created using REST/HTTP endpoints

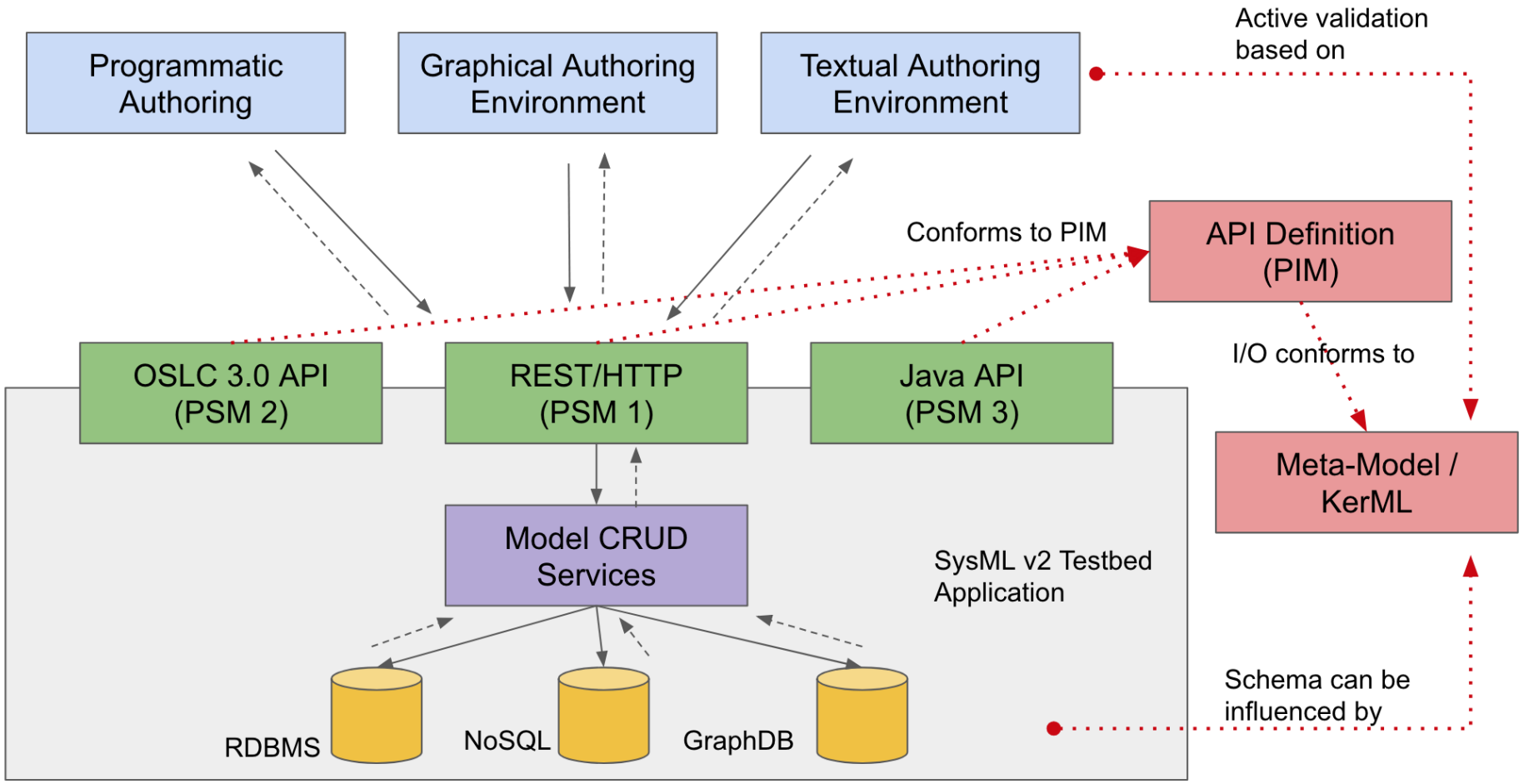
API Architecture – PIM and PSM

SST



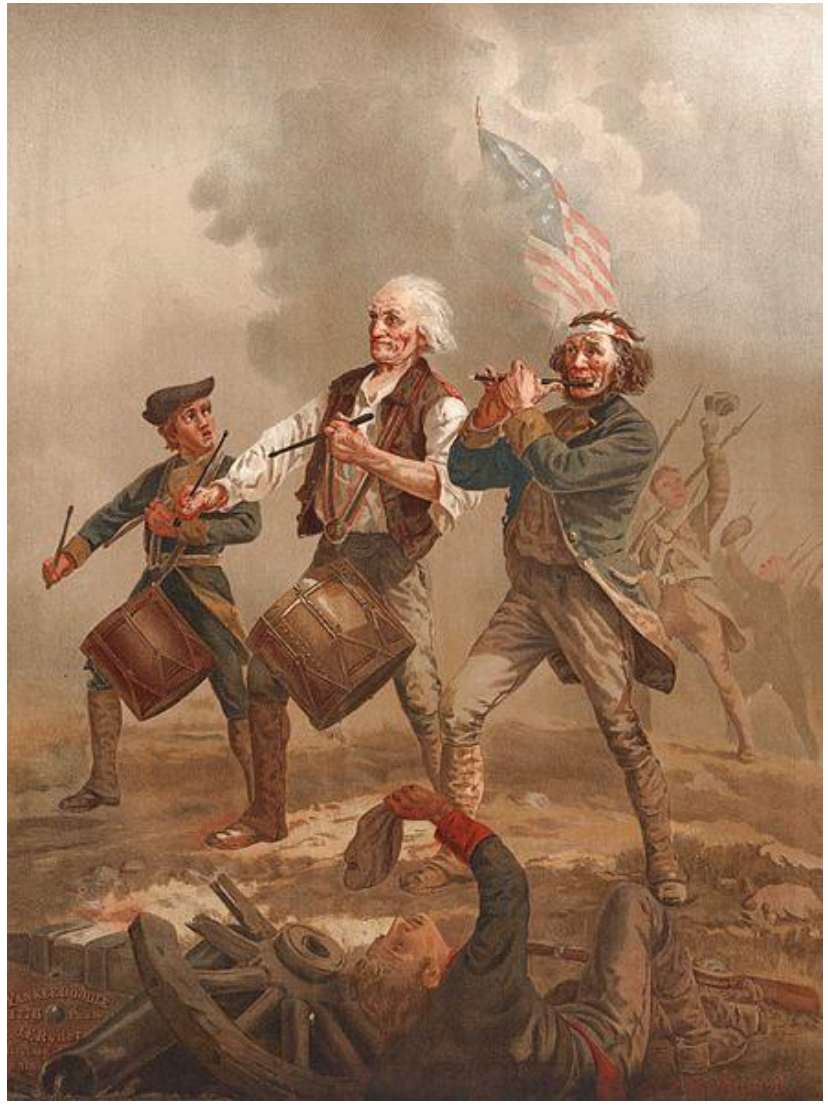
Reference Implementation

High-Level Architecture of SysML v2 Testbed



CONCLUSIONS

- A digital revolution is taking place within systems engineering
- Multiple initiatives are supporting this conversion
  - INCOSE
  - NDIA
  - OMG
  - US DoD DEWG
  - OASIS
  - The Open Group
- A holistic (Systems Engineer) view is required
  - System data interchange would quickly overwhelm available resources
  - System Interoperability is more effective
- Be sure to play your part!



Q&A

Thank You!

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