
# Future Direction of MBSE with SysML v2

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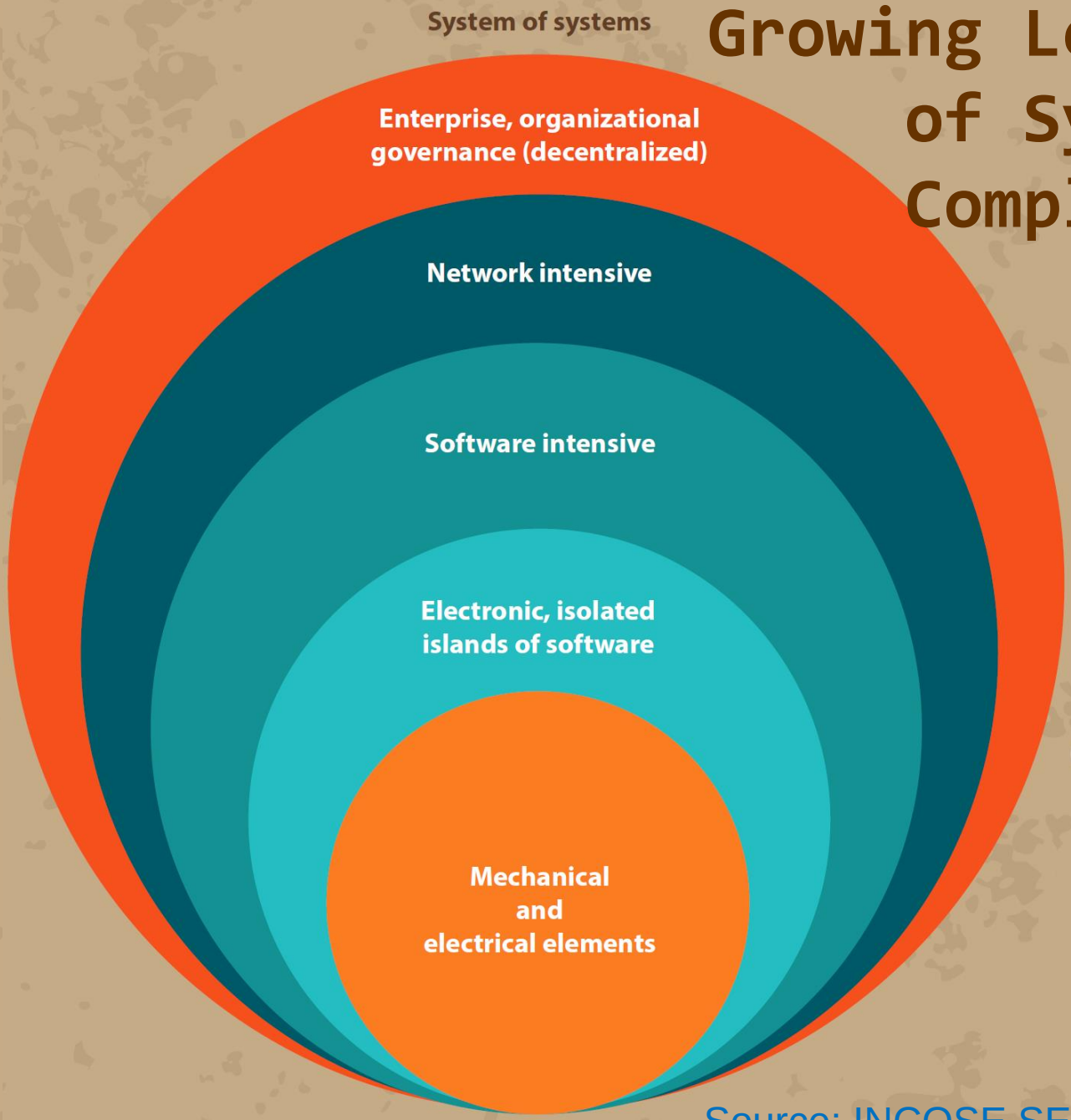
# Topics

- Introduction
- MBSE Directions
- SysML Status and Directions
- Summary

# Introduction

# Growing Levels of System Complexity




Increasing complexity, cumulative ambiguity, "lack of control"

Source: INCOSE SE Vision 2025

# Premise

- Increasing complexity and constraints
  - Systems (e.g., software, networked, human interaction)
  - Rapid technology change
  - Business regulations, distributed environments, shrinking cost and schedule, competitive pressures
- Systems engineering value proposition
  - System complexity and risk management
  - Facilitate integration across engineering disciplines and life cycle
  - Rigor in the design process
- MBSE is a key practice to enhance this value proposition

**Systems Engineering**

focuses on ensuring

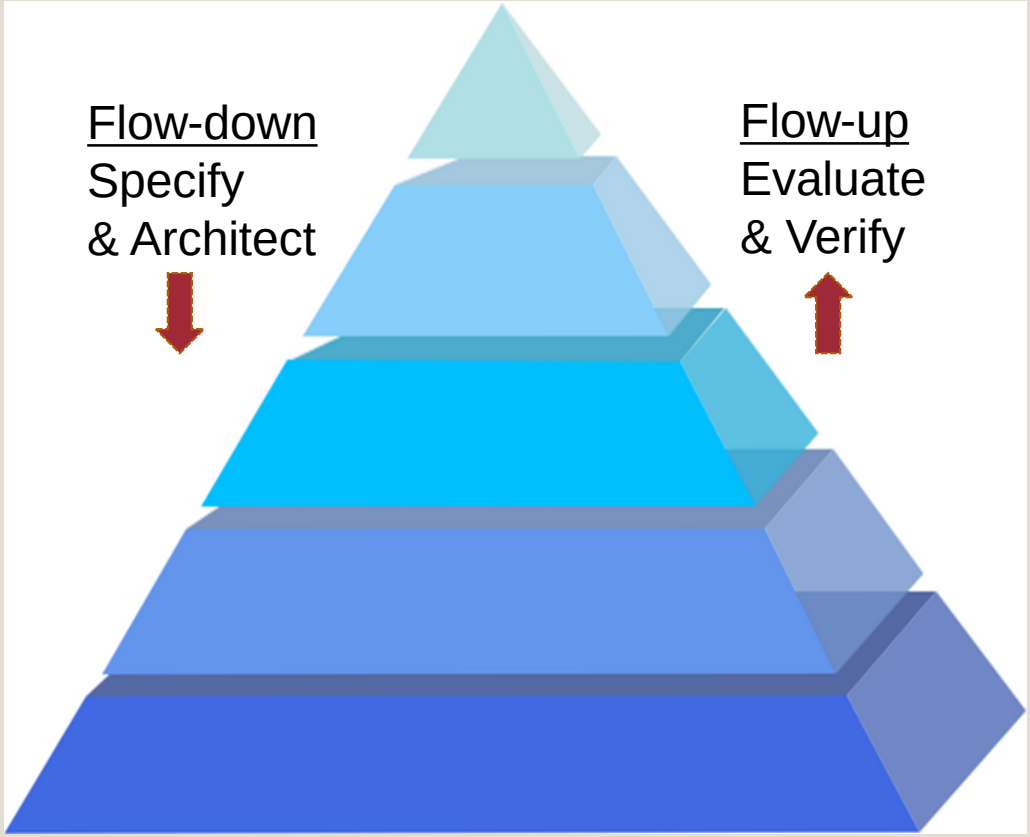
the pieces work together

to achieve the

objectives of the whole.

Source: INCOSE SE Vision 2025

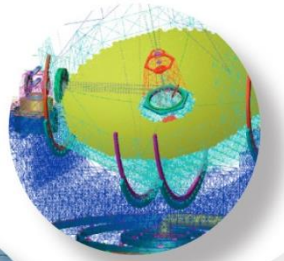
# Systems Engineering Practice



# Transforming Systems Engineering

## Architecting Systems to Address Multiple Stakeholder Viewpoints

Engineering Views



Construction Views

Science Views

Maintenance Views

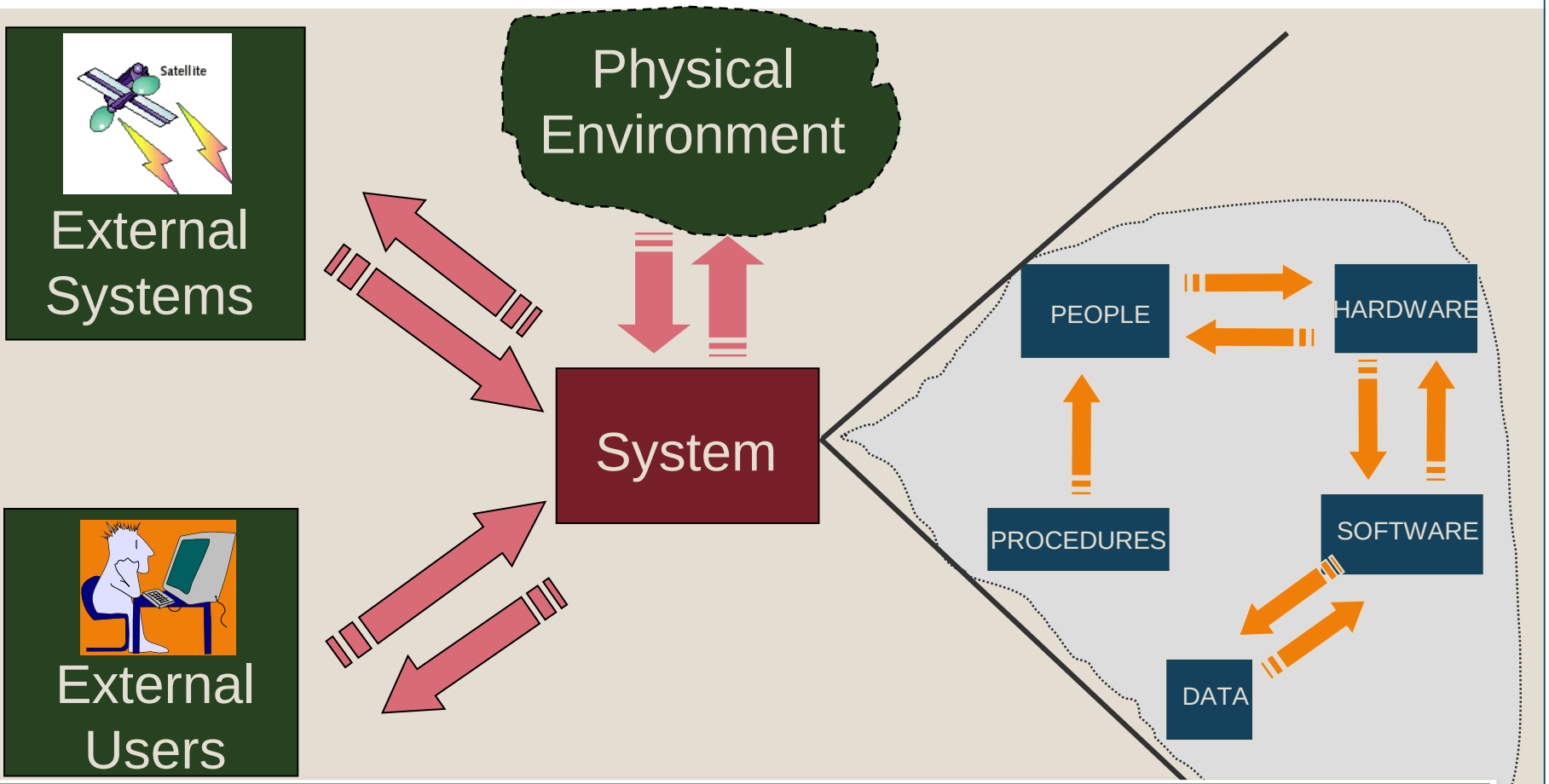
Management Views

**The European Extremely Large Telescope**

*Courtesy of the European Southern Observatory.*

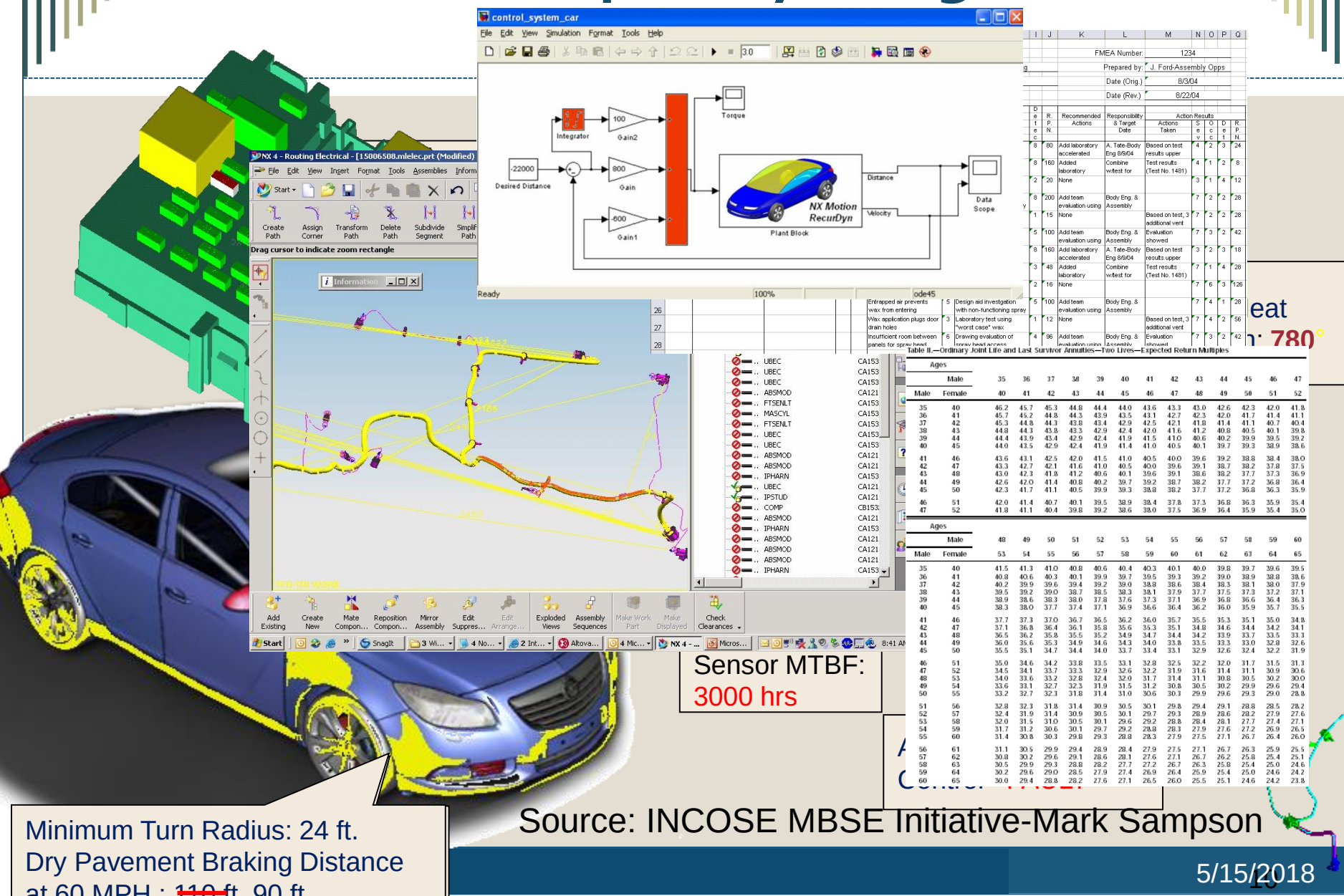
Source: INCOSE SE Vision 2025

# System Black Box/White Box




An *engineered system* interacts with its environment, and
is composed of interacting hardware, software, data, people, and procedures

# Multi-Disciplinary Integration




Source: INCOSE MBSE Initiative-Mark Sampson

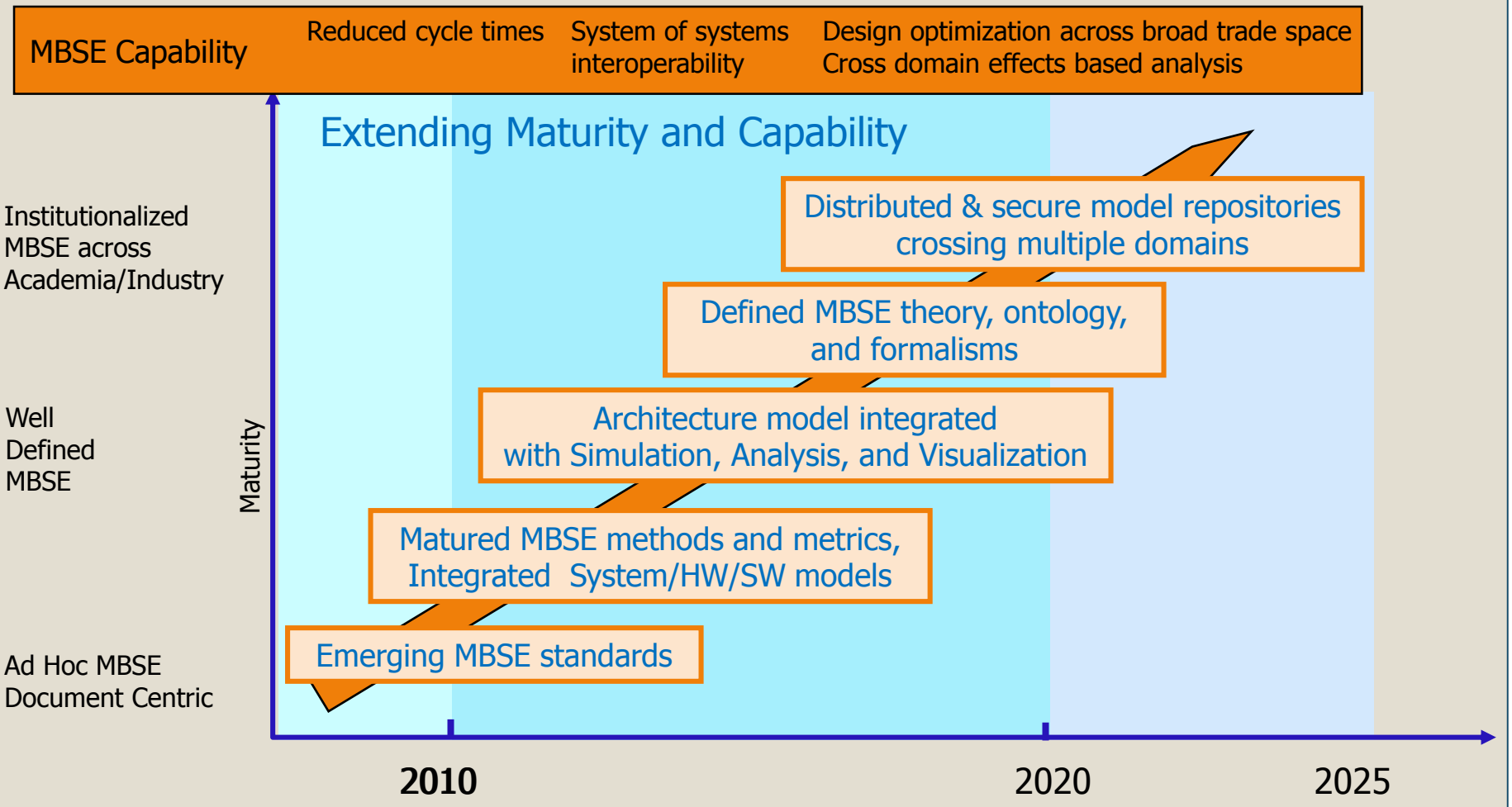
# System Model Facilitates Management of Complexity

- A specification model that abstracts the detailed design but captures rich data set with complex relationships
  - System, subsystem, and component (e.g., hw, sw) specifications
  - Can span operational & enabling systems (e.g., verif, mfg, support)
  - Integrates with multi-disciplinary design and analysis models
  - Support variant designs, patterns, and reuse
- Abstraction approaches
  - Black box/white box
  - Cross-cutting views and viewpoints
  - Logical abstractions
  - Usage in a context

# MBSE Directions

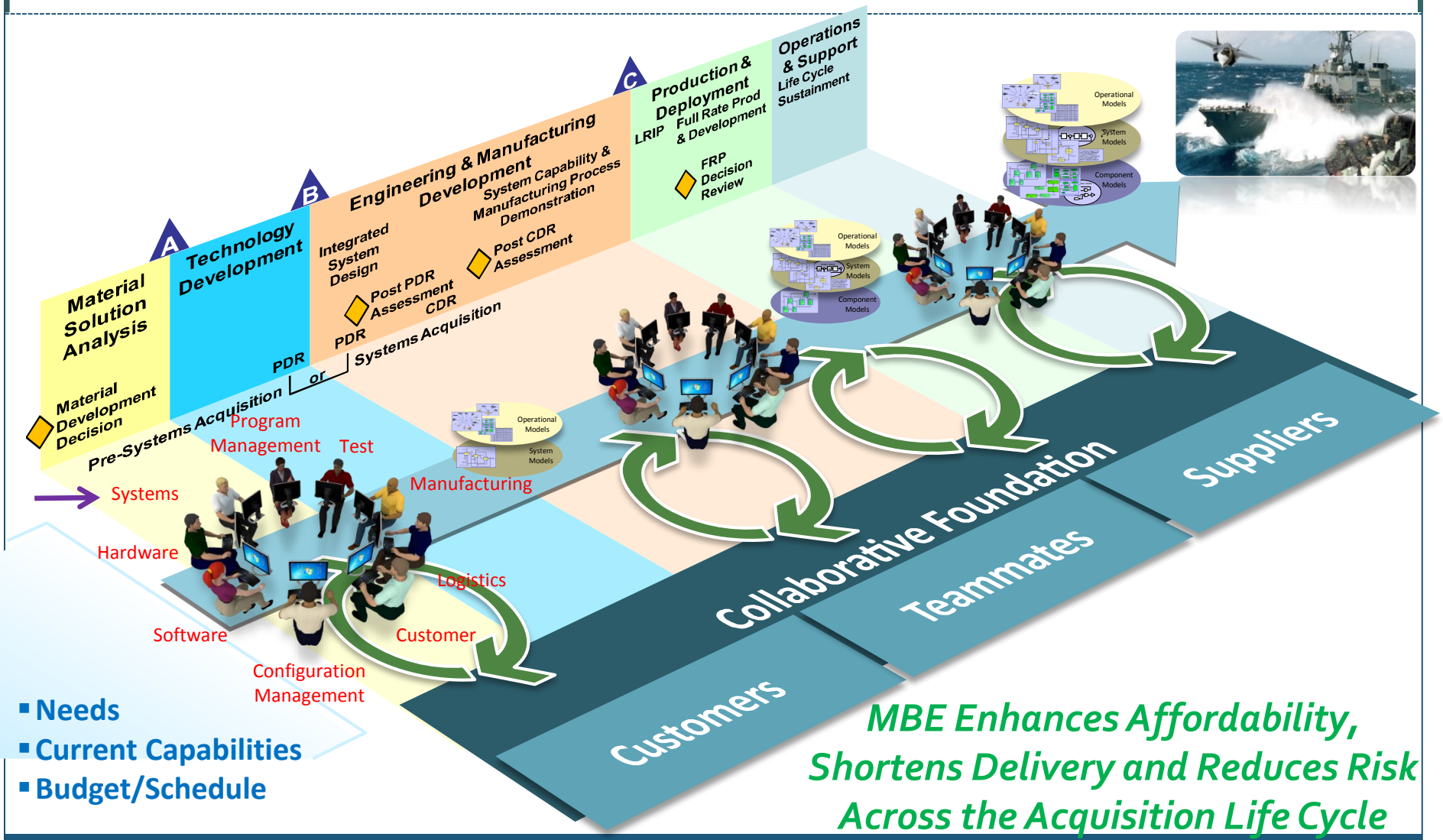
# INCOSE MBSE Roadmap

## Original Version dated 2007



# MBE To-Be State

Source: NDIA MBE Final Report dated February 2011

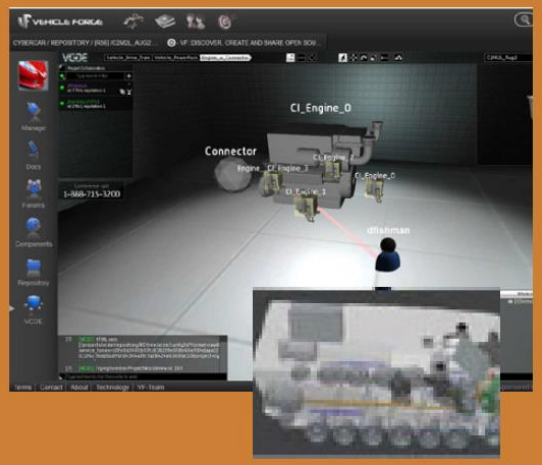



- Needs
- Current Capabilities
- Budget/Schedule

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

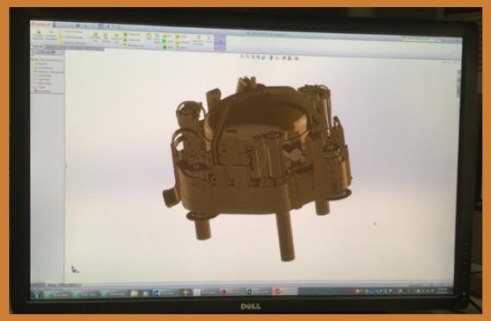
# Transforming Systems Engineering

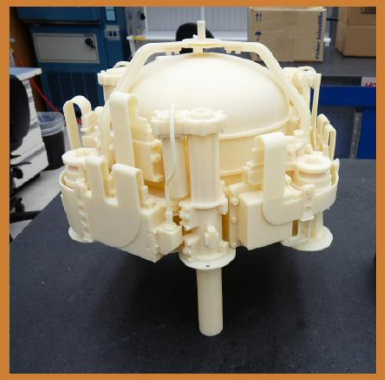
# Virtual Engineering
# Part of The Digital Revolution




DARPA's Adaptive Vehicle Make program is setting the vision for the future of an integrated, model-based tool chain.

Modeling, simulation and visualization will become more integrated and powerful to cope with the systems challenges in 2025.



Digital printing and related technologies enable rapid iterations from concept to hardware prototype and even production.

Source: INCOSE SE Vision 2025

# INCOSE SE Vision 2025
# MBSE: Standard SE Practice

**F R O M**

- Model-based systems engineering has grown in popularity as a way to **deal with the limitations of document-based approaches**, but is still in an early stage of maturity similar to the early days of CAD/CAE.

**T O**

- Formal **systems modeling is standard practice** for specifying, analyzing, designing, and verifying systems, and is **fully integrated with other engineering models**. System models are adapted to the application domain, and include a broad spectrum of models for representing all aspects of systems. **The use of internet-driven knowledge representation** and immersive technologies enable highly efficient and **shared human understanding of systems in a virtual environment** that span the full life cycle from concept through development, manufacturing, o

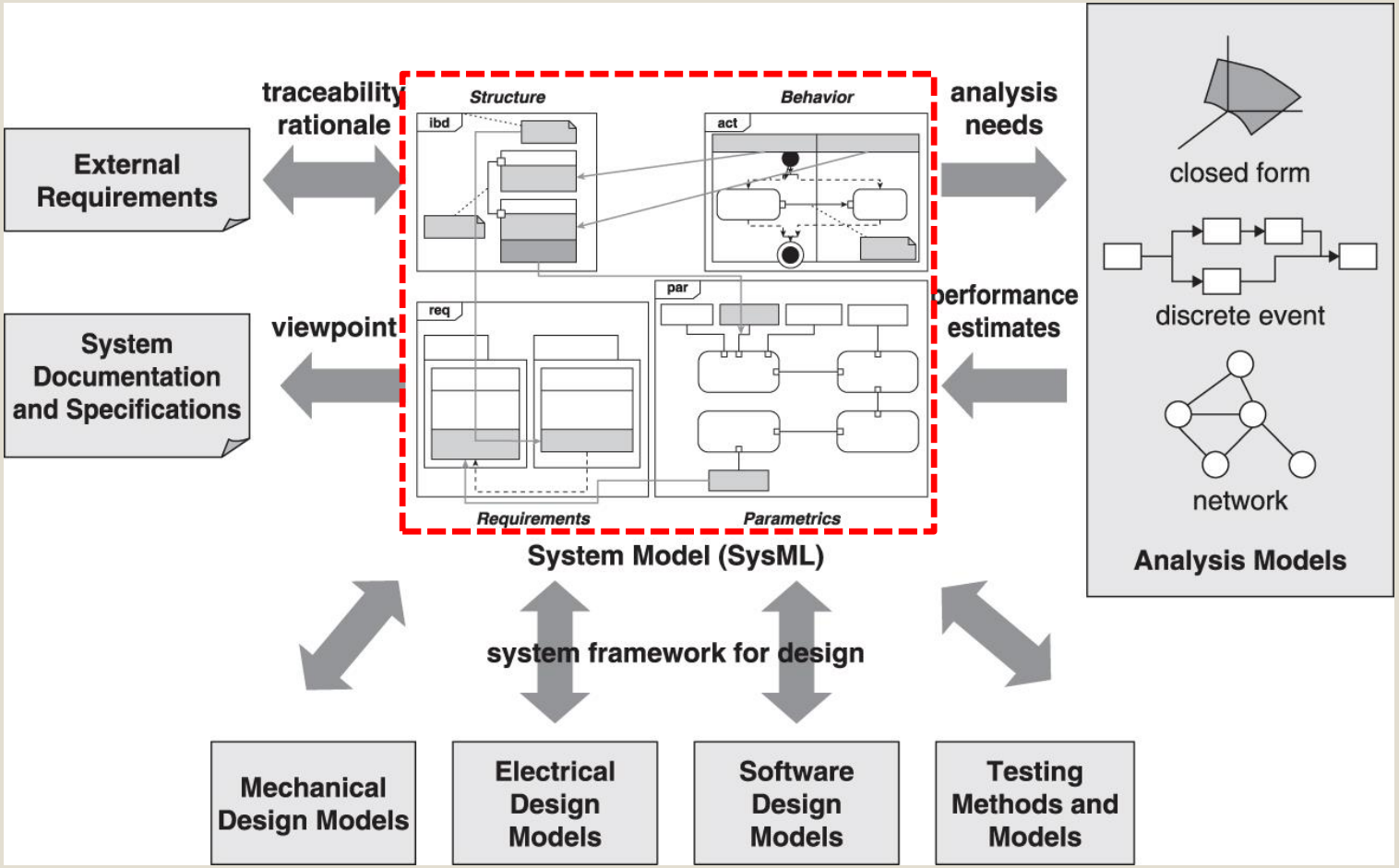
# SysML Status and Directions

# SysML Background

- SysML v1 adopted in 2006
- Continued evolution to address user and vendor needs
  - SysML v1.5: current version
  - SysML v1.6: in process
- Facilitated awareness and adoption of MBSE
- Much learned from applications of MBSE using SysML

Goal: Develop next generation of SysML to support MBSE over next 10+ years

# Using SysML Model as an Integration Framework

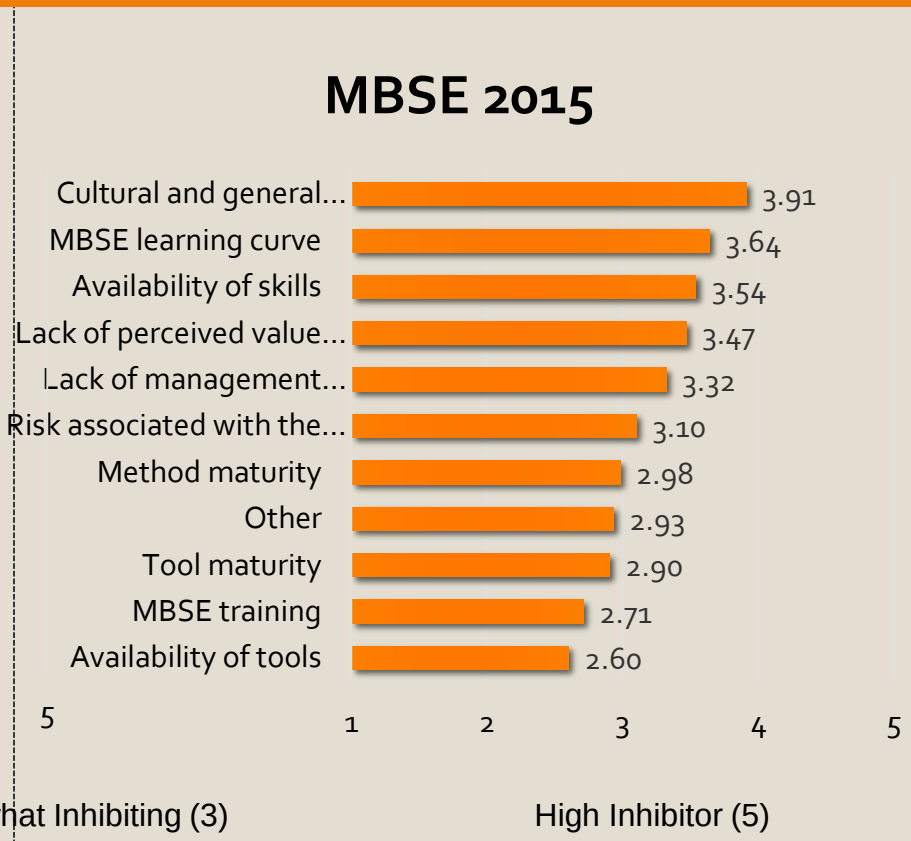



Source: A Practical Guide to SysML 3rd Ed: Figure 18.1

# MBSE Adoption Challenges

Source: MBSE Survey January 24, 2015: Dr. Robert Cloutier, Ms. Mary Bone

**Rank each item below in terms of the extent that it currently inhibits successful adoption of the MBSE within your organization/company.**

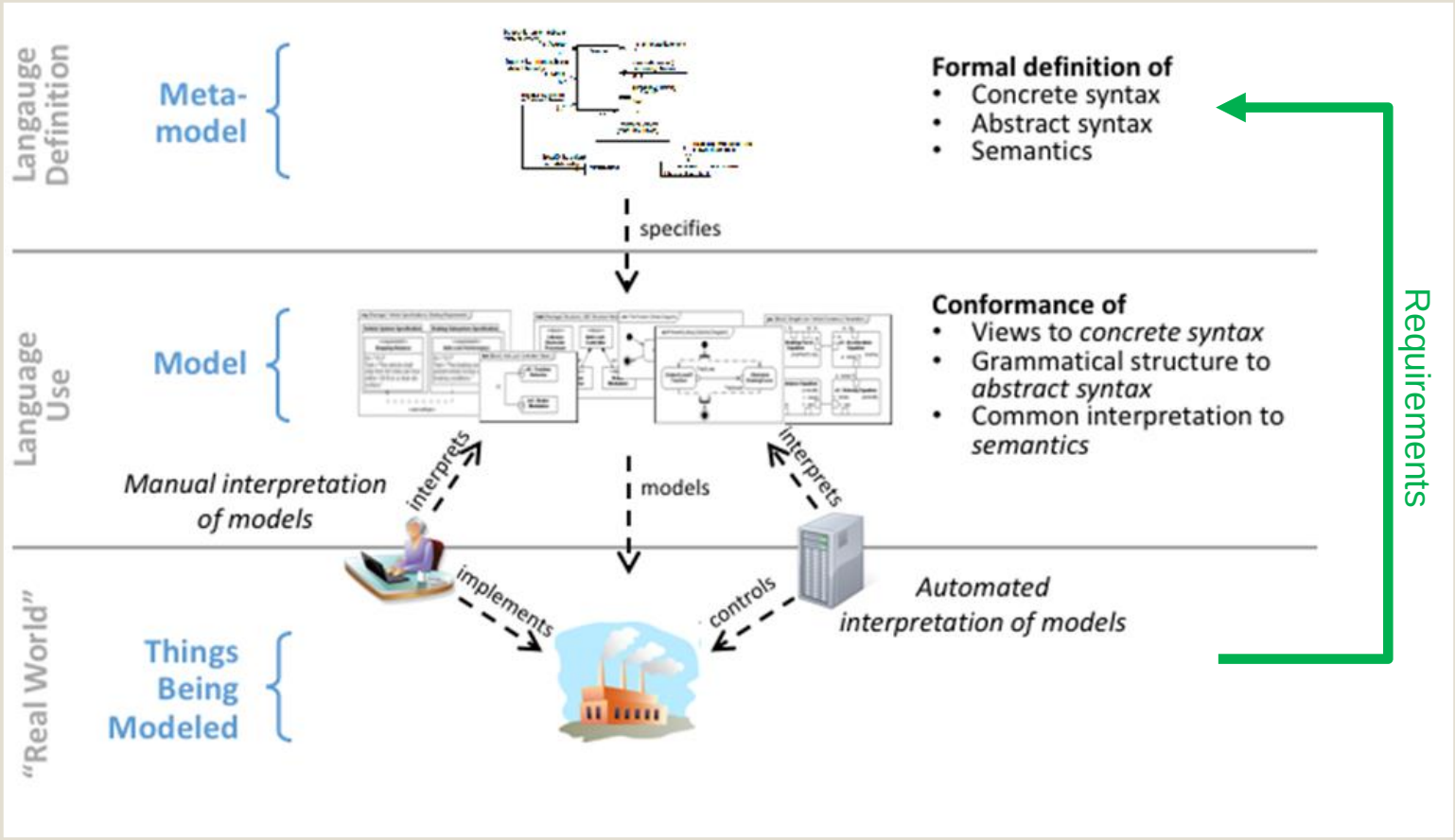
# SysML v2 Status

- SysML v2 RFP issued December, 2017
- SysML v2 API & Services RFP expected to be issued June, 2018
- Two Submission Teams Formed
  - SysML v2 Submission Team (SST)
  - Unified SysML Submission Team (UST)
- Submission Deadlines
  - Initial Submission: November, 2019
  - Revised (Final) Submission: November, 2020

# SysML v2 Effectiveness Measures

- Enable a model-based approach to improve systems engineering productivity, quality, and management of complexity and risk
  - *Expressive:* Ability to express key system concepts
  - *Precise:* Concise representation that enables unambiguous human and computer interpretation that supports model checking, execution/solvers, and reasoning
  - *Visualization:* Ability to effectively communicate with diverse stakeholders
  - *Interoperable:* Ability to exchange and transform data with other models
  - *Manageable:* Ability to efficiently manage change to models
  - *Usable:* Ability for stakeholders to efficiently and intuitively create, maintain, interpret, and use the model
  - *Adaptable/Customizable:* Ability to extend model to support domain specific concepts and terminology

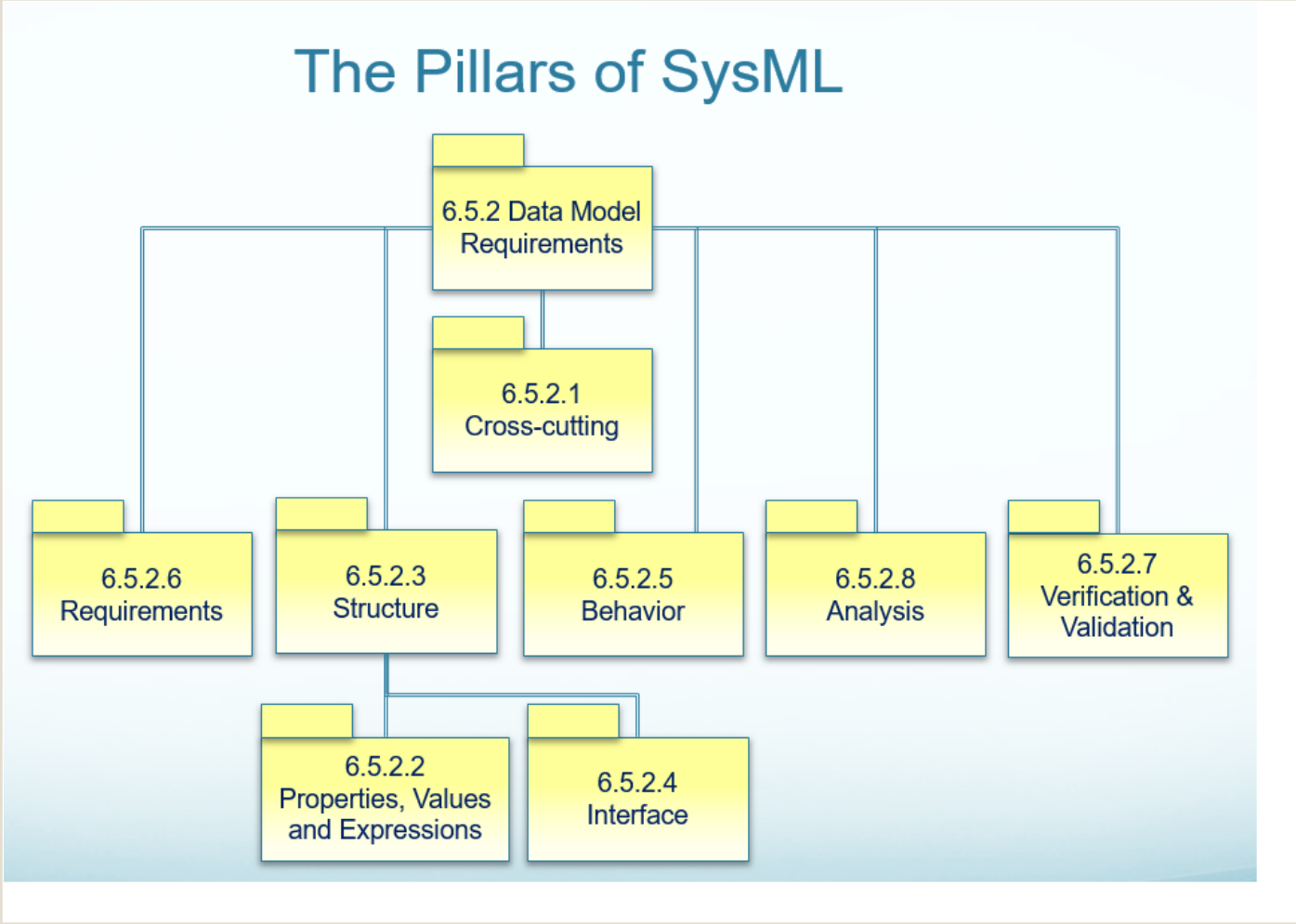
# Language Specification: Providing a Uniform Interpretation




Source: Derived from SysML Formalism WG Presentation dated March 21, 2017

# SysML v2 Modeling Concepts

Source: SysML v2 RFP

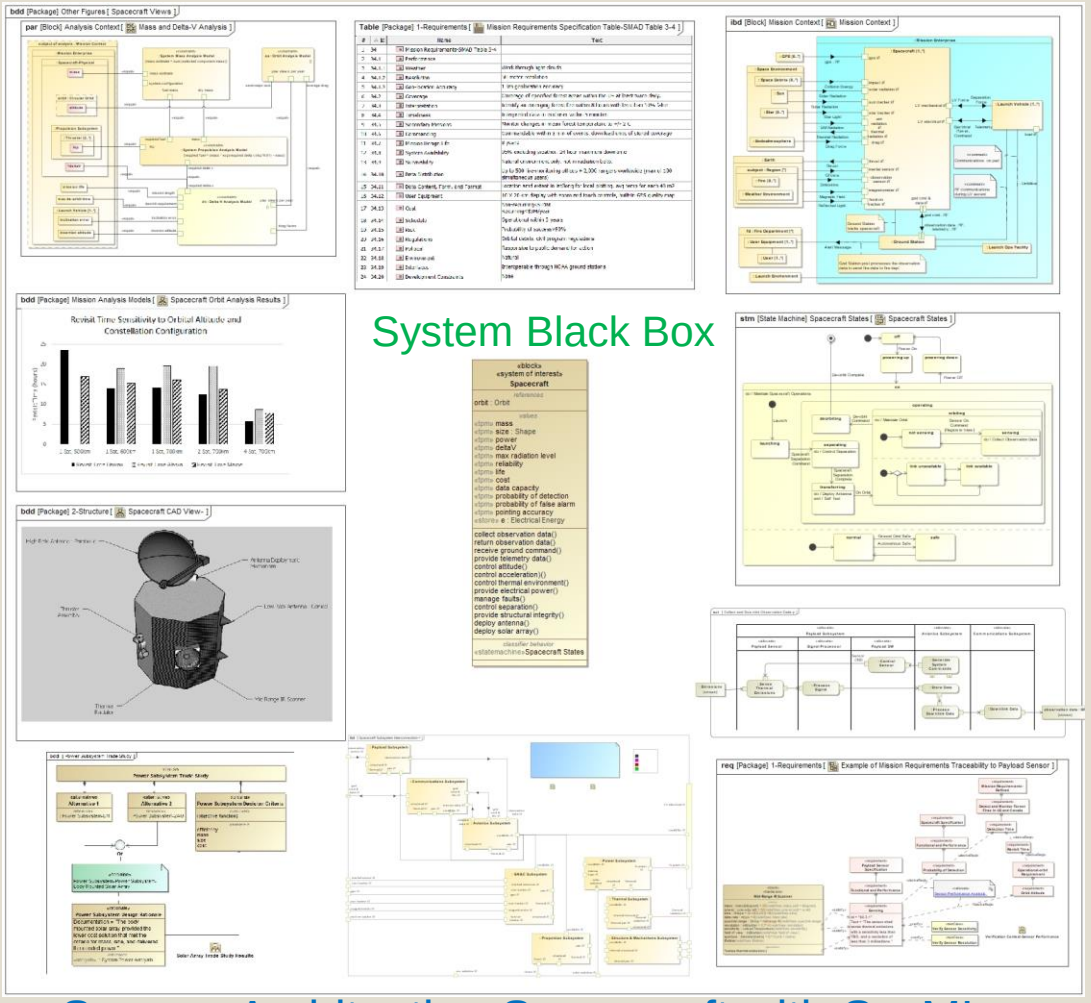


# Integrated Views of a System
# SysML v2 Enhancement Areas over SysML v1

Improved integration with Analysis

Geometric View

Trade Studies



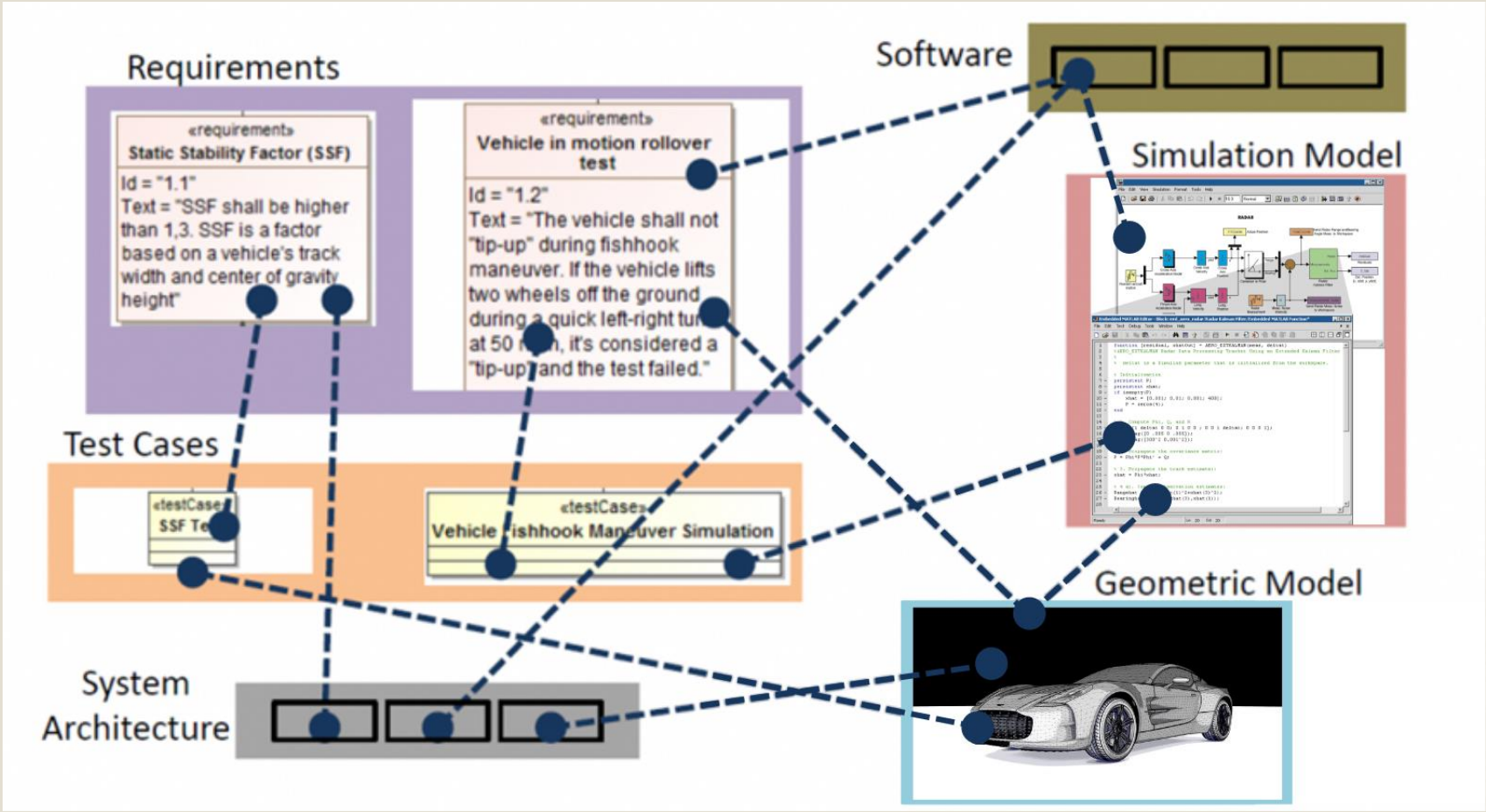

Variant Modeling & Design Configurations

Improved integration between Behavior & Structure

Property-based requirements

Source: Architecting Spacecraft with SysML

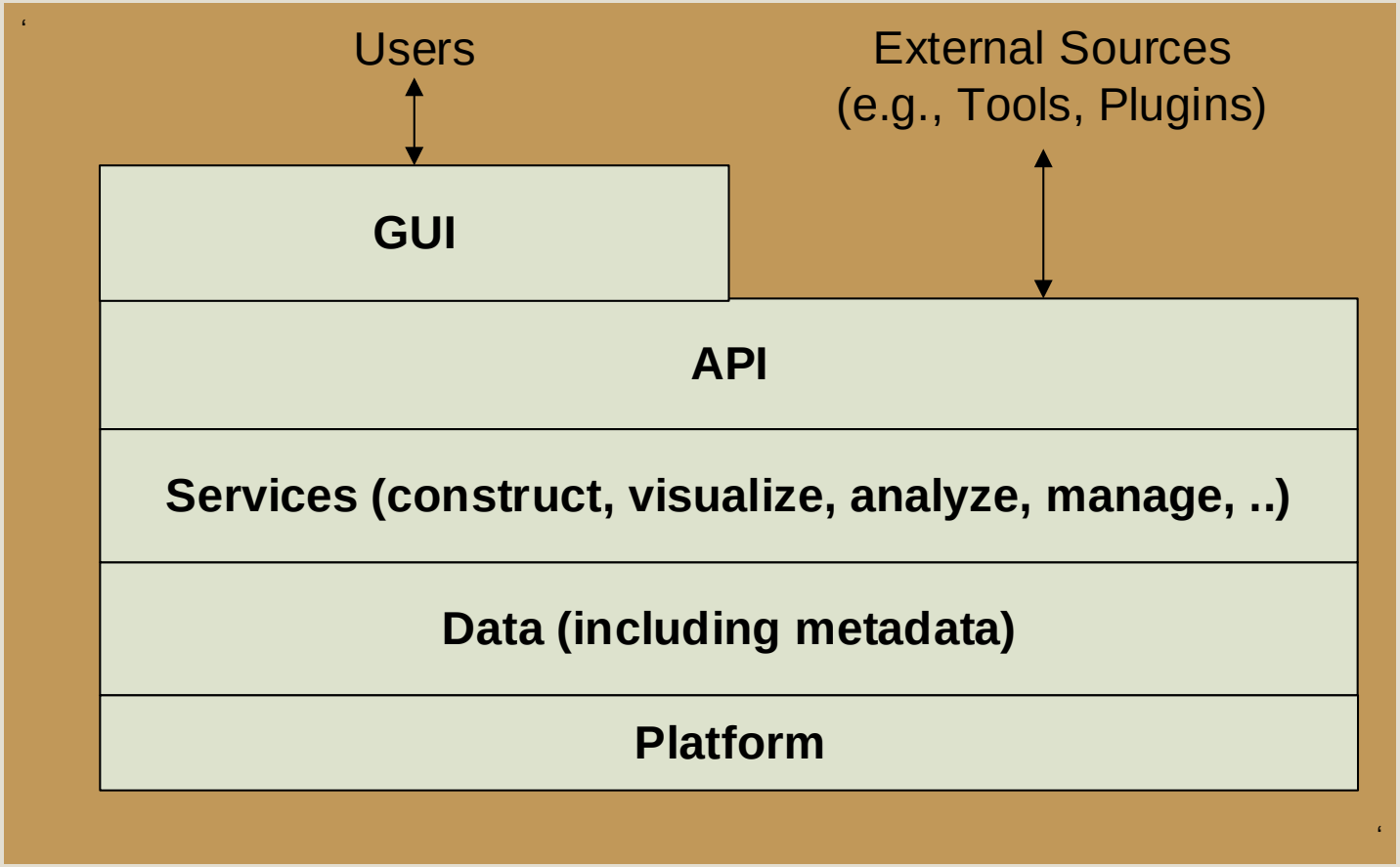
# System Model Interoperability




Source: Axel Reichwein , Koneksys

SysML v2 Model Interoperability & Standard API Requirements

# Layered Architecture




Standard API enables interoperability and access to modeling services

# Summary

# Summary

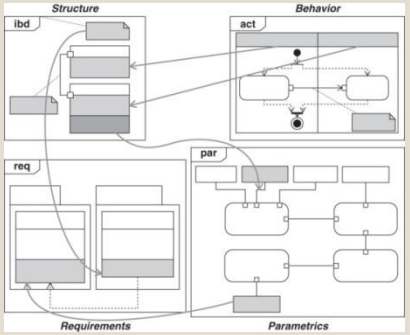
- Systems engineering practice must evolve to address evolving challenges of system complexity
- MBSE is part of the digital engineering transformation to improve SE and manage complexity and risk, and support reuse
- SysML v1 adopted in 2006 and facilitated awareness and adoption of MBSE
- SysML v2 facilitates increased adoption and effectiveness of MBSE over SysML v1 through enhanced:
  - Precision & expressiveness
  - Consistency and integration among the language concepts
  - Interoperability with other engineering models and tools
  - Usability by model developers and consumers

# Questions ?

# ModelCenter + MBSE Pak

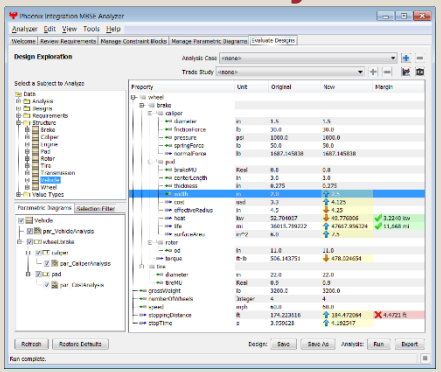
*Integrate Simulation Workflows with SysML Models*

## Rhapsody / MagicDraw



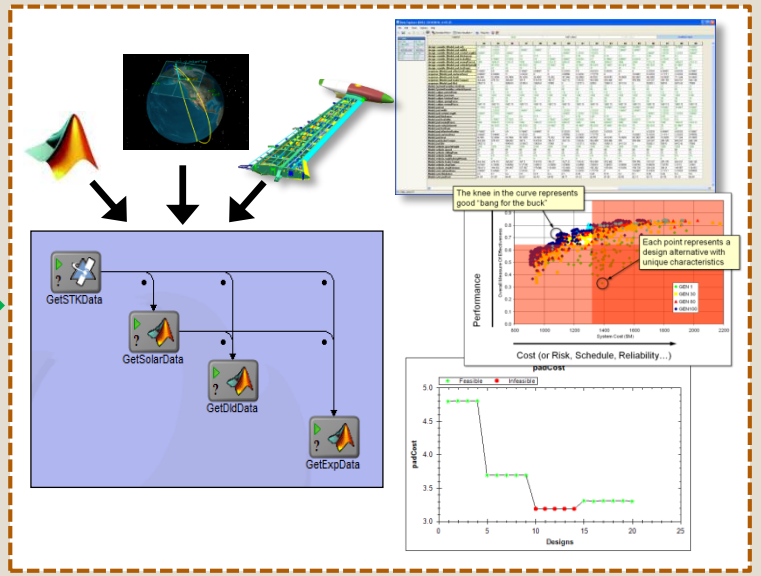

**System Model: Requirements, Structure, Behavior, Parametrics**

## MBSE Analyzer



**Rhapsody/MagicDraw Plug-In that connects a systems architecture model with engineering analyses**

## ModelCenter




**Multidisciplinary Distributed Simulation Workflows, Optimization, Design Space Exploration**

- Execute SysML parametric diagrams to evaluate designs
- Perform requirements compliance analysis using modeling and simulation
- Perform design trade-off studies
- Update SysML models with analysis results
- Import engineering analyses into a SysML model