Integrating Analytical Solutions with SysMLv2 for Requirement Verification

1834645

Ansys SAM
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BLUF: Ansys MBSE / Product Strategy / Ecosystem

no lock-in — providing an **open solution** and built on a solid partner framework - openness in terms of models, data, remote APIs as well as willingness to be open

future-proof — based on **most up-to-date standards & state of the art**

collaborative — provide easy-to-use & easy-to-understand engineering language, core **MBSE components in web & cloud with enterprise scalable real-time collaboration**

scalable & consistent — managed and federated source of truth for models and data - holistic approach support in terms of **consistent interoperability** with other Enterprise Systems
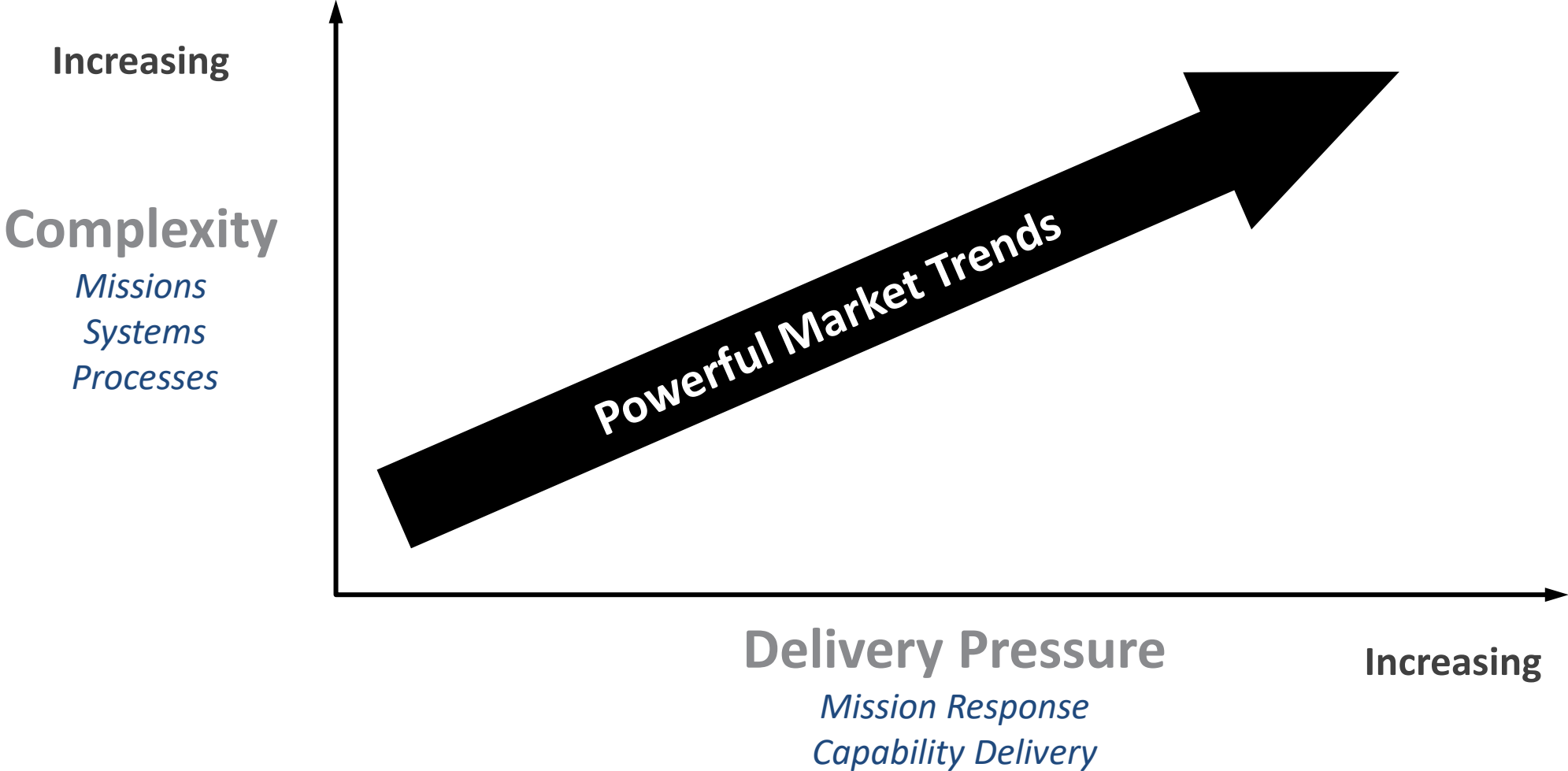
engineering in a single framework — **integrate best in class solvers and engineering analysis tools** - strong and deep connection to an unmatched collection of analysis & engineering solutions.
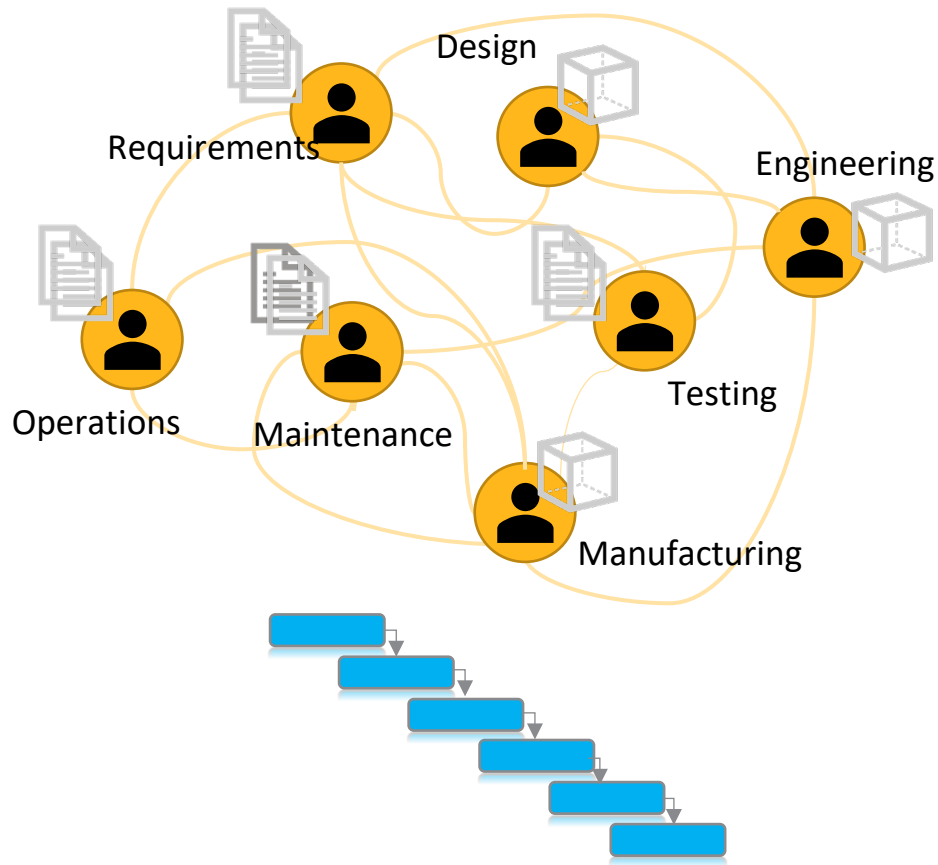
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Time Is of the Essence...and Complexity Will Only Increase

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Increasing

Complexity

Missions
Systems
Processes

Powerful Market Trends

Delivery Pressure

Increasing

Mission Response
Capability Delivery
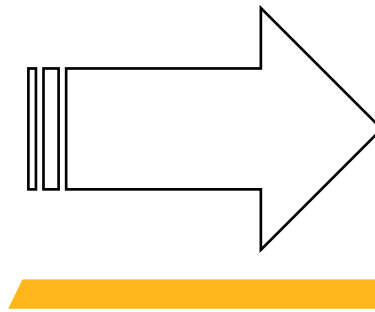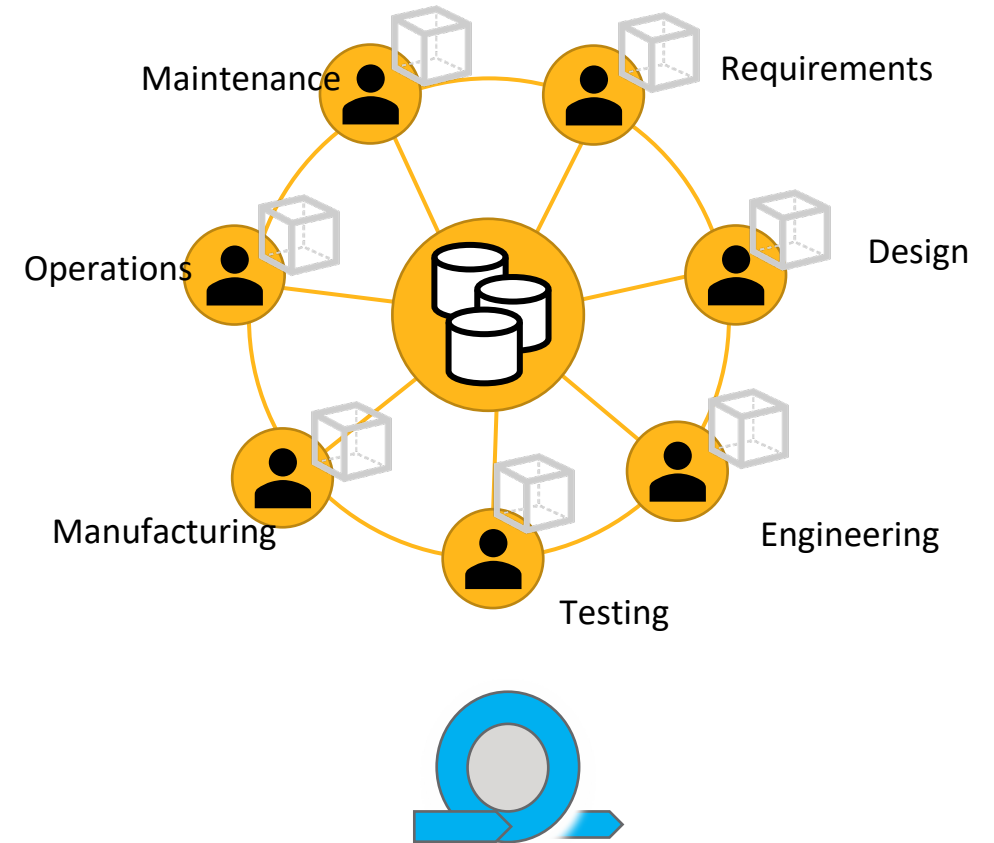
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Shift from Traditional Engineering to Digital Engineering
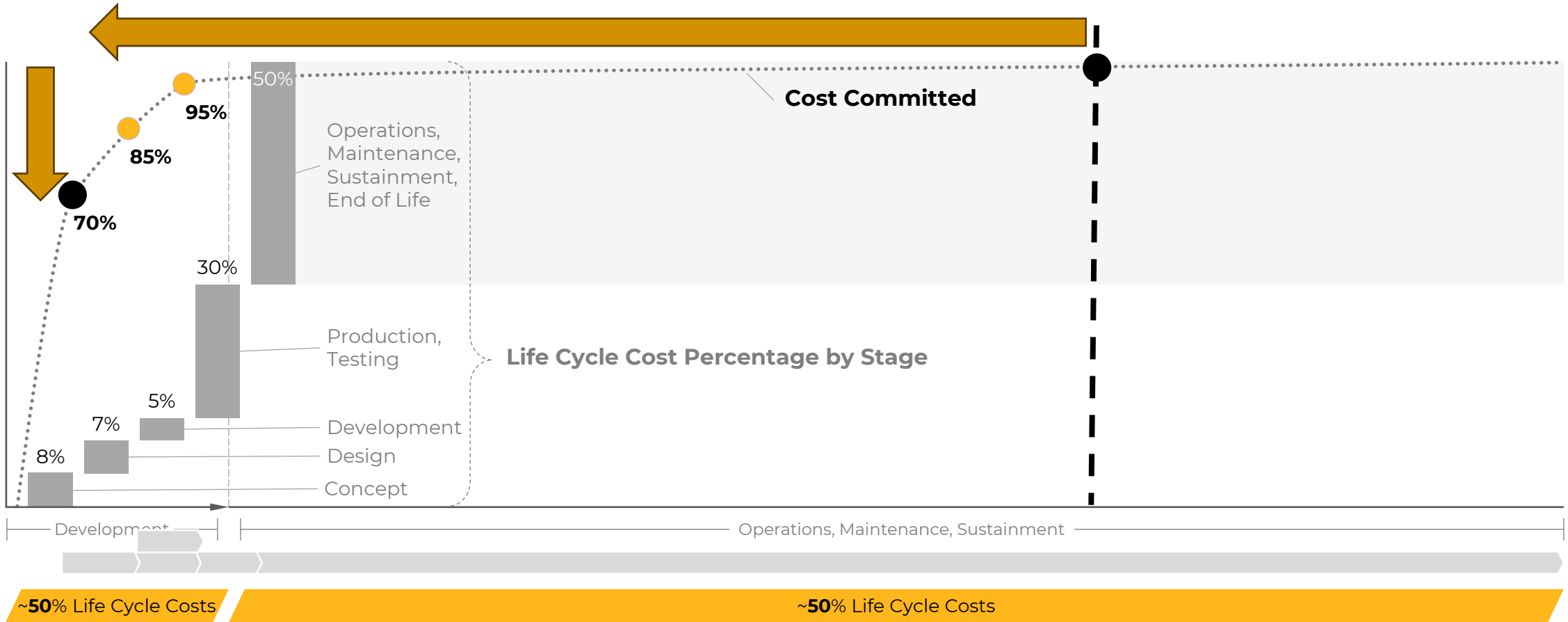

Current State

Desired State

- Model-based
- Collaborative
- Agile
- Connected
- Traceable:
  - Right Information
  - Right Time
  - Right Format
- Dev(Sec)Ops

Total Life Cycle Costs Over the Program Milestones

Cost Committed

50%

Operations, Maintenance, Sustainment, End of Life

30%

Production, Testing

Life Cycle Cost Percentage by Stage

5%

Development

7%

Design

8%

Concept

95%

85%

70%

Development

Operations, Maintenance, Sustainment

~**50**% Life Cycle Costs

~**50**% Life Cycle Costs

Value Drivers

Reduce Development Cost & Risk

Accelerate Time to Market

Reduce Cost of Quality

Higher R&D Efficiency

Enhanced Life Cycle Mgmt

Based on INCOSE Systems Engineering Handbook

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Model Based System Engineering (MBSE)

- **MBSE is simply Systems Engineering with _models_**

- **Use of a _Model-Based_ approach instead of a _Document-Based_ approach**

- **Used _throughout_ the product life-cycle**

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MBSE Methodology (Not just a System Model)

What do we mean by Models?

1. **A detailed *description* of the system being designed (the System Architecture Model)**

    AND

2. **Engineering *analysis* and tools to assure that the system meets requirements.**

What are the benefits of MBSE?

- **MBSE promises to dramatically improve product development**

  – Manage the increased _complexity_ associated with today's systems

  – Reduce _cost_ and _schedule_, and therefore _risk_

  – Design _better_ products; better _performance_
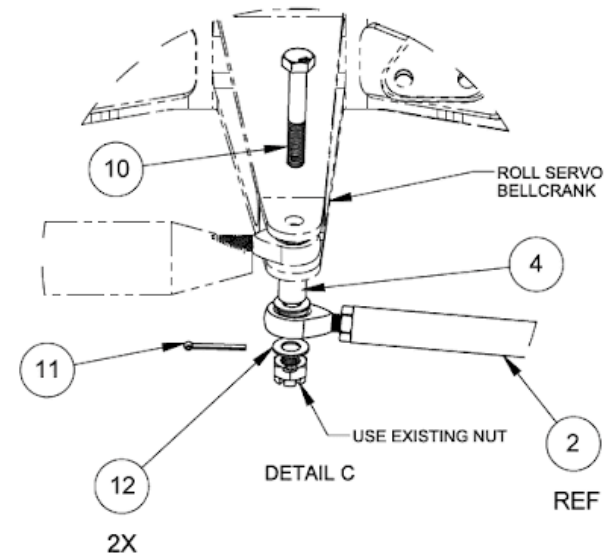
- **MBSE = Better Communication & Decision Making Throughout the Product Life Cycle**

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Lessons Learned From SysMLv1

THE SECRET CONVERSATIONS WITH SYSTEM ENGINEERS

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At the Dawn of Engineering…

(REF)

C

1.00
REF

7.60
REF

B

FWD CROSS TUBE MOUNT R/H SIDE

D

2

D

SECTION A-A | 2 | A |
                  | | 8 |

REF

1

6 7
4X 4X

6 7
2X 2X

3

7 6
2X 2X

UP

SECTIONS OF AIRCRAFT

3X

8

11

5

2
REF

9

DETAIL B

ROLL SERVO
BELLCRANK

10

4

11

2
REF

12
2X

USE EXISTING NUT

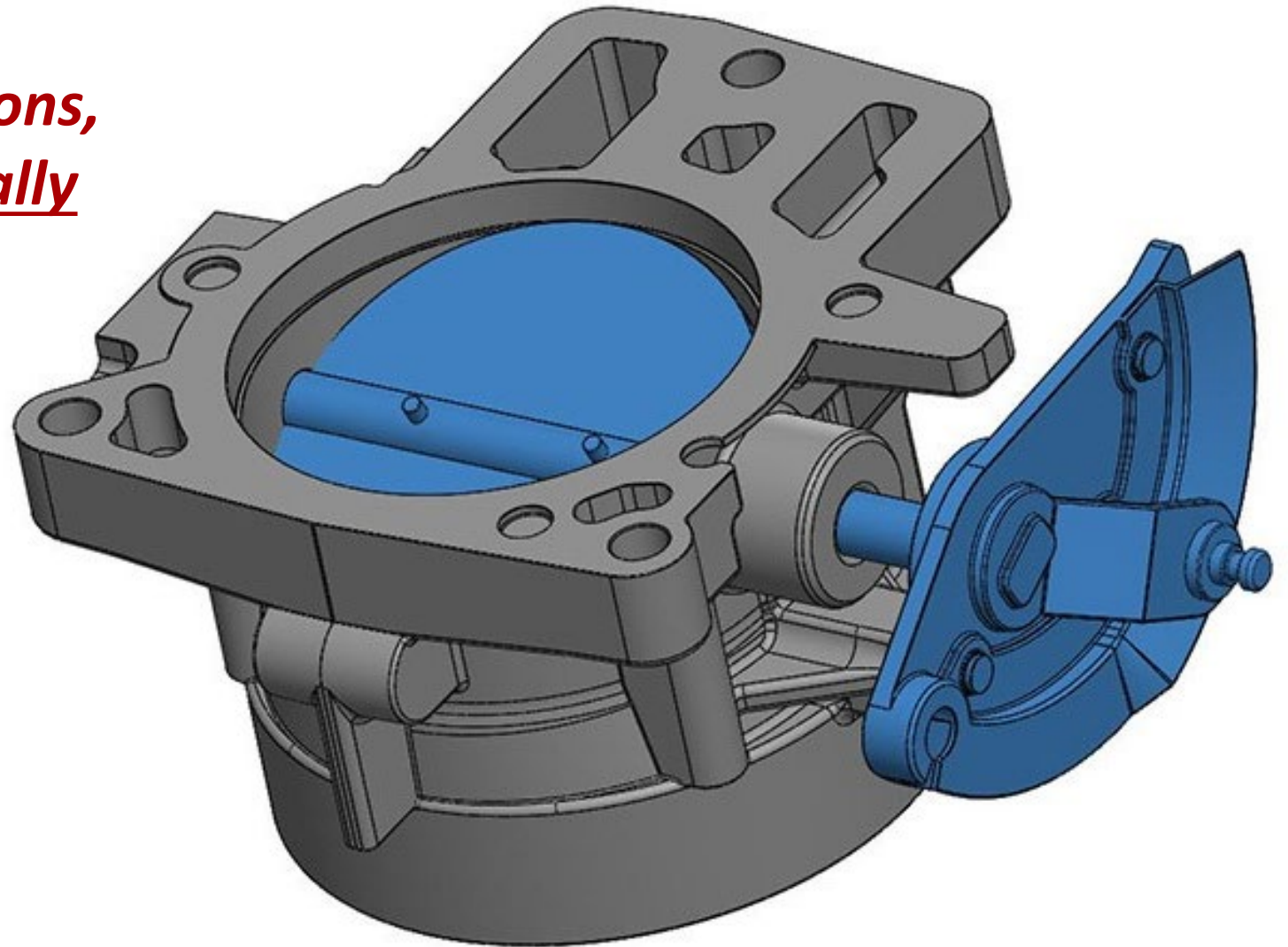DETAIL C
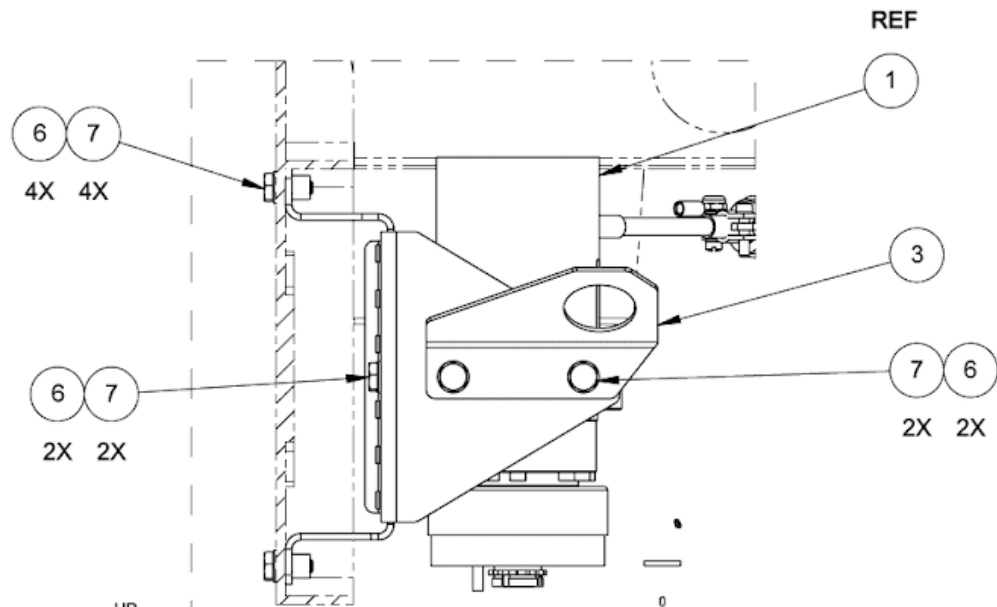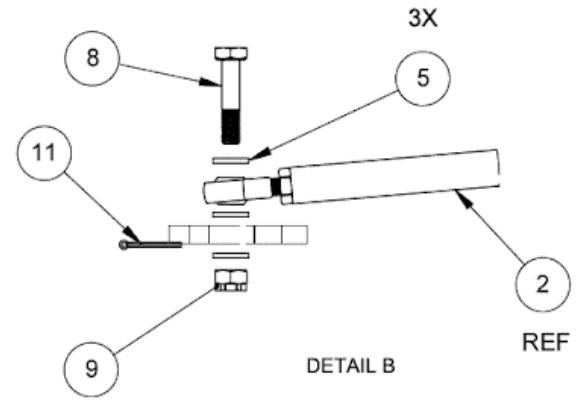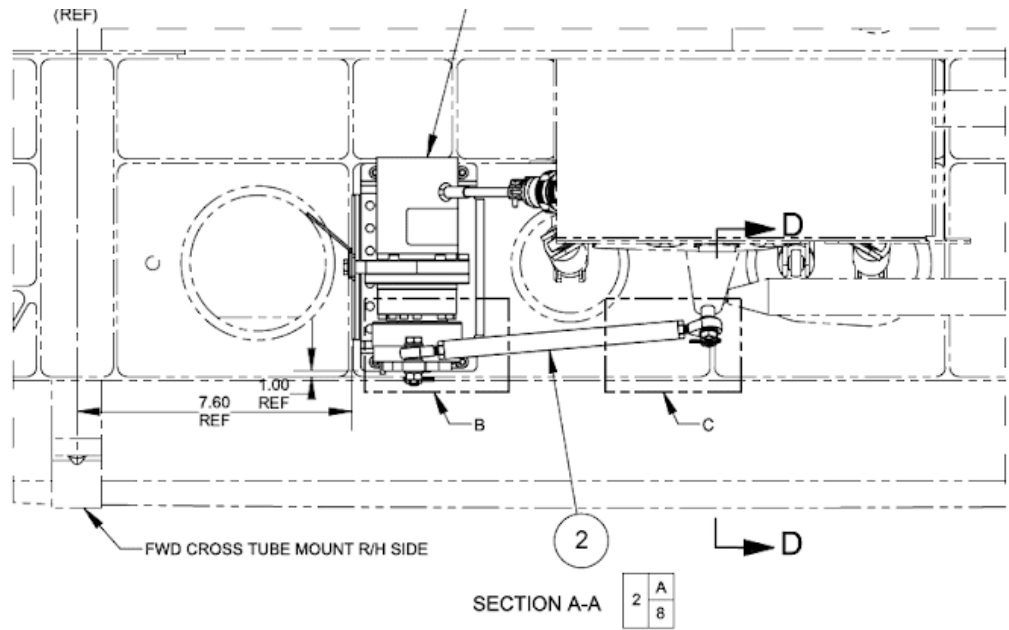
**And Engineers Asked…
"What's the Point of CAD,
If we are only going to use it to
make Drawings?"**

It wasn't until CAD was connected to Other Solutions, that it became Exponentially Valuable!

- **CAM**
- **FEA**
- **CFD**
- **3D Printing**
- **CNC**
- **BOMs**
- **Integrated Circuits**
- **Photorealistic Rendering**
- **... List goes on, and on!**

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Fast forward to Today...

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System Models Today Are Like CAD in 1980

*They **ONLY** describe the Behaviors, Requirements, & Structure of the system we want to build.*

System Models hold a lot of promise...

***BUT**... They are not enabled until the system model is connected to other existing digital assets...*

We asked organizations...

- **Are your engineers creating system models?**

- **What are your engineers going to do with the system models?**

Their Responses...

- "Good Question..."

- "I'm not sure..."

- "What do you suggest?

Our Response…

- **What if we could integrate your system model to mission, physics, cost models so that you can verify your requirements and ensure you are getting the behaviors you want from your system?**

- *…And do it in a in real-time, open, collaborative environment?*

Ansys SAM (Systems Architecture Modeler)

- **Based on SysMLv2. Utilizes the latest, most powerful, and easiest to learn modeling language**

- **Cloud-Based. Users can access and build models using any modern web browser**

- **Real-time Collaboration. Users can collaborate in real time with their colleagues**

- **Open Infrastructure. Integrates with any other tool to fully implement Model-Based Systems Engineering**

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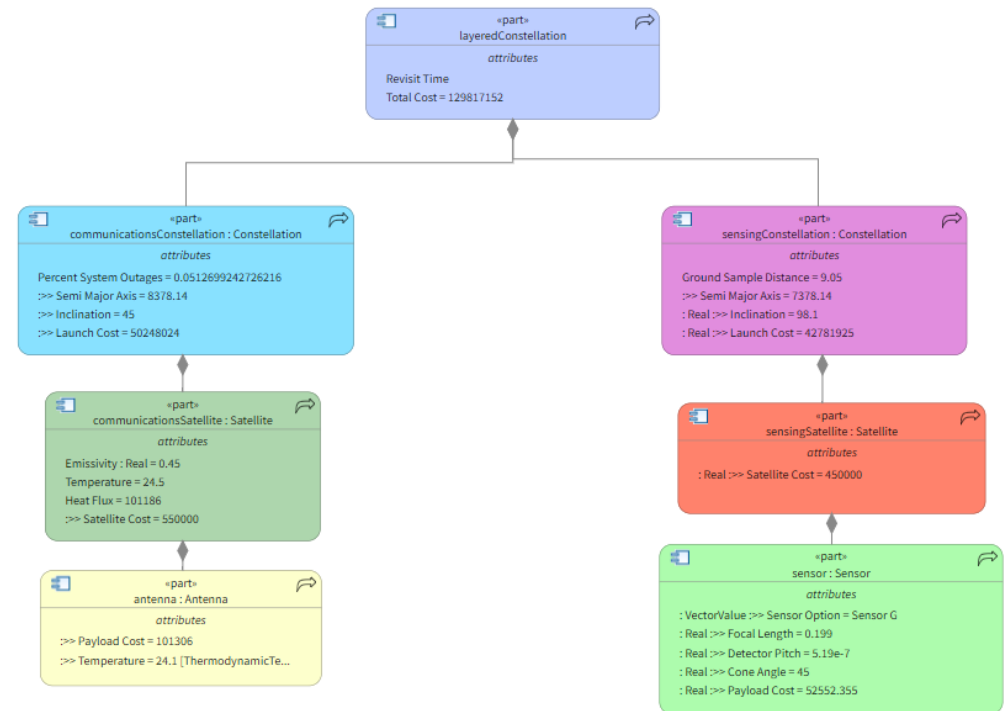
Digital Engineering Enabled using Ansys – The Big Picture

SPDM

Multiphysics collaboration / Simulation applications / Simulation data science
Hybrid HPC / Visualization / Simulation analytics / Enterprise connectivity

Multidisciplinary Analysis & Optimization

Simulation workflow / CAx automation
Robust design optimization / MBSE integration

Digital Mission Engineering

Mission evaluation / Design Reference Mission / Systems of systems

Multiphysics

Pre-processing
/ Structures / Fluids / Electronics
/ Systems
/ Embedded software
/ Semiconductors / Optics

Digital Twins

ROMs / FMUs / 0D-1D Libraries
Hybrid Analytics / FUSION / Bayesian
Inference / Uncertainty Quantification /
Web-apps / Containers

MBSE

/ Requirements
/ Systems Architecture

Materials Management

/ Materials Intelligence
/ Materials Exploration
/ Materials Data
/ Materials Compliance

Software Development

/ Model-based software development
/ Architecture safety
/ Architecture reliability

PLM   ALM (Other)   In-House Tools

ERP   IIOT

1 Build Digital Reference Missions (DRM's); derive and evaluate requirements. **5** Manage design and process workflows to integrate enterprise data.

2 Connect MBSE requirements to analytical models. **3** **4** Add fidelity to verify DRM requirements with multiphysics simulations and twins.

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How do you implement MBSE?

| Conceptual Phase | Preliminary Phase | Detailed Design Phase | Prototype & Test |

Model-Based Systems Engineering (MBSE) it is **NOT** a tool! It **IS** a *methodology*!

Requirements Management
← IBM Rational DOORS Next Generation · codebeamer a ptc technology · Jama software · POLARION …
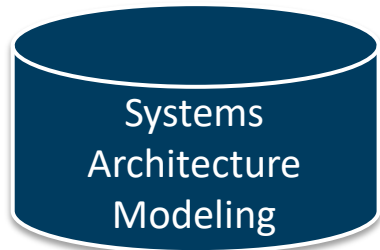
Systems Architecture Modeling
← CAMEO SYSTEMS MODELER · IBM Rational Rhapsody · ENTERPRISE ARCHITECT · Ansys SCADE ARCHITECT · Capella · windchill modeler · GENESYS …

Analysis, Software, & Test
← python · CATIA · Ansys / FLUENT · Ansys / MECHANICAL · Ansys MEDINI ANALYZE · Simcenter™ · Excel · creo · STAR-CCM+ · Ansys SCADE Suite · MATLAB · *Any Software tool*

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Ansys integrates with major **Requirements Management Systems**

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Provides Functional **Safety and Cybersecurity** Analysis for System Architectural Models

Ansys Medini

CAPTURE

ANALYZE

Ansys interfaces with major **System Architecture Modeling Tools**

Ansys Modeler

MODEL

System Architecture Modeler based on SysML v2

Stakeholder Requirement

System Requirement

Perform Analyses Simulate/Validate

Connects System Architectural Models with:
- Engineering Analysis
- Design Tools & Verification Workflows

Ansys ModelCenter

VERIFY

System Architecture

Perform Analyses Simulate/Validate

2023: Will be packaged with ModelCenter, SCADE, and Medini

Physical Design

Software Design

CODE

Ansys SCADE

Provides Model Based Design & Verification of **Critical Embedded Software**

Provide detailed **Physics Simulation and Optimization** capabilities

Ansys 3D Physics Solvers optiSLang Twin Builder

SIMULATE

CI/CD

Ansys Minerva

DEPLOY

Simulation Data Management backbone

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Open Ecosystem

SysML2

ANSYS SAM INTRO

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Why SysML v2?

- We chose SysML v2 for our modeler because we believe that it will be significantly easier to learn, easier to use, and more powerful that SysML v1.

- Compared to SysML v1, SysML v2 was designed to be:
  - More Precise
  - More Expressive
  - More intuitive and Regular
  - More Consistent
  - Have better Interoperability with other engineering models and tools

- SysML v2 is grounded in formal semantics and includes a very powerful API.

Key Characteristics of the Ansys SAM

- **Cloud Based.** The Ansys SAM can be installed on a public cloud (*e.g.* AWS, Azure, etc.) or installed on an on-premise server. It will be accessible to any user from a standard web browser. This means that our modeler will be scalable to large numbers of users.

- **Real-time Collaboration.** A key feature of the Ansys SAM is real-time collaboration. Multiple users will be able to work on model development at the same time, and each user will be able to see in real-time what other users are doing.

- **Open Infrastructure.** The SAM is built using an open infrastructure philosophy – open in terms of data, models, and APIs so that it fits into our customer's MBSE ecosystem. Close integrations with both Ansys tools (*e.g.* ModelCenter, Medini, Scade, solvers) *AND* third-party tools (*e.g.* PLM, external simulations, etc.)

- **...** You can get it today!

SYSML V2 HIGH LEVEL OVERVIEW

The Pillars of SysML (v1)

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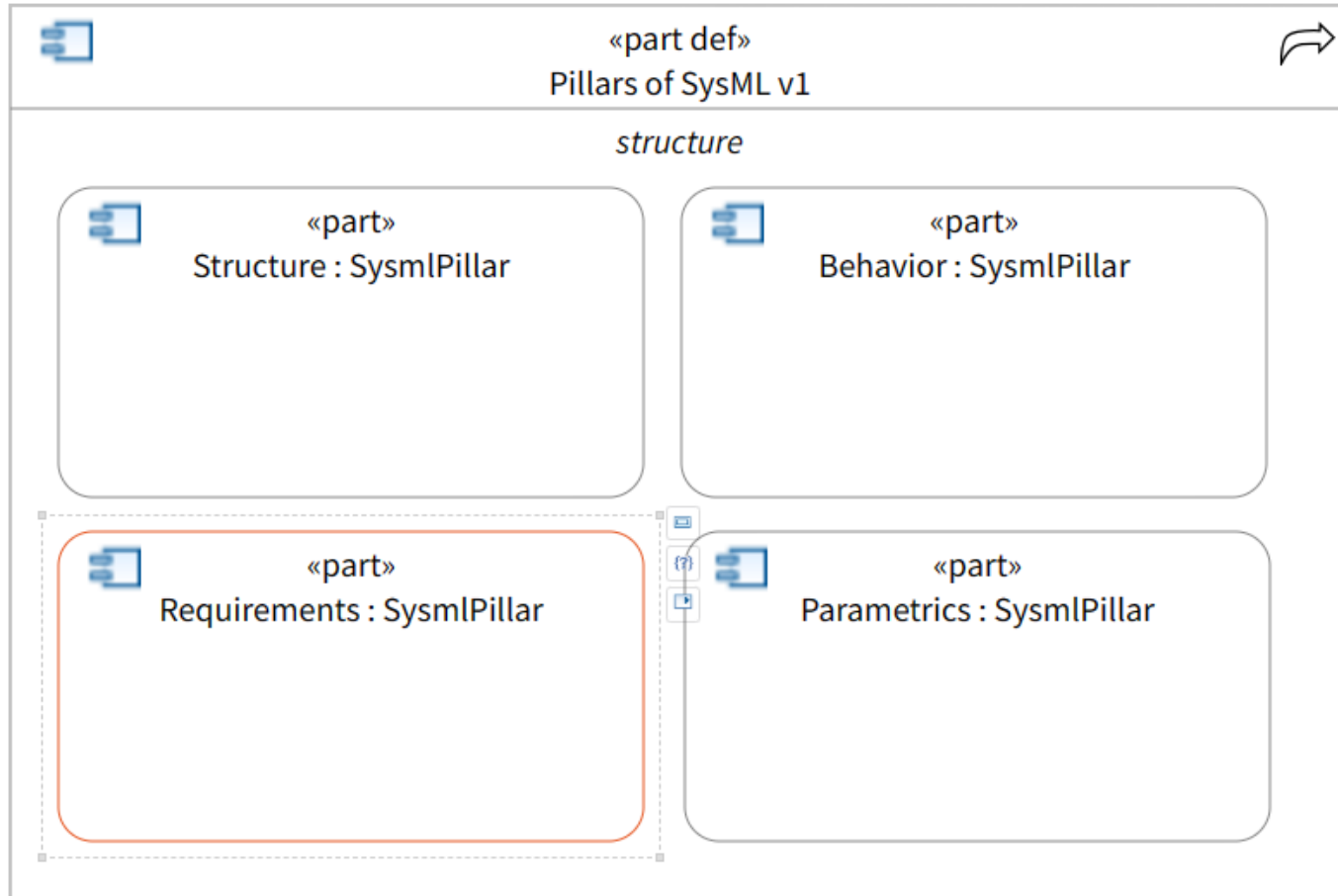
The Pillars of SysML (v2)
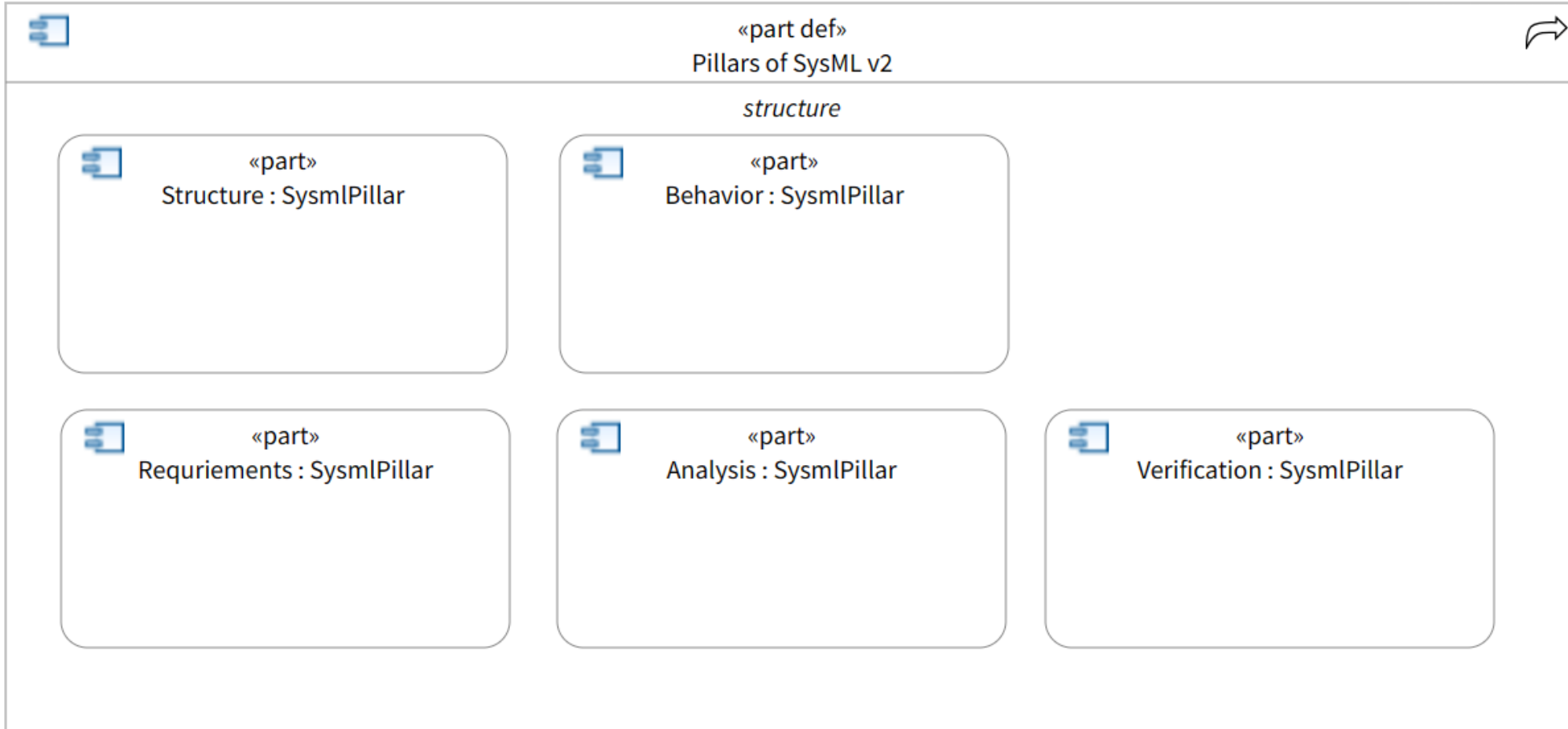
Mapping SysML v1 to v2 – The Semantics are Different (!1:1)

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SysML v1 Elements	SysML v2 Elements
Block	Part Definition
Part Property	Part
Interface Block	Port Definition
Port	Port
Activity	Action Definition
Action	Action
Constraint Block	Constraint Definition
Constraint Property	Constraint
State Machine	State Definition
State	State
Value Type	Attribute Definition
Value Property	Attribute

! = NOT, for the Non-Scripters in the room

Source: https://www.linkedin.com/pulse/enhanced-sysml-naming-convention-boosts-adoption-usability-aktas/

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Demonstration

Integration of System Model (SysMLv2) + Analytical Models for Requirement Verification
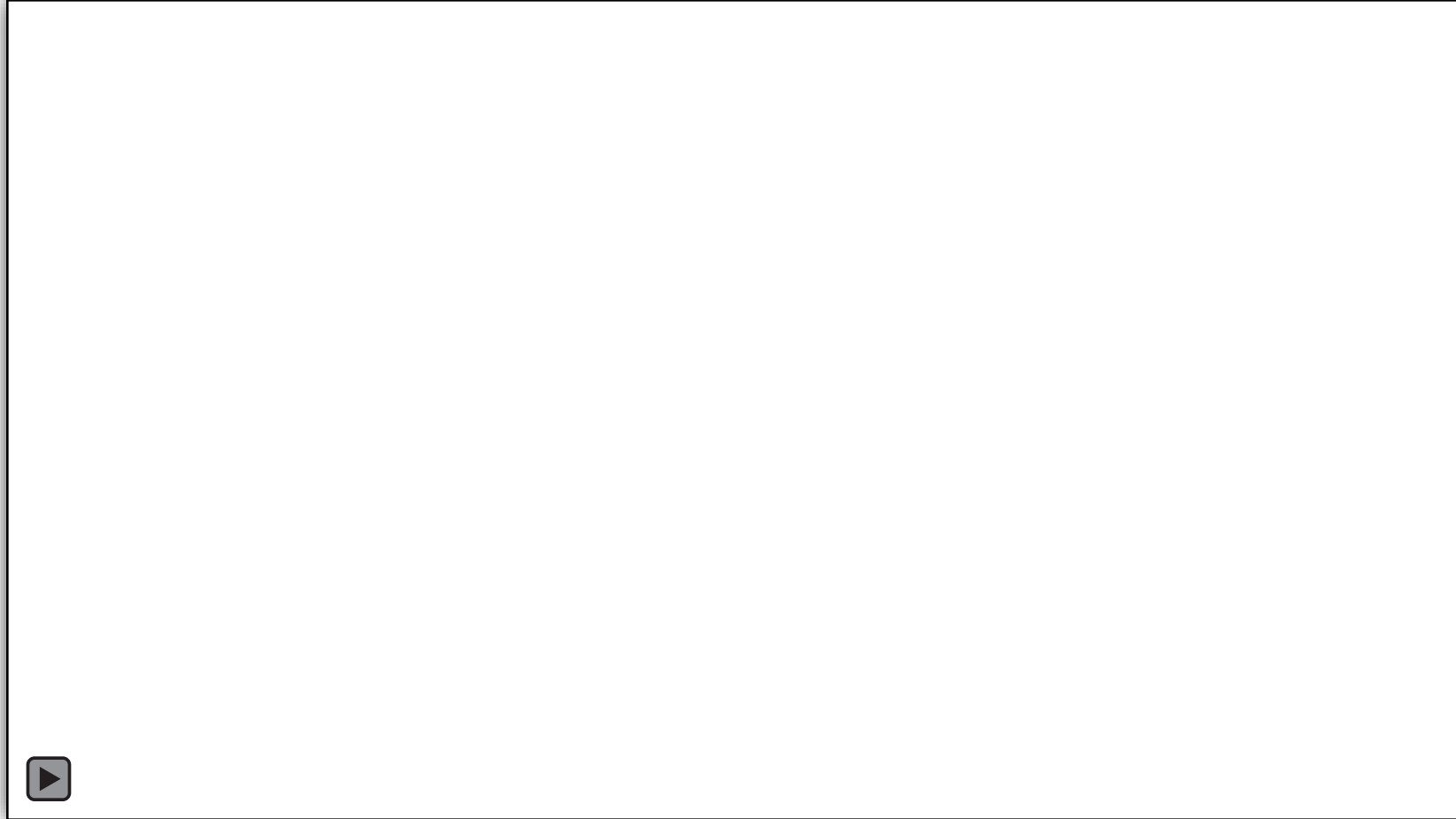
Demonstration

Part 1 - Simulation Connectivity & Requirements Verification

Part 2 – Trade Studies

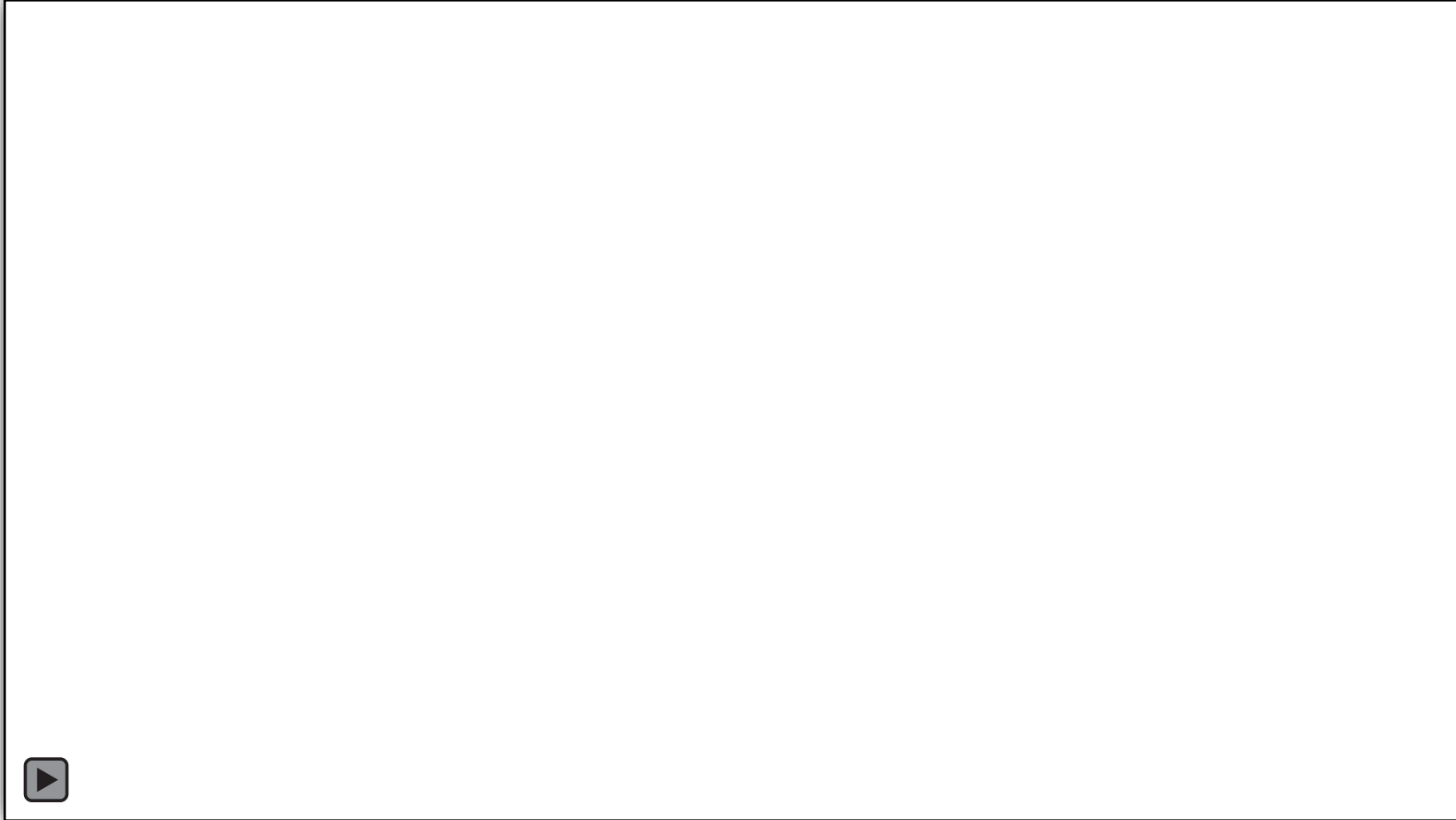*Part 3* – SME Perspective, Optimization

Part 1 - Simulation Connectivity & Requirements Verification

- Remote Execution of Analysis (IP Protection + Shared Execution)

- Simulation Model Automation in ModelCenter

- Simulation Model Integration with Ansys SAM (SysMLv2)

- What If Analyses

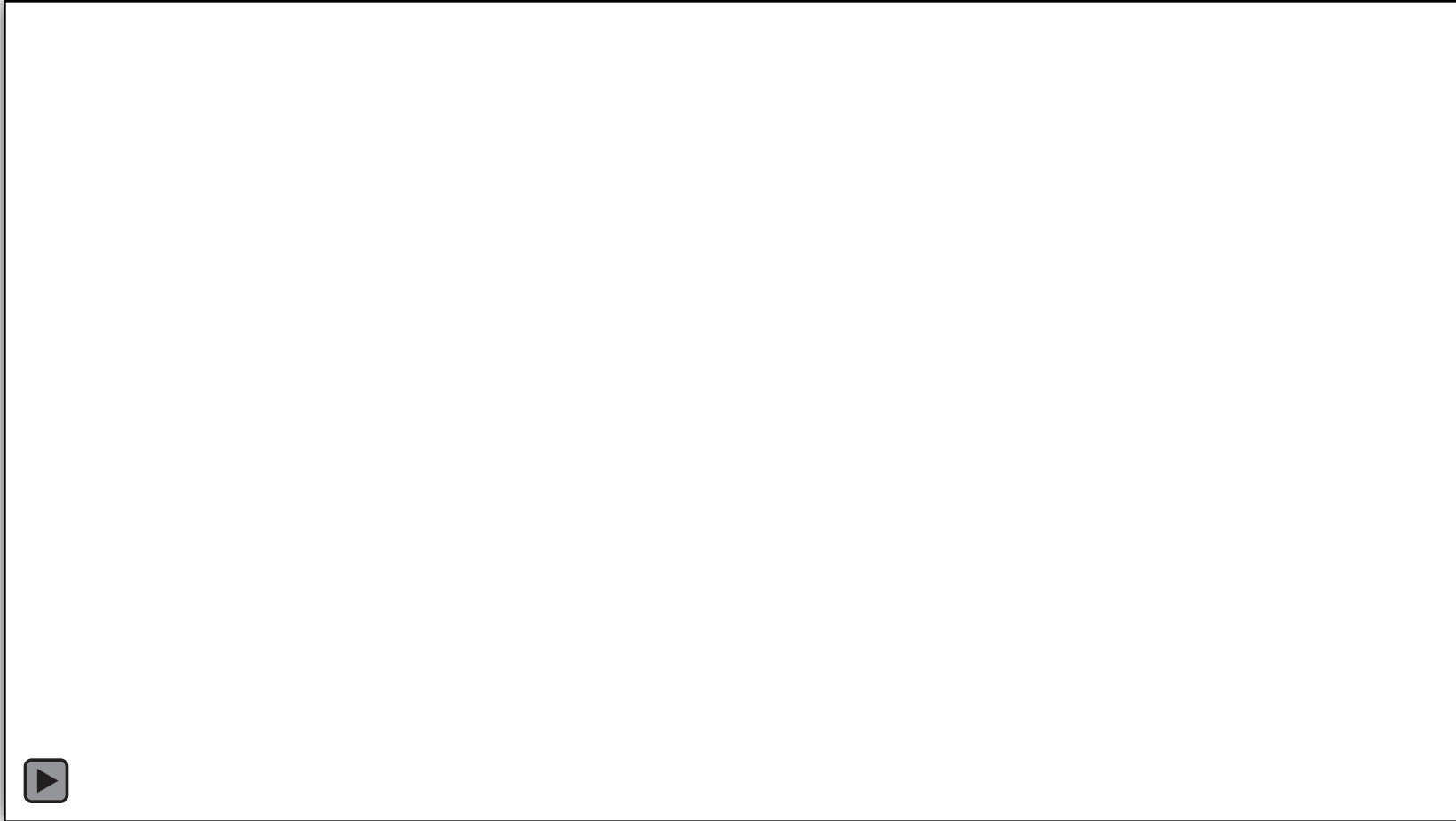- Requirements Verification

- Results Storage

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Part 2 – Trade Studies

- Design of Experiments (DOE) Configuration

- DOE Analysis of System

- Graphical Post-Processing of Results

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Part 3 – SME Perspective, Optimization

- SME User – Working in ModelCenter*

- Ansys SAM Connectivity

- Optimization of Cost vs Performance

- Saving Results Directly in SAM as a Instance (ASoT)

*Note: Workflow structure had been saved in ASoT, and is immediately rebuilt when called

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