# Realizing the Full Value of MBSE Models through Digital Thread Implementation at Applied Materials

Transitioning from legacy document-based to model-based systems engineering

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APPLIED MATERIALS®
make possible

# Agenda

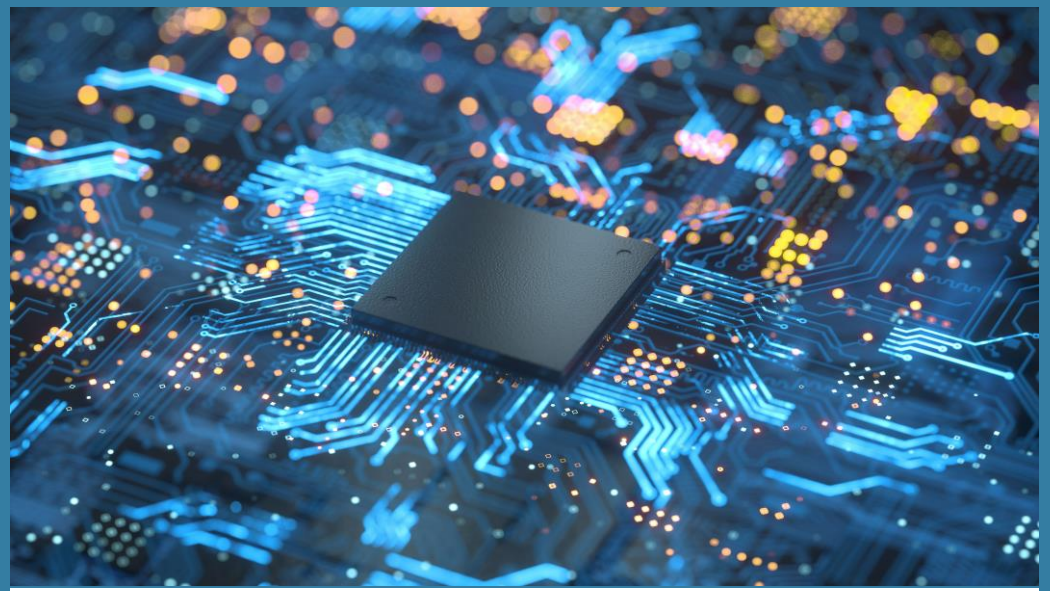
- Introduction & Context
- Why we chose MBSE
- MBSE & Digital Thread Production Pilot
- Achievements, Challenges & Learnings
- What’s Next?

# Who We Are

APPLIED MATERIALS®
make possible

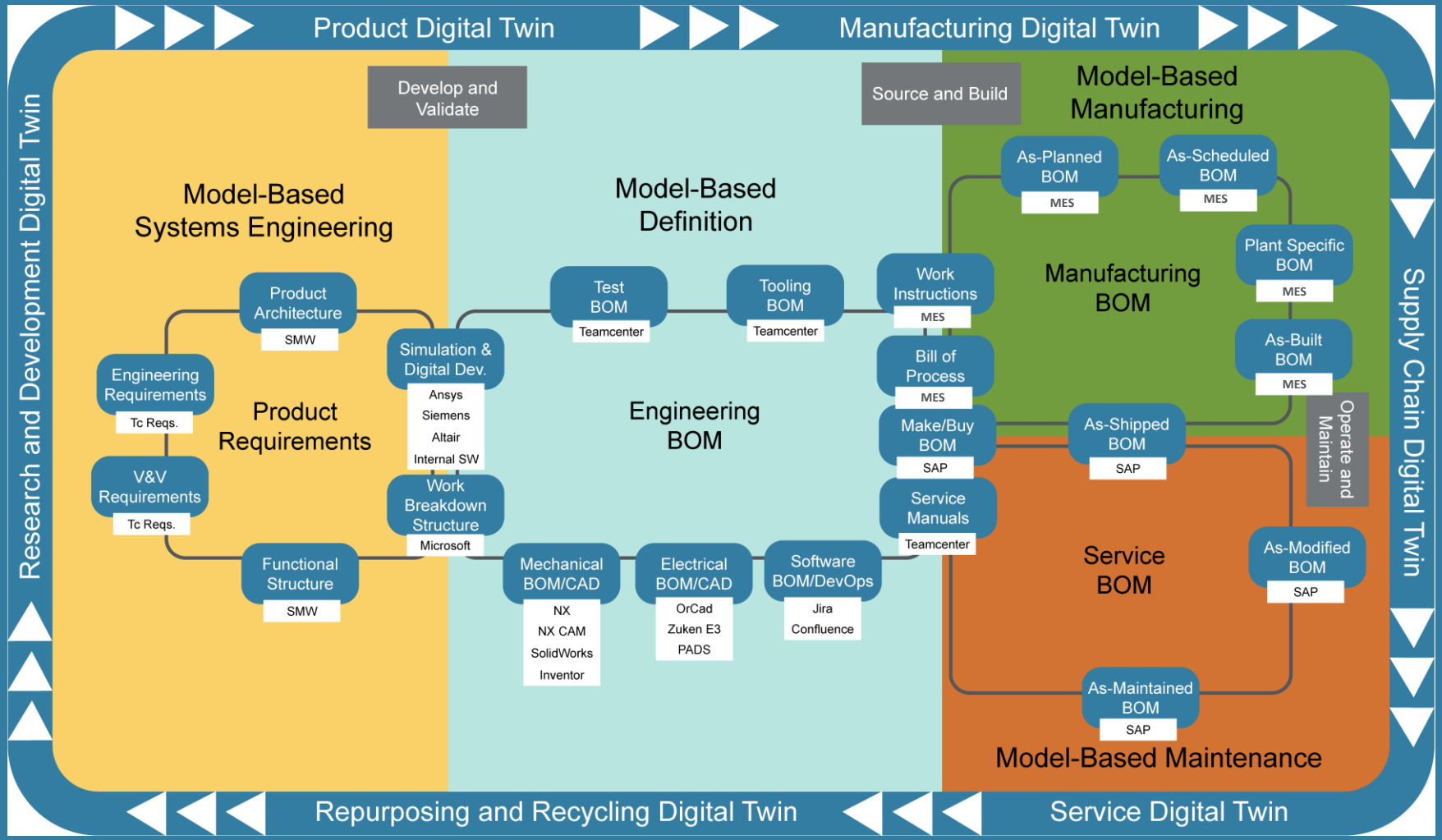
We are the leader in materials engineering solutions used to produce virtually every new chip and advanced display in the world.

World's #1 semiconductor & display equipment company. Our systems make semiconductor devices called chips—the brains of the electronics used in almost every aspect of our lives. The technologies we create are the foundational building blocks of future electronics that **Make Possible® a Better Future**.



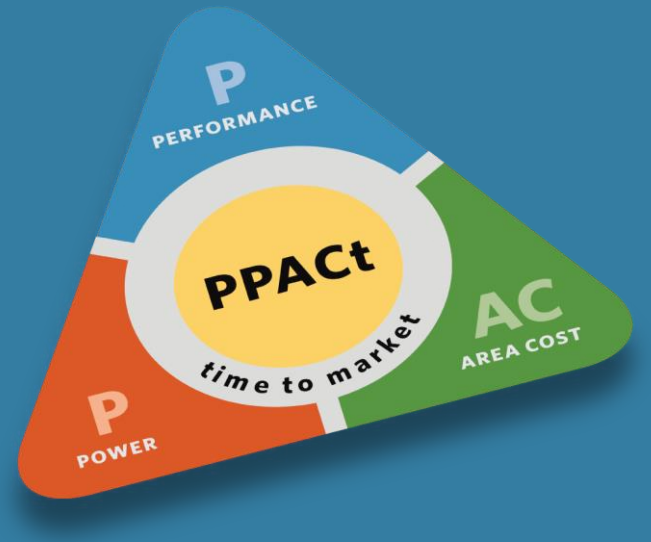
# Our Vision | Digital Engineering Ecosystem

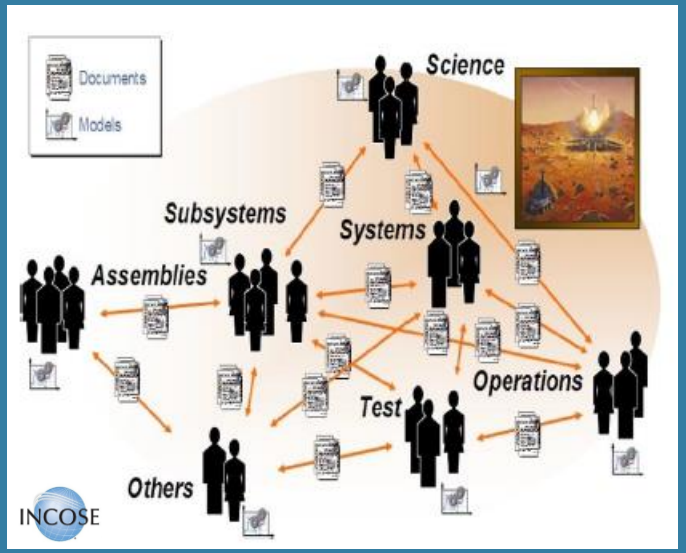
Digital engineering has emerged as a transformative approach that leverages data and IT capabilities to optimize product development throughout its lifecycle. Our goal is to establish a single source of truth that integrates and tracks information across the entire lifecycle and corresponding stakeholders.



# Business Need & Challenge | Complex products & Document-based processes

- Multiple business driving forces making our products and services more complex:
  - PPACt
    - Increasing transistor density requires advances in 2D and 3D scaling to improve power, performance, area, cost, and time to market
  - IMS™
    - Co-optimization of multiple process and materials in order to enable Integrated Materials Solutions for advanced scaling
  - Sustainability
    - Growing pressure on semiconductor industry to help reach Net Zero through increased eco-efficiency during device fabrication and development of power-efficient chips
- Requirements Management was document-based and not integrated with enterprise PLM system
- Product Architecture information was document-based thus unable to reuse the design or analyse effectively
- Applied Materials has a wide ecosystem of standalone applications & business processes which results in siloed processes & disconnected artifacts




https://www.omgwiki.org/MBSE/doku.php?id=mbse:incose_mbse_iw_2014

# Solution | Transition to Model Based Systems Engineering (MBSE)

- MBSE is an engineering methodology that utilizes models to represent and analyze systems throughout their lifecycle. It offers the promise of capturing the complexity of systems in a structured and visual manner, enabling better understanding and communication among stakeholders.

- Evaluation started in 2023 and implemented Production Pilot in 2024 with various POCs planned ahead

## Objectives

- Enhances Communication
- Improves Productivity
- Improves Quality
- Supports Integration
- Manages Complexity
- Facilitates Reusability

## Contenders

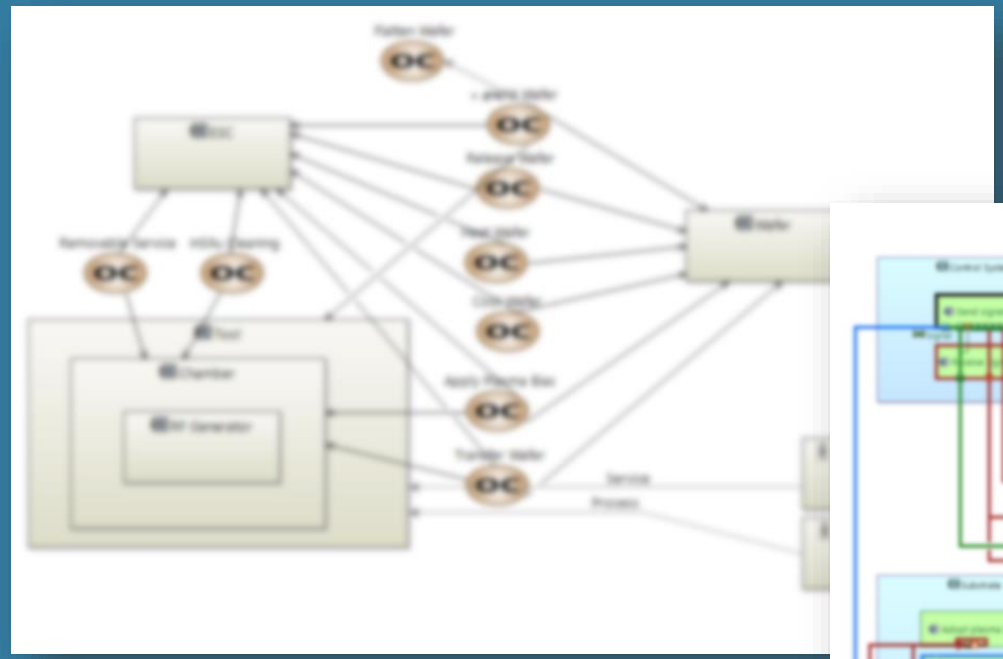
- MBSE Modeling:
  - Capella/SMW (Siemens)
  - Cameo Systems Modeler
  - Altair OmniV
- Requirements Mgmt:
  - Tc Requirements (SE)
  - Polarion

## Why SMW/Tc Reqs?

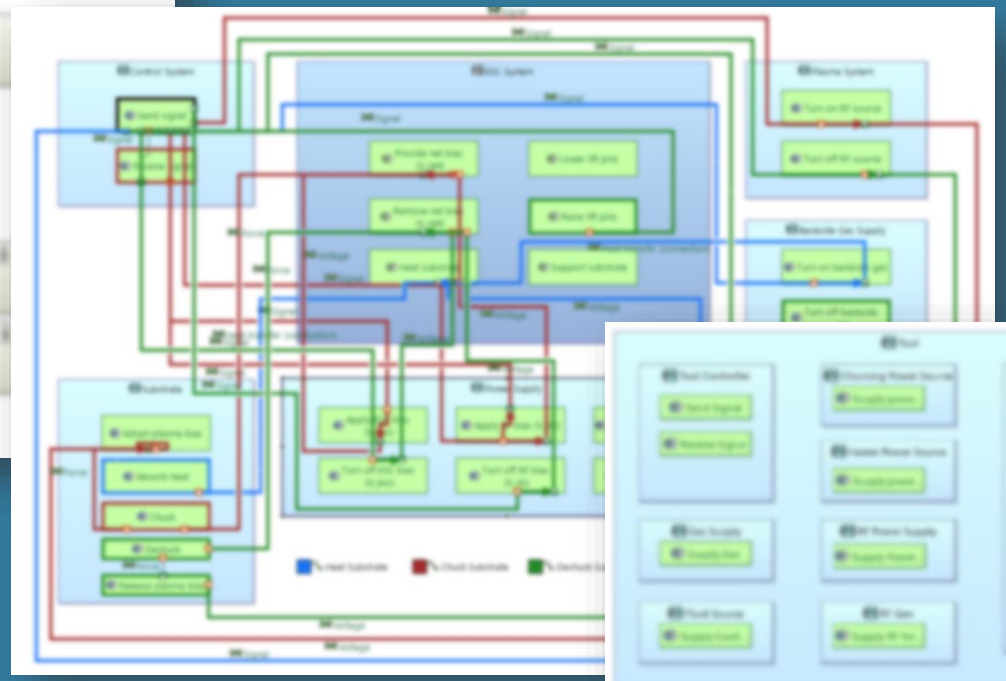
- Integration with Teamcenter (PLM) & Tc Reqs traceability
- Integrated collaborative platform that can be extended as required
- ARCADIA Methodology enables to capture products' complexity
- SysML v2 Export compatibility
- Shorter Learning curve for Capella Vs Cameo
- Easy-to use interface for Tc Reqs Authoring

# MBSE Production Pilot | Product Architectures in SMW

## Operational Capabilities

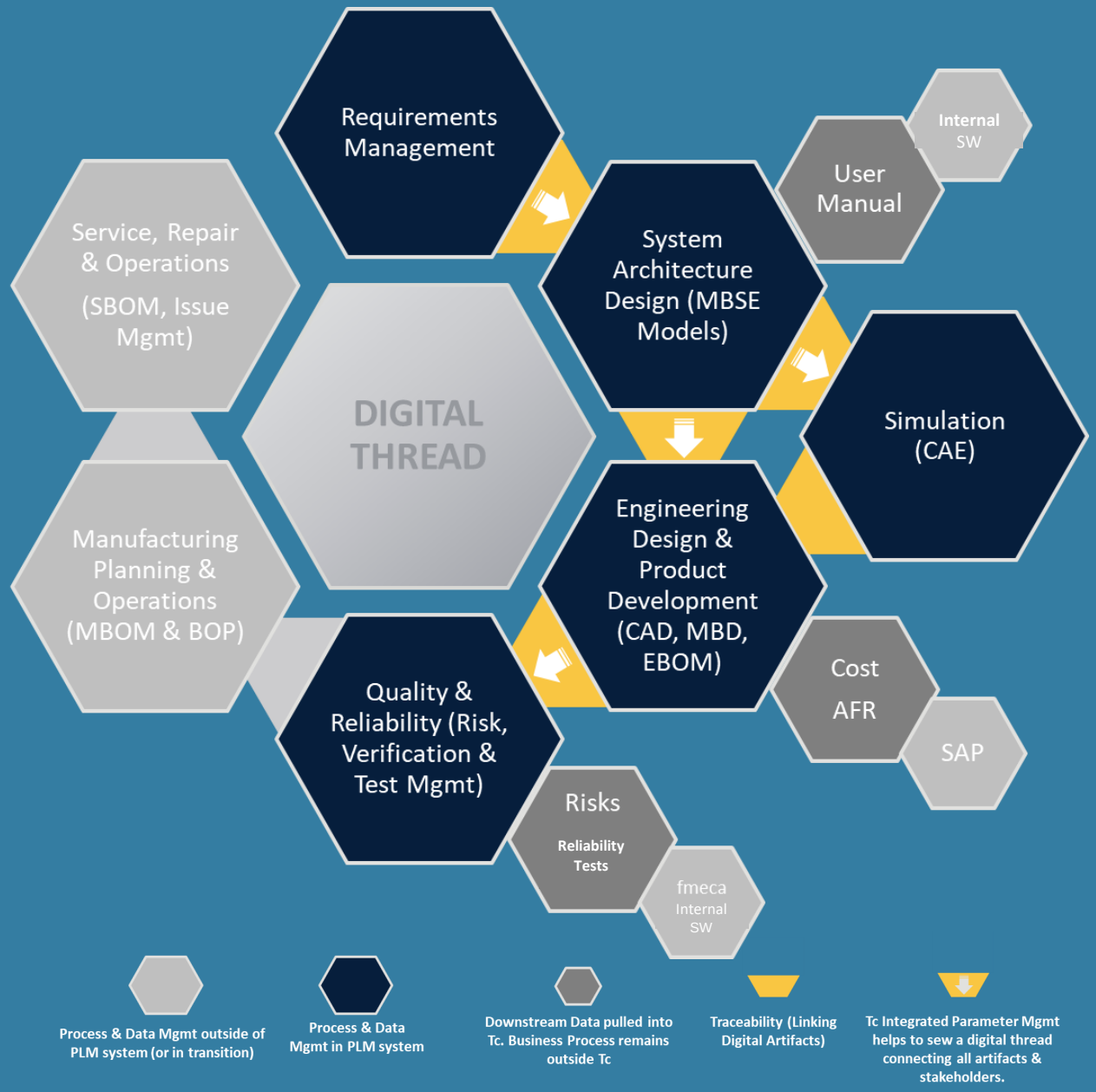


## System Architecture



## Physical Architecture

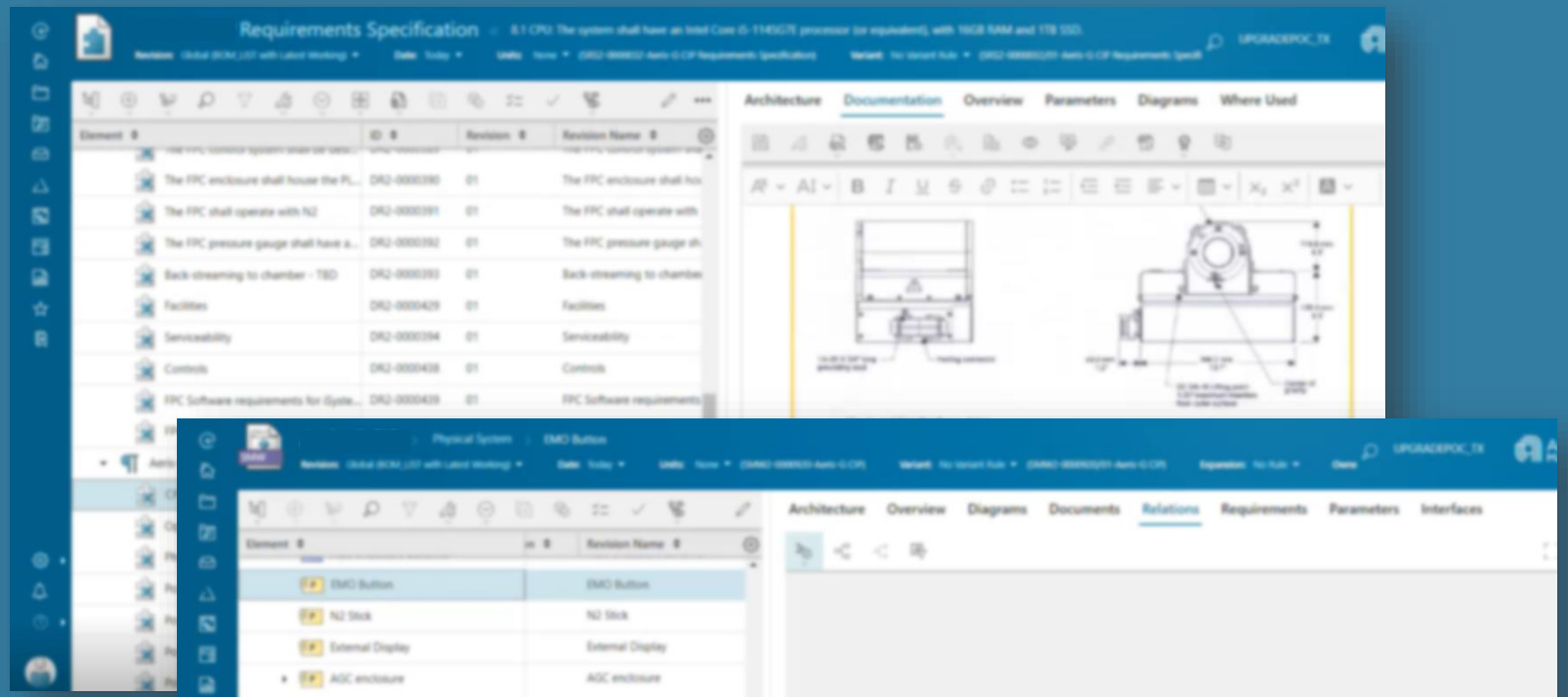
# MBSE forms a foundation for Digital Thread




Applied is focusing on reducing the learning curve of MBSE & eliminate the creation of sub-standard Requirement Specifications & MBSE models.

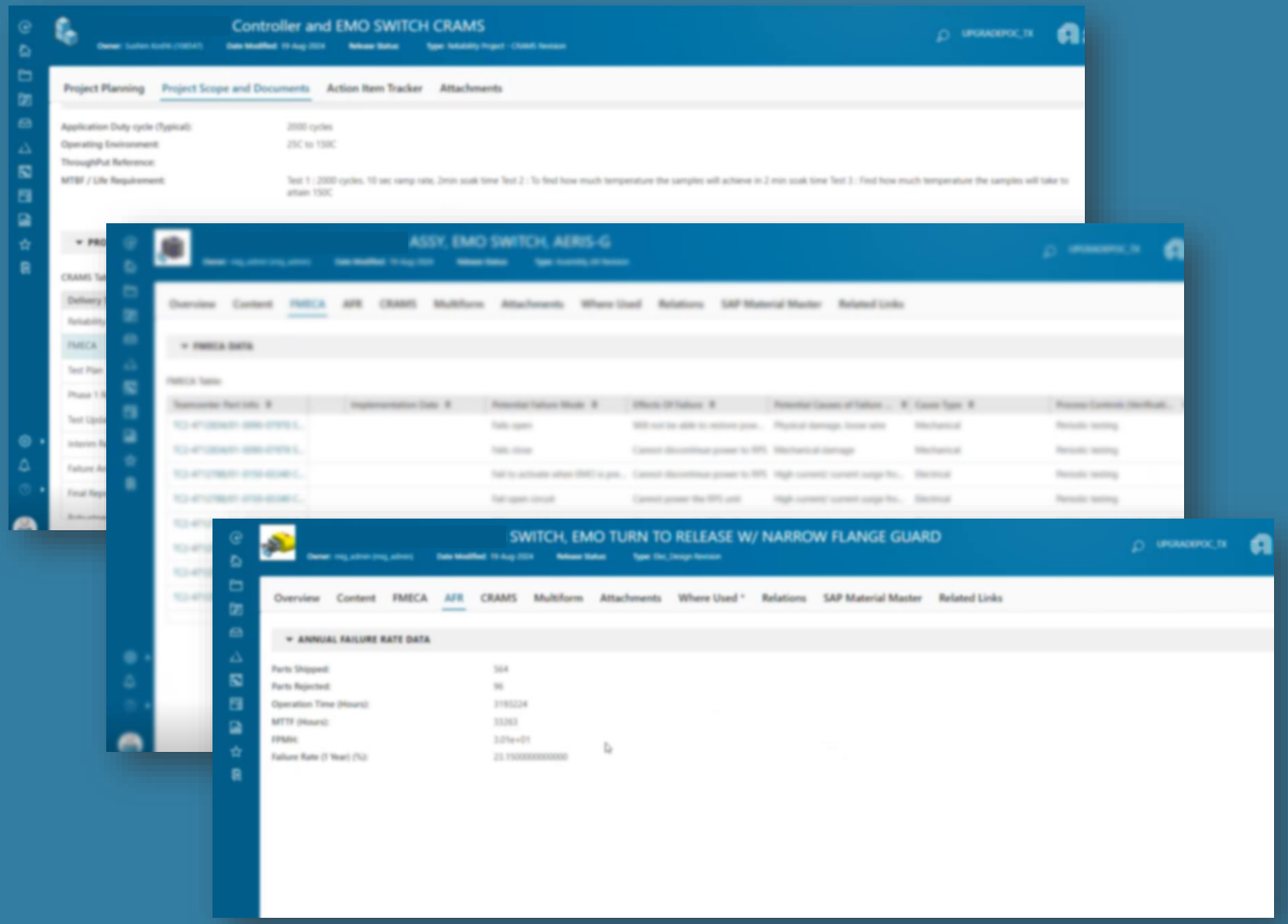
- Integration/Connectivity between Requirements, MBSE Models & CAE Simulation Models leveraging Tc Parameter Management
- Establishing Digital Thread by connecting MBSE, MBD, CAE, Quality & Reliability digital artifacts
- Connectivity between MBSE & CAE POC through Notebook & Pycapellambse
- Design Reusability POC based on modified Requirements & Design Parameters from MBSE

# Traceability between Requirements, MBSE & CAD Parts



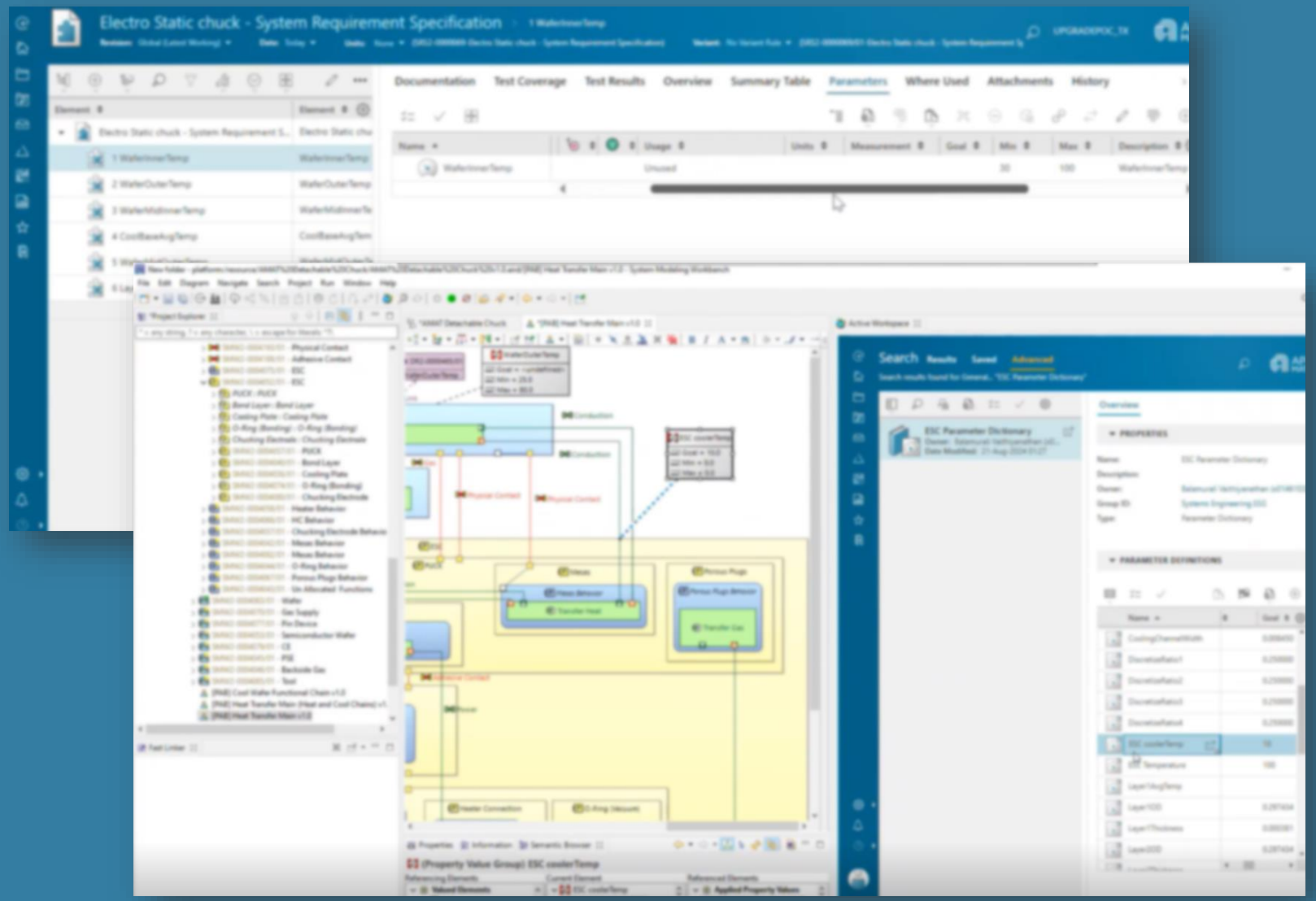

- Clear documentation of Requirement Specifications through Requirements Decomposition in conjunction with Product Design Architecture development in Capella/SMW
- Tracelinks between Functional or Design Requirement, MBSE Physical Function or Component Node & CAD Parts in Teamcenter
- Requirements Coverage Assessment
- Architecture & Relationship Viewer for traceability navigation

# Connecting Design with Downstream Quality & Reliability Data




- Looking at these data in the context of Product Design Decisions while making changes to Product Architecture in MBSE Tool
- Availability of relevant FMECA data (Product/Design FMECA) within Teamcenter Part
- Assessment of Annual Failure Rate for individual Component Parts
- Business Process & Data Management of Physical Reliability Test for Prototype Parts within Teamcenter

# Integrated Parameter Management




- Configure Parameter Dictionary with industry-based set of Parameter Definitions
- Assign Requirement Target Parameters to Functional, Design, Software & other requirements
- Define Design Parameters to MBSE Model Elements which would potentially satisfy the requirement targets
- And validate the Requirement Targets via Simulation using those design input parameters
- Integrated Parameter Mgmt helps sew that Digital Thread connecting all artifacts & stakeholders in the product development

# MBSE, Design & Simulation Digital Thread – POC for Electro-Static Chuck (ESC)

Extract Requirements' Parameter Targets from Tc

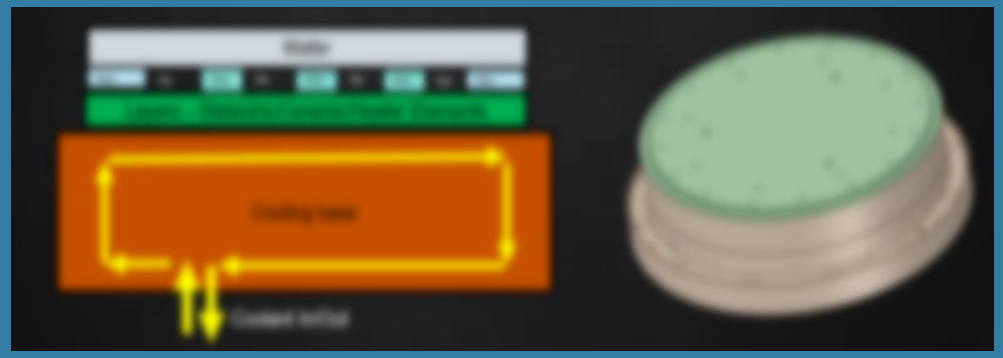
Extract Design Parameters from MBSE Models

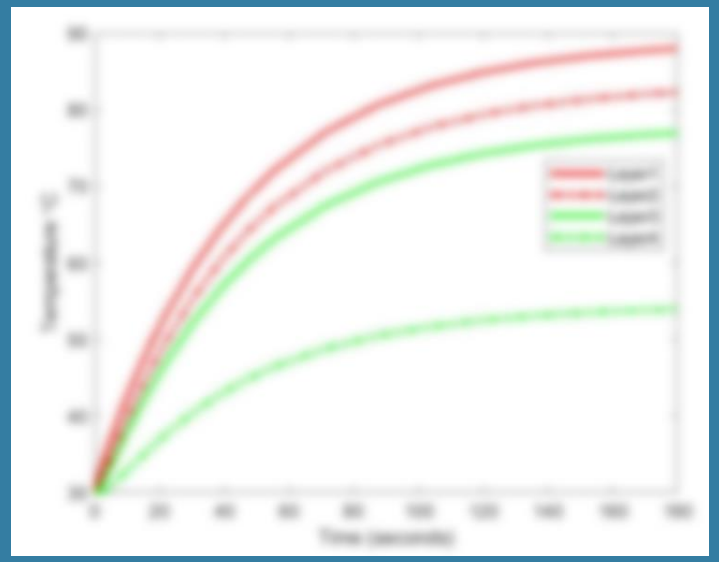
Run CAE Model with MBSE Design Parameters as Input

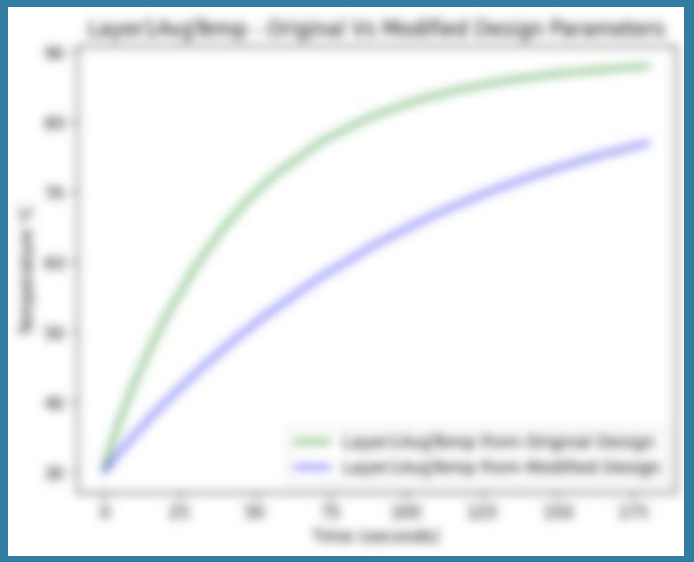
Validate if CAE Output satisfies the Requirement Targets

Re-run CAE Model with modified Design Parameters to make sure Output satisfies the Req Targets

Update the modified Design Parameters back into MBSE Model





**SMW/Capella + Teamcenter + Jupyter Notebook**
**Pycapellambse + Matplotlib + MATLAB**

# MBSE & Digital Thread Production Pilot | Outcomes

**2**

Products' Architectures

**models**

>50 Physical Component Nodes
>200 Physical Functions
~100 Physical Links
~ 100 Functional Exchanges
~50 System Functions

**standard**

Requirements & MBSE Models are clearly defined based on templates
>500 Reqs

**traceability**

Requirements to MBSE Models to MBD
Models/Parts connectivity
~15 CAD Assemblies Tracelinked

**digital-thread**

MBSE serves as a foundation to establish Digital Thread connecting Reqs, Design, Validation & Test

# MBSE & Digital Thread Production Pilot | Benefits and Learnings

## Benefits

- Clear strategy on Integrated Requirements & MBSE
- Educated systems engineers on MBSE methodology & tools
- Lower cost & high-quality deliverables in Product Development
- Improved collaboration among multidisciplinary teams
- Shorted Development Time & better reusability of product designs
- Reduced errors and model iterations (by using Templates)

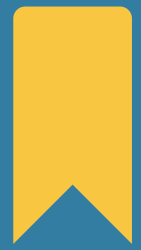
## Learnings

- Substantial learning curve for Systems Engineers to study & utilize MBSE concepts and tools
- Better upfront scoping of IT implementation requirements, especially working on complex, legacy PLM landscape
- Legacy data must be well analyzed and understood to be transitioned into MBSE models

# MBSE & Digital Thread | What's Next?

**MBSE Adoption Strategy**

- Leverage GenAI to automatically create MBSE Model Elements in SMW using the Requirements & existing Design documents (RAG Stack + LLM + Pycapellambse)
- Programmatically create MBSE Model Architecture Diagrams (LLM + Python + Capella APIs)



**Documentation, Standardization & Validation**

- Creating valuable document deliverables from MBSE models including diagrammatic representations (Pycapellambse + Declarative Modeling Addon)
- Leverage GenAI & Teamcenter to standardize Requirements' Syntax,  Formation & Derivation Rules
- Model Standardization & Validation through Templates & Python/Python4Capella

# Thank You

For more information you may contact us!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