Get the Data Right for Effective SPDM

Making the Case for a Unified Data Model

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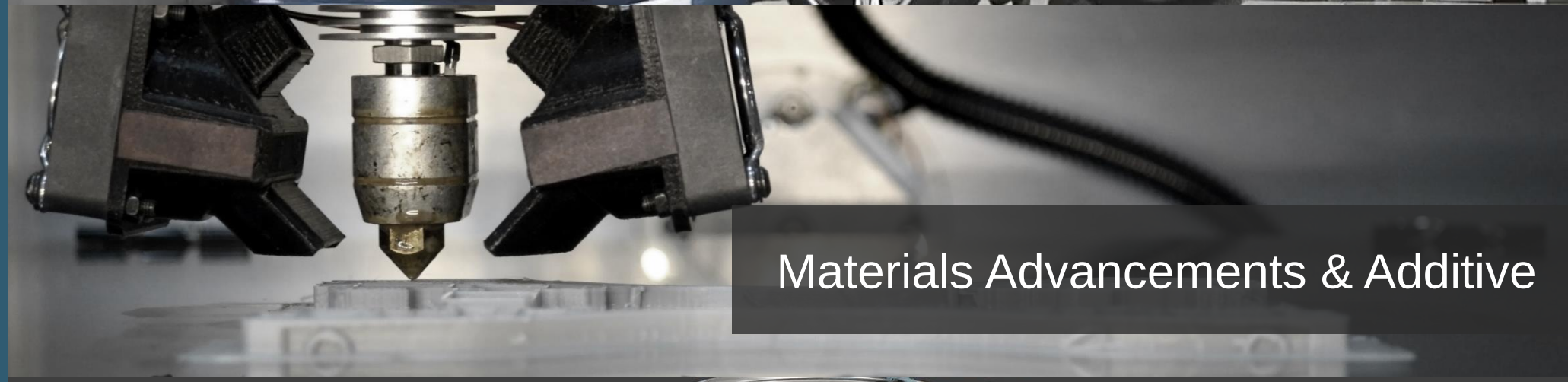
June 2019

Need for Simulation Increasing Rapidly

Verification & Validation

source:youtcar



Materials Advancements & Additive

Design Space Exploration

source: wirth research

Future:

More & More Simulations across the Lifecycle

Silos: Unable to Achieve Business of Engineering Strategies

Source: ESPRIT Program Excellence

Simulation Management: Challenges

- Large number of tools
  - Mixed-fidelity modeling (from systems models to 3-D models)
  - Multi-physics modeling
  - Multi-disciplinary modeling (including mechanical, software, electronics)
  - Tools from multiple vendors
- Data models (tool file formats) are all different
  - Each tool speaks its own language
  - Simulation processes usually use multiple tools
- Simulation Processes are manual and only run by experts in silos
  - Non-experts do not have access to simulation
  - Large number of product variants and autonomous testing requires full automation
- Simulation data not connected to other engineering (PLM) data
  - Tools from all vendors, all physics and all levels of fidelity must be integrated
  - Results from all tools should be available to the enterprise for decision-making

Risks compounded by Multidisciplinary Products & Use of Machine Learning and AI in Design

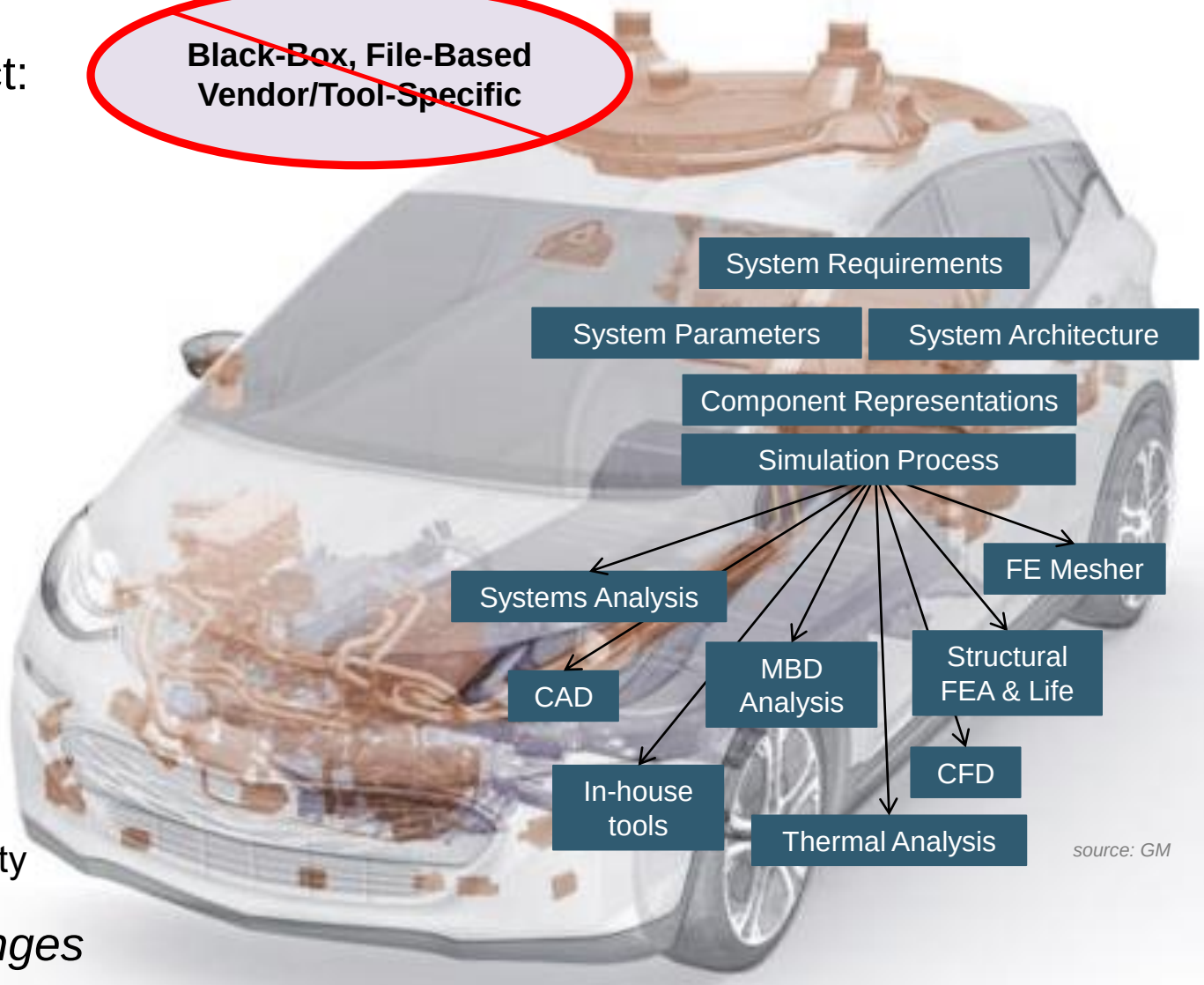
Effective SPDM Should Enable

- Experts & Engineers
  - Deliver better/timely requirements-driven simulation coverage
  - Stay in sync with design / variant changes
  - Eliminate redundant administrative tasks
- Analyze Variations Quickly and Automatically
  - Rapidly conduct analysis on product variations, options and design changes
  - Enable “right-fidelity” simulation throughout the lifecycle
  - Fully-Automate repeatable tool chain processes
- Digital Thread
  - Across Concept Engineering, Detailed Design, Simulation & Test
  - From Requirements through entire Lifecycle

What's Missing in SPDM – a Systems-Centric View

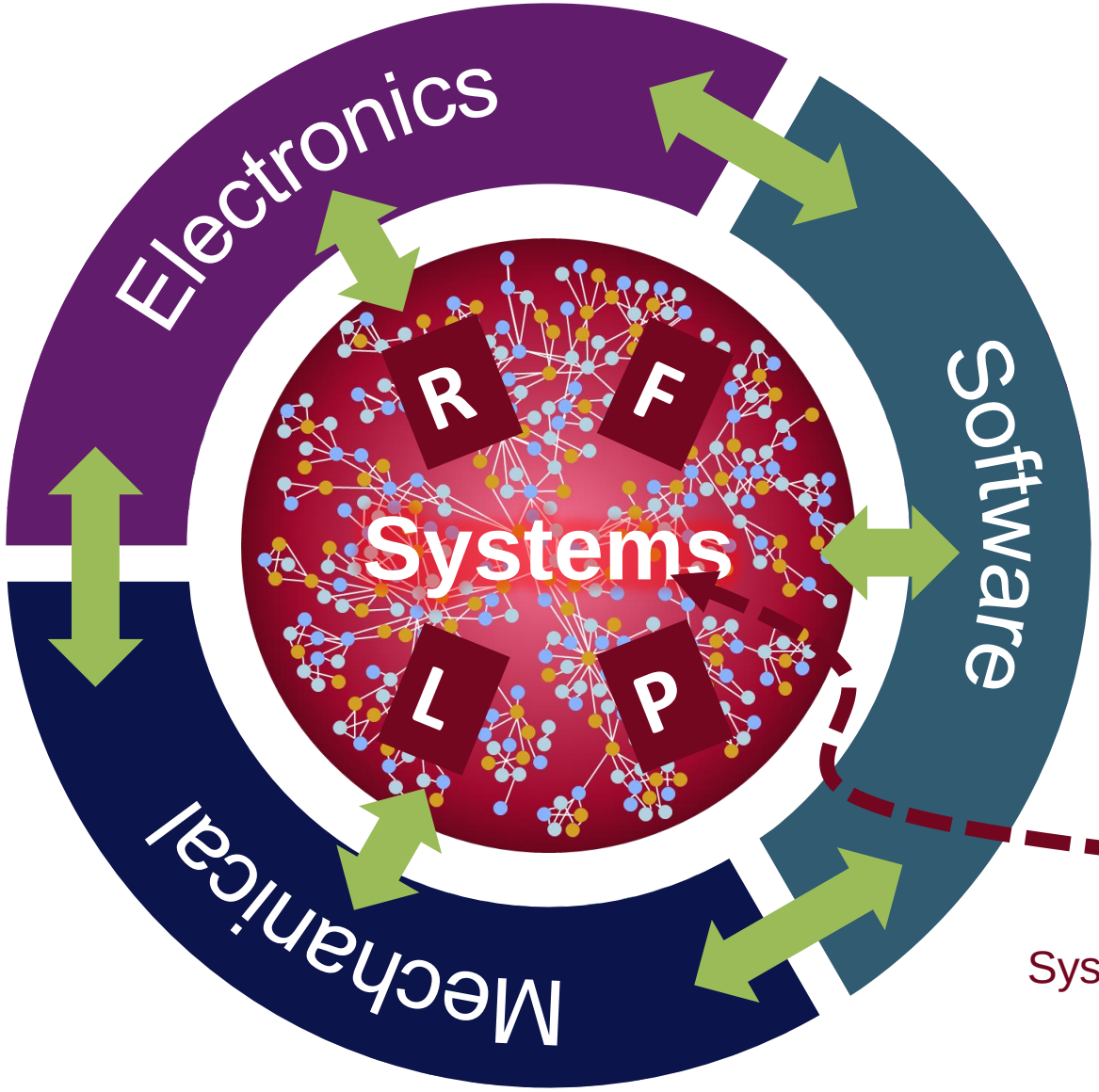
- Complete representation of the Product: A Systems-Centric view
  - System intent & System requirements
  - System Architecture & System Parameters
  - Multiple component representations
  - System constraints & Operating conditions
  - Performance metrics
  - Product variants/configurations
- Tool-agnostic data & processes
  - Commercial, in-house custom, etc.
  - "Lights-out" automation at any level of fidelity
- *Robust automation across design changes and product family variants*

~~Black-Box, File-Based~~
~~Vendor/Tool-Specific~~



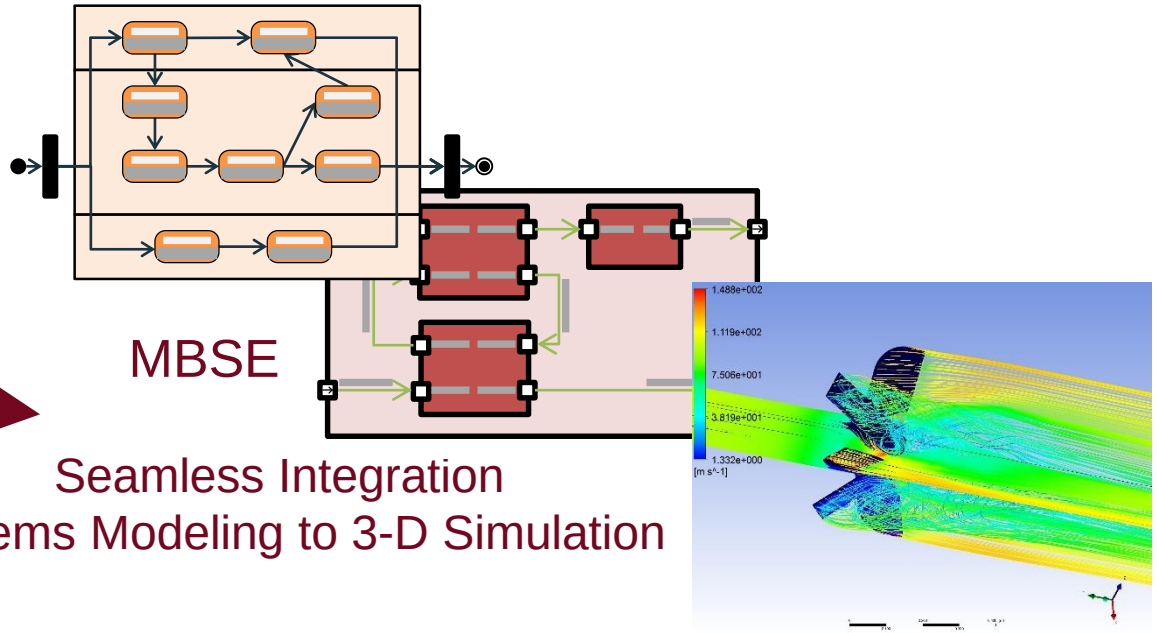
Systems-Centric, Template-Driven Simulation Management

Interdisciplinary Collaboration with Systems Thinking



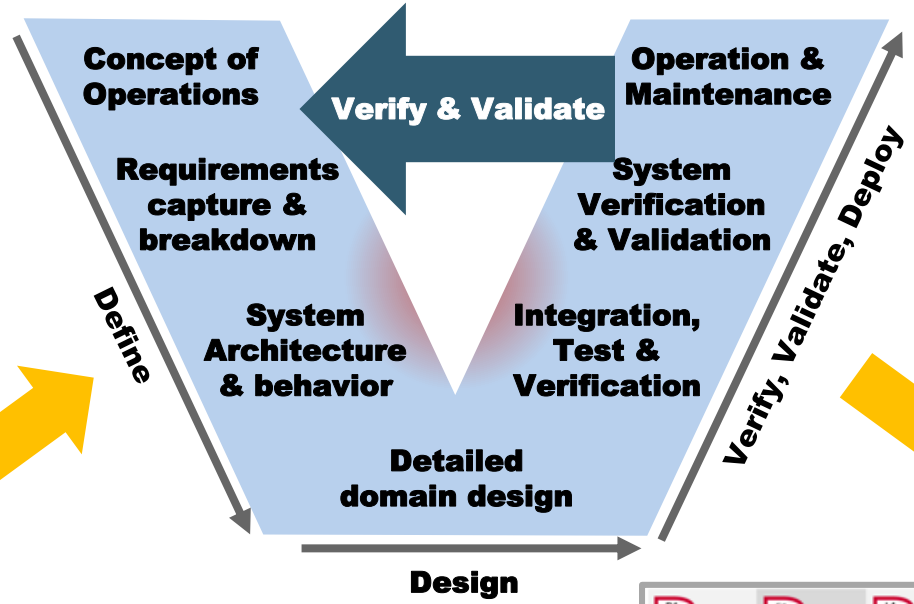
When systems models sit at the center of designs, they become the connective tissue

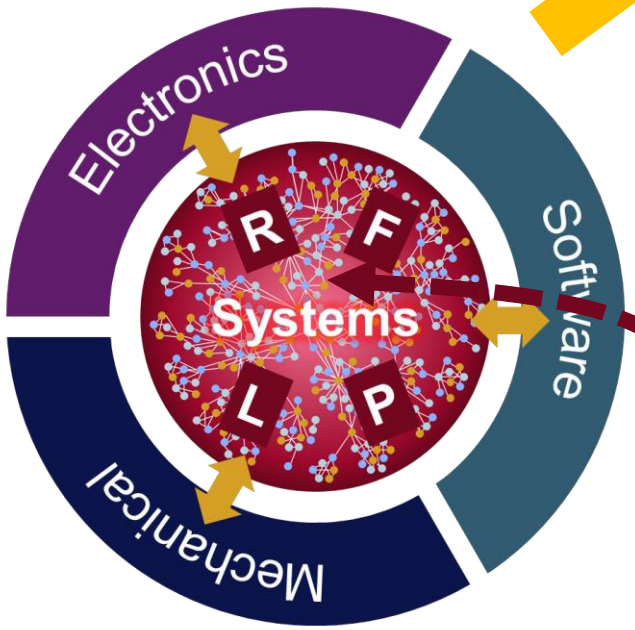
The Digital Thread runs through them



Seamless Integration
Systems Modeling to 3-D Simulation

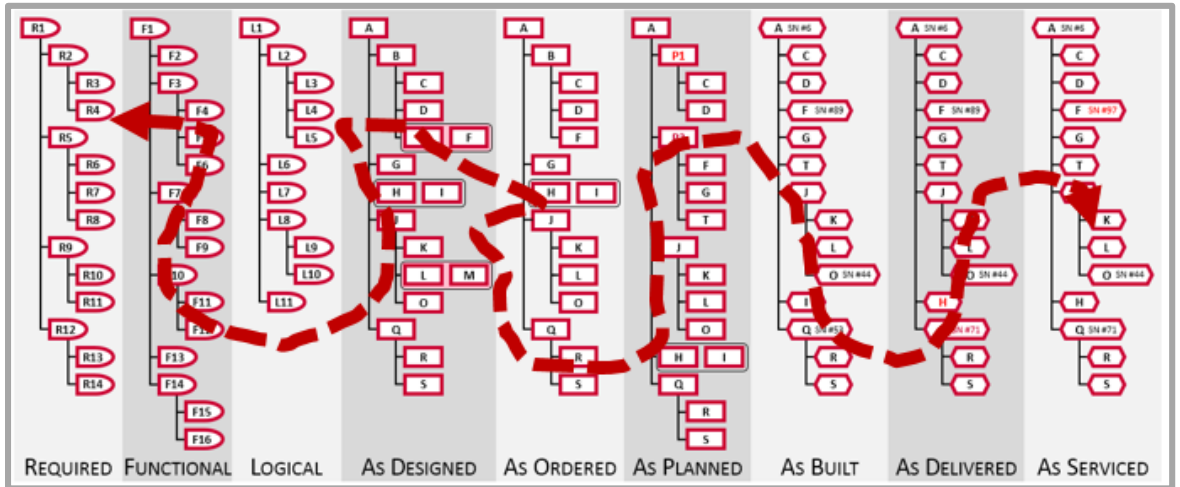
Simulation On-Demand from Concept to Operation





Digital Thread

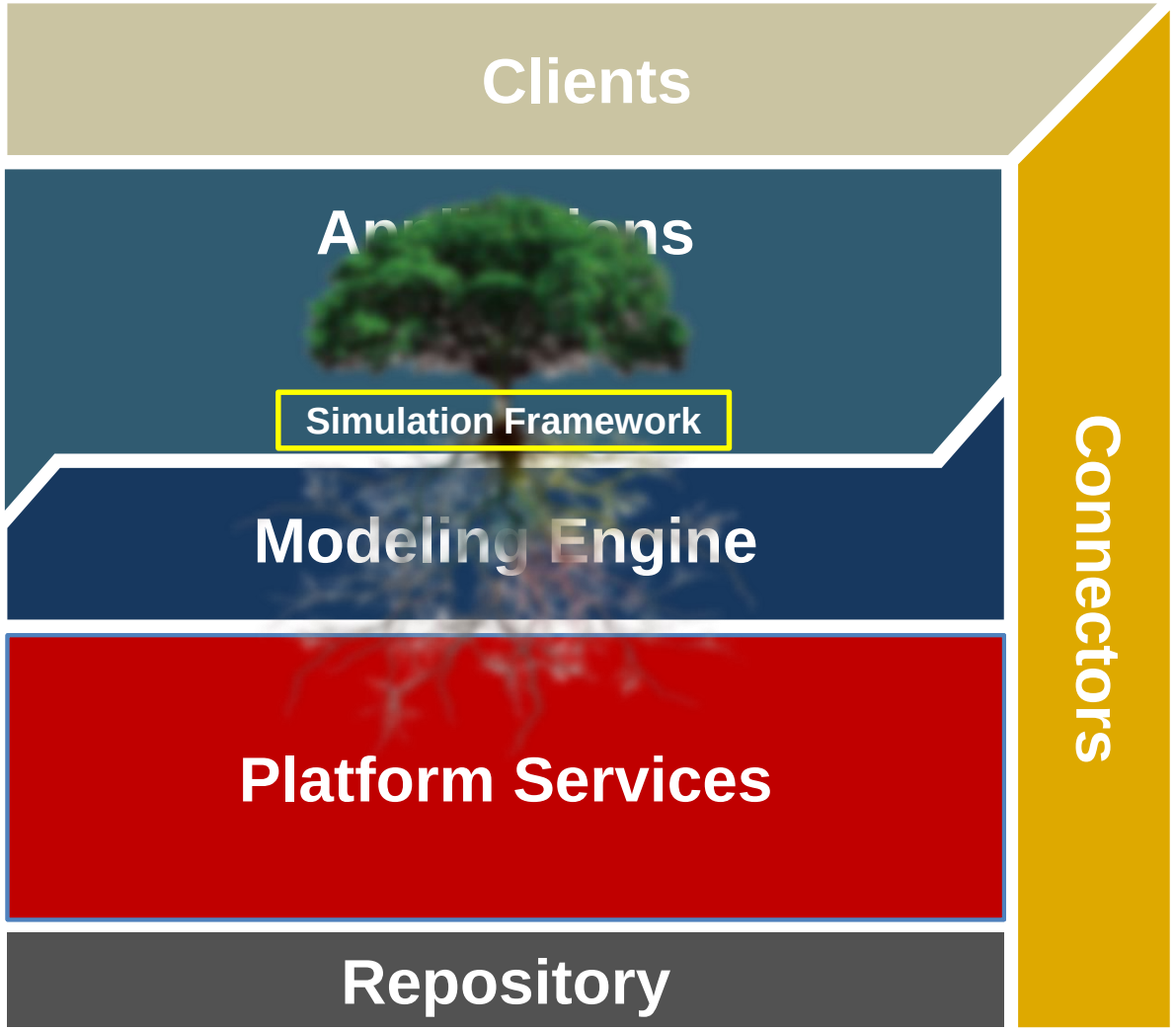
- Traceability
- Support Iterative-Development Systems Models (Agile, Spiral…)



"Right-Fidelity" simulation available on-demand

Simulation in an Integrated, Open, Extensible Platform

- Simulation integrated with all core PLM services
  - Configuration, ECO, and Lifecycle processes
  - Visual Collaboration
  - Configurator
  - Branch/Merge
  - Graph Navigation
- Open unified data model and APIs
  - Consistency for all users/implementations
  - Supports simulation data and processes
  - Custom extensions (data model, process, applications)
  - Connectors for commercial and in-house tools



Tool-Agnostic, Open Product Innovation Platform

Core Beliefs That Drive Our Solution

1. Get the data right
   - Create and manage an engineering abstraction layer that is vastly tool-independent
2. Fully-Automate repeatable simulation processes
   - Simulation templates must be robust across significant design changes and across the entire product family, at the required level of fidelity
   - You must auto-generate the simulation models
3. Connect simulation data to the product architecture
   - Simulation data must be requirements-driven and systems-centric

Simulation Framework Architecture

Secure User Access

Scripting & Process Definition

Process Execution

High Performance Open APIs

Remote Execution

Scalable Back End

Unified Data Model

Persistent & Transient Data

Web Client

Workstation Client

Scripting & Process Modeler

Process Engine

Remote Job Engine

Tool Connectors & Open APIs

PLM Platform Server

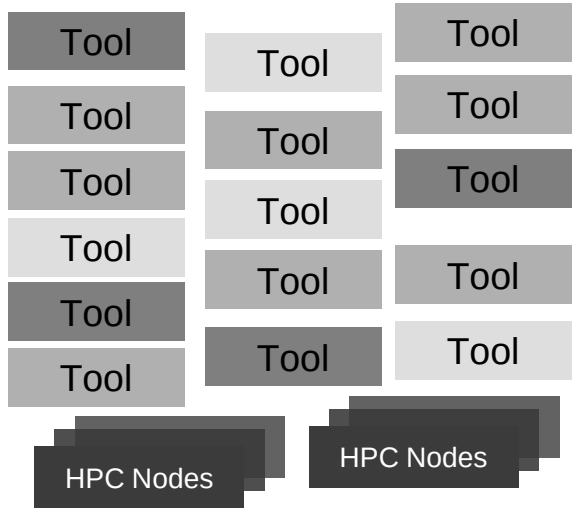
Temp Files

File Vaults

Metadata Repository

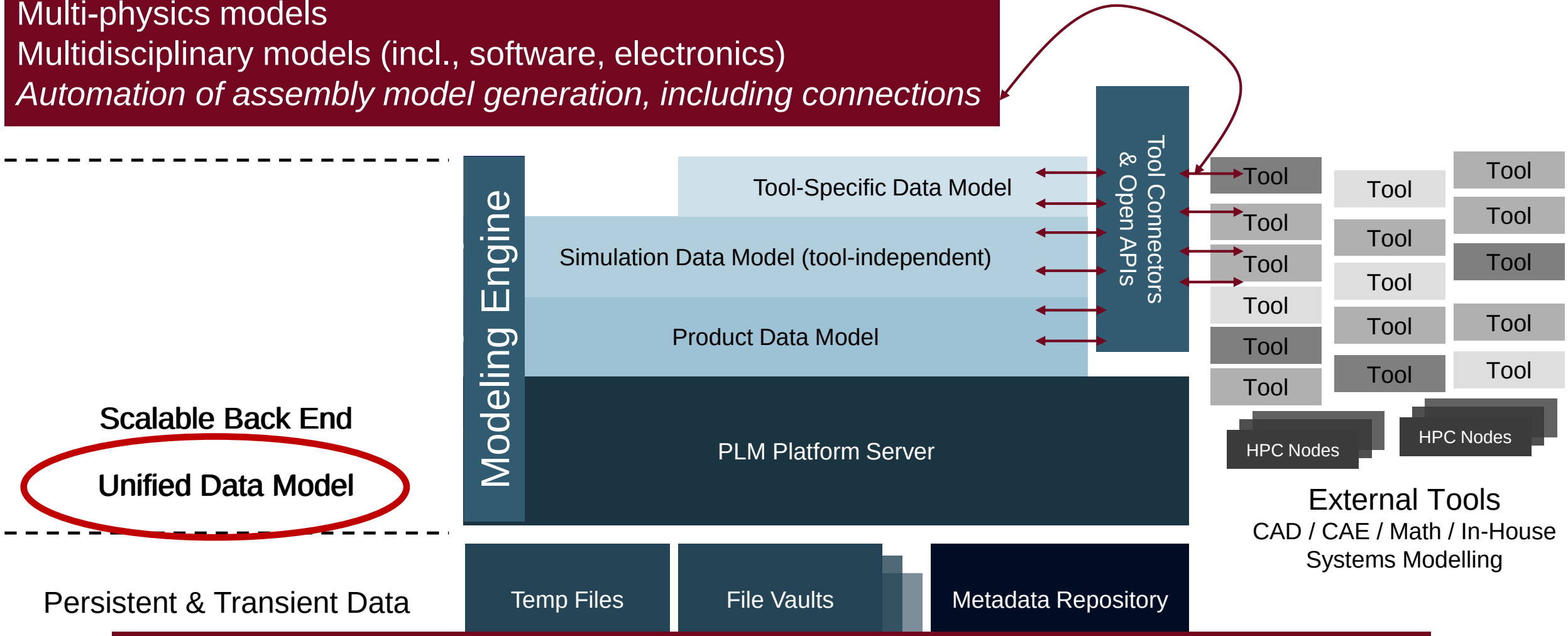
External Tools

CAD / CAE / Math / In-House Systems Modelling



Tool-Agnostic Unified Product Data Model

Mixed-Fidelity models (systems to 3-D)
Multi-physics models
Multidisciplinary models (incl., software, electronics)
Automation of assembly model generation, including connections



Requirements-Driven, Systems-Centric, Template-Enabled Simulation Management

Tool-Agnostic Unified Product Data Model

Component reps.
Discrete reps. (e.g., mesh)
Engineering reps. (e.g., joints, welds)
Abstract groups
Environments (tool-, physics-specific)
Simulation Templates
Simulation material data
…

<5%

Numerical abstractions
Numerical properties
Solver parameters
Solver model templates
…

Requirements
Operating conditions
System architecture
eBOM / MBOM
CAD
Material data
Software
…

>95%

Tool-Specific Data Model

Simulation Data Model (tool-independent)

Product Data Model

Tool Connectors & Open APIs

PLM Platform Server

Unified Data Model

Persistent & Transient Data

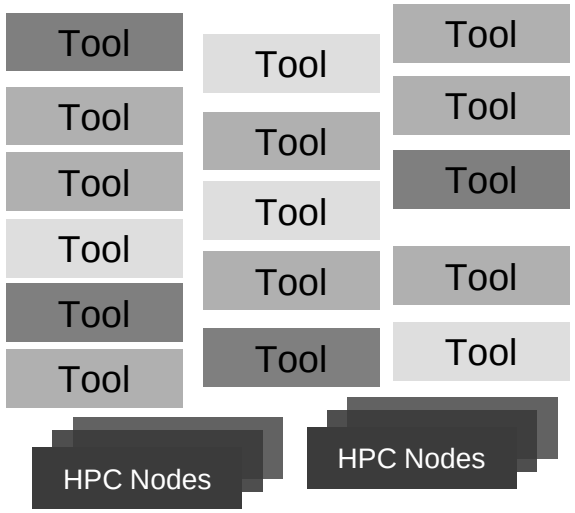
Temp Files

File Vaults

Metadata Repository

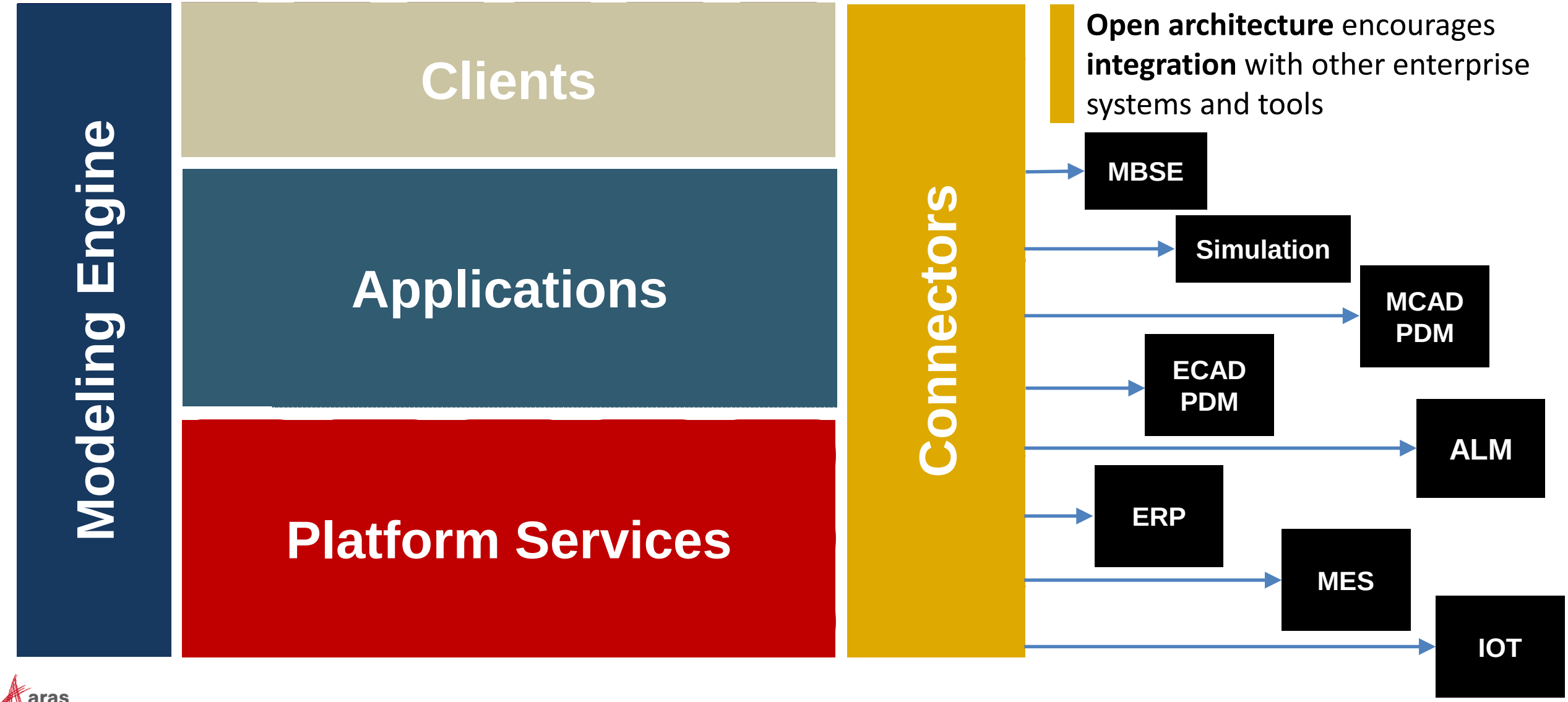
External Tools

CAD / CAE / Math / In-House Systems Modelling

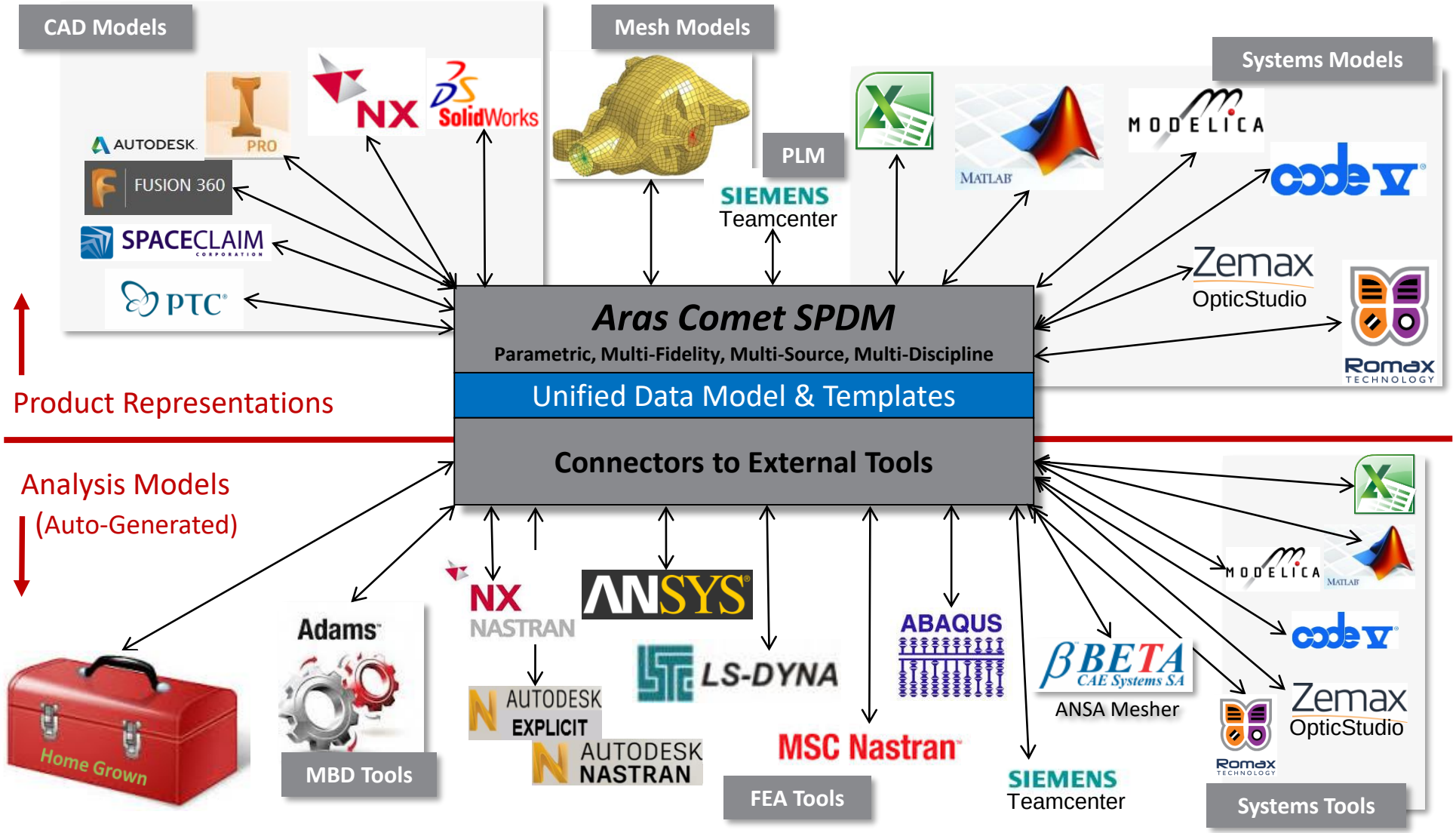


Requirements-Driven, Systems-Centric, Template-Enabled Simulation Management

Aras Platform – Connectors



Simulation Automation – Templates & Connectors



Foundations of Effective Simulation Mgmt

- Open & extensible **Unified Data Model**
  - Across all physics, levels of model fidelity and disciplines
  - Simulation data captured mostly independent of the underlying tools
  - Vendor- & tool-agnostic
- Open & extensible **Connector Architecture**
  - Cover in-house tools & data
  - Enable commercial tools covering all required physics and levels of fidelity
  - Tight integration between parametric CAD & parametric mixed-fidelity CAE models
- **Robust Automation** across design changes & configuration variants
  - Simulation rules not based on CAD, instead product engineering / system architecture
- Part of mainstream engineering processes across lifecycle – **Digital Thread**
  - Connected to Requirements, System Architecture and variant eBOMs

Customers who use Aras Comet SPDM…

American Axle

Magna Cosma

Air Force Research Labs

GKN Driveline

ZHONGLI

SITP

CIOMP

John Deere

China Northern Railway

CAST

Superior Industries

XIOPM

IAPCM

TYUST

BIRSE

Changchun University

BCC

AVIC

CNIGC

Call to Action

Aras is actively engaging in proof of concept initiatives for open reference architecture development

Please share your use cases & best practices:

Simulation Management / Test Management / MBSE / Requirements

To collaborate & contribute your Simulation Management use cases, please contact:

Malcolm Panthaki | Aras

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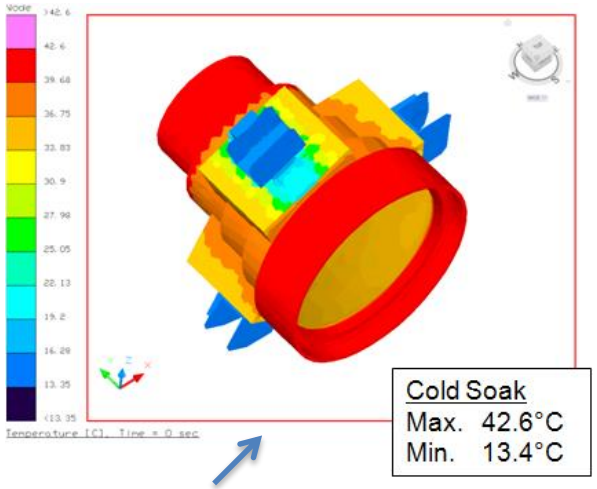
Customer Use Case #1

Rapid, High-Fidelity, Validated Analysis of Flight Hardware

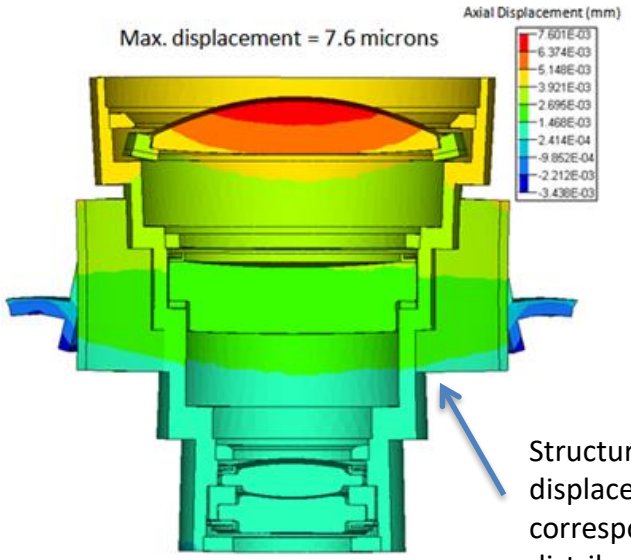
The Aerospace Corp.

Aerospace Corp: Understanding HVAC Test Data

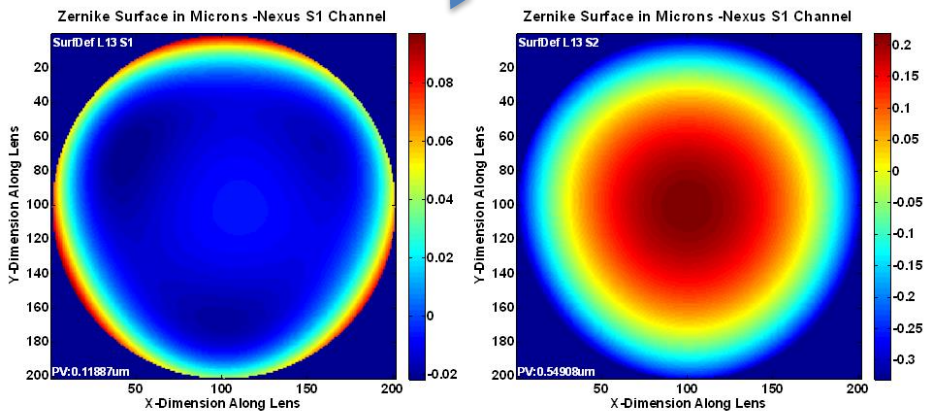


Distribution of temperatures across L13-16

Rigid body motions and wavefront errors introduced to individual lens components



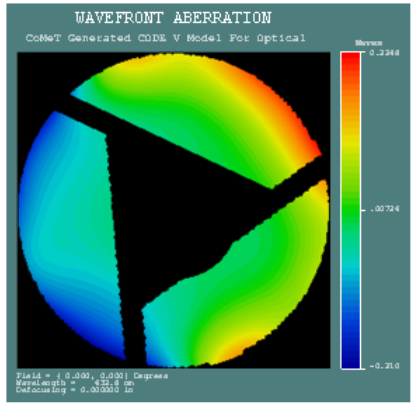
Structural node displacements across L13-16 corresponding to temperature distribution



Lens 13 S1 Decenters	
X-decenter (µm)	2.44
Y-decenter (µm)	1.38
Z-decenter (µm)	5.86
α-tilt (µrad)	1.78
β-tilt (µrad)	-2.06
γ-tilt (µrad)	-17.94

L13 moves as a rigid body

Lens 13 S2 Decenters	
X-decenter (µm)	2.47
Y-decenter (µm)	1.42
Z-decenter (µm)	3.85
α-tilt (µrad)	1.52
β-tilt (µrad)	-2.28
γ-tilt (µrad)	-17.93



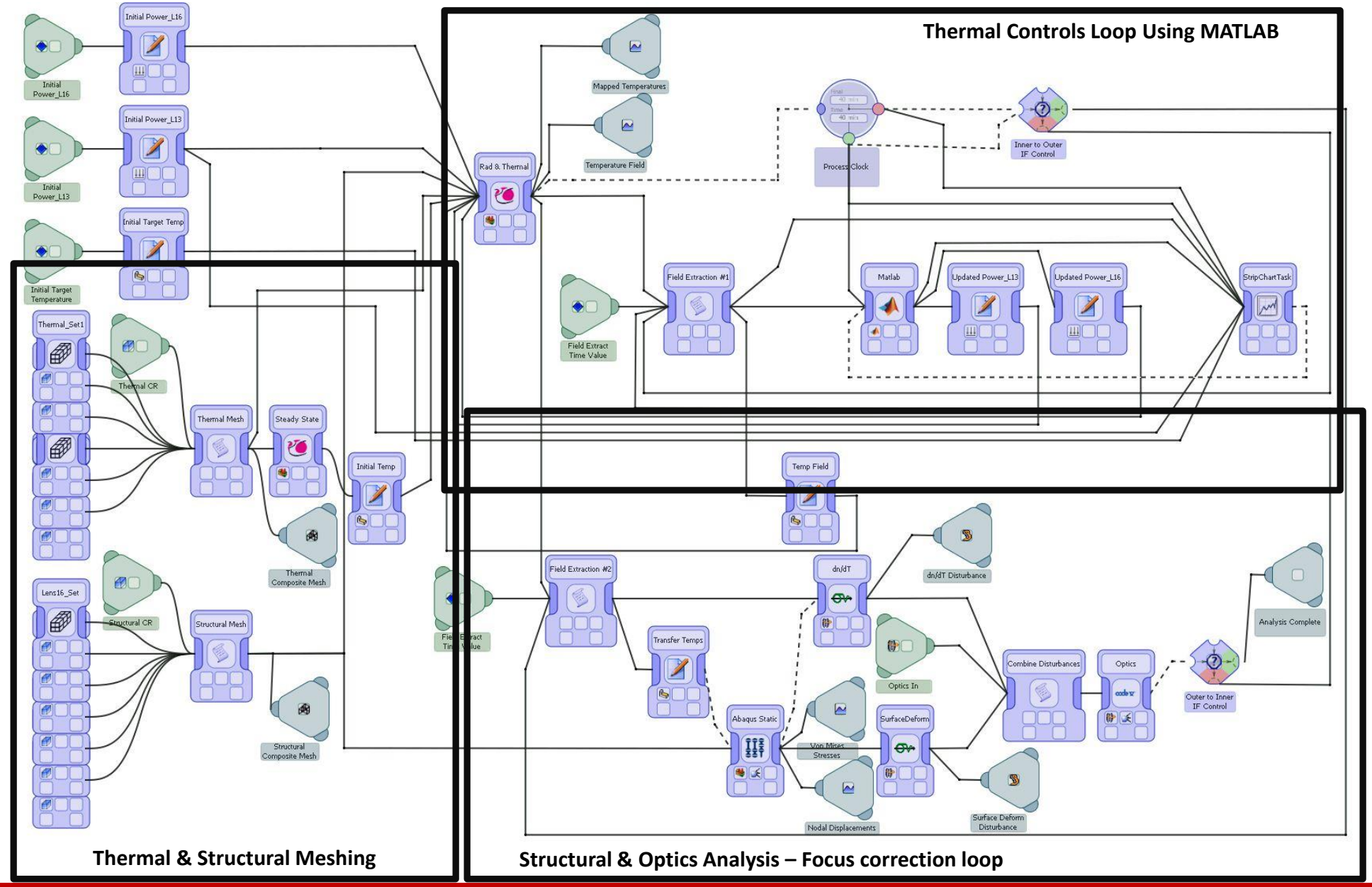
Best focus = -9.4mil from paraxial

RMS Wavefront Error (λ = 630nm)	
(0°, 0°)	0.017
(0°, 0.45°)	0.103
(0°, -0.45°)	0.105
(0.45°, 0°)	0.103
(-0.45°, 0°)	0.105

Avg. RMS WFE over field = 0.087λ

Wavefront error impact to entire visible camera

Integrated Optics Process With Thermal Controls Loop



Aerospace Corp: MBSE Initiative Benefits

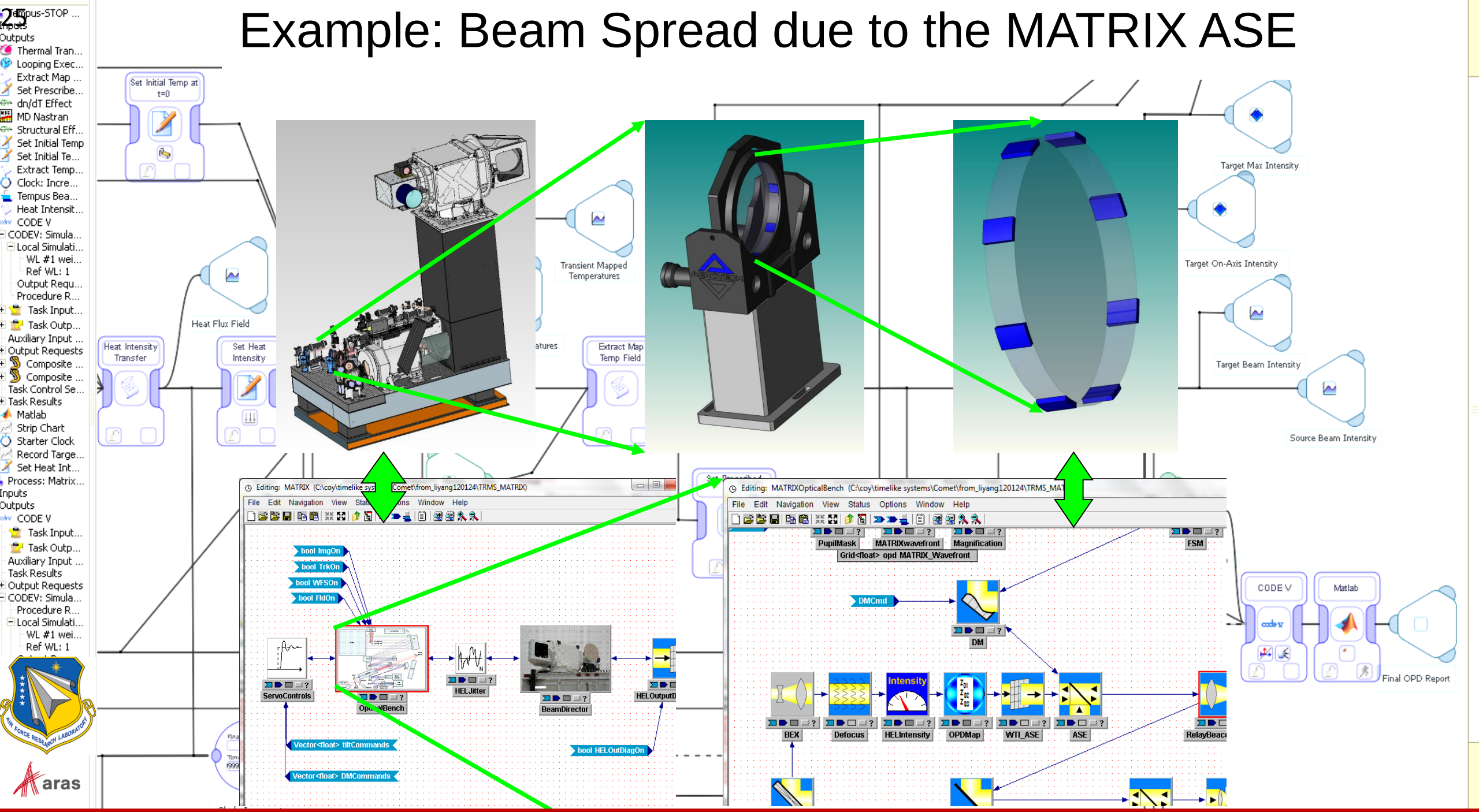
- MBSE is highly effective for the design of complex systems by multidisciplinary teams.
- Product quality is maintained or improved while reducing resource (cost, schedule) requirements by substantial margins (2X to 4x) by streamlining and improving the interfaces between discipline contributors.
- Additional benefits include:
  - Improved collaboration between discipline experts at Aerospace
  - Early discovery of problems/conflicts that lead to expensive rework or mission-critical failures
  - Cost-effective development of new space system concept designs
  - High fidelity system engineering of space systems early in the product development cycle
  - Excellent system engineering training vehicle for young engineers
  - Reduces overdesign of space systems with consequent cost reduction
  - Applicable throughout the product acquisition cycle
- The Aerospace Corporation is currently on the leading edge of applying MBSE methods to the design of Electro-Optical sensors due to the use of Concurrent Engineering practices and the use of the Comet automation platform.

Customer Use Case #2

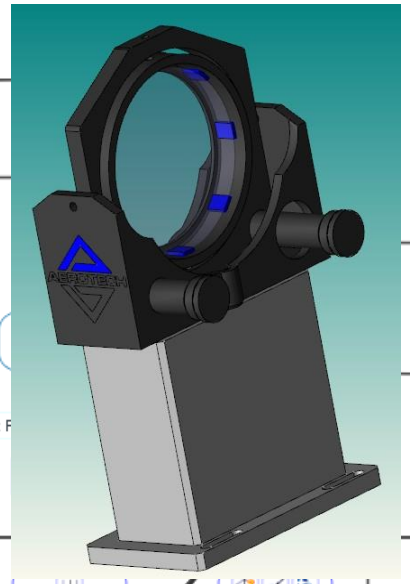
Understanding a Performance Issue in a Complex Laser System using automated Mixed-Fidelity Modeling

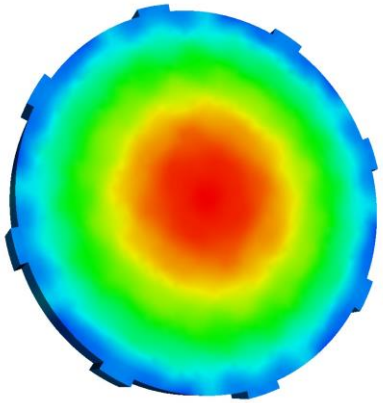
Air Force Research Labs.

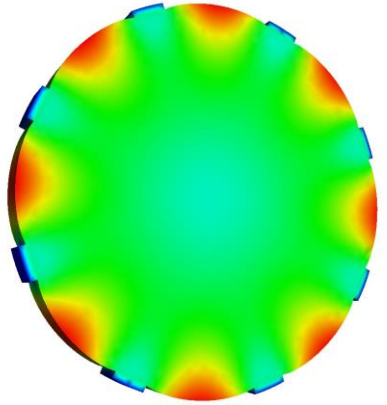
Example: Beam Spread due to the MATRIX ASE

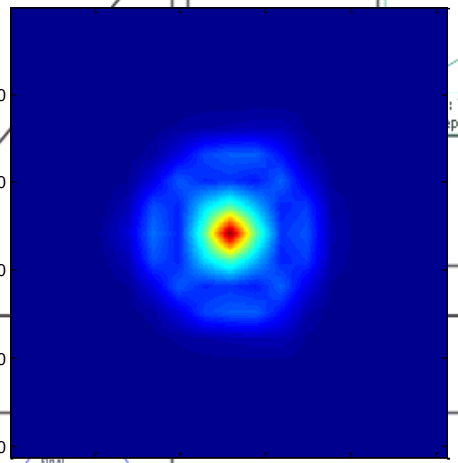


Results




Final ASE Temperature (degC)
22.54 22.66 22.78 22.90 23.02 23.14 23.26 23.38


ASE Final Nodal Displacements--Displacement Magnitude (m)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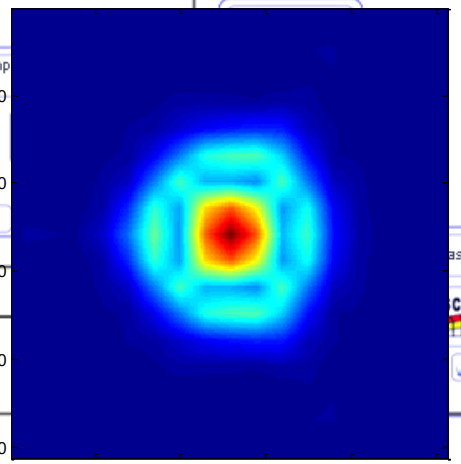
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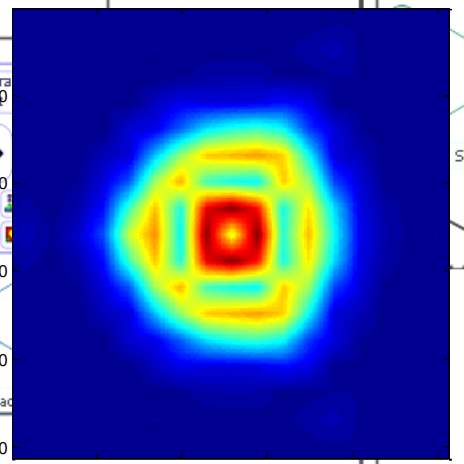
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AFRL: Project Benefits

- Automate Mixed-Fidelity Modeling:
  Ability to perform systems level analysis using a combination of a custom systems analysis tool and 3-D FE COTS tools
- Selectively use high-fidelity models in a limited set of components – spend more computational power exactly where it is most required
- Rapidly validate complex multi-physics models against test results
- Reduce cycle time per iteration from weeks to hours while increasing accuracy and consistency
- Run large numbers of simulations automatically, looking for a better design

Thank You

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