Powering Innovation That Drives Human Advancement

ModelCenter Intro: Tool Chain Integration, Optimization, & MBSE;

18 Nov, 2024

Brian Brown
Systems Lead, Americas
brian.brown@ansys.com

INCOSE SE Lab – Seven (7) Part Series

Topic	Time
Overview of the Ansys Digital Engineering solutions in the INCOSE SE Lab	Monday, 4 Nov, 2024
Real-time collaborative system modelling with Ansys System Architecture Modeler	Monday, 11 Nov, 2024
★ Connect Analysis to Models and Verify System Requirements Early with ModelCenter	Monday, 18 Nov, 2024 11AM (EST) – 60mins
Model-based Embedded software with Ansys Scade One	Monday, 2 Dec, 2024 11AM (EST) – 60mins
Safety Analysis across the system architecture with Ansys medini	Monday, 13 Jan, 2024 11AM (EST) – 60mins
Model and simulate systems at the mission level with Ansys STK	Monday, 20 Jan, 2025 11AM (EST) – 60mins
Simulation-based digital twins with Ansys TwinBuilder	Monday, 10 Feb, 2025

Agenda

- Enabling Digital Engineering (DE)
  - ModelCenter overview
    - What is ModelCenter?
    - What ModelCenter
    - What are the benefits?

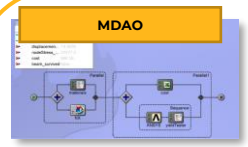
- Objectives:
  - Model connectivity to SysML;
  - Orchestration/automation to downstream workflows;
  - MBSE and v&v,
  - Trades (AoA's)(aka Design Explorations);
  - Tool-chaining, integrations, to SysML, and other tools (COTS/GOTS)

Digital Engineering Enabled using Ansys – The Big Picture

SPDM

5

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



Multidisciplinary Analysis & Optimization

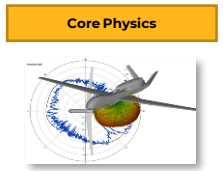
2

Simulation workflow / CAx automation
Robust design optimization / MBSE integration

Digital Mission Engineering

1

Mission evaluation / Design Reference Mission / Systems of systems



Multiphysics

3

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

Digital Twins

4 6

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

MBSE

1 2

/ 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.

2 Connect MBSE requirements to analytical models.

3 4 Add fidelity to verify DRM requirements with multiphysics simulations and twins.

5 Manage design and process workflows to integrate enterprise data.

6 Operationalize physics, telemetry and AI/ML for asset management.

Open // No Vendor Lock // Interoperable // Scalable // Dialable Fidelity

Digital Transformation (DT)

What DT is Not:

- Running individual solvers locally
- Storing data locally
- Siloed data/workgroups
- Engineering by PPT
- Static data
- Manual processes

What DT Is:

- Federated data - ASoTs
- Integrated data
- Accessible data
- Collaborative processes
- Systems driven
- Traceable data

ModelCenter enables MDAO:

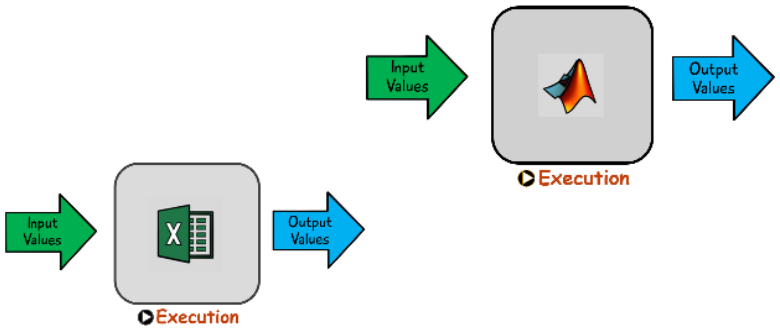
- Multi-Disciplinary Analysis & Optimization
- Tool Chaining & Model Execution
- Remote Execution

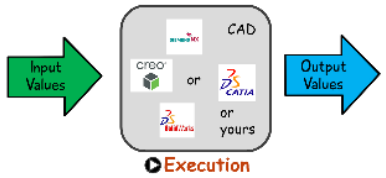
ModelCenter enables MBSE:

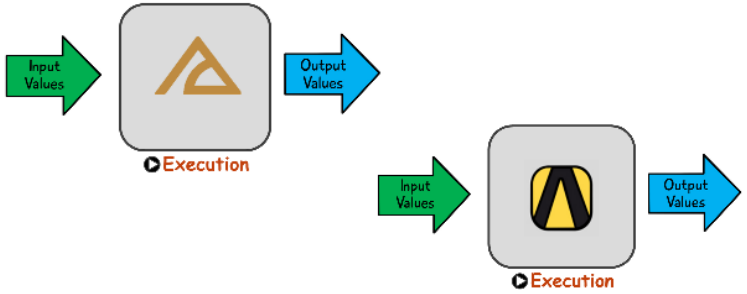
- Integrating MBSE Models (System Models) with Analytical Models
- Requirements Validation
- Behavior Validation (BEE)

Analytical Model Automation

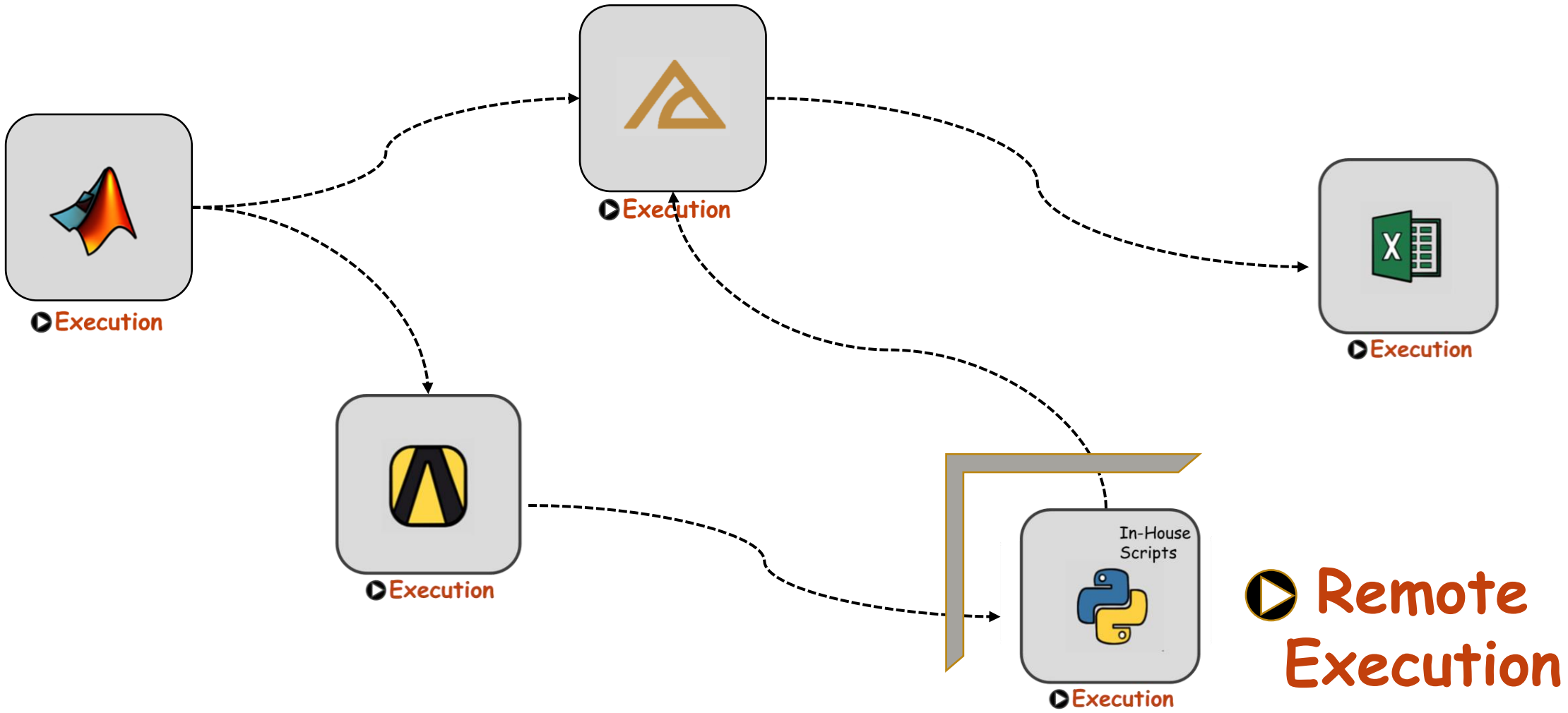
Analytical Model Automation – vendor nuetral







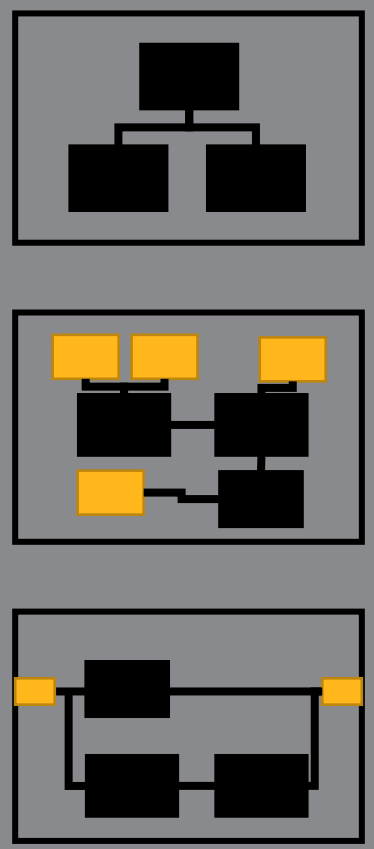
Tool Chaining - Automatic Data Flow



Vendor Neutral Tool Connectivity/Automation

ModelCenter: MBSE, Workflow Integration, and Automation

System Architecture Model



Systems Engineering Models

Descriptive
- Structure
- Behavior
- Requirements
- Parametrics

Dynamic, High-Fidelity
- Behavior Simulation
- Requirements Verification
- Design Exploration
- Optimization

MBSE Integration

Ansys
WORKFLOW INTEGRATION

Architecture Design → Model-Based Engineering, Analysis

Requirements ← Analysis Results

Engineering Workflows

Mechanical

Electrical

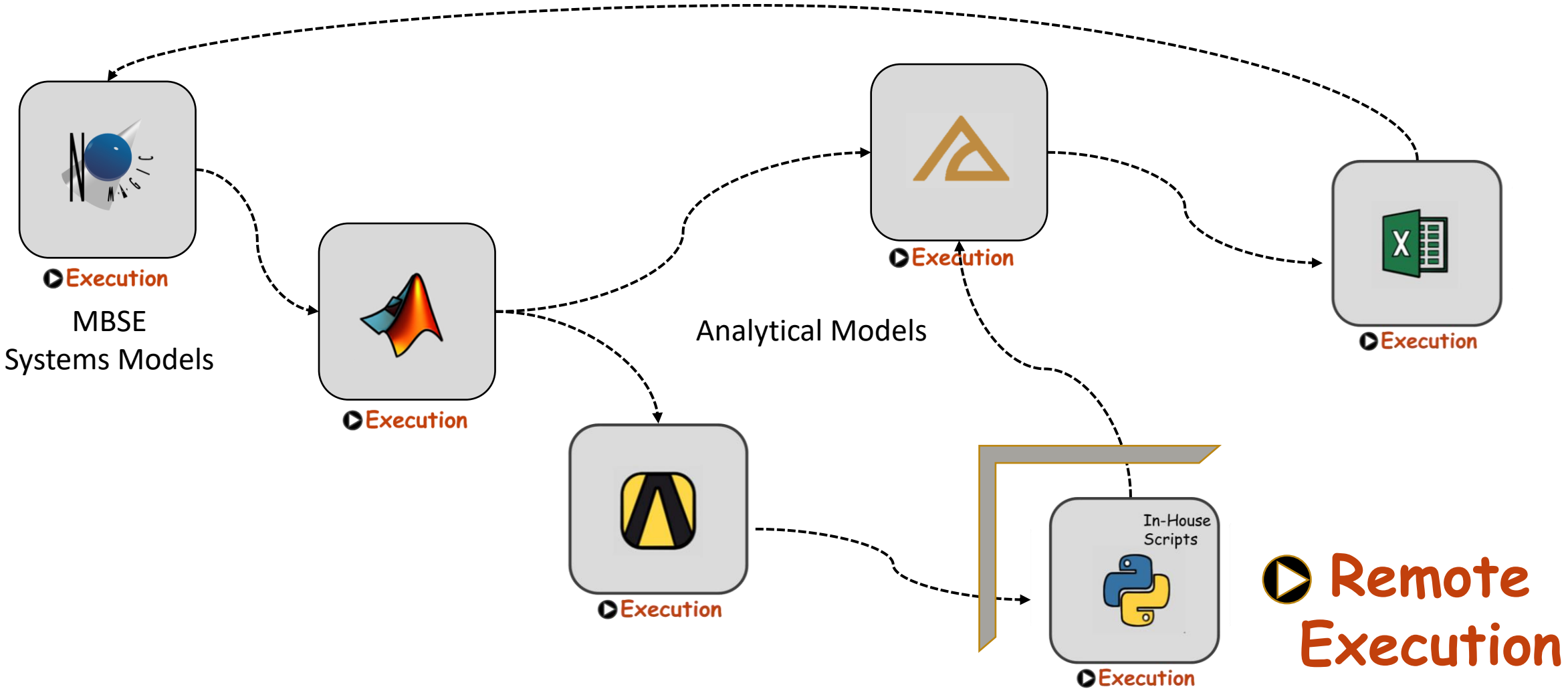
Fluids

Software

Safety

Domain Engineering Models

V&V – Analytical Results to Satisfy Requirement (Vendor Neutral)



PARSONS – USE CASE

- MBSE
- Digital Mission Engineering

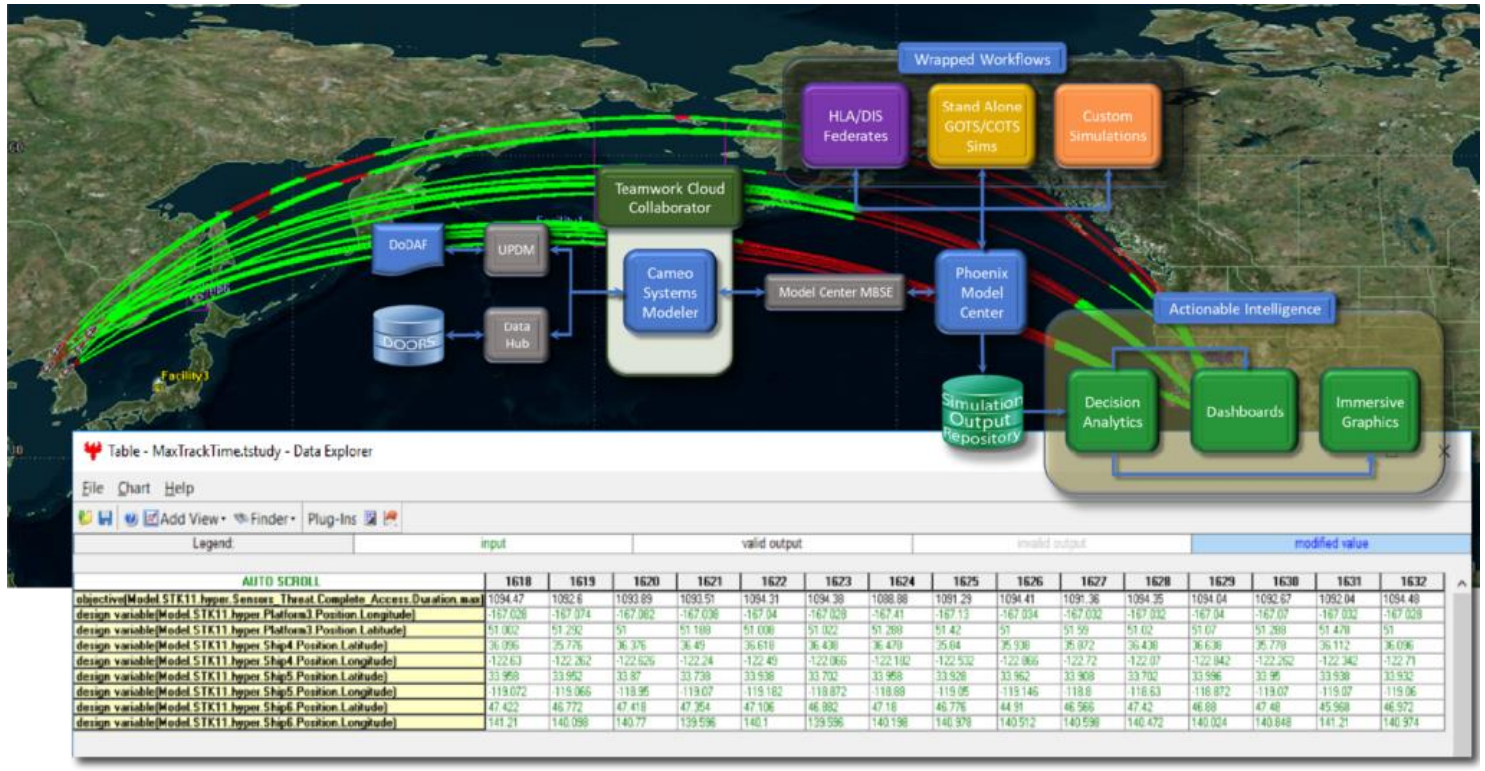
Ansys

Parsons Digital Engineering Framework (PDEF) Hypersonic Dem

Parsons Digital Mission Engineering Case Study

A digital framework that was used to create the workflow and integrate various simulations tools such as STK and MATLAB into the process. The framework consists of a Model Based Systems Engineering tool, **No Magic's Cameo**; am integration tool and simulation execution engine, **Phoenix ModelCenter**, and performance models developed in **Systems Tool Kit and MATLAB**. **Outputs from these studies** are configuration managed in a SQL database and performance metrics **can be viewed through a Digital Dashboard**, such as Microsoft's PowerBI tool. Finally, **all simulations are run in a virtual environment hosted in Microsoft Azure.**

Hypersonic Demonstration using the Parsons Digital Engineering Framework Webinar | PARSONS | Phoenix Integration (phoenix-int.com)



"PDEF allows for the detection and characterization of performance metrics on the Left Side of the Systems Engineering V which yields savings by identifying key performance metrics that contribute to the overall Systems Requirements. **Reducing Risk, Schedule, and Cost**"

LMCO – USE CASE

- MBSE & Optimization
- Digital Mission Engineering

Ansys

OSIRIS-REx Spacecraft

Challenge

- Landing a spacecraft on a moving, rotating, debris expelling object while maintaining communication and preventing damage to sensors.
- One week of simulated mission activity equated to one day of real-time simulation; a 10-year mission required months of simulating and analyzing data, making it impossible to simulate all possible scenarios and events.

Solution

- Lockheed Martin Space (LMS) was able to connect their MBSE models to the simulation tools using Ansys ModelCenter.
- The system model captured mission and simulation parameters and thermal constraints. The parameters and constraints were time-stepped through a simulation that modeled the spacecraft's orientation and trajectory concerning the Sun, Earth, Moon, and other solar bodies.
- ModelCenter was used to evaluate the results from the simulation to ensure adherence to the mission constraints.

Outcome

- LMS performed many more analyses than previous efforts.
- Design tasks were accomplished **seven times faster.**

"Automating and integrating the simulation into this system model allows the team to **rapidly identify potential issues with changes to mission requirements**, as well as perform **continuous verification of requirements and mission design parameters** throughout the life cycle of the spacecraft... The overall improvement versus the original process was about a **7X speedup in turnaround time**."

Phathom Athena Donald
Systems Engineer, **Lockheed Martin Space**

NGC N^2 ESAVE – USE CASE

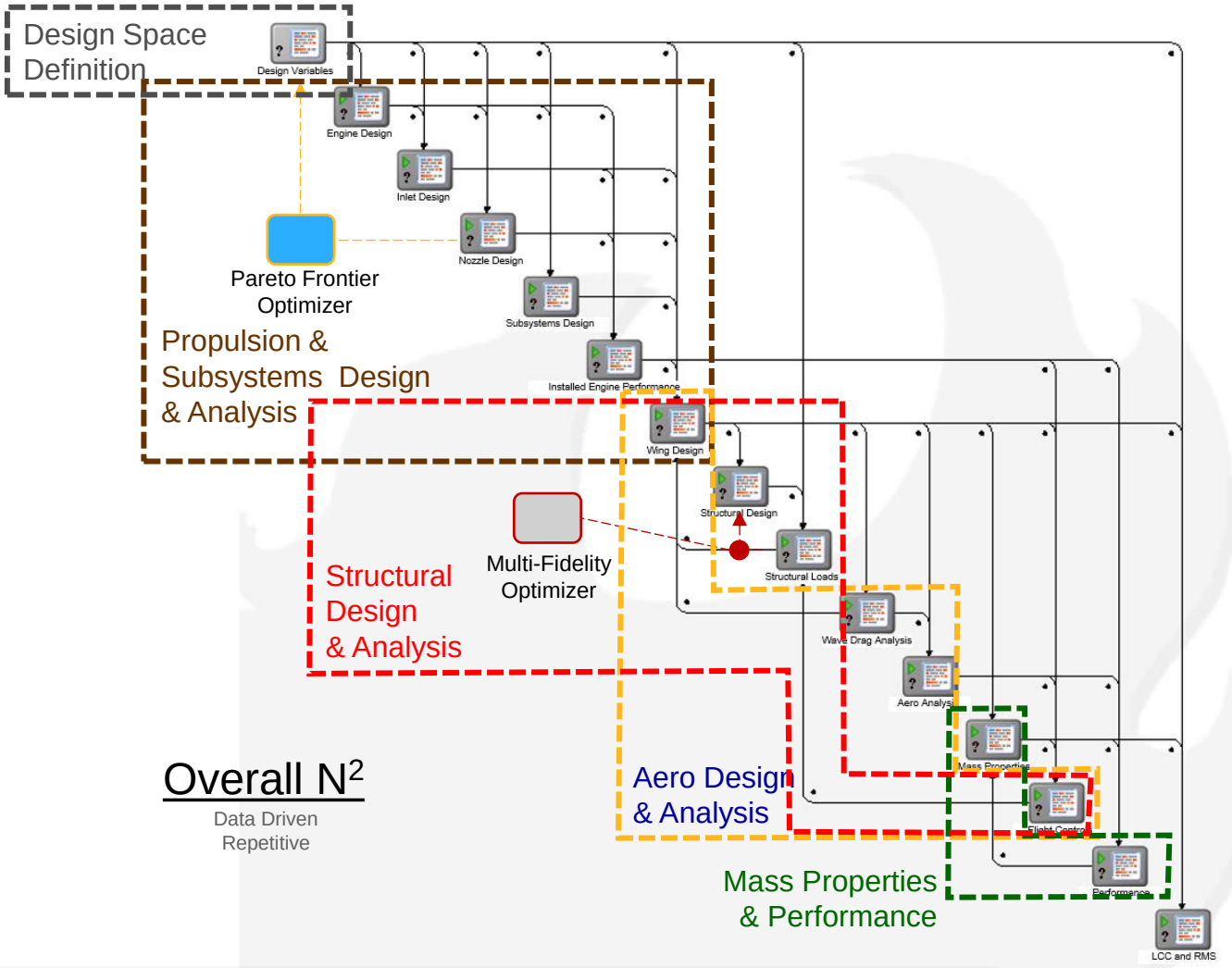
- Tool chaining
- Multi-Disciplinary Analyses & Optimization (MDAO)

Ansys

Example Integration: ESAVE N^2 Model
(Efficient Supersonic Air Vehicle Exploration)

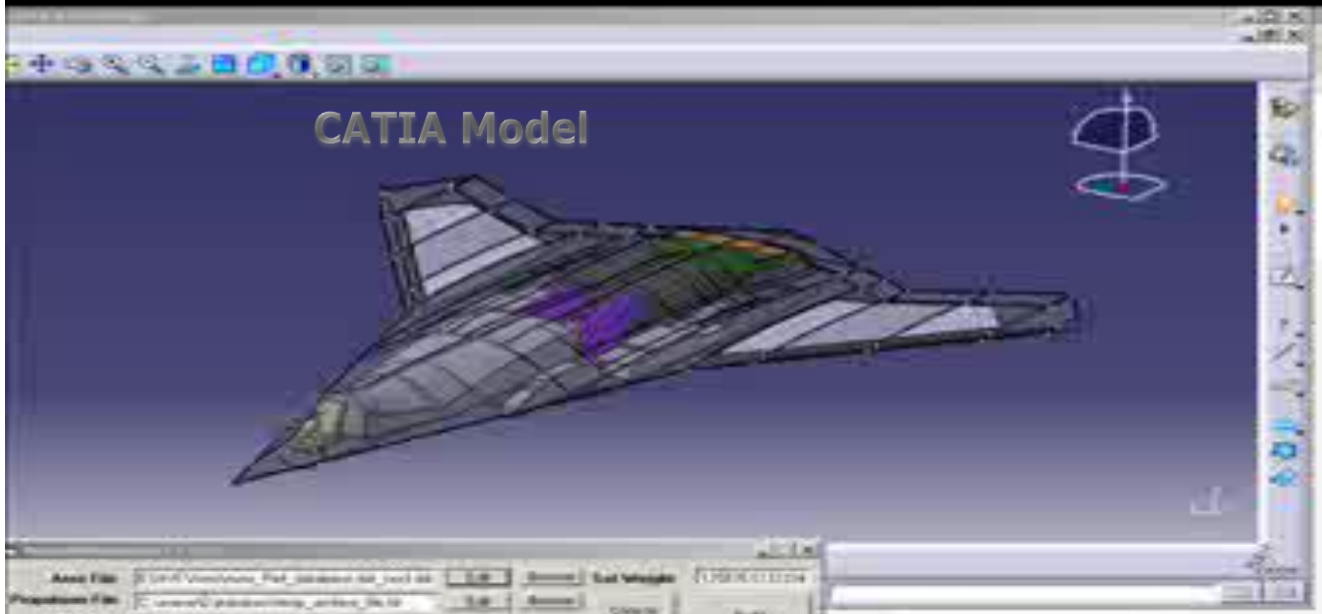
- **Requirements**
  - Mission
  - Structures
  - Flight Controls
- **Constraints**
  - Propulsion
  - Structures
  - Flight Controls
- **Variables**
  - Vehicle
  - Propulsion
- **Objective**
  - Minimize TOGW (*maximize affordability*)

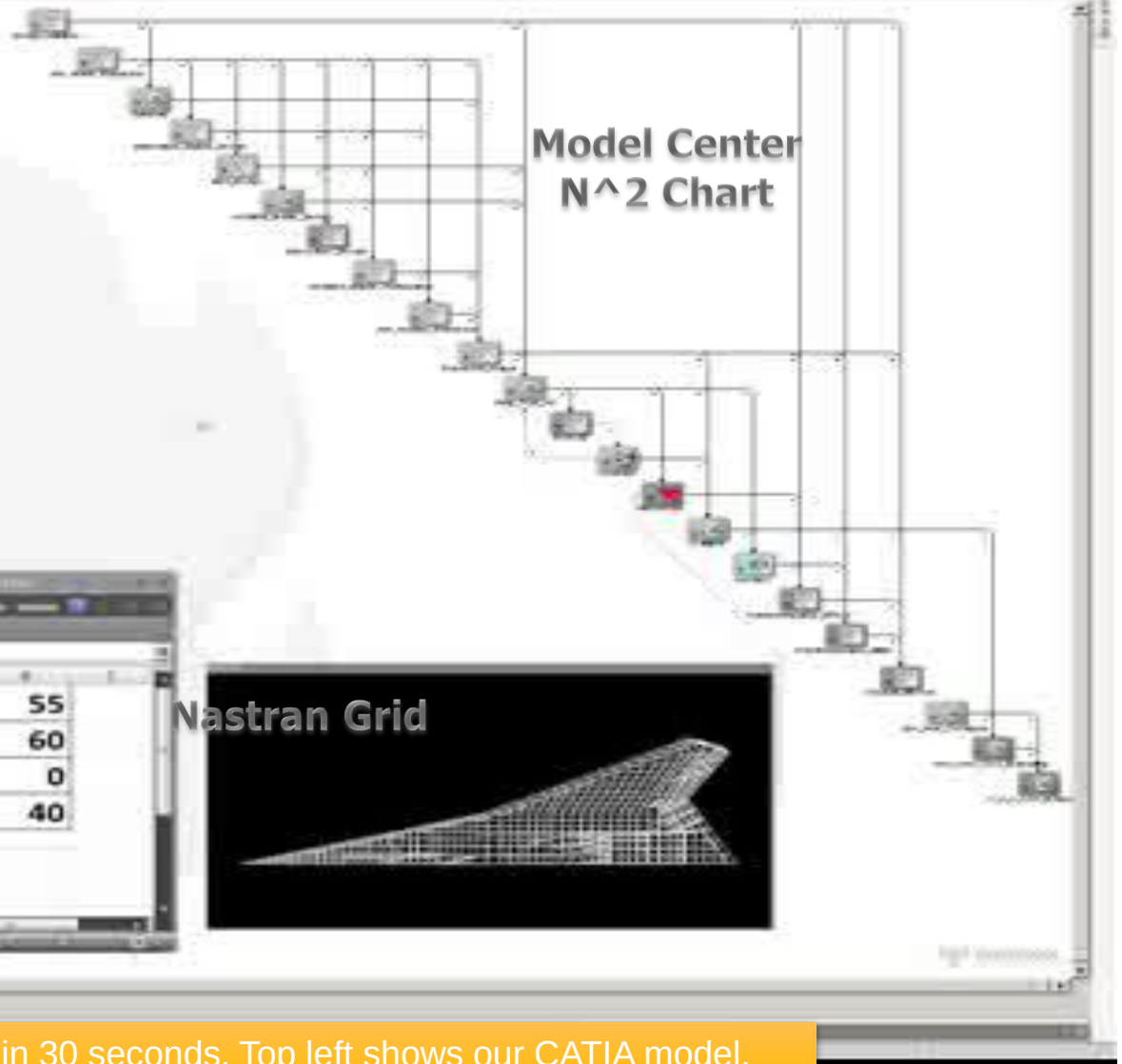
MDAO Design / Analysis Modes
- Interactive design space exploration
- Design of Experiments (DoE)
- Response Surface Model (RSM) generation
- Local vs. global optimization studies
  - Pareto frontier optimizer
  - Gradient based vs. line search

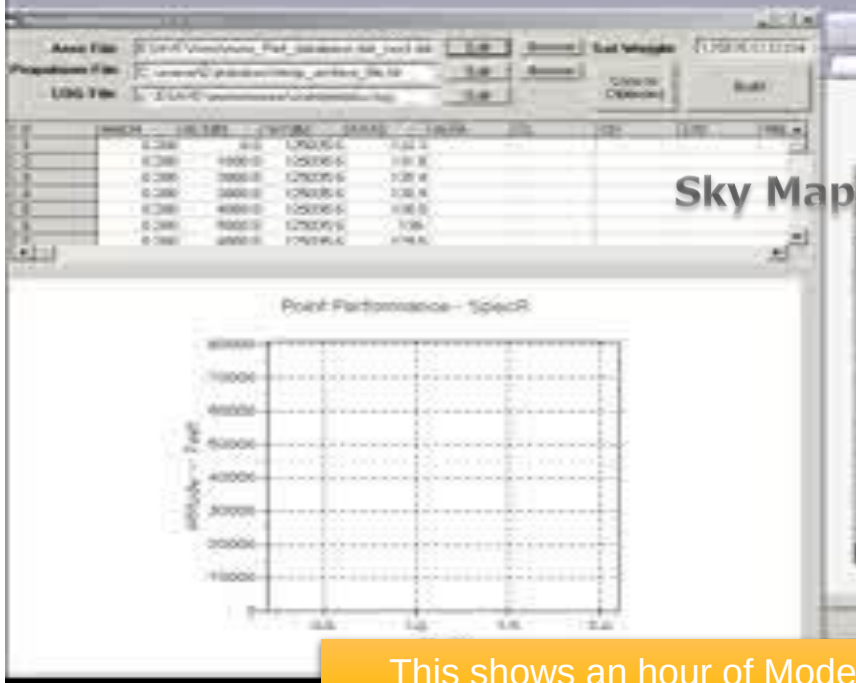


N^2 Architecture couples disciplines in both inner and outer loops and supports a wide range of trade studies and optimization methods

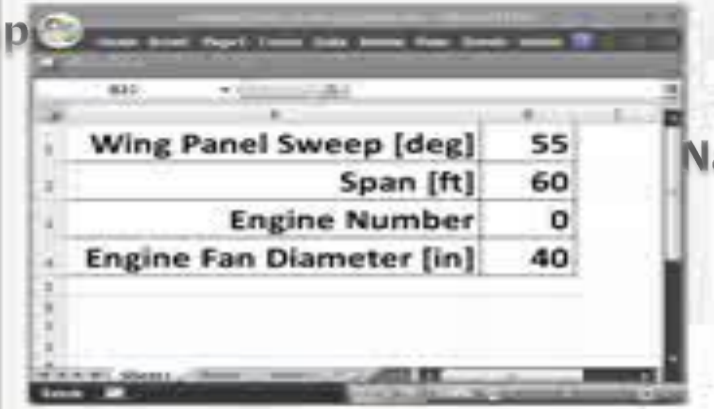
ESAVE MDAO Model Animation







Sky Map



Nastran Grid

This shows an hour of ModelCenter runs (~40 iterations) in 30 seconds. Top left shows our CATIA model. Bottom left shows a sky map of specific range at MTOW. Bottom right shows the NASTRAN grid.

STELIA – USE CASE

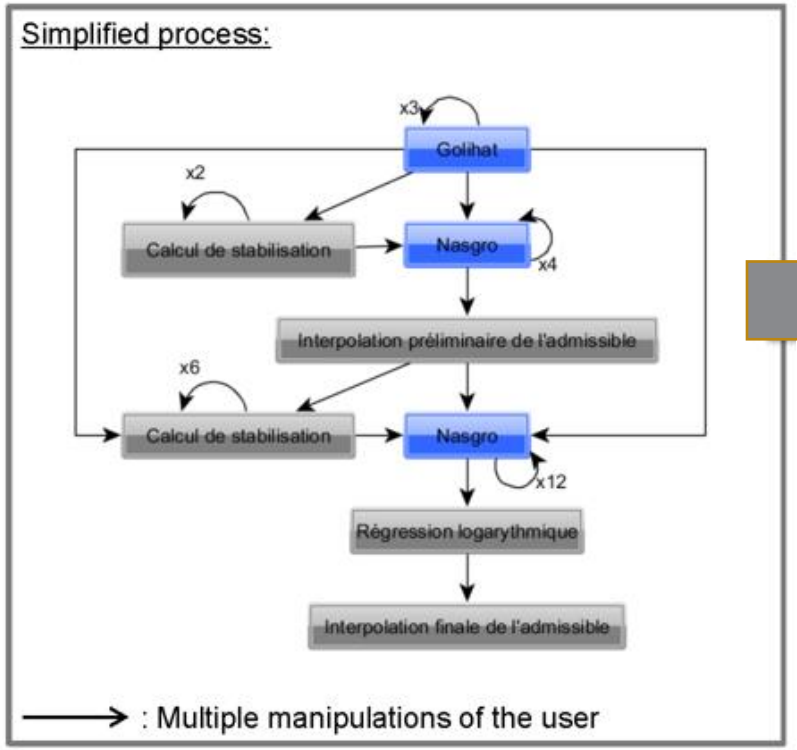
- Process Optimization
- Design of Experiments (DoE)

Ansys

Crack Propagation Allowables

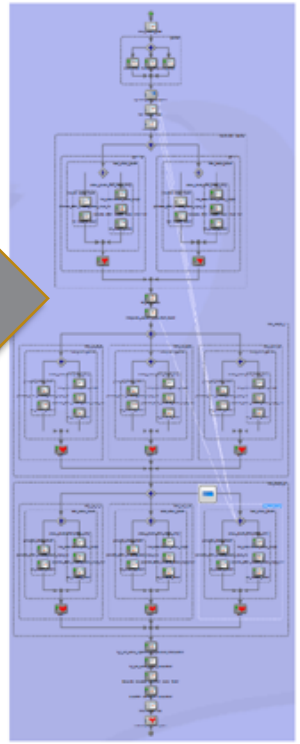
Before ModelCenter: Manual Process

2 calculations/day



After ModelCenter: Automated Process

750 calculations/day

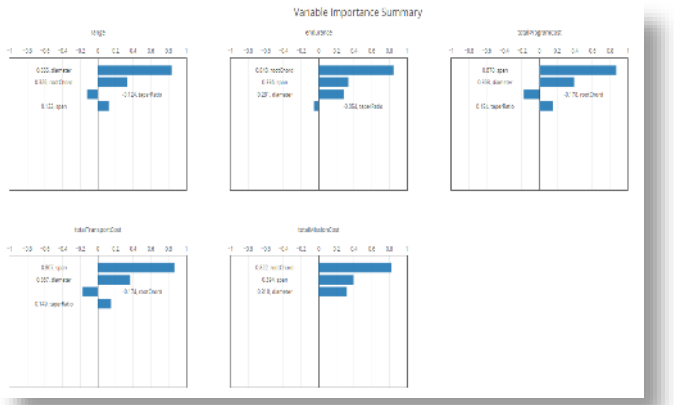


After integration in a calculation loop in ModelCenter:
1500 points of calculation in 2 days

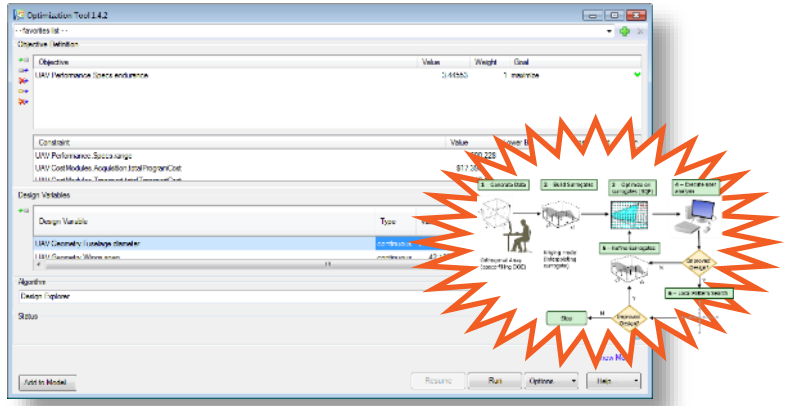
Offered possibilities:

- Design Of Experiment
- Optimization loops
- Parametric studies
- …

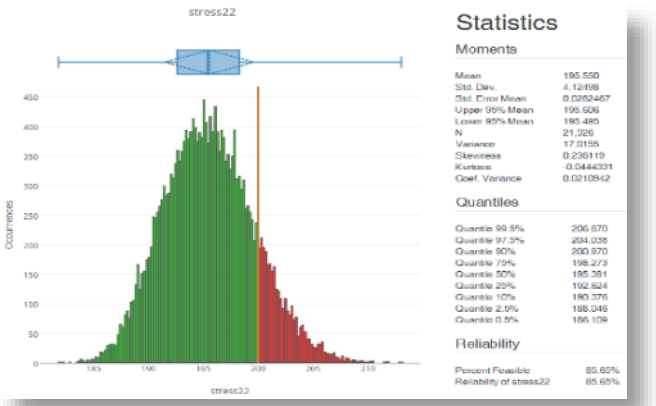
Iterate: Design Space Exploration



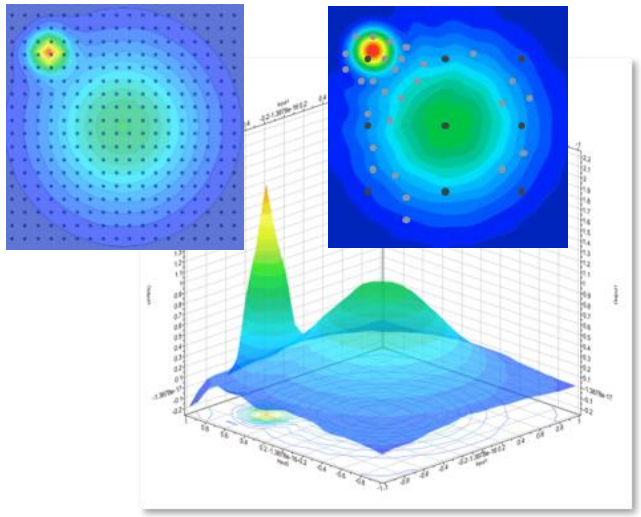
DoE/Sensitivity Analysis

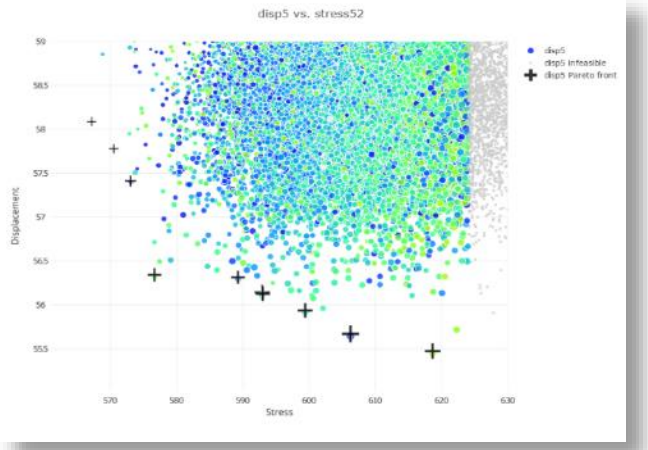


Optimization

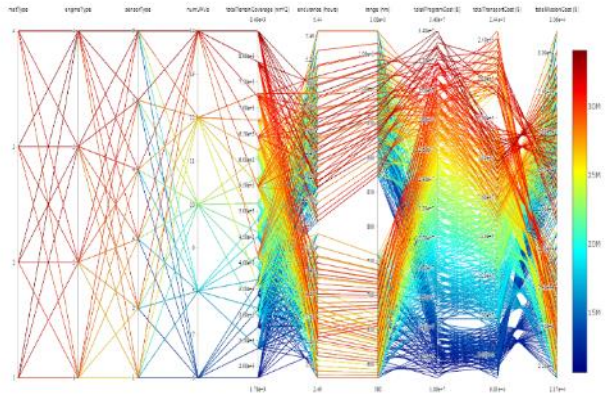


Probabilistic Analysis





Trade Space Visualization



In Summary

MBSE Integration	**Ansys ModelCenter bridges the architecture (SysML) and requirements to the physics – to VERIFY the requirements captured in models.**
Toolchain Automation	**ModelCenter is open, and already enables integration/automaton of best-in-class modeling and simulation tools across the industry.**
Virtual Integration	**ModelCenter enables Developers/Suppliers to deliver IP-protected artifacts/models for virtual integration and risk reduction.**
Efficient MDAO	**ModelCenter supports Multi-Disciplinary Analysis and Optimization, including automation of DoE, for optimization, etc.**
Digital Engineering	**ModelCenter is a MODERN TOOL enabling MODERN METHODOLOGIES, and has been in use for 25+ years within the Defense Industry.**


Ansys

Powering Innovation That Drives Human Advancement

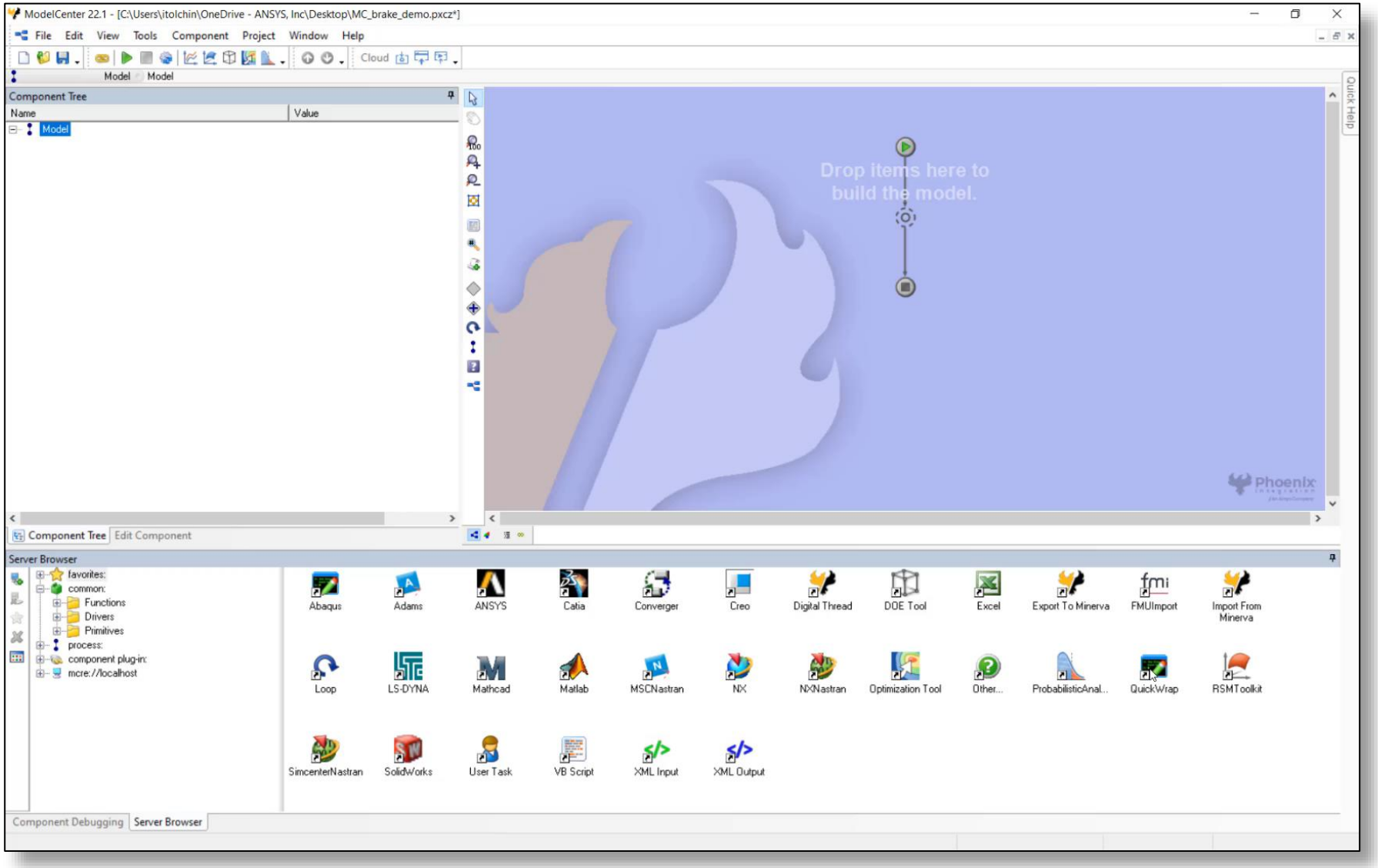
BACKUP SLIDES

Powering Innovation That Drives Human Advancement

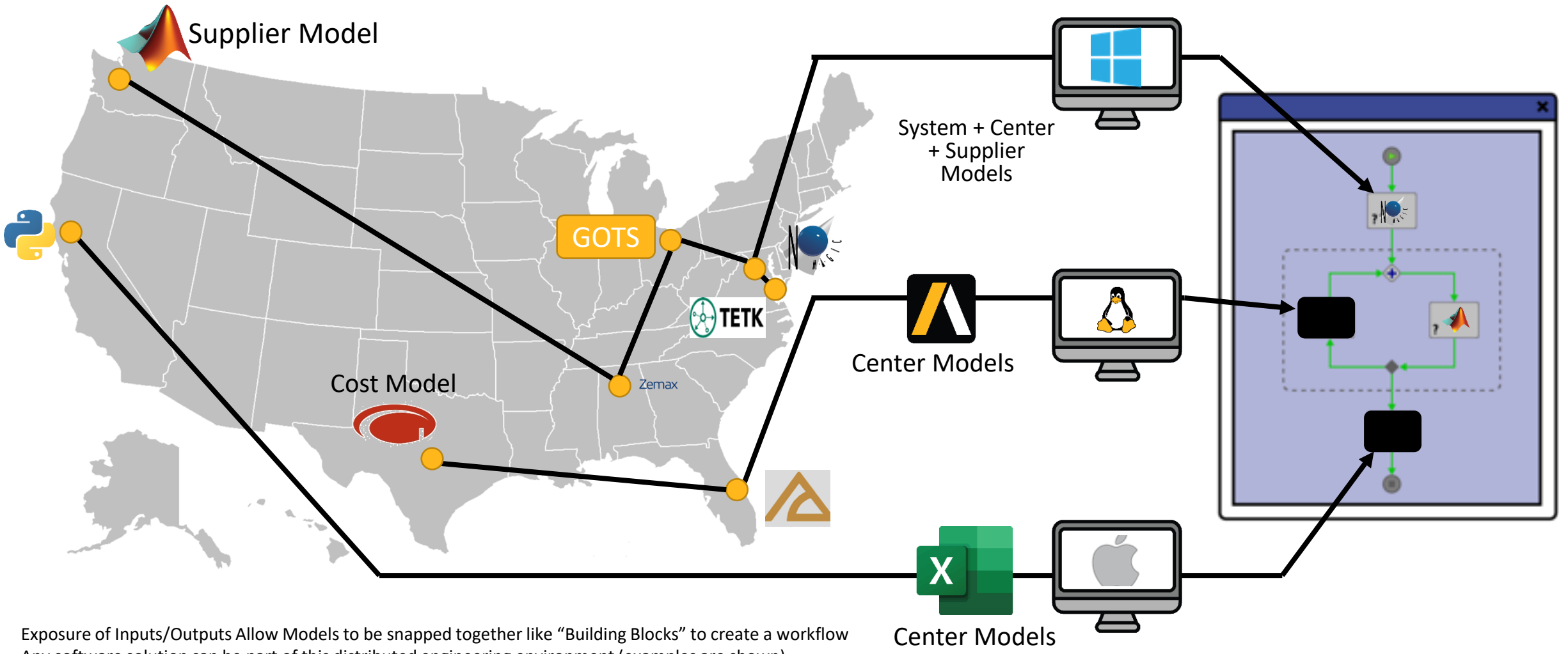
ModelCenter 1-2 min videos

Automation of engineering tools

- Automate any engineering tool that can be executed in batch.
- Plugins for common tools such as Excel, Matlab, and CAD, any solution.
- We teach our customers how to automate and integrate.
- Ease of use. GUI is easy. Training enables users to perform automations and integrations with 2 days of on-demand, self-paced training.



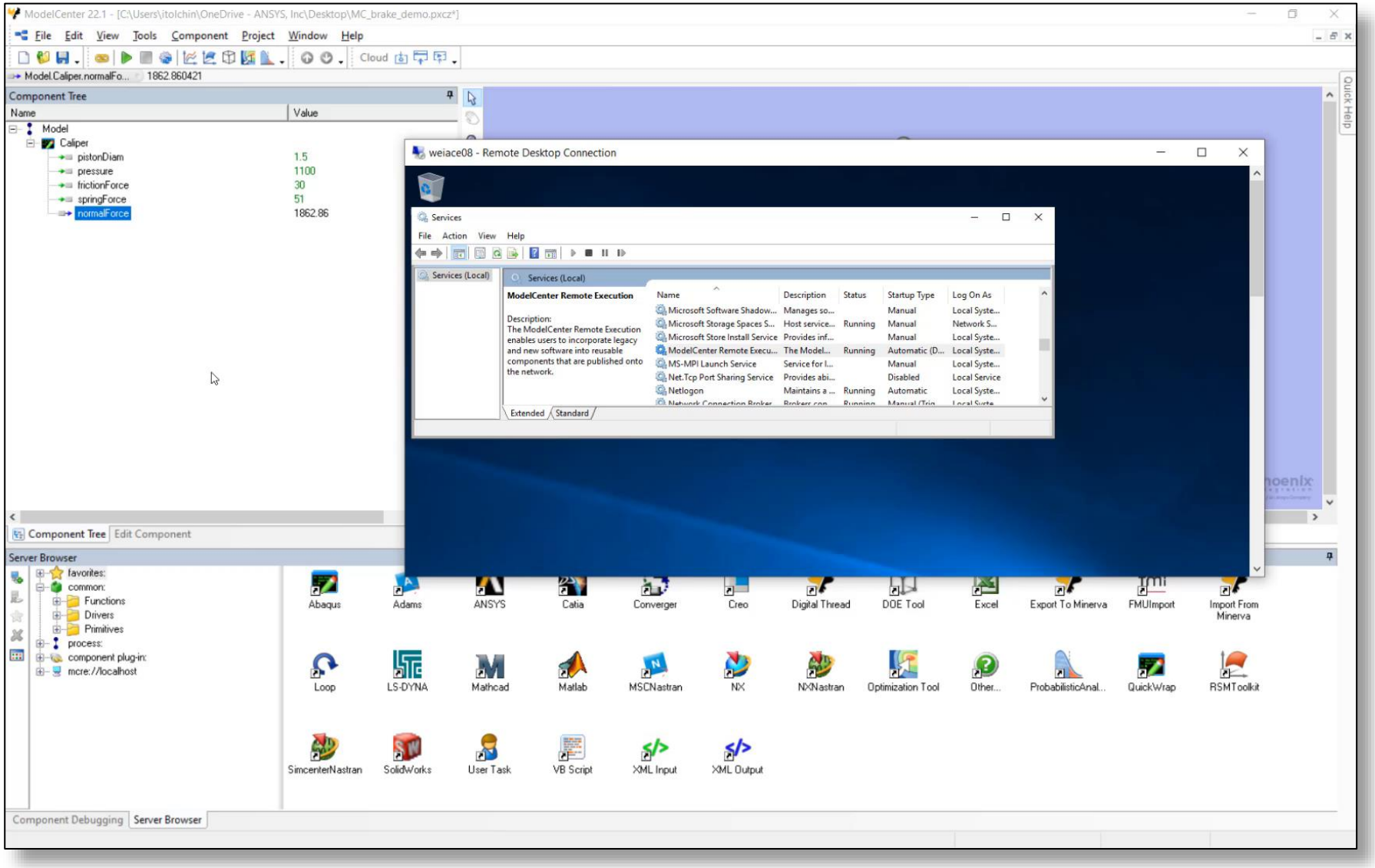
ModelCenter Distributed Models for Remote Execution/Collaboration Only Inputs/Key Results Pass Over Network



Exposure of Inputs/Outputs Allow Models to be snapped together like “Building Blocks” to create a workflow
Any software solution can be part of this distributed engineering environment (examples are shown).

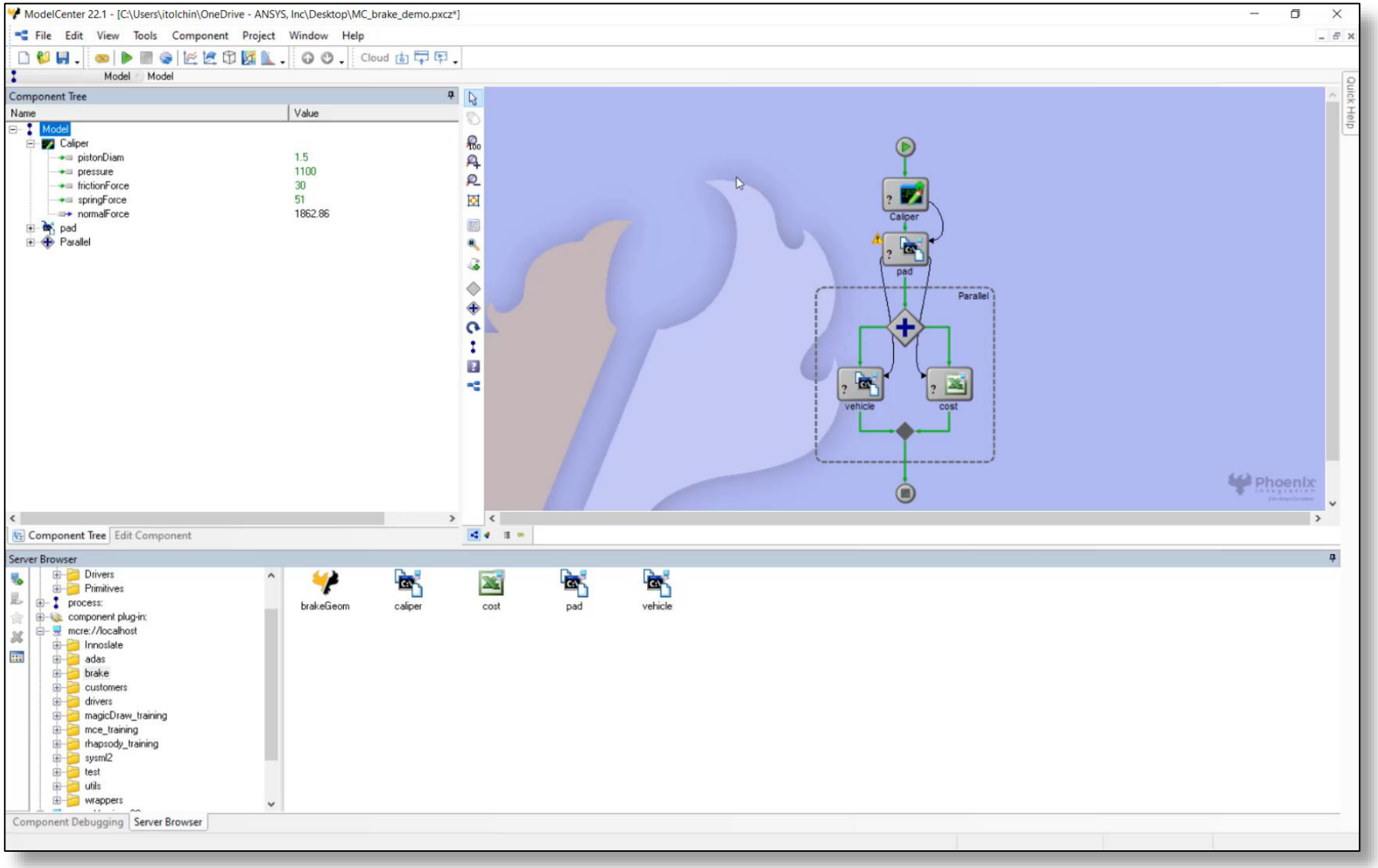
Create a workflow using distributed components

- Bring in components from machines visible in your network
  - Access to supply chain models while protecting their IP
- Build complex workflows
  - Parallel branches
  - If branches
  - For loops
  - Workflows can be re-used as components



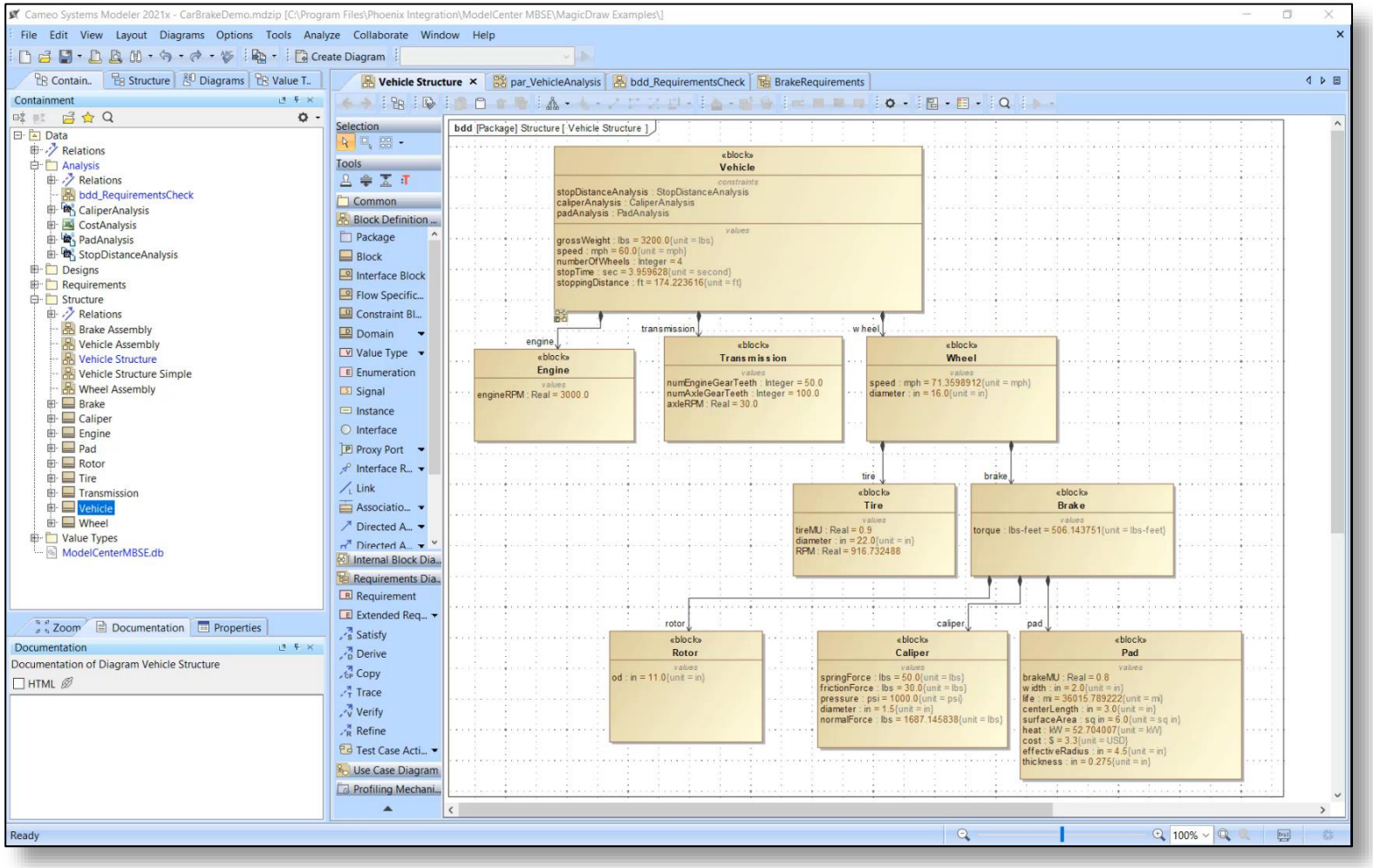
Search for best designs

- Explore all possible options using Design of Experiments (DoE)
- Understand which are the most important parameters in your design space
- Visualize trade-off relationships
- Automated search - Optimization



Connect System Models to Simulation

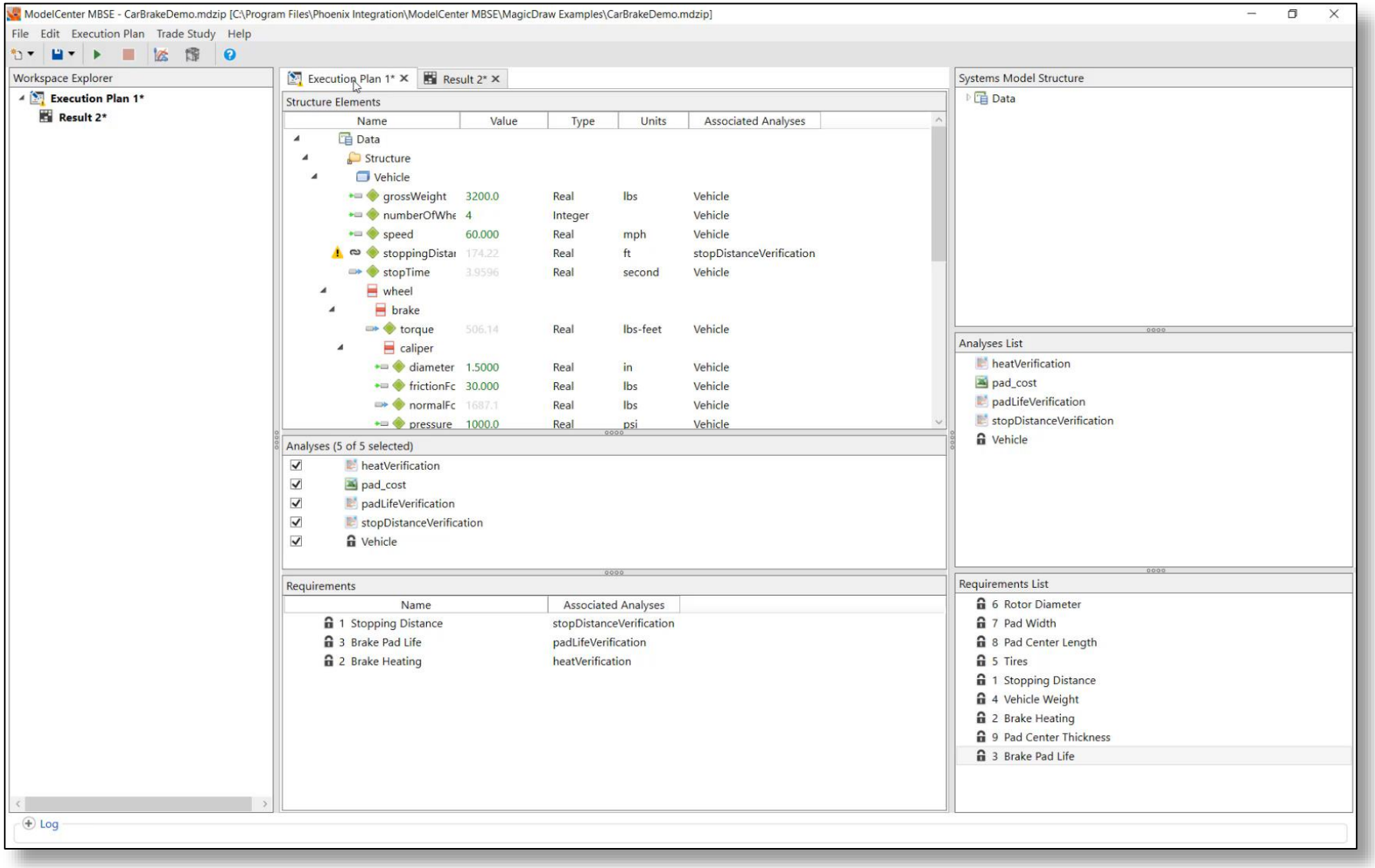
- Important Note: System Models are Boxes, Lines, and Values (Descriptive)
- Integrate System Model with Simulation to Predict performance of candidate architectures
- Check if system will meet its requirements



Start in Cameo. Move to ModelCenter for Integration and Requirement Verification

Run trade studies from the architecture modeling tool

- Find the best performance that a particular architecture can deliver
- Understand relationships between competing requirements to include performance vs costs!



ModelCenter & optiSLang – Better Together

- oSL can become a component inside a ModelCenter workflow to connect it to the system models.
- Optimize system behavior using ModelCenter design exploration capabilities