

No MBSE without ModSim

Modelling and Simulation in a Systems Engineering Context

Klaus Krohne – SIMULIA APAC Senior Sales Director



EMPOWERING MBSE WITH SIMULATION

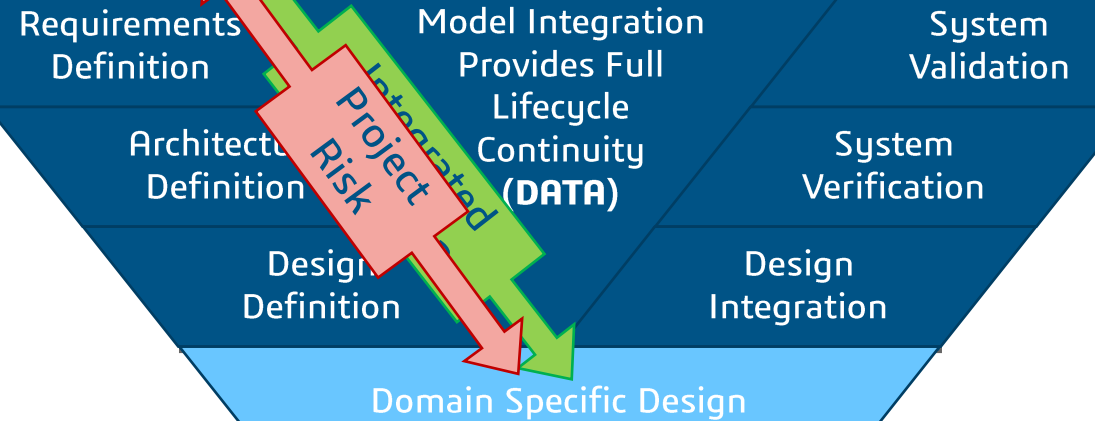
Project Mgrs /
Systems Engineers

better decisions...

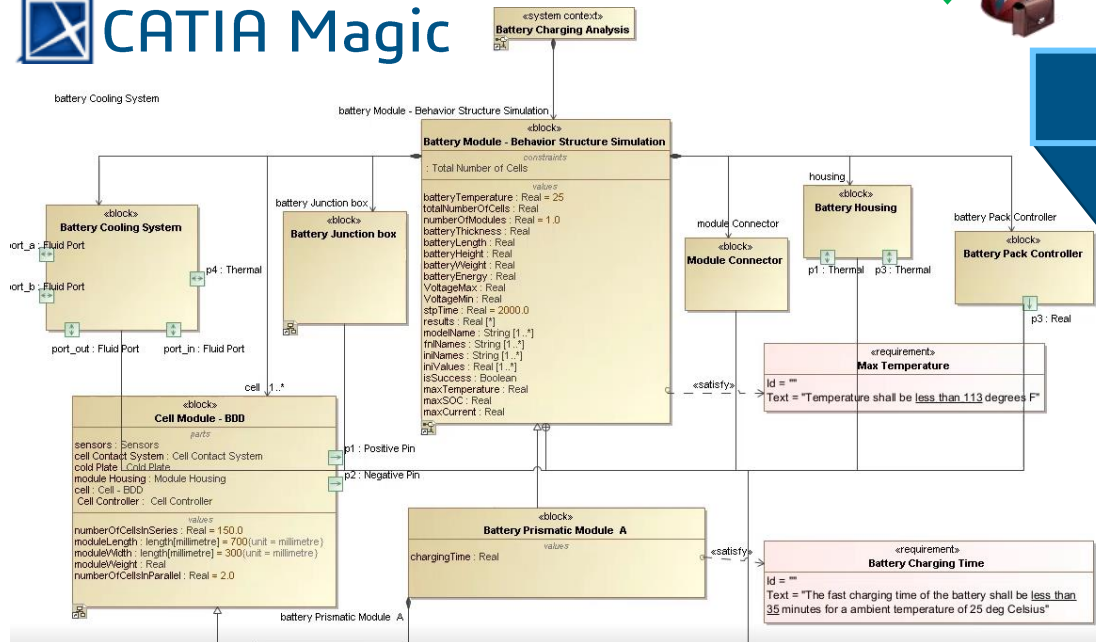
Program/Project Management (Wisdom)

Technical Management (Knowledge)

System Analysis (Information)



Domain Experts (SMEs)

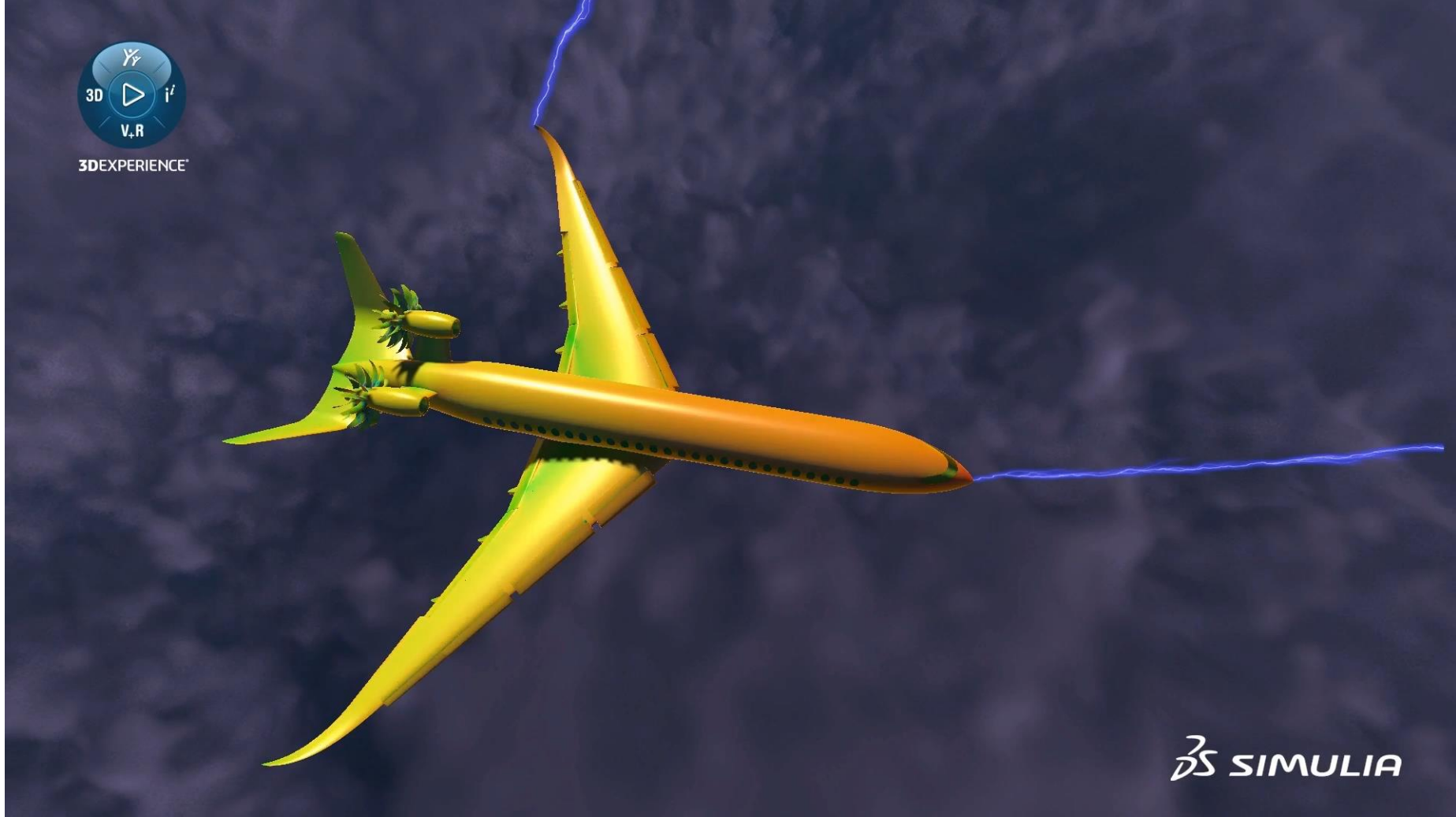


Benefits

Earlier detection, fewer issues, reduced cost

AERODYNAMICS

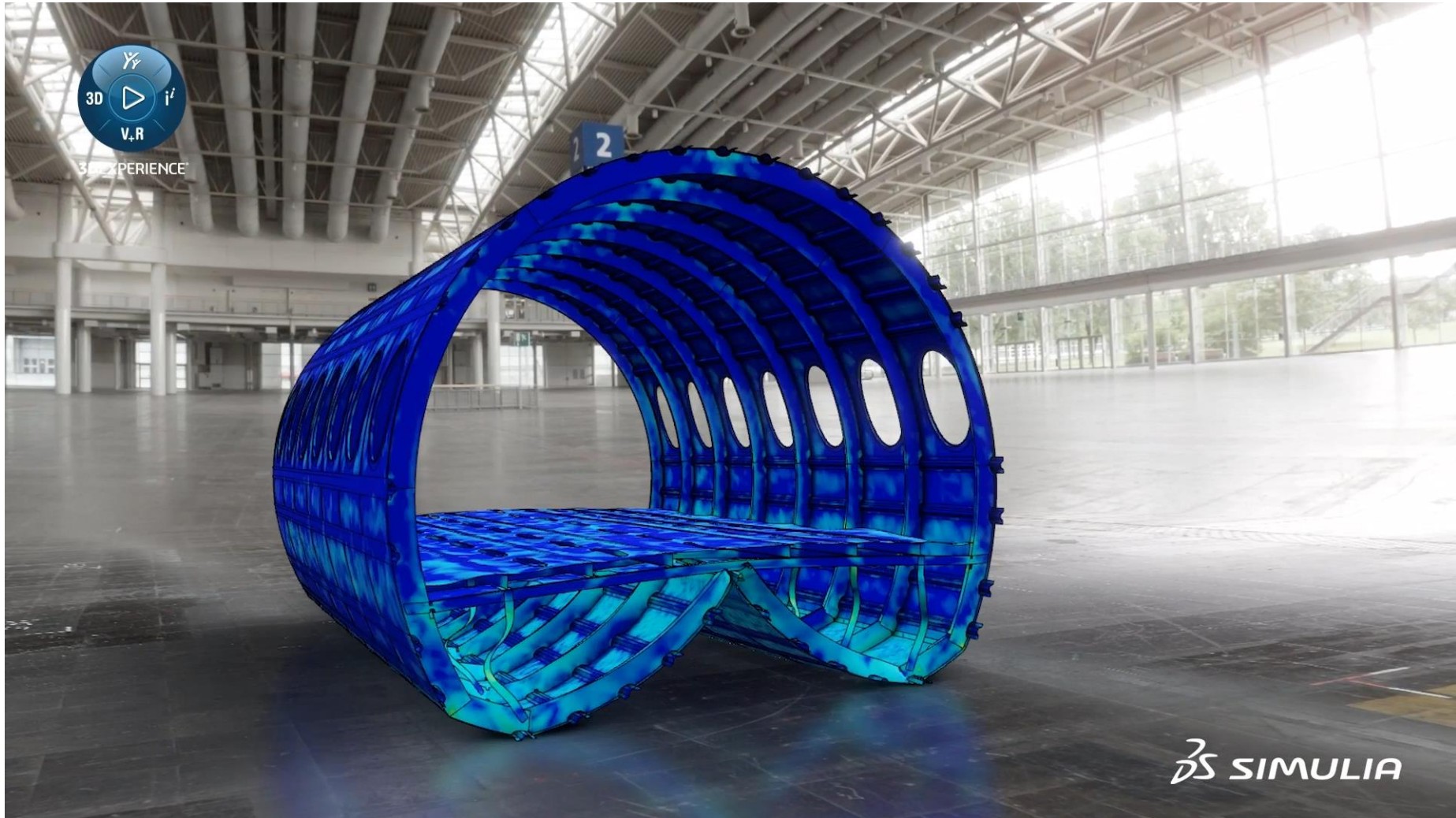




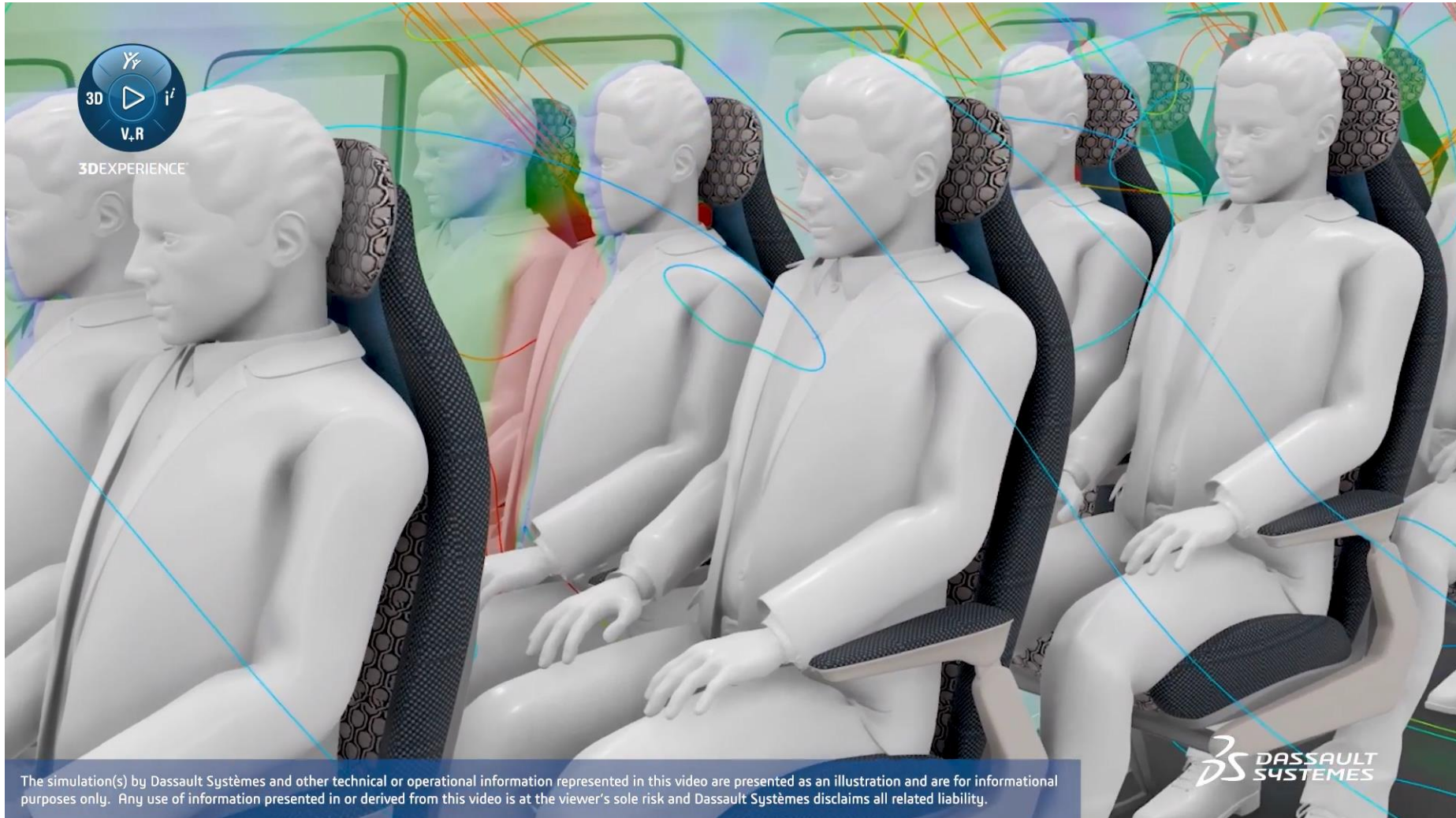
COMMUNICATION



EXTERNAL LOADS



CABIN COMFORT



The simulation(s) by Dassault Systèmes and other technical or operational information represented in this video are presented as an illustration and are for informational purposes only. Any use of information presented in or derived from this video is at the viewer's sole risk and Dassault Systèmes disclaims all related liability.

PROPULSION



EXAMPLE CONTEXT

Autonomous Package Delivery via Drone

“Amazing Invention – This Drone Will Change Everything”,
YouTube, uploaded by Mark Rober, 18 Mar 2023,
<https://youtu.be/DOWDNBu9DkU>



Amazing Invention- This Drone Will Change Everything

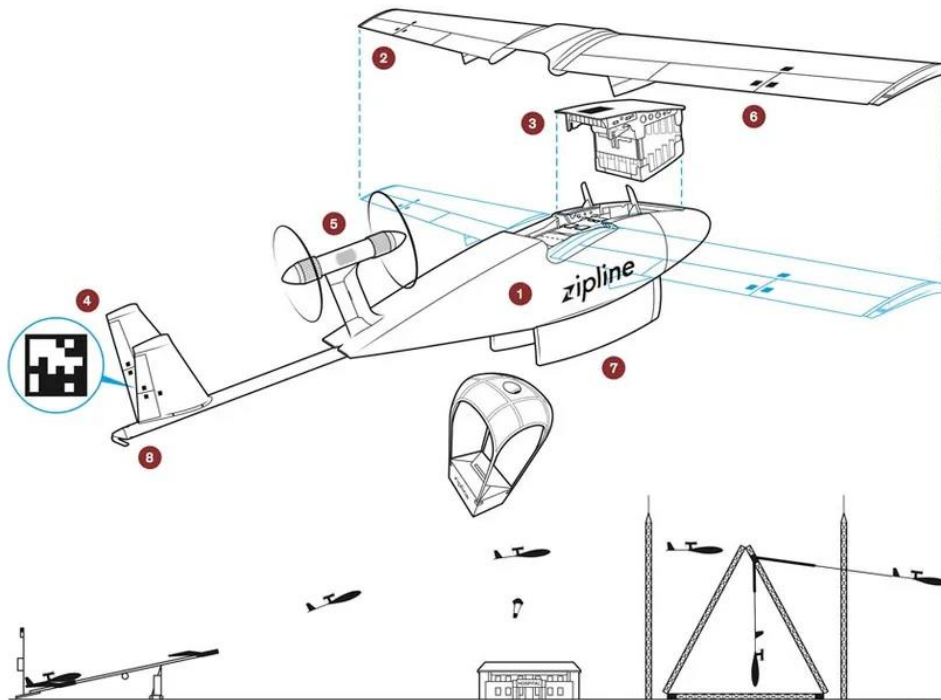
Mark Rober
2.4M subscribers

Subscribe

839K

Share

Save



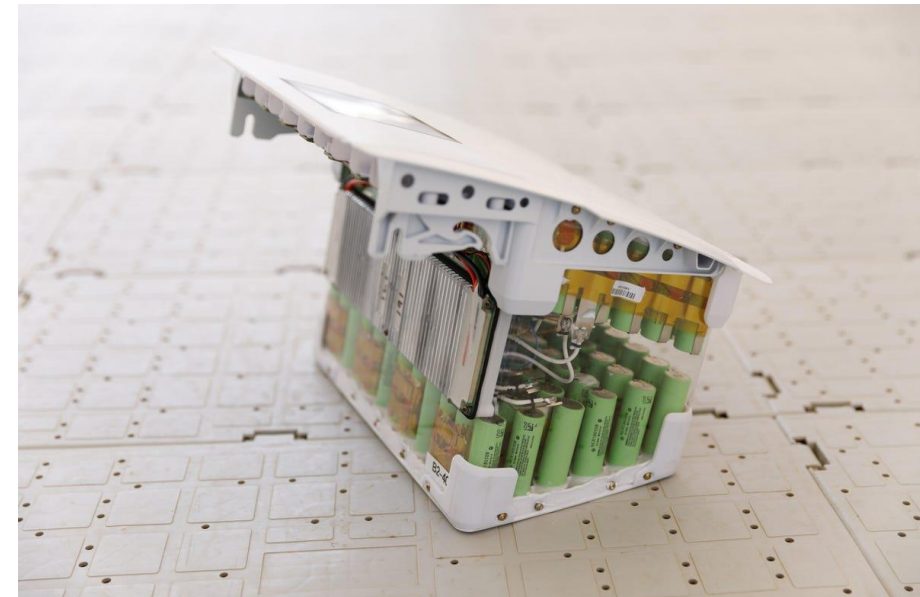
Chris Philpot, The Zippy Flier, digital image, IEEE, accessed 19 May 2023,
<<https://spectrum.ieee.org/in-the-air-with-ziplines-medical-delivery-drones>>

INTEGRATION 1: SIM PROCESS WITHIN SYSML

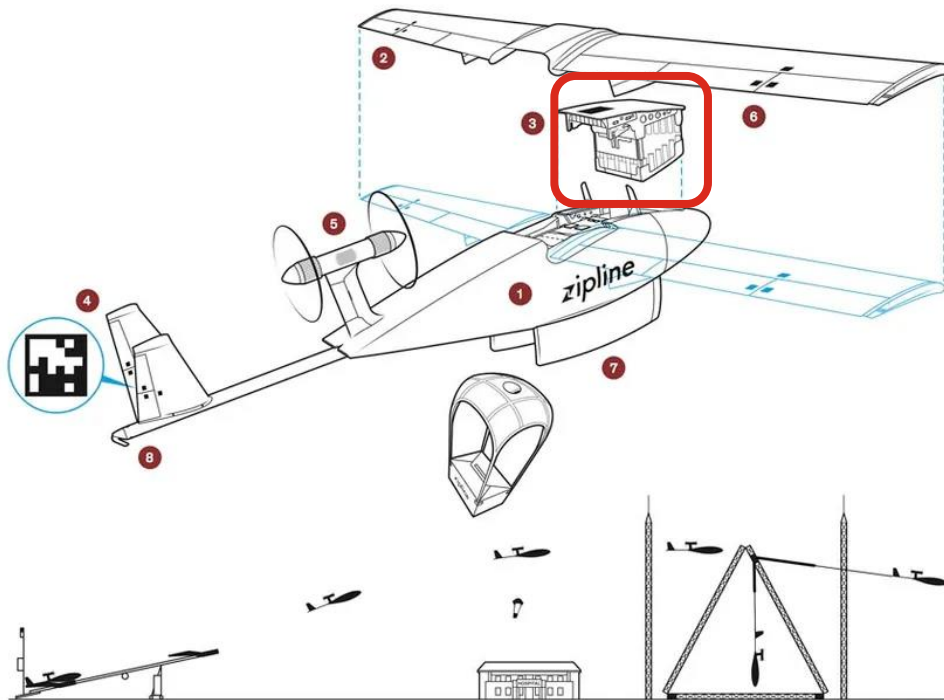
Drone Battery Charging



“Amazing Invention – This Drone Will Change Everything”, YouTube, uploaded by Mark Rober, 18 Mar 2023, <https://youtu.be/DOWDNBU9DKU>



Stephen Shankland, Zipline Battery, digital image, CNET, accessed 19 May 2023, <https://www.cnet.com/pictures/take-a-look-at-ziplines-new-drone-delivery-system/12/>

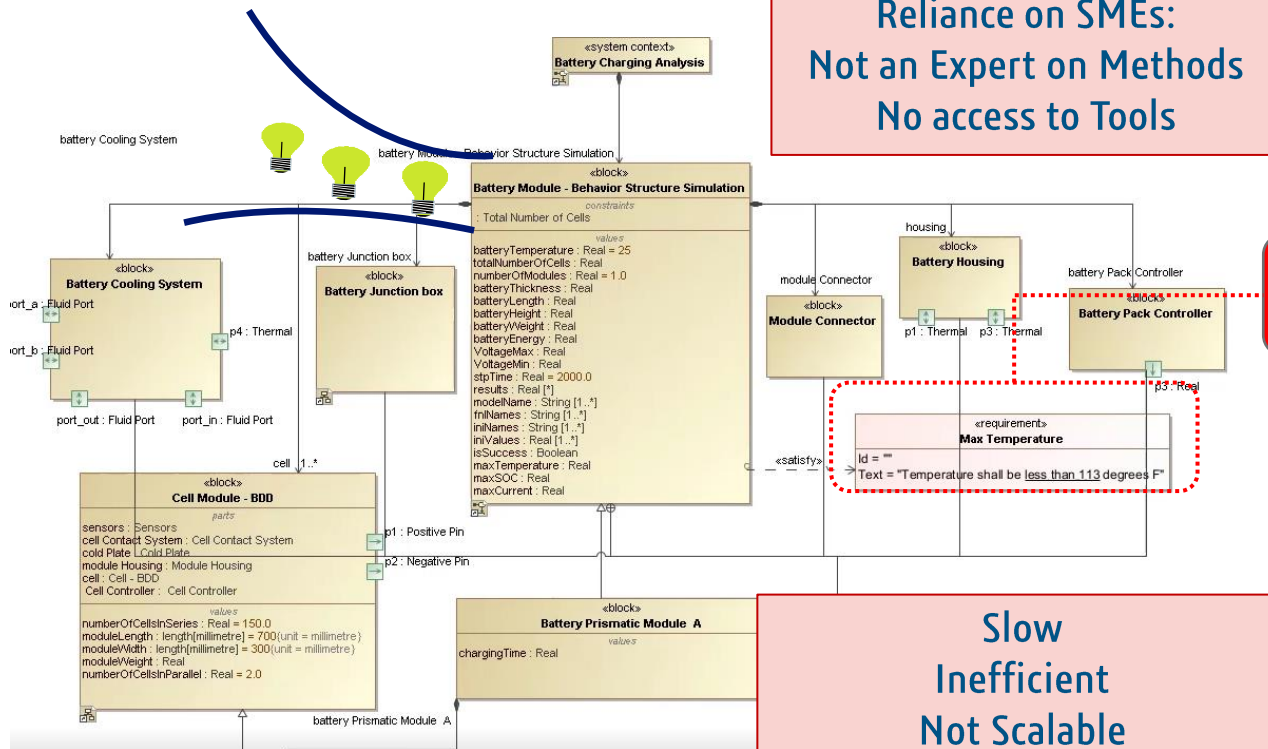


Chris Philpot, The Zippy Flier, digital image, IEEE, accessed 19 May 2023, <https://spectrum.ieee.org/in-the-air-with-ziplines-medical-delivery-drones>

AS-IS: VERIFYING REQUIREMENTS WITH SIMULATION

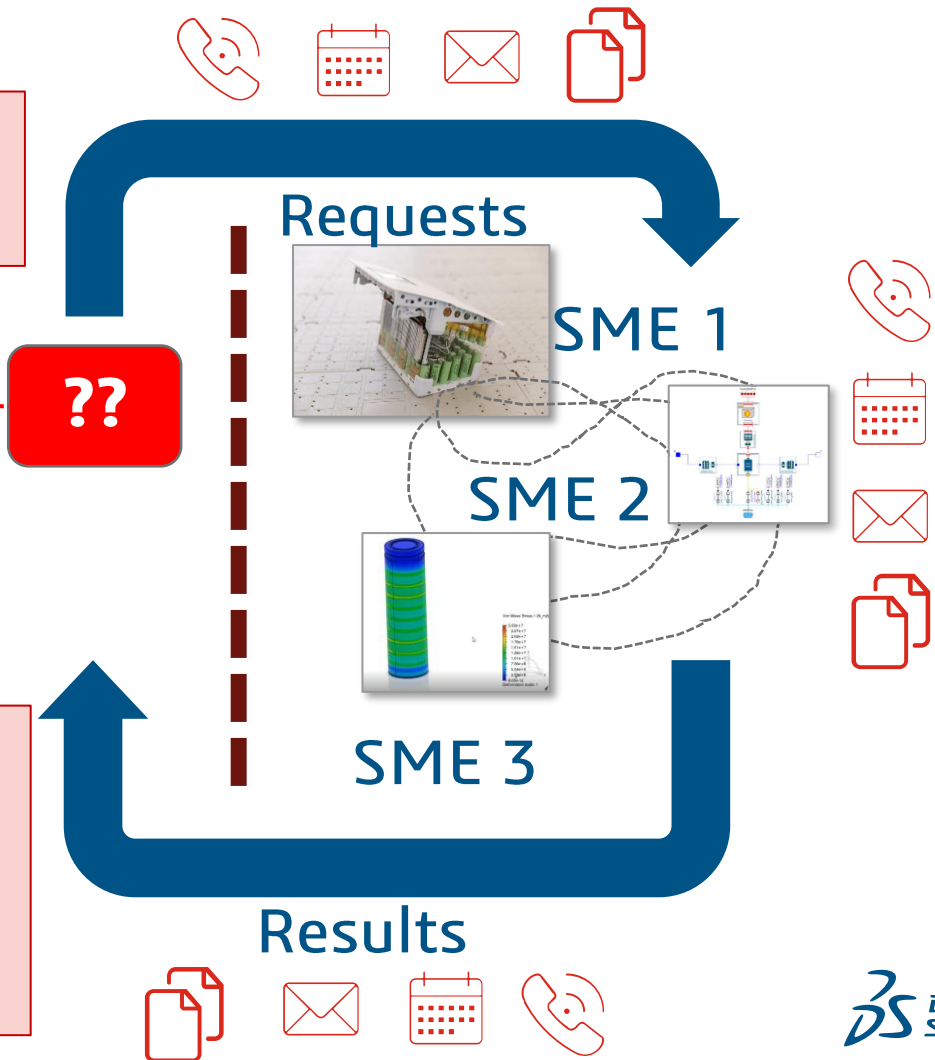
Evaluating changing requirements often requires some simulation expertise to verify
 Example: What is the maximum battery temp during an EV rapid charging cycle?

Sys Engineer



Reliance on SMEs:
 Not an Expert on Methods
 No access to Tools

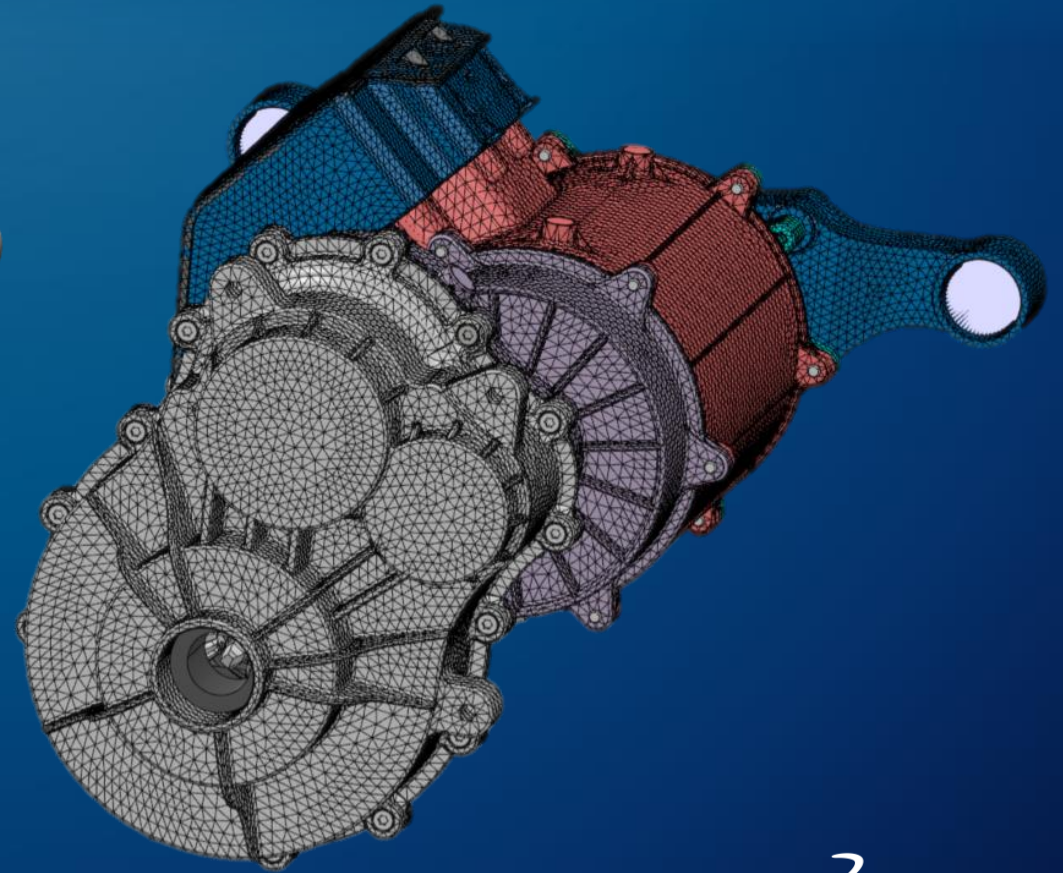
Slow
 Inefficient
 Not Scalable
 Introduces Error
 No Traceability
 No Oppty to perform trades



Accurate Simulation Is A Start, But ...

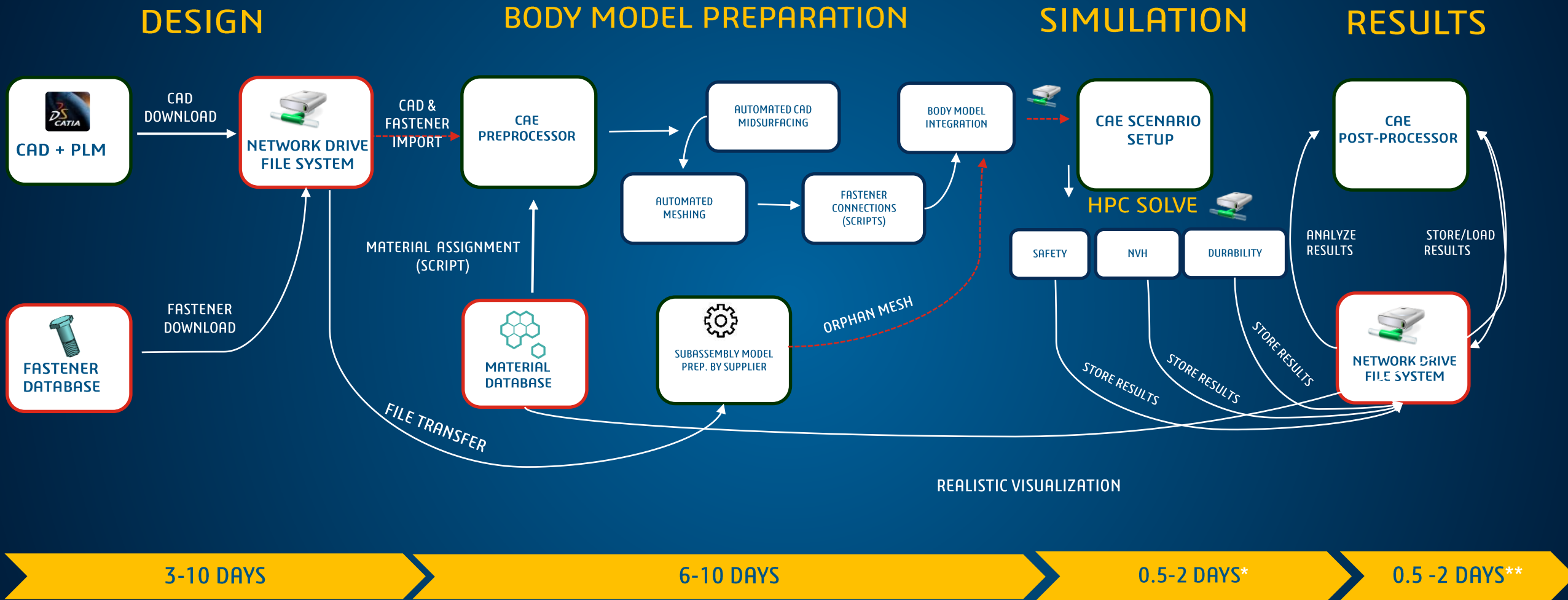
“I can build a prototype faster than you can build a (simulation) model.”

- Executive of a large American OEM



CAD-CAE Silo Process

AS IS ~ 3-4 WEEKS



* ONLY CAE SCENARIO SETUP PER VERIFICATION
** CAE ANALYSIS & REPORT GENERATION PER VERIFICATION

MODELING & SIMULATION

© Dassault Systèmes | 2024



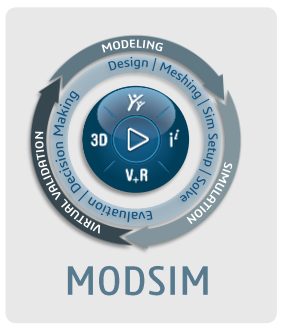
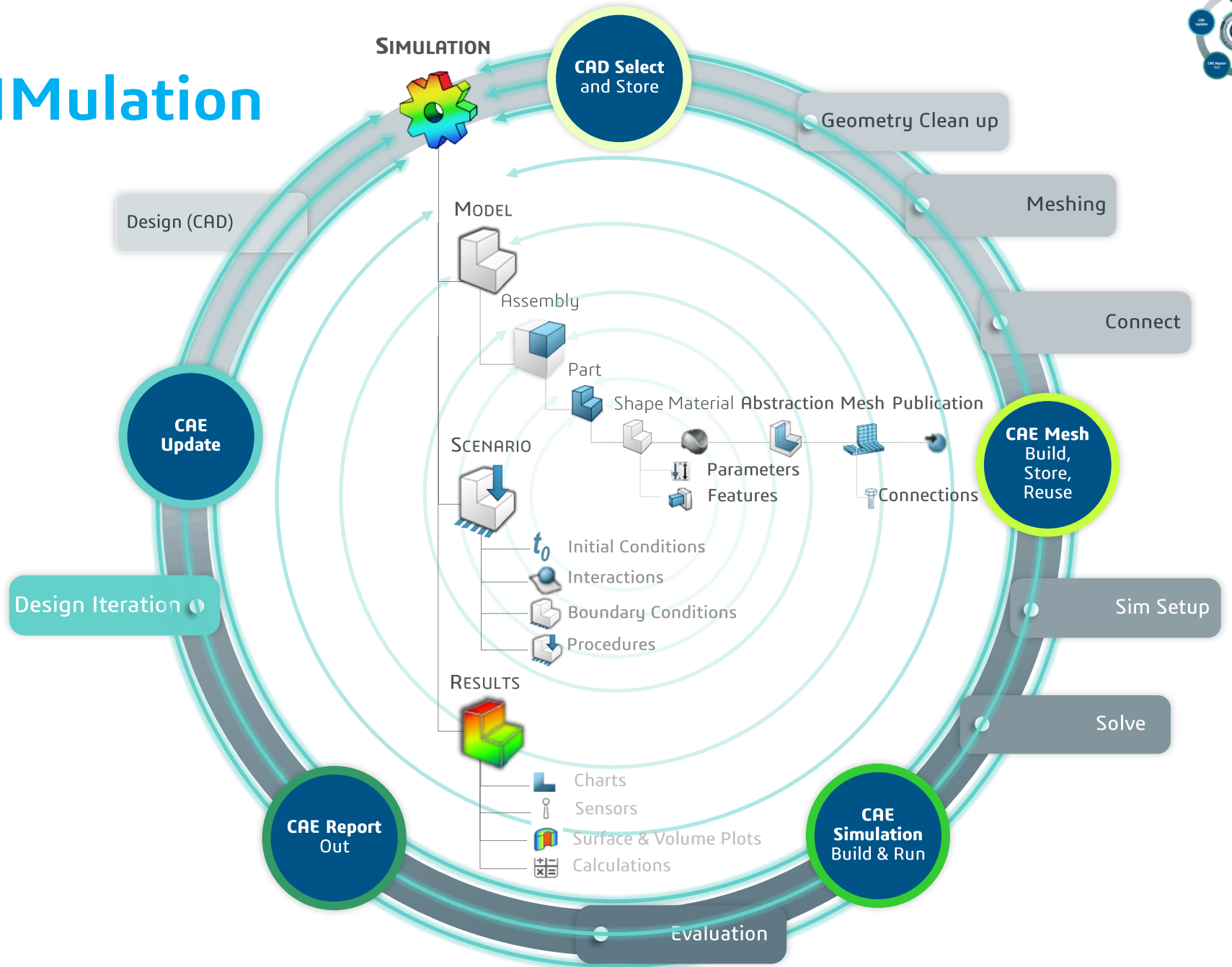
MODSIM:

MODSIM unifies modeling and simulation on a common data model

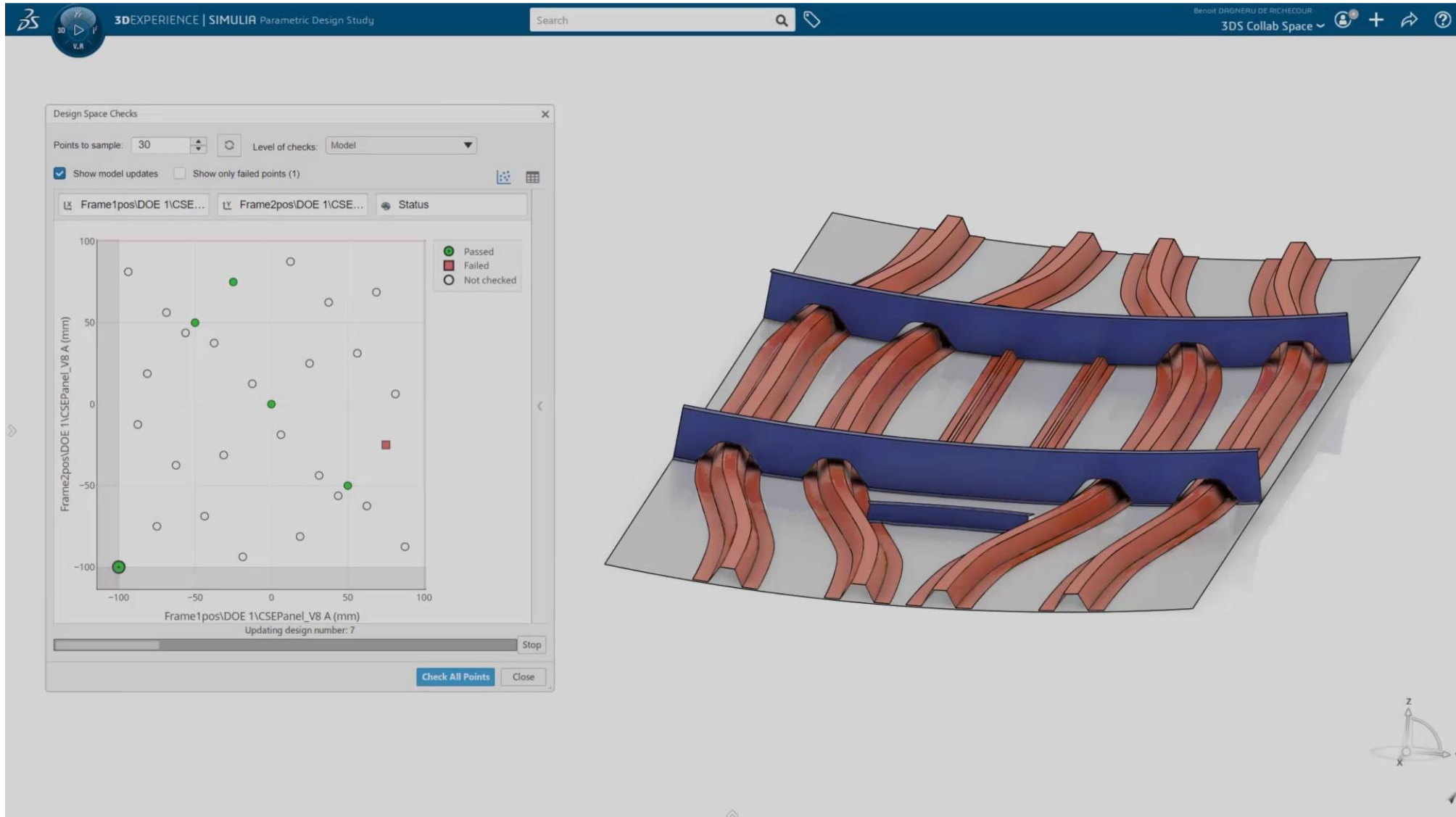
within a single user experience on the 3DEXPERIENCE platform



MODSIM – MODEling and SIMulation



Expand physics-based design space upfront



INCREASE MBSE PRODUCTIVITY WITH 3DEXPERIENCE

Evaluate Requirements Directly from CATIA Magic using latest SME-approved validation models

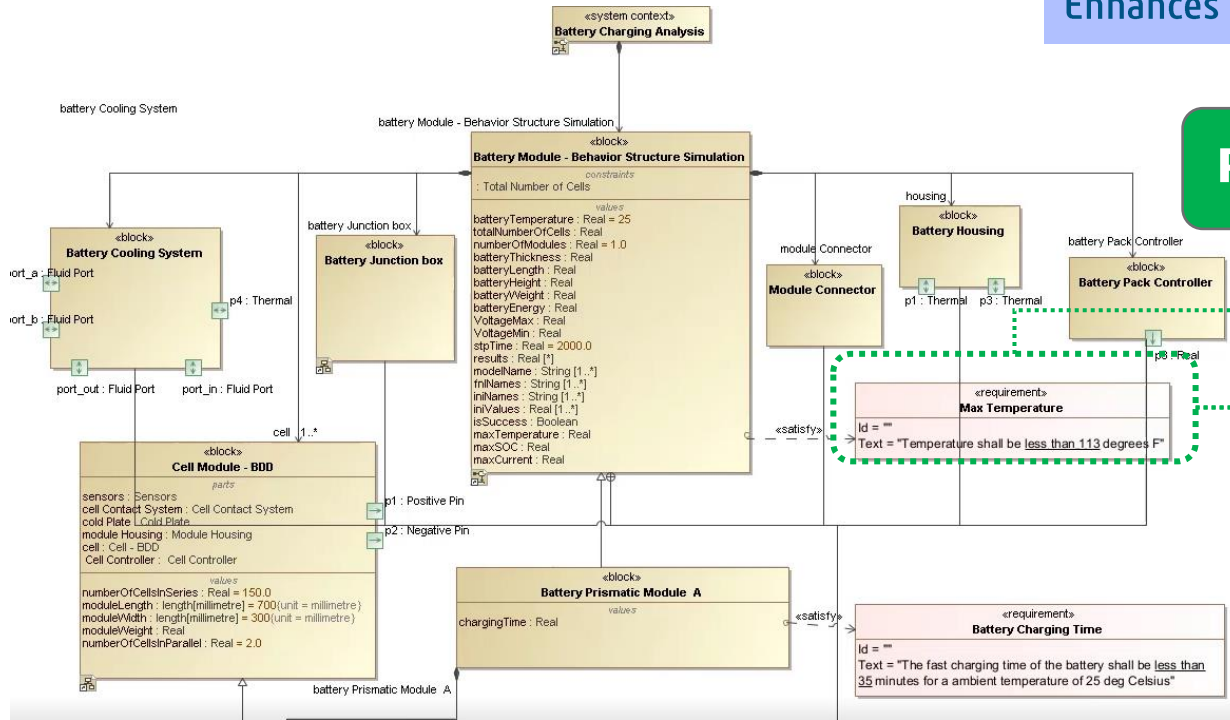
Value to
Sys Engineer

Decreased Reliance on SMEs
Verify on-demand
No tool access required
Enhances SysML model

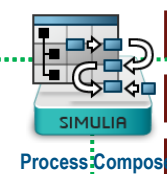


V&V Models can be:
Shared
Lifecycled
Executed by SE

Value to
SMEs

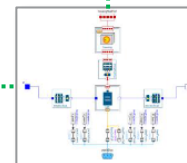


PASS



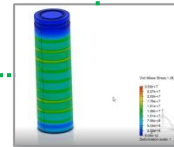
Share in 3DX
Pack Assembly

Parametric Model Template



Share in 3DX
1D Controls

Parametric Model Template



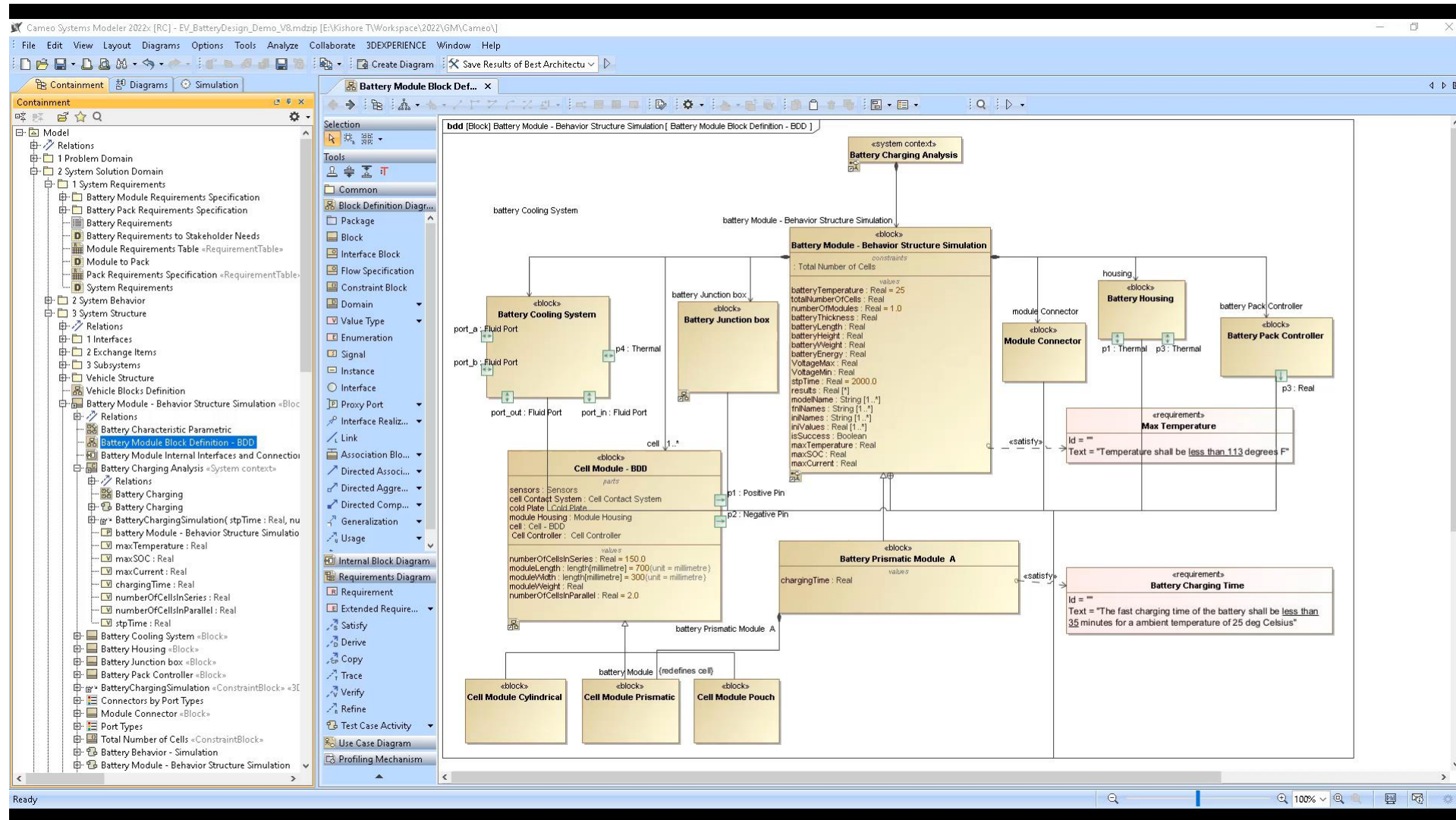
Share in 3DX
3D Physics

Parametric Model Template

Verification Frequency
Verification Accuracy
Confidence in System Model



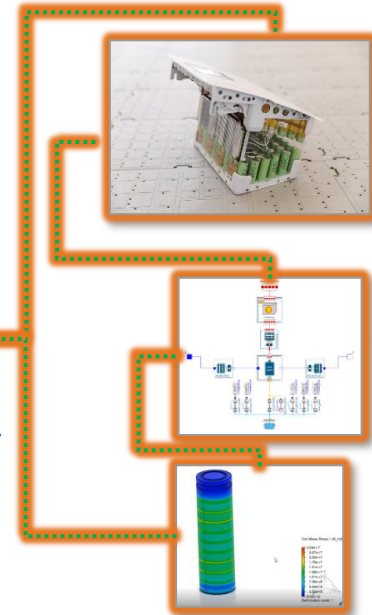
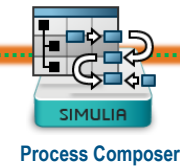
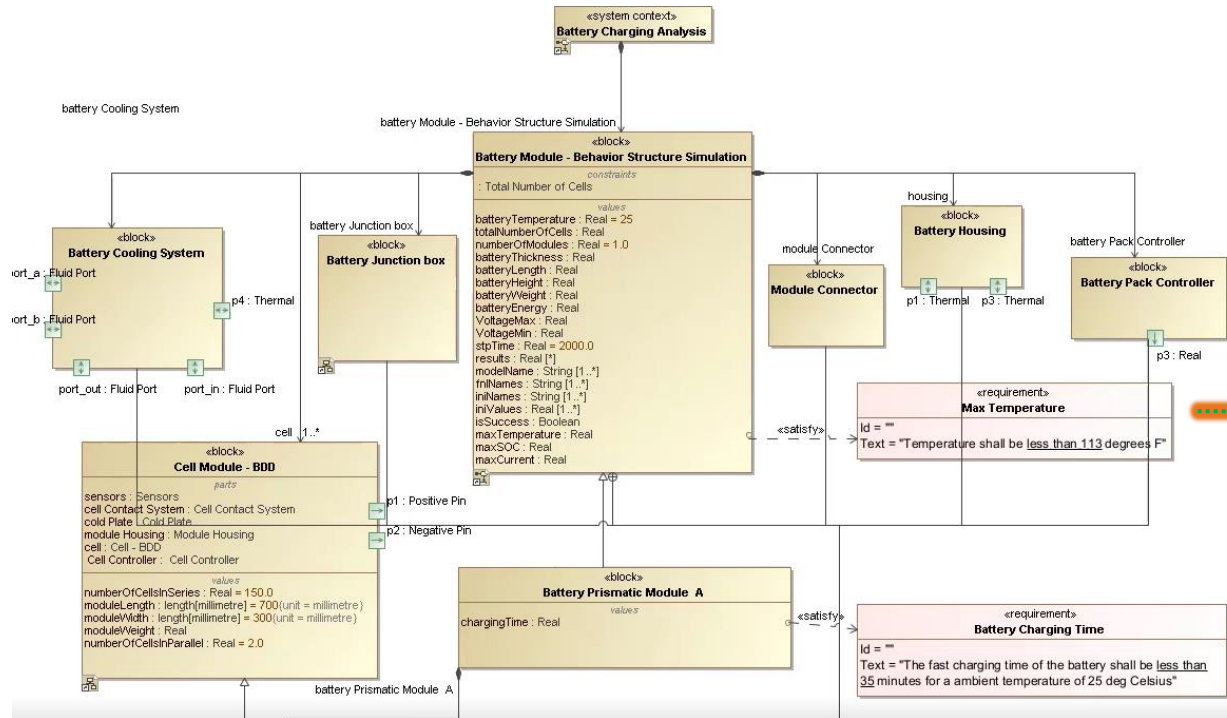
DEMO: CHARGING SYSTEM ANALYSIS USING SIMULATION



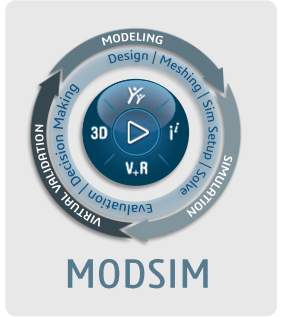
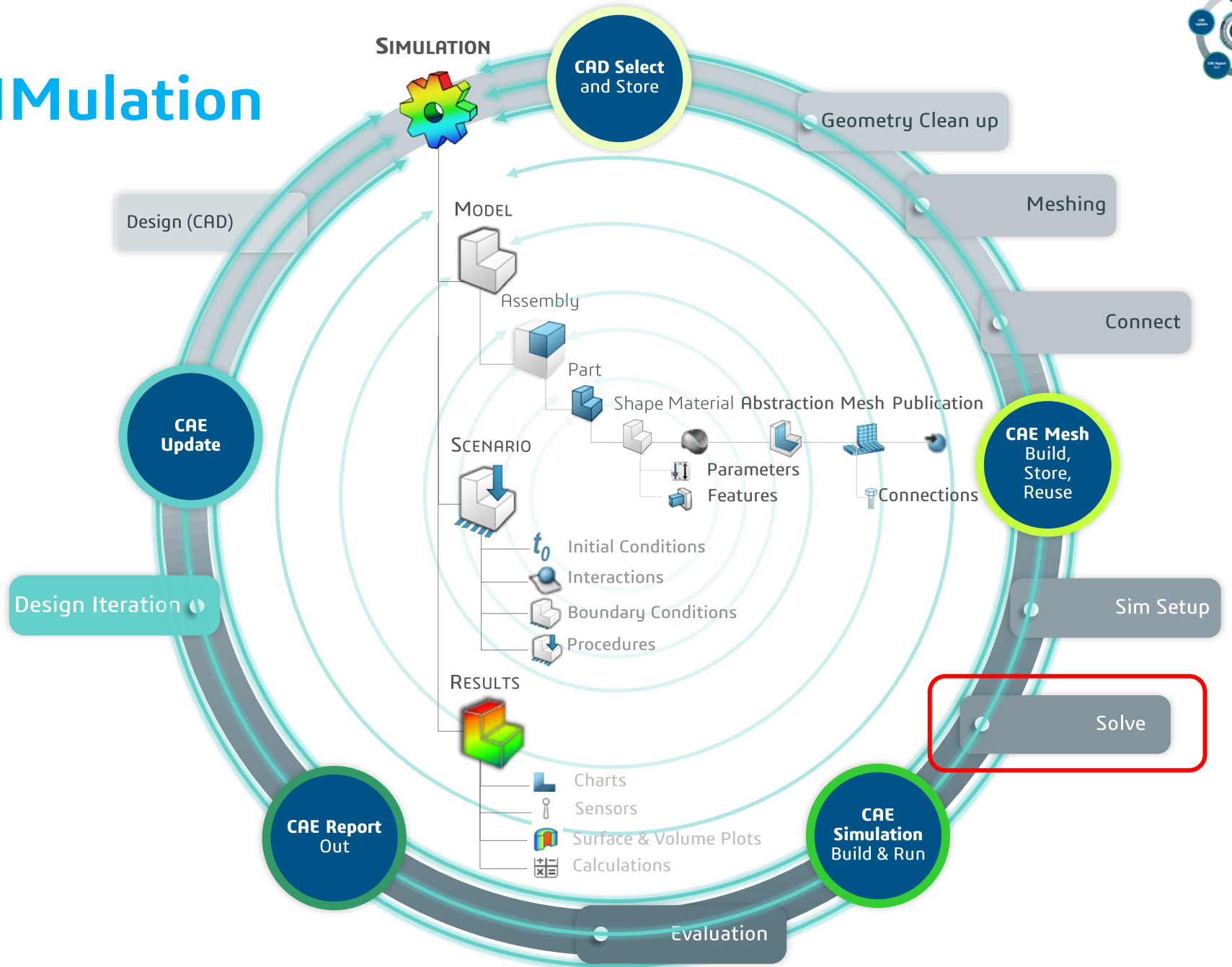
VERIFICATION USING SIMULATION

Sys Engineer

SMEs



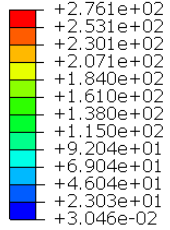
MODSIM – MODEling and SIMulation



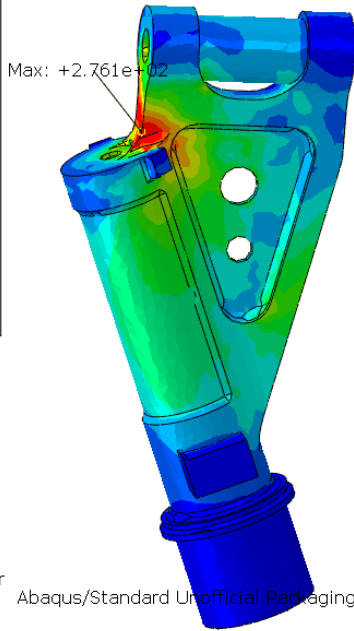
WHICH IS FEA? WHICH IS ML?

2023

S, Mises
(Avg: 75%)

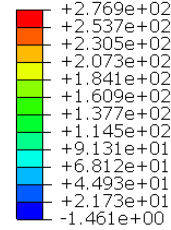


Max: +2.761e+02
Elem: SHAFT2.1040
Node: 1321

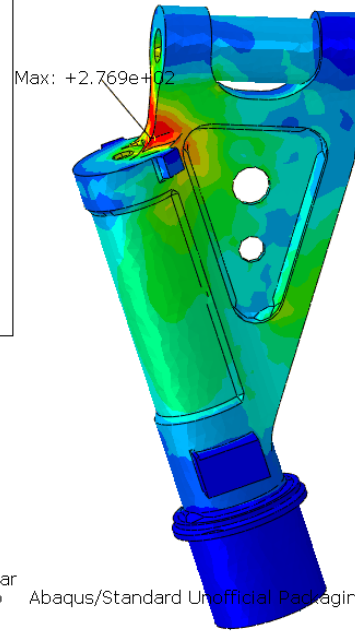


Landing Gear
ODB: 2.odb Abaqus/Standard Unofficial Packaging Version (MNT) Mon Oct 24 10:36
Z
Y
X
Step: Step-1, KINEMATIC ANALYSIS
Increment: 10; Step Time = 1.000
Primary Var: S, Mises
Deformed Var: U Deformation Scale Factor: +1.000e+00

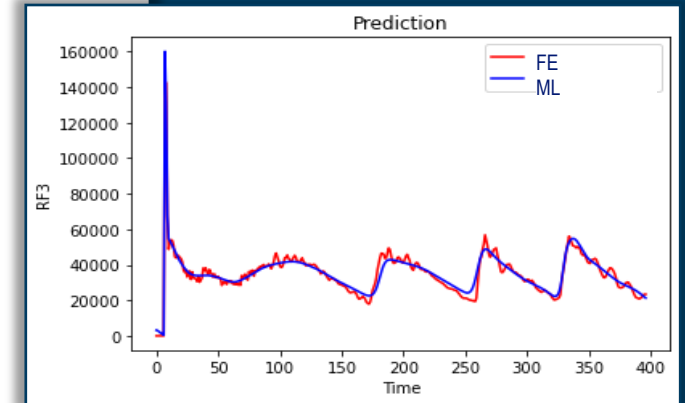
ML
(Avg: 75%)



Max: +2.769e+02
Elem: SHAFT2.1040
Node: 134



Landing Gear
ODB: 2.odb Abaqus/Standard Unofficial Packaging Version (MNT) Mon Oct 24 10:36
Z
Y
X
Step: Step-1, KINEMATIC ANALYSIS
Increment: 10; Step Time = 1.000
Primary Var: ML
Deformed Var: U Deformation Scale Factor: +1.000e+00



FEA Total Cost:
1x per result

ML Total Cost:
100s/1000s of times faster per result
(plus training runs)

Panel_surrogate_model(-)
Panel_surrogate_mode... Completed on Aug 26, 2024 [Run] [Settings]

Inputs/Outputs Monitor Files

Inputs

Frame 1 position (L1)
Slider: -100 to 100, Value: -100

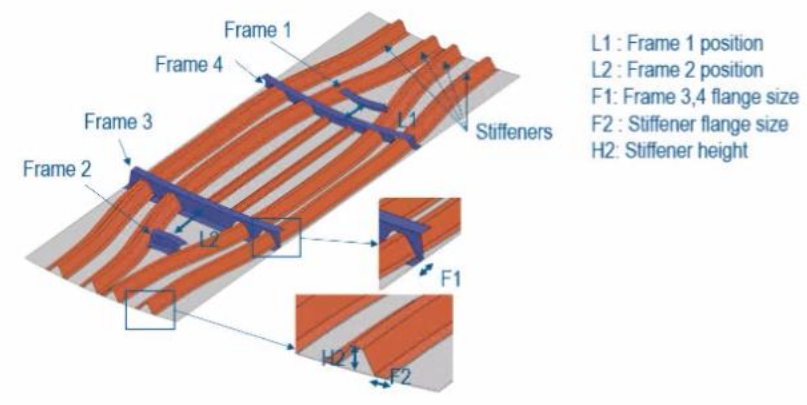
Frame 2 position (L2)
Slider: -100 to 100, Value: 100

Stiffener height (H2)
Slider: 25 to 45, Value: 25

Frame 3,4 flange size (F1)
Slider: 20 to 25, Value: 20

Stiffener flange size (F2)
Slider: 15 to 40, Value: 40

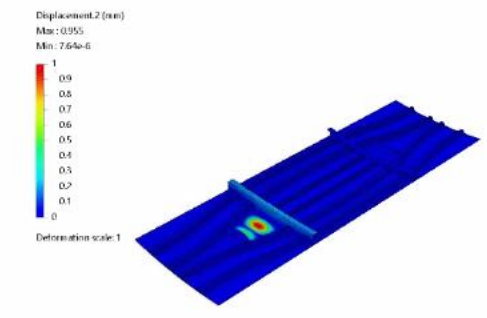
Parameter details



Outputs

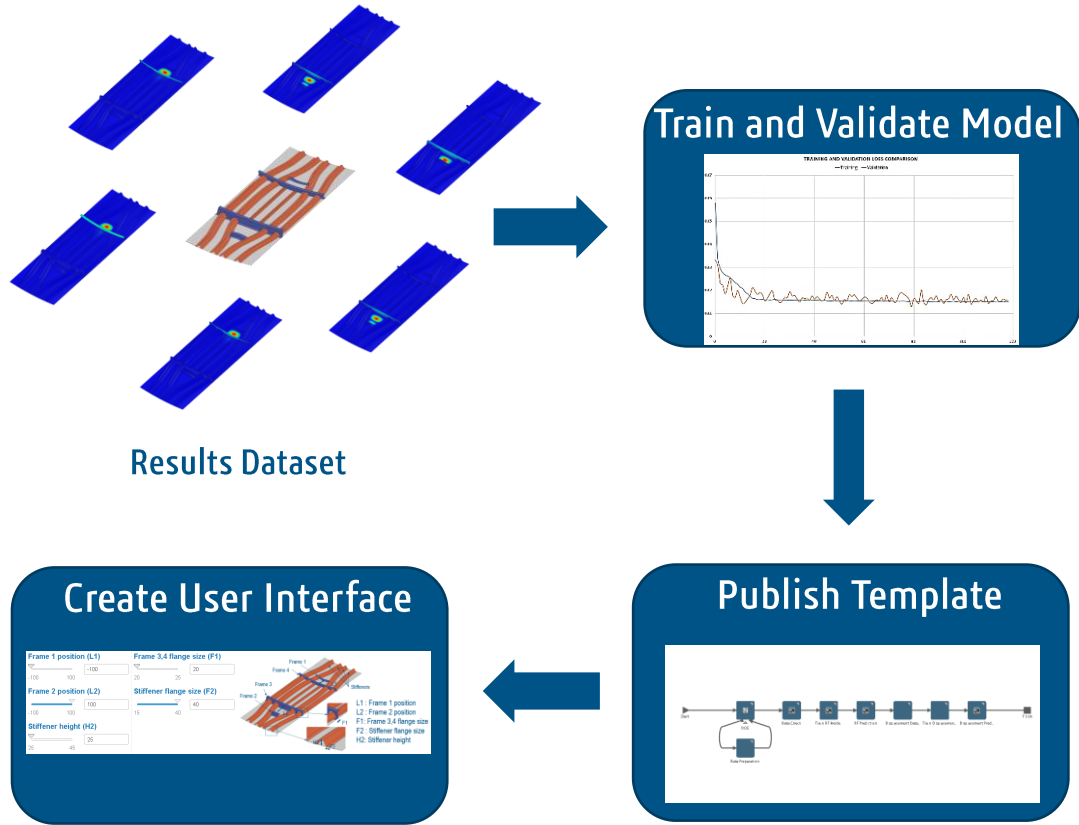
Simulation results
Surrogate_model_results

Displacement plot

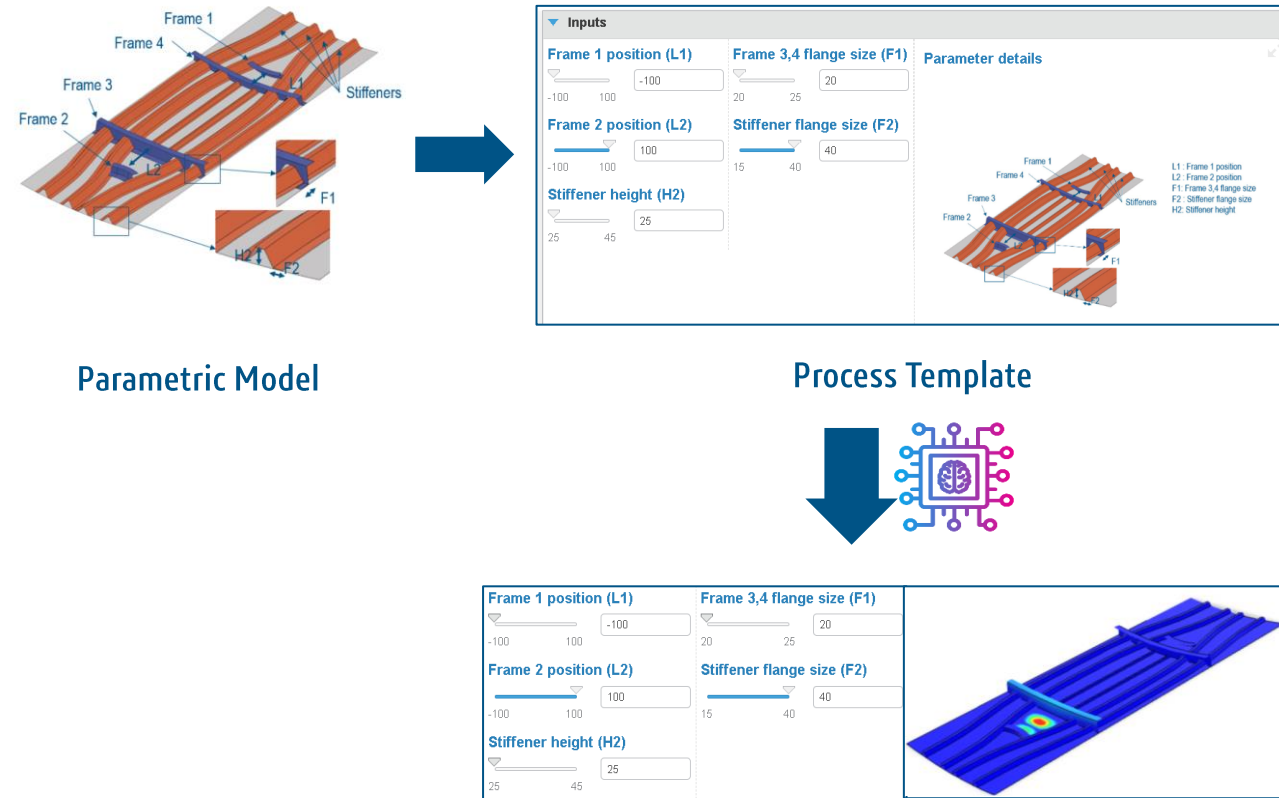


SURROGATE MODEL GENERATION & USAGE

Generation of Surrogate Model

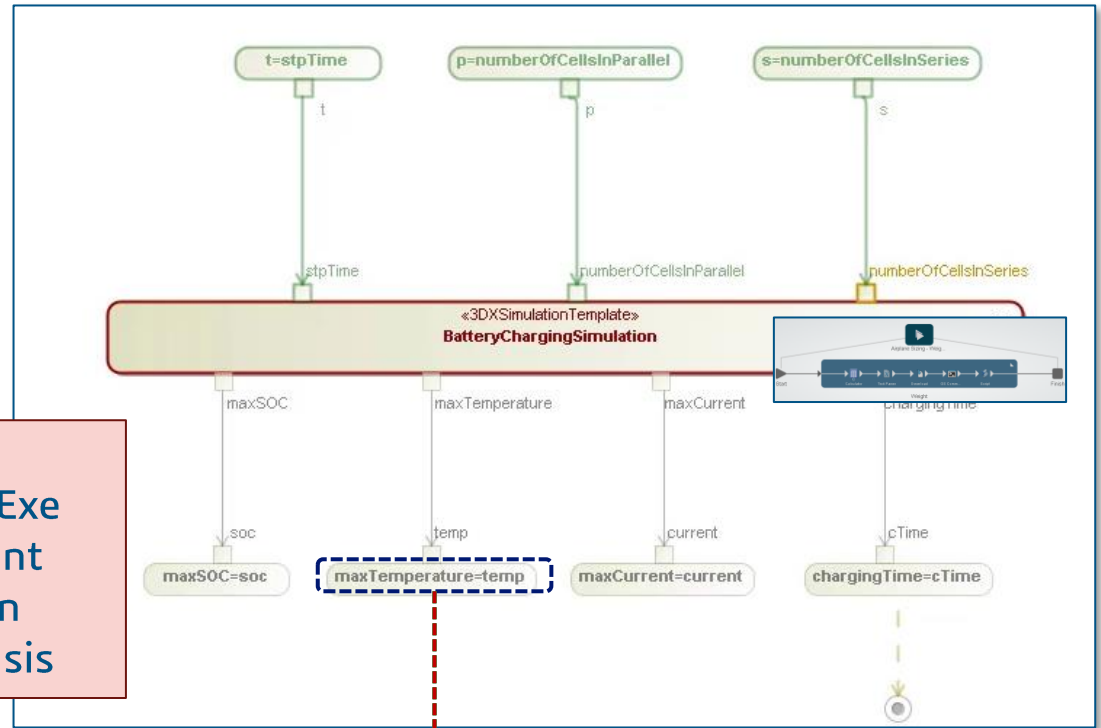
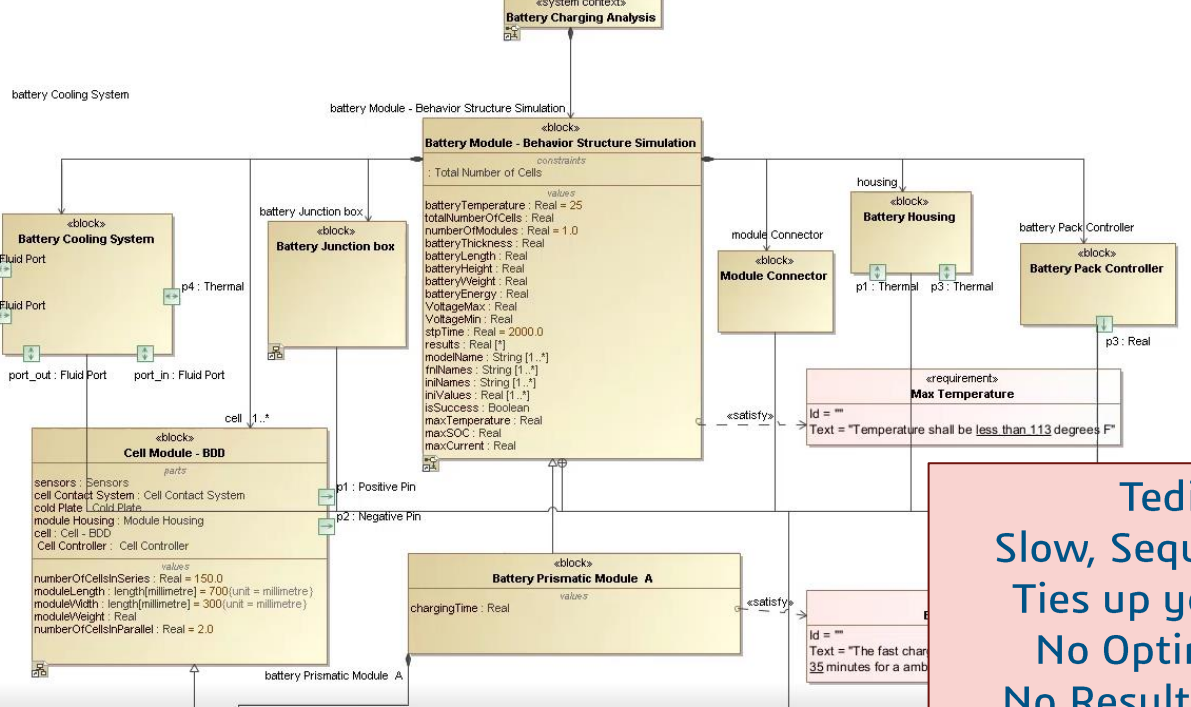


Usage of Surrogate Model



SYSTEM TRADE STUDIES & OPTIMIZATION

How does a System Engineer evaluate alternatives?

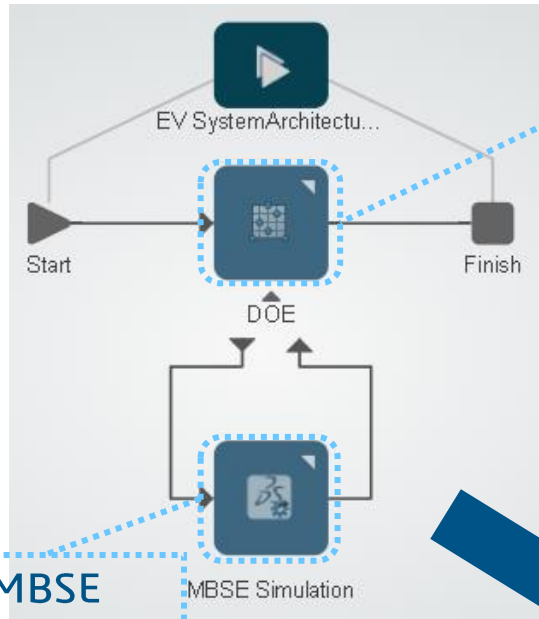


Tedious
Slow, Sequential Exe
Ties up your Client
No Optimization
No Results Analysis

User-defined Instance table

#	SeriesCells	Parallel Cells	Cell Type	State of Charge	Temperature
1	XXX	AAA	YYY	BBB	❌
2	YYY	BBB	ZZZ	CCC	✅
3	ZZZ	CCC	XXX	AAA	✅

TO-BE: SYSTEM TRADE STUDIES USING 3DEXPERIENCE



DoE, Optimization, Uncertainty Quantification (UQ) techniques

Auto matrix Generation

Fast, parallel execution

Execute at any level of System Model



11 Design of Experiment Techniques

- Efficiently assess the Design Space

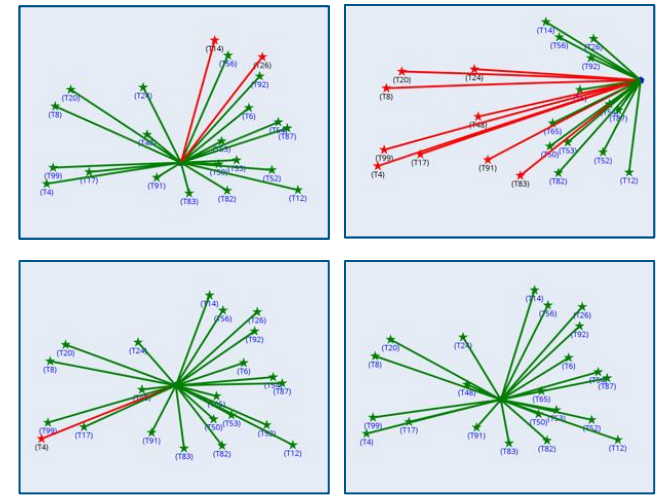
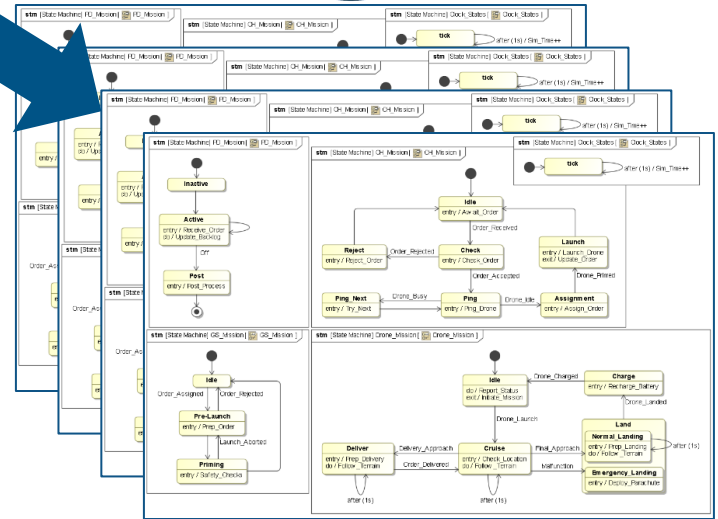
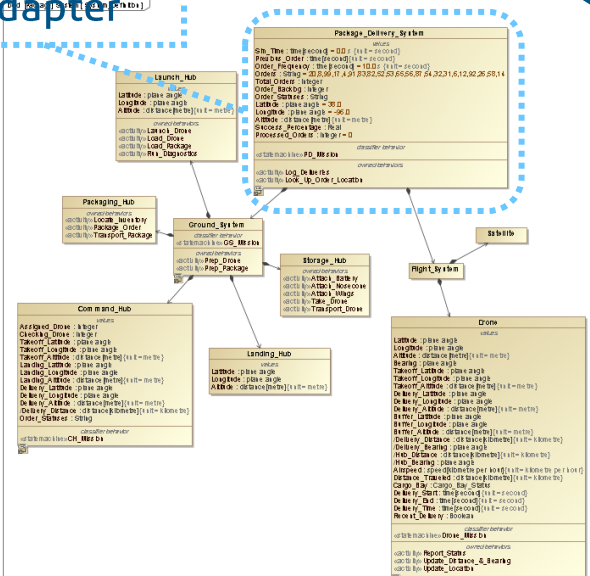
16 Optimization Techniques

- Drive design towards desired objectives
- Includes DS-proprietary Hybrid Optimizers

Monte Carlo Simulation for UQ

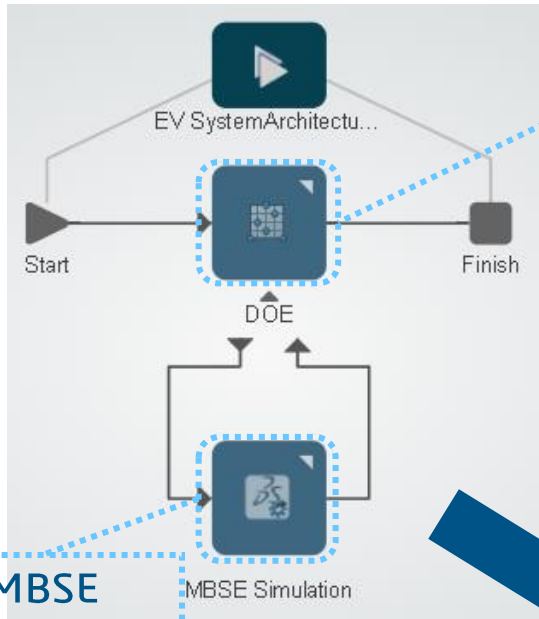
- Evaluate robustness of designs when introducing uncertainty / tolerances

MBSE Adapter



Execute Analysis of Alternatives

TO-BE: SYSTEM TRADE STUDIES USING 3DEXPERIENCE



DoE, Optimization, Uncertainty Quantification (UQ) techniques

Auto matrix Generation

Fast, parallel execution

Execute at any level of System Model

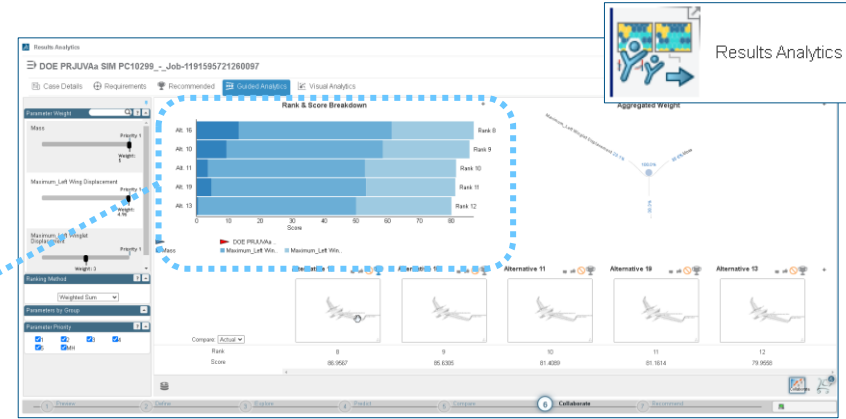
Manage Datasets

Filter/Sort/Rank Alternatives

Perform Trade Offs

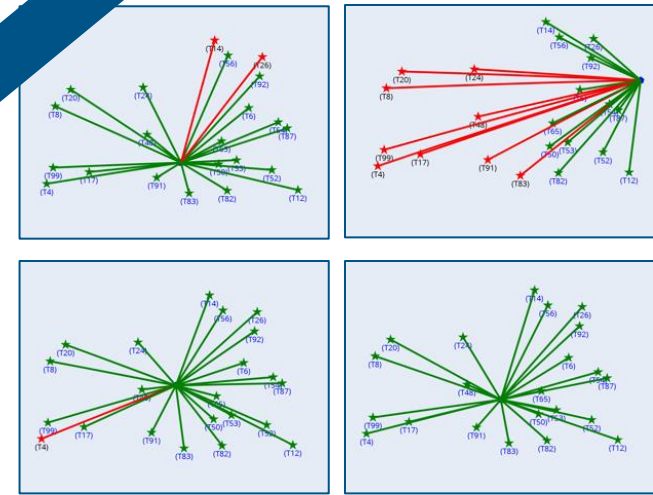
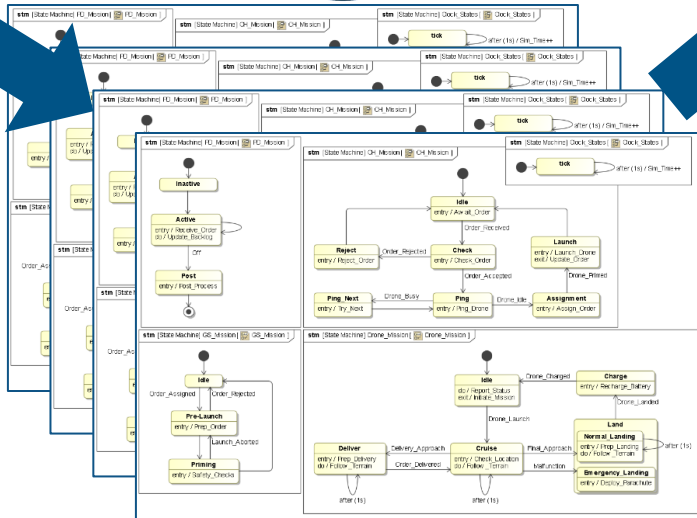
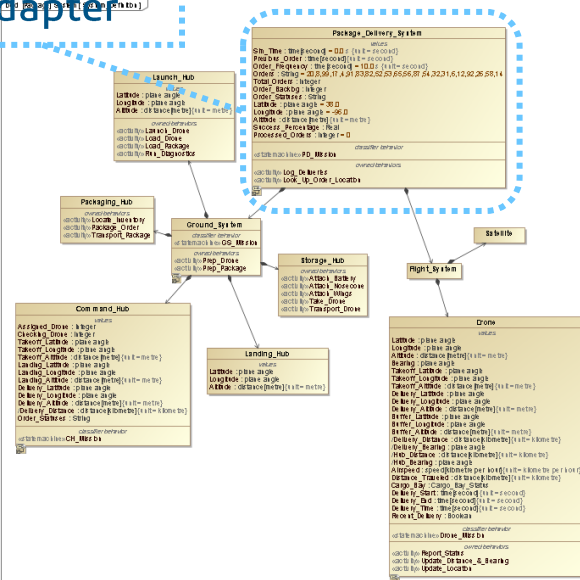
Rich Visualizations

Export to Req'mts



Explore and Evaluate Results

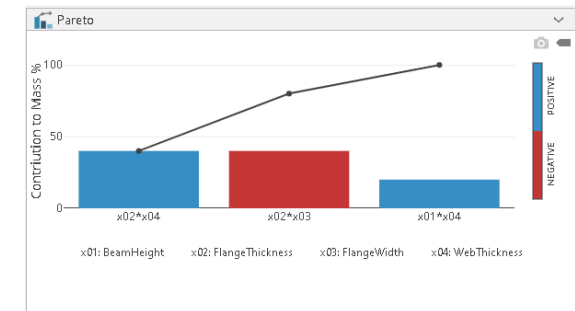
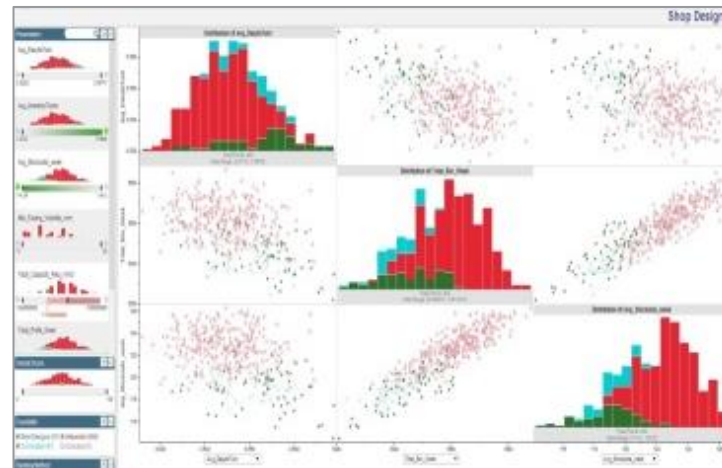
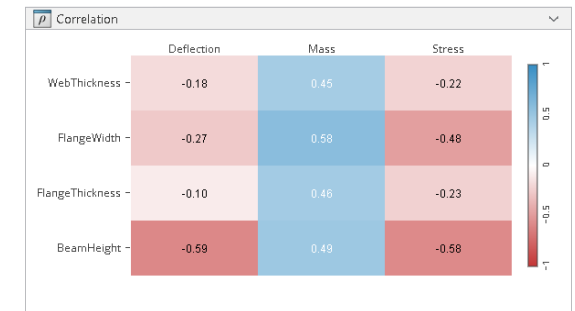
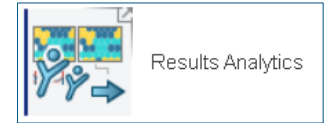
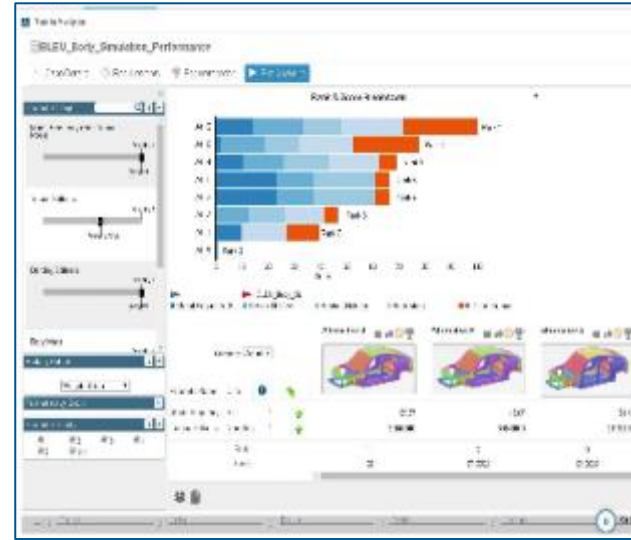
MBSE Adapter



Execute Analysis of Alternatives

ANALYZING RESULTS TO DRIVE ENGINEERING DECISIONS

- Collect analysis datasets to study
- Rank and score alternative designs
- Compare the performance KPIs of designs in a single view
- Update Requirements from study
- Create reduced order models (FMUs) from the datasets



USING CATIA MAGIC & 3DEXPERIENCE FOR TRADE STUDIES

© Dassault Systèmes | Confidential Information | 23/07/2021 | ref.: 3DS_Document_2021

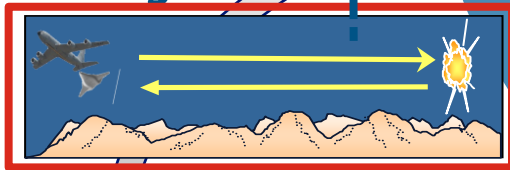
Validation

Evaluate Performance against Targets

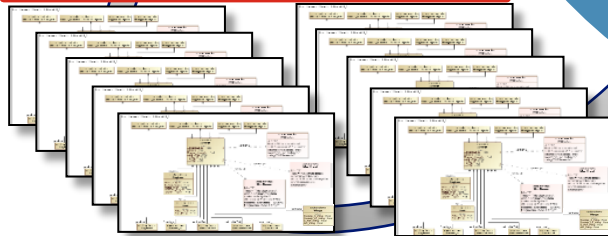


Load Results

Execute system-level trade analyses



Scalability

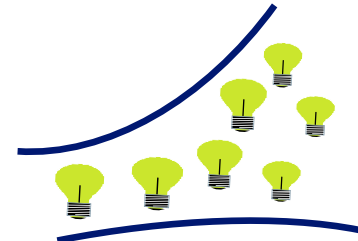
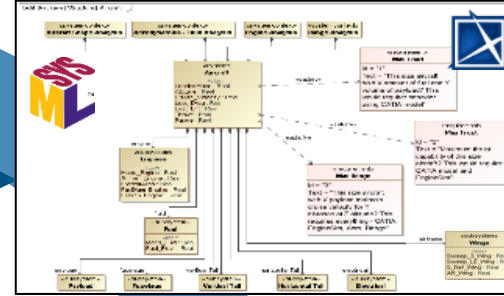


Update and repeat

Revise Architecture

Export Requirements

Develop Architecture



Develop analysis & design models

CATIA Design



External Analysis



SIMULIA Experience Studio



Integrate 3DX Models



Integrate External Models

SIMULIA Results Analytics



3D



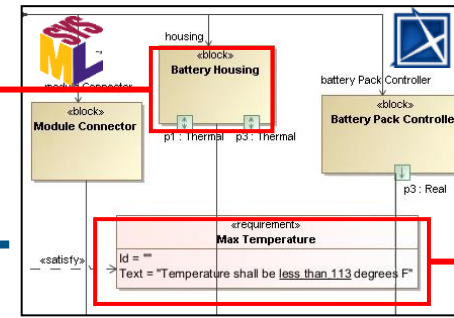
i

V+R



SIMULIA Process Composer

Link to models



TAKEAWAYS ON IMPROVING SIMULATION TO SYSTEM MODELS

- **Enable Systems Engineers** to validate within Cameo using *managed* Methods/Processes supplied by SMEs
- **Easy Drag & Drop** to create *integrated* SysML Models
- Perform **trade-studies & optimizations** quickly through parallel execution and easily Analyze Results
- **Extends the SysML Model** *rather* than replicating the System Definition *as seen in other software offerings*



System
Architecture



Simulation
Execution



Trade Studies
& Optimization