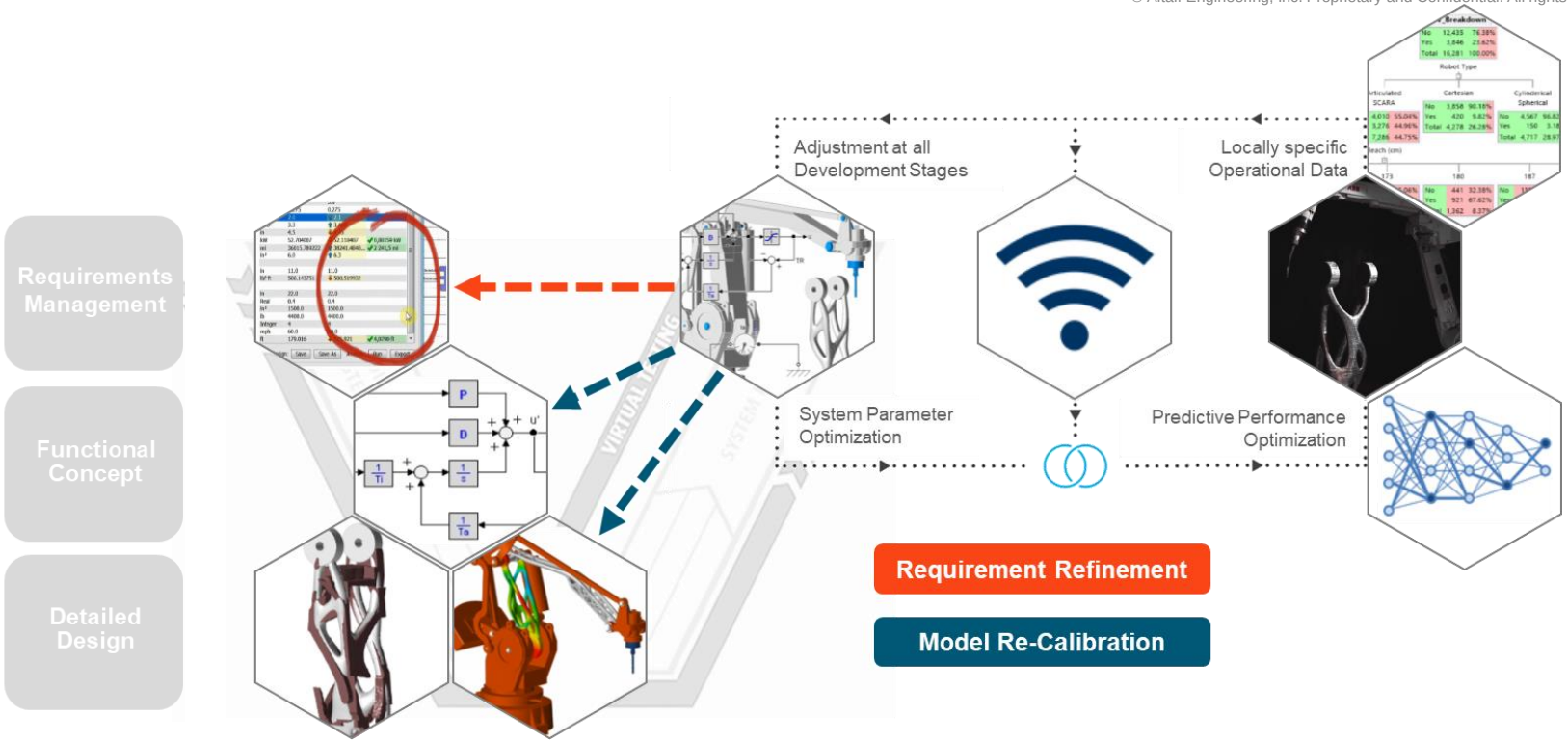
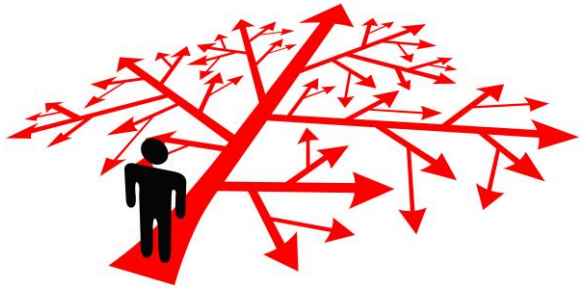


MODEL-BASED DEVELOPMENT WITH ALTAIR COMPOSE® AND ALTAIR ACTIVATE®

Christian Kehrer / Business Development Manager – System Modeling / 9/16/2021

Common Challenges of Mechatronic Product Development

Manage Risks
due to Product Complexity
(Smart, Connected, Electro-Mech)



Accelerate
Time-to-Market

Reduce
Development Costs

ALTAIR

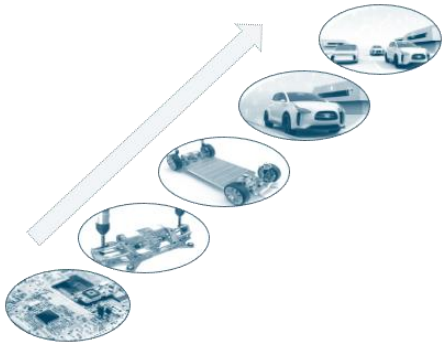
Altair's Top 3 Solutions addressing those Mechatronics Challenges

Manage Risks due to Product Complexity
(Smart, Connected, Electro-Mech)

Handling Complexity

Optimizing mechatronic product performance holistically as system-of-systems

(using physics-based Digital Twins)

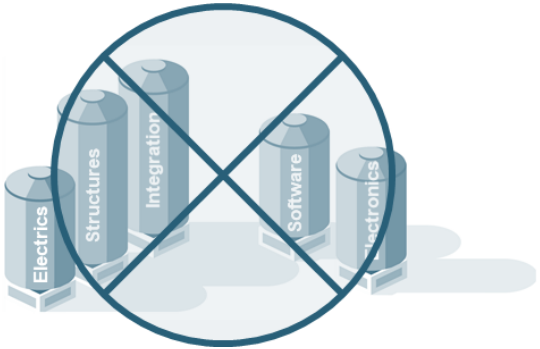


Accelerate Time-to-Market

Facilitating Teamwork

Breaking down silos between mechatronic disciplines

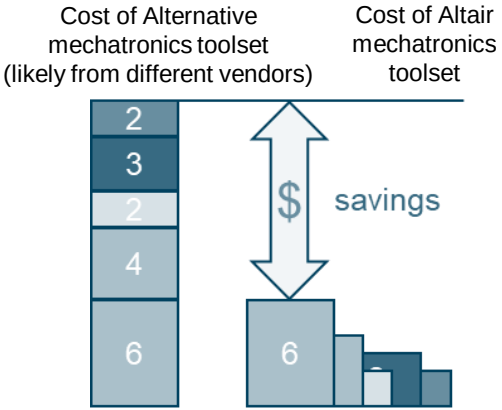
(Mechanical, Electrical, Controls, etc.)



Reduce Development Costs

Managing Costs

Streamline Product Development teamwork & tool set, affordably



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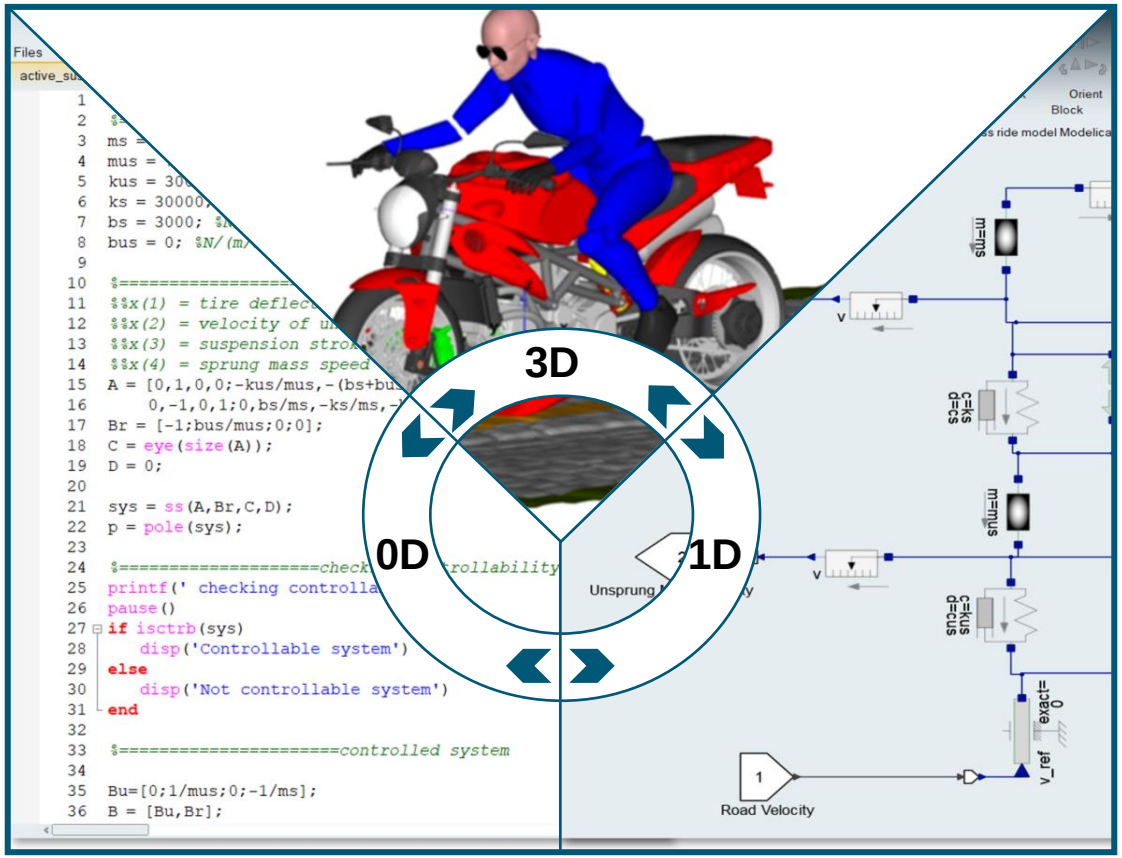
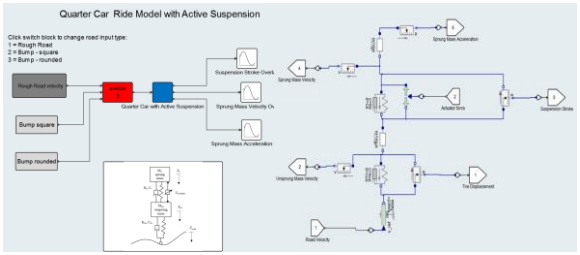
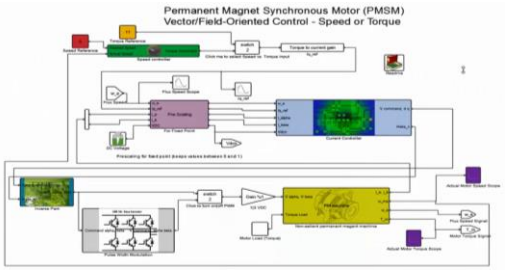
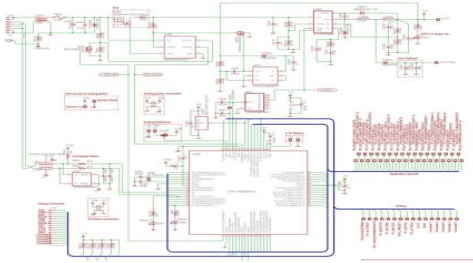
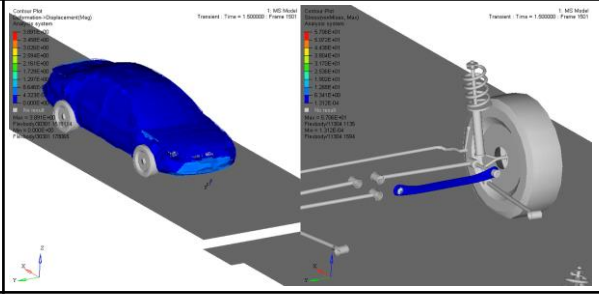
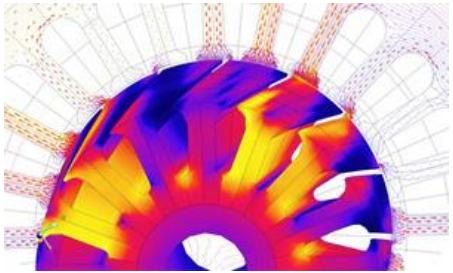
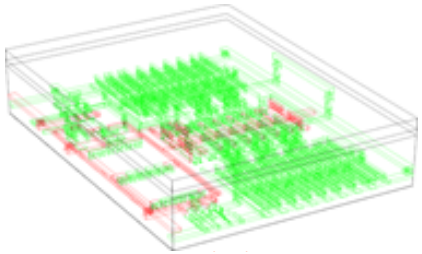
Flexible, Purpose-Driven Modeling



ALTAIR

Models: From 0D to 3D

	Suspension	E-Motor	Electronics
0D	$\begin{bmatrix}\dot{x}\\ y\end{bmatrix} = \begin{bmatrix}A & B\\ C & D\end{bmatrix} \cdot \begin{bmatrix}x\\ u\end{bmatrix}$	$\frac{\Theta(s)}{E_{in}(s)} = \frac{\alpha}{JRs^2 + \left(B_r R + \alpha^2\right)s}$	$\dot{x} = f(x,u,t)$ $y = g(x,u,t)$
1D			
3D			

MATH AND SCRIPTING WITH ALTAIR COMPOSE®

ALTAIR

A Digital Bridge from Present to Future: Altair Compose®

Present and Future Challenges

Converge and connect Simulation, Data Science and Engineering

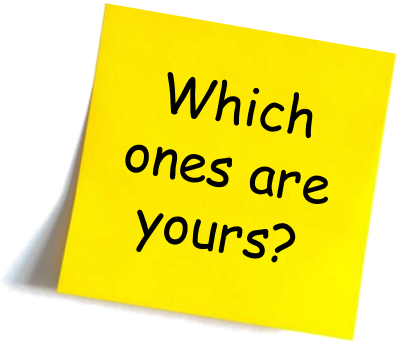
- More throughput/insight, faster with your CAE simulations

Reuse Math-based procedures invested over the years

- Commercial, well-supported tool compatible to MATLAB
  - Reduce dependence on MathWorks with minimal disruption
  - Reduce #1 largest spend ($) on engineering software

Foster new Technology horizons leveraging open-source languages

- Freedom & flexibility with scripting tools: synchronize MATLAB®, Python and user communities



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Different Tools for Similar Tasks

Altair Compose® - All-in-one Math Tool

MATLAB

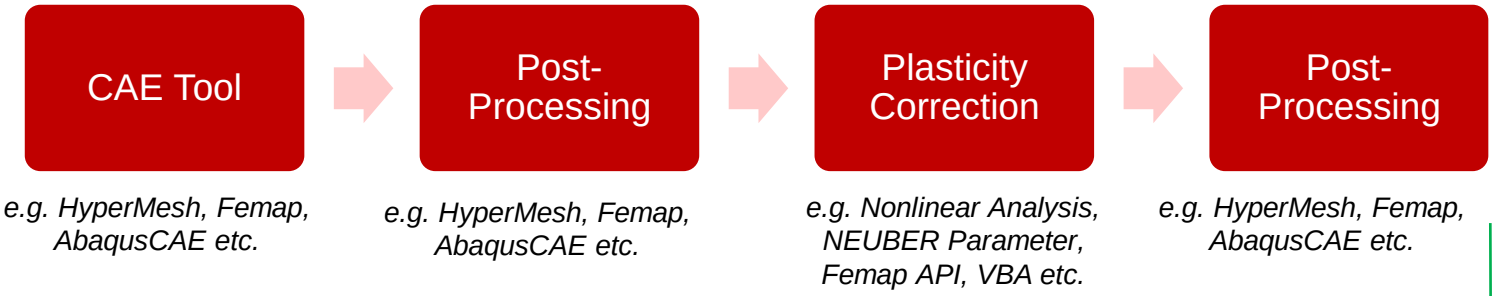
Python

MS Excel

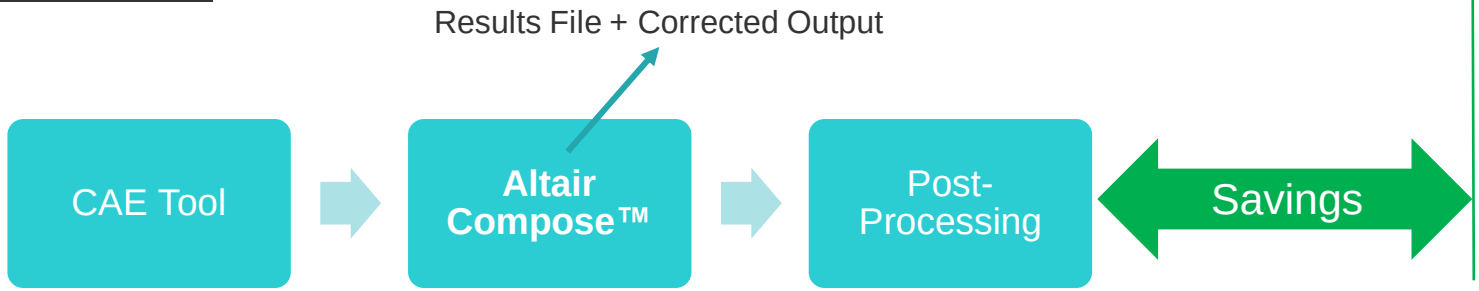
CAE Tools

DEMO: Altair Compose™ for Advanced Post Processing

Current Process:



Enhanced Process:



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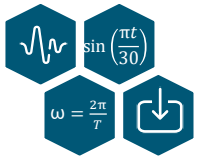
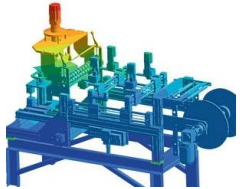
Our Solutions for Your Present Challenges: CAE Workflows



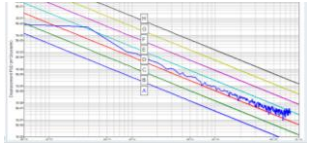
No Additional Toolboxes Required

Extensive Math and Engineering libraries available in a single, multi-functional tool



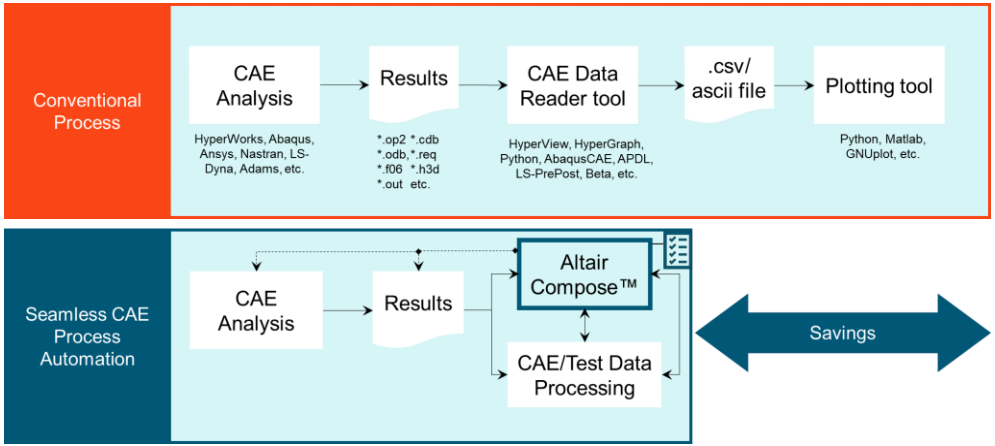
Solver-Neutral CAE Readers

Extremely simple and fast importation and manipulation of input and output data for CAE tools



Efficient Numerical Computing

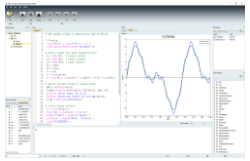
Hundreds of powerful Math functions applied for Data Science



Customer	Benefit
Sarcos	-81% time savings for human & exoskeleton evaluation
Mabe	Complete process automation from lab data preparation to simulation post processing
Altran	Shorter time-to-market due to >90% Simulation time reduction

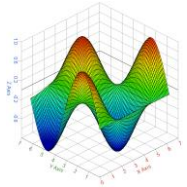
ALTAIR

Our Solutions for Your Present Challenges: Compose® Adoption



Compatibility with MATLAB®

High-level matrix-based language (OML) with syntax compatible with MATLAB®



Reuse of Legacy Data

OML leverages the reuse of past investments in other matrix-based languages

Domain	Customer Use Case	Effort
Signal Processing	• CAE & test data rocessing: NVH, fatigue & durability • Squeak & Rattle process automation	< 3 days
Statistics	• RMS & Rainflow cycles for accelerometers • Seat pull testing	< 3 days
Electromagnetics	• Wireless data transmission – Bianchi generation & link budget analysis	< 1 day
Plant & Control Design	• First-principles modeling and analysis of multi-axle vehicle & stability controller	< 1 day

NUMBER OF TOOLS CONVERTED

14

LINES OF CODE CONVERTED

160.000+

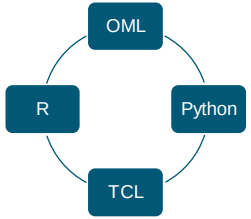
AVERAGE CARRY-OVER PERCENTAGE

95%

ALTAIR

Our Solutions for Your Future Challenges: Diversity

Open and Multi-language IDE
Support for OML *(Open-Matrix Language)*, Python, R and TCL



Interoperation of Different Languages
Supported languages are able to communicate and be part of the same workflow

- **Expand** OML functionalities with ready-to-use Python libraries, seamlessly
- **Increase usage** with custom, user-friendly GUIs around your proven Python scripts
- **Combine** different scripting languages without long-term migration and validation of existing *.m files to Python
- **Benefit** from strong technical support

NumPy
pandas
SciPy
matplotlib
TensorFlow
scikit learn

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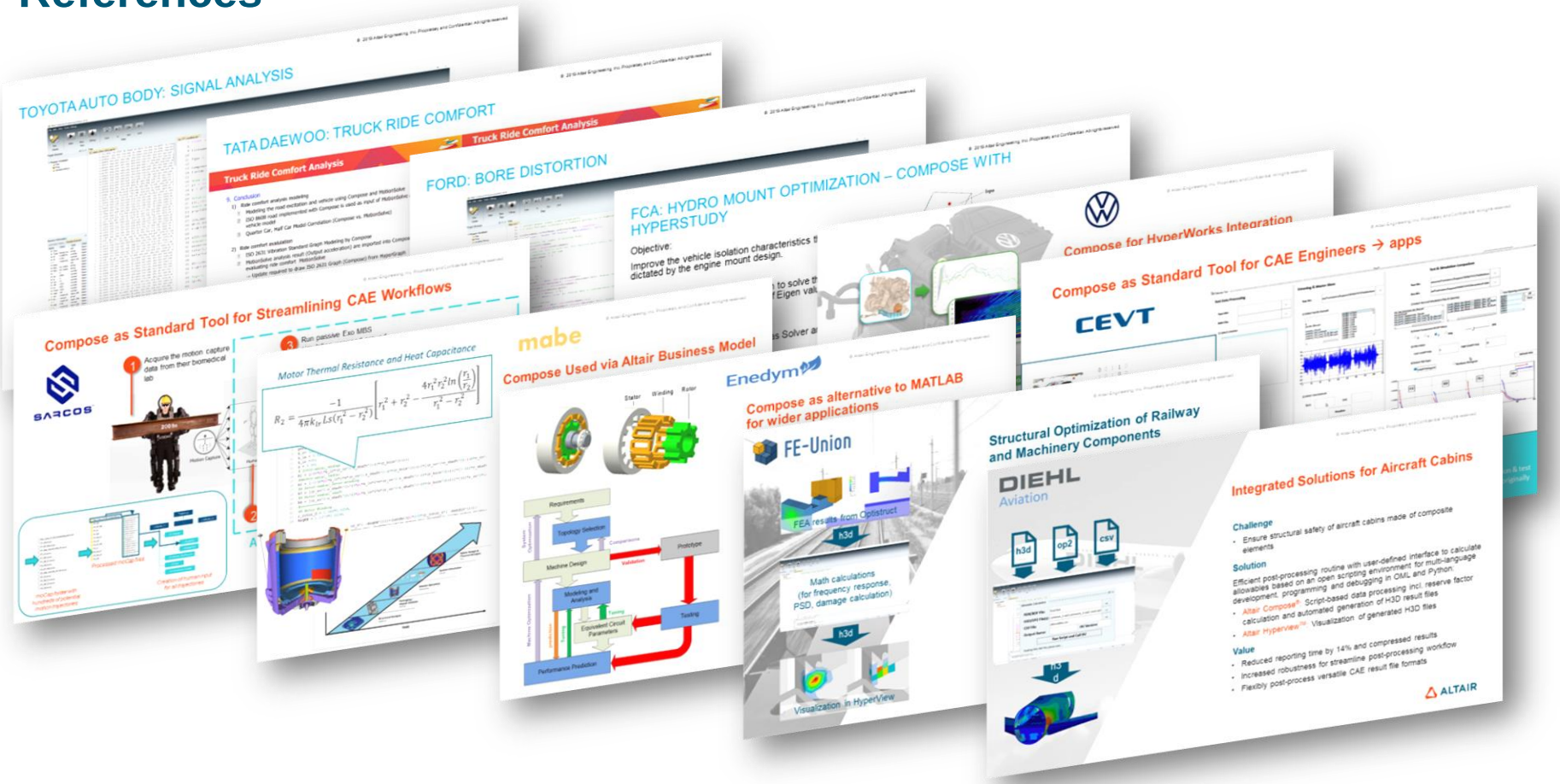
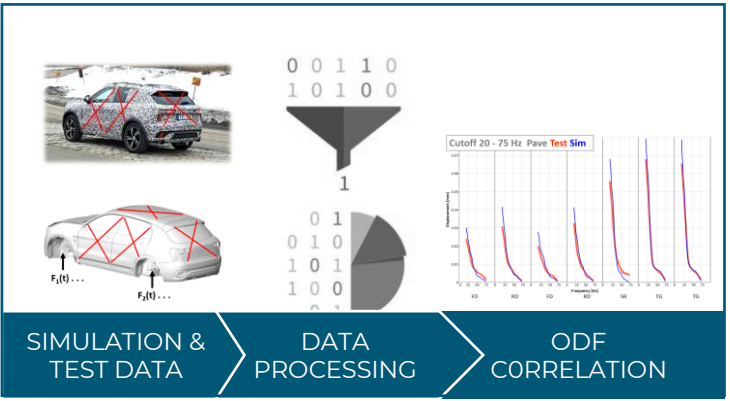
References

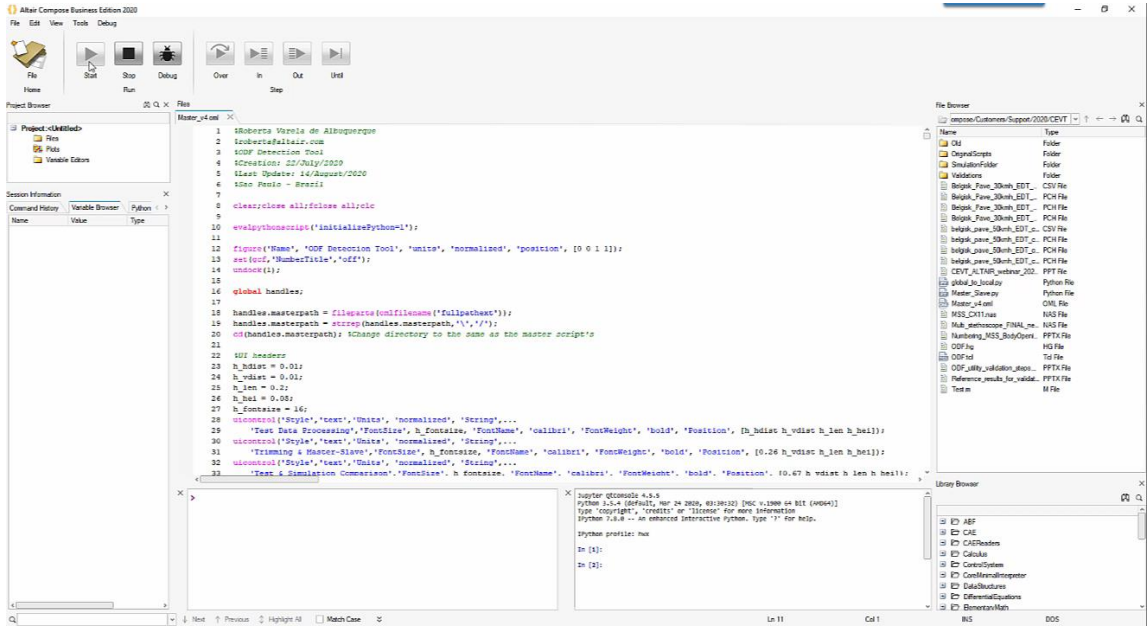


CEVT

NVH ODF Detection – 18X Faster With Altair Compose®

Unified Body Opening Distortion Fingerprint (ODF) app for simulation & test





CHALLENGE

A tedious 15 step process took **>3 hours** (using Python & META Post-processor) to calculate ODF

SOLUTION

Altair Compose® Process automation. 800+ inbuilt signal analysis functions with direct read of simulation & test channels as vectorized data

VALUE

From simulation & test results to ODF **in 10 minutes!** Data processing & visualization **18X faster** compared to the original process

Value Proposition – What to keep

Converge and connect Simulation, Data Science and Engineering

- ☑ **Streamline workflows** and automate processes for Math & Visualization of **CAE simulations and test results**

Reuse Math-based procedures invested over the years

- ☑ Democratization of a Math-based tool based on Altair Units
  - ☑ **Reuse legacy scripts** from MATLAB with minimal adjustment
  - ☑ **Immediate, significant cost savings** from the beginning while stepwise, use-case driven adoption

Foster new technology horizons leveraging open-source languages

- ☑ Open Environment for **multi-language development**, scripting, programming and debugging

ALTAIR

MULTIDISCIPLINARY SYSTEM SIMULATION WITH ALTAIR ACTIVATE®

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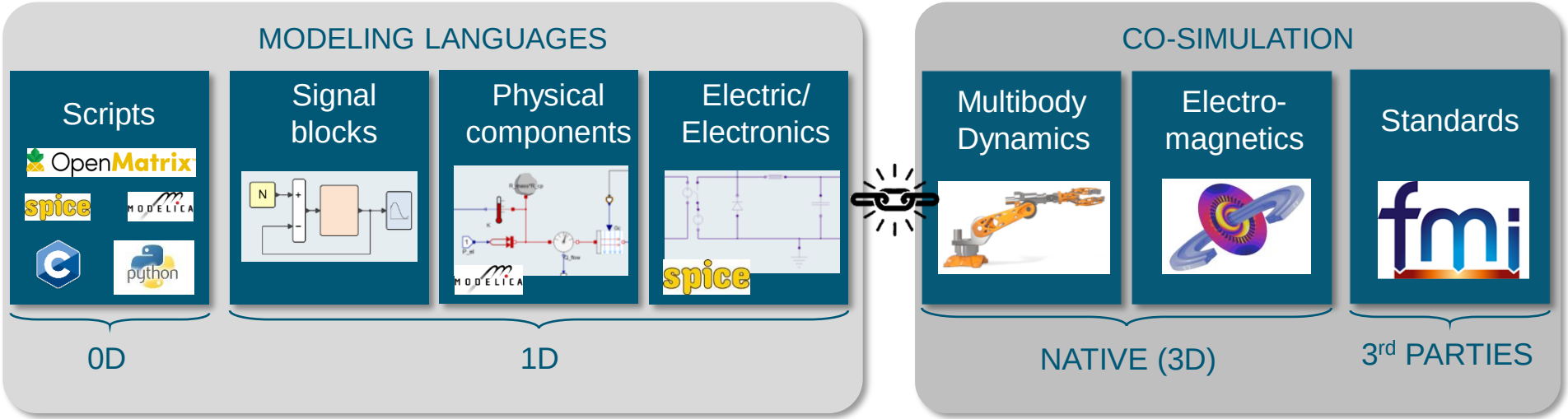
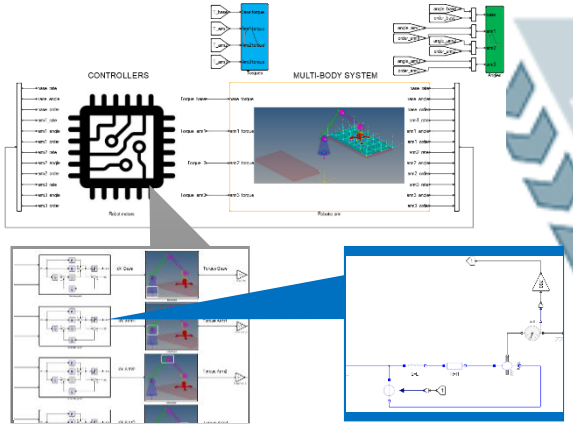
Altair Activate® – System Integration PLATFORM

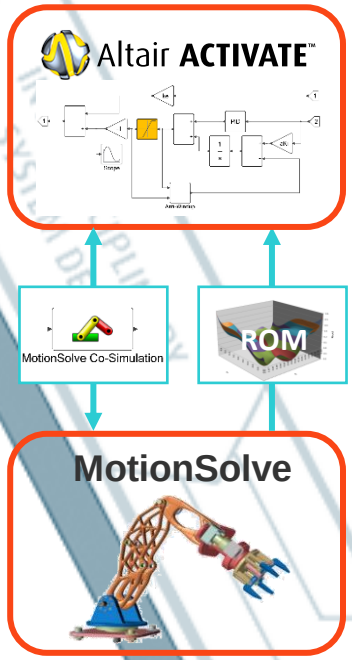


ALTAIR

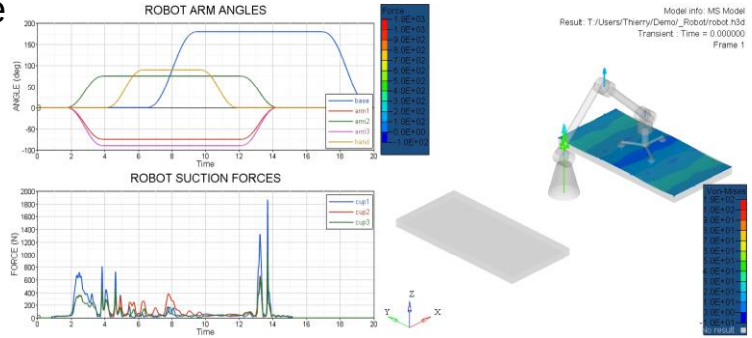
Closing Gaps: From System to Multi-Body-Simulation

- Suspension model on different levels of detail, i.e. signal based or physical to evaluate actuator's performance
  - **Activate**: System simulation environment to enhance dedicated MBS tools with multi-domain capabilities and evaluate cross-domain interdependencies

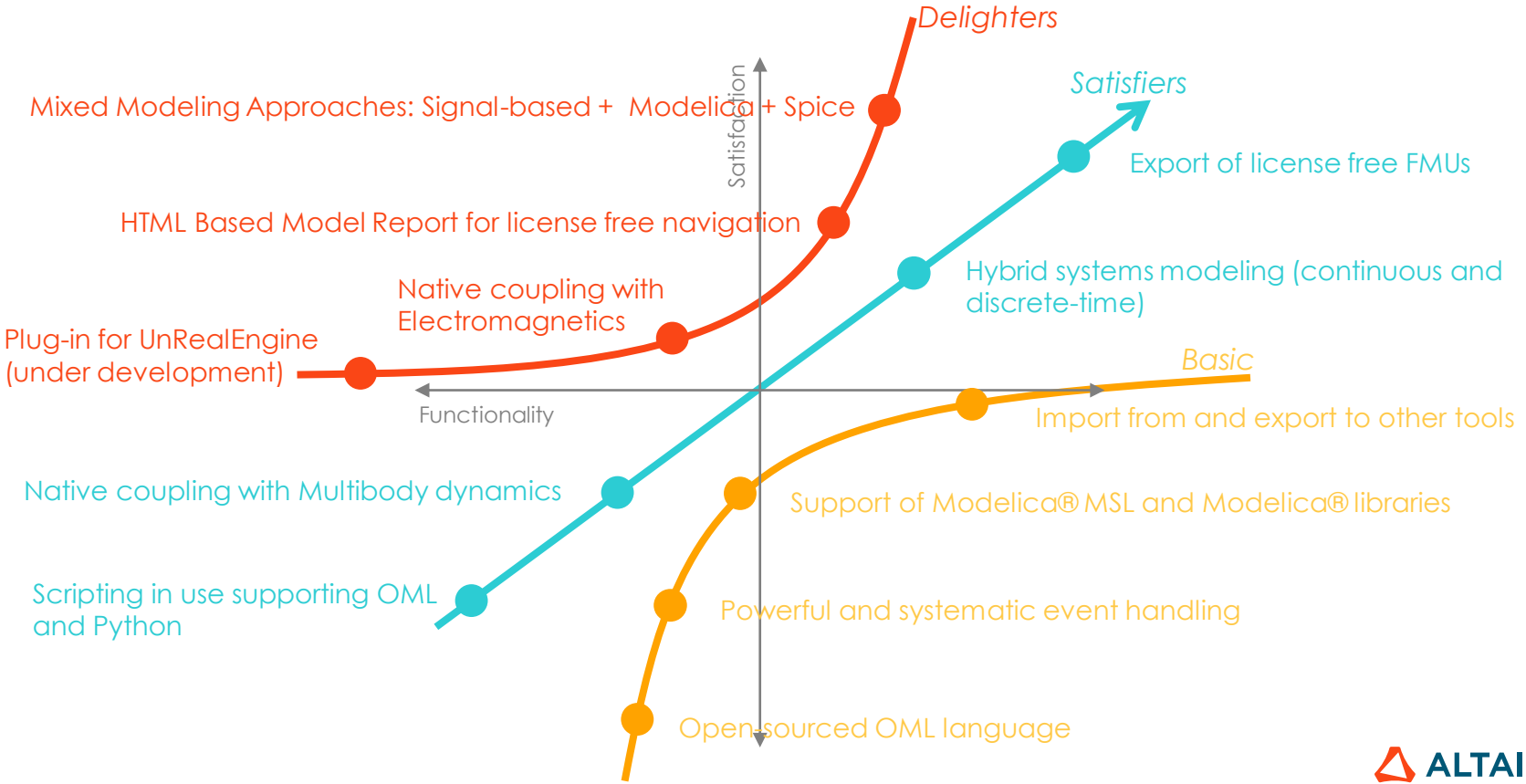




- Investigate stress, strain and deformations in flexible bodies in the vehicle system during pothole event
  - **MotionSolve**: Multi-body simulation tool incl. flexible bodies



Altair Activate® – Unique Features



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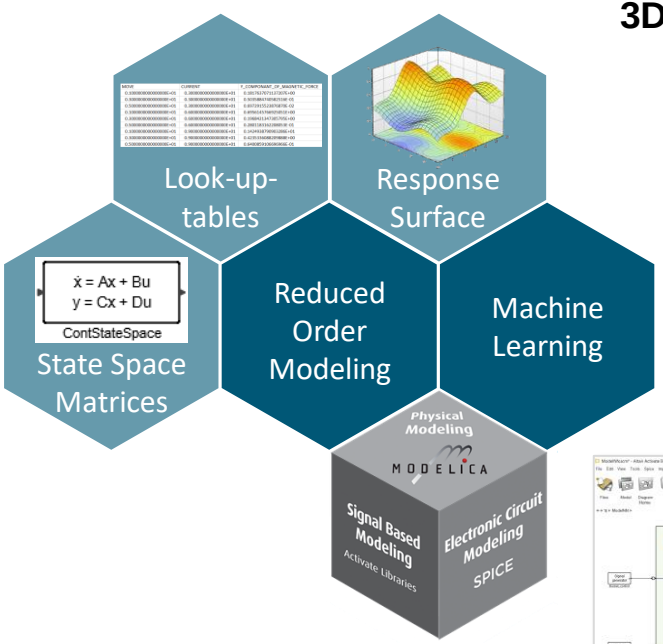
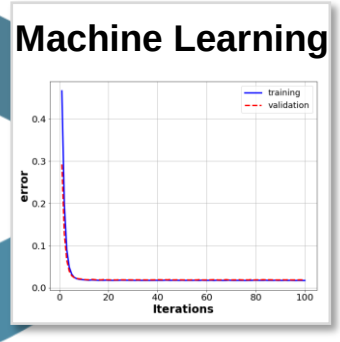
AI for Reduced Order Model Generation and System Identification

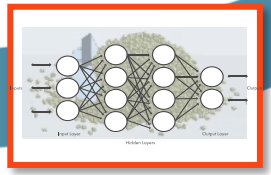


3D Analysis / Measurement

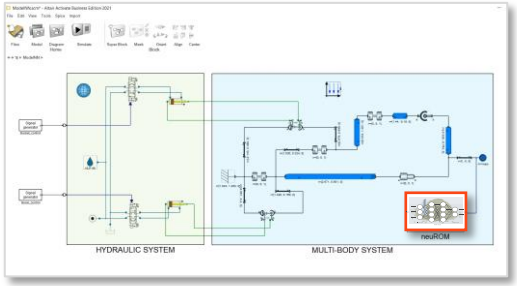
Training Data

$$\begin{bmatrix} u(t_i) \\ y(t_i) \end{bmatrix}$$





romAI



System Simulation

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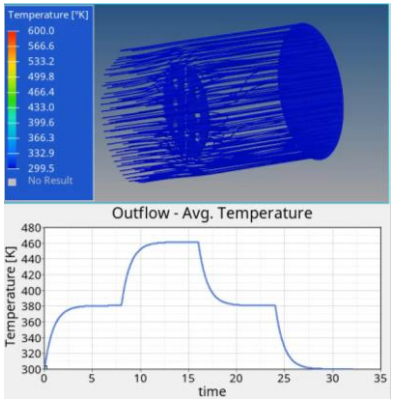
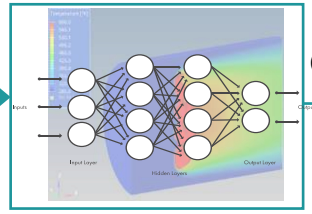
romAI™: Application Examples

CFD



Input: u

P_{el}

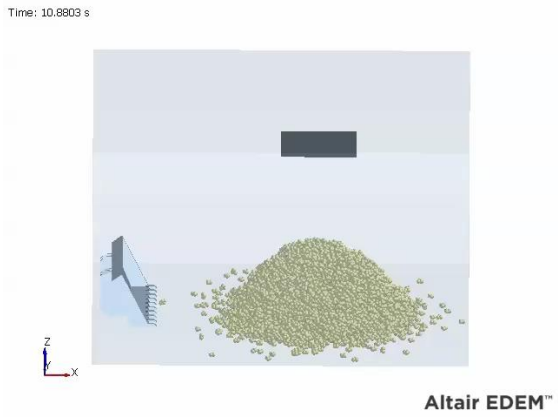


Output: y

T_{out}

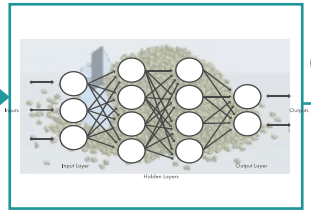
Speed-up factor: 3 000

DEM



Input: u

$x, \dot{x},$
$z, \dot{z},$
ϑ_y, ω_y

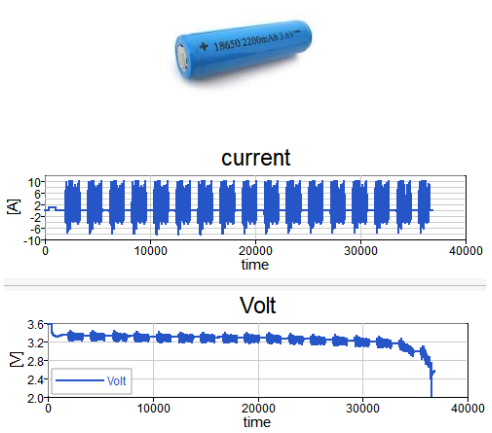


Output: y

F_x
F_z
T_y

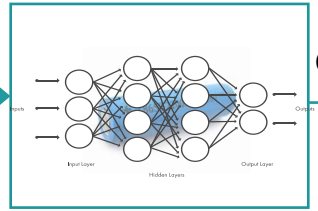
Speed-up factor: 60

Battery Test Data



Input: u

i

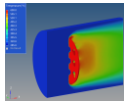


Output: y

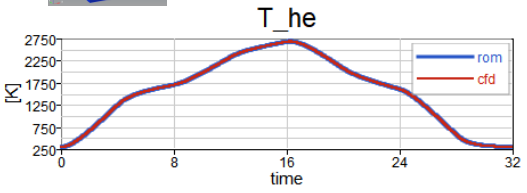
V

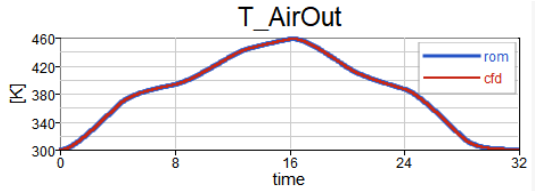
Speed-up factor: n.a.

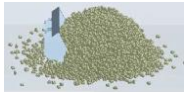
romAI™: Application Examples - Validation



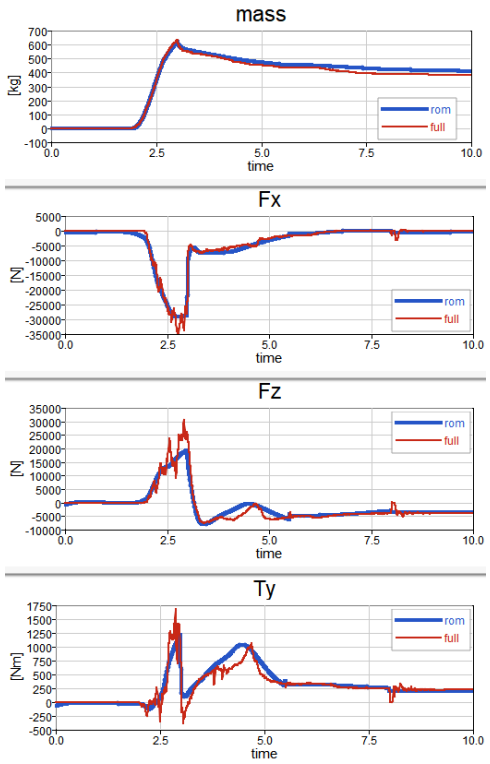
CFD



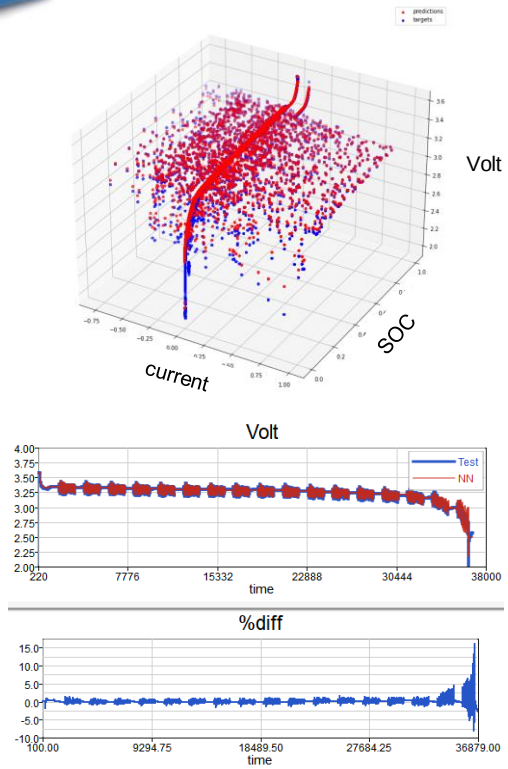




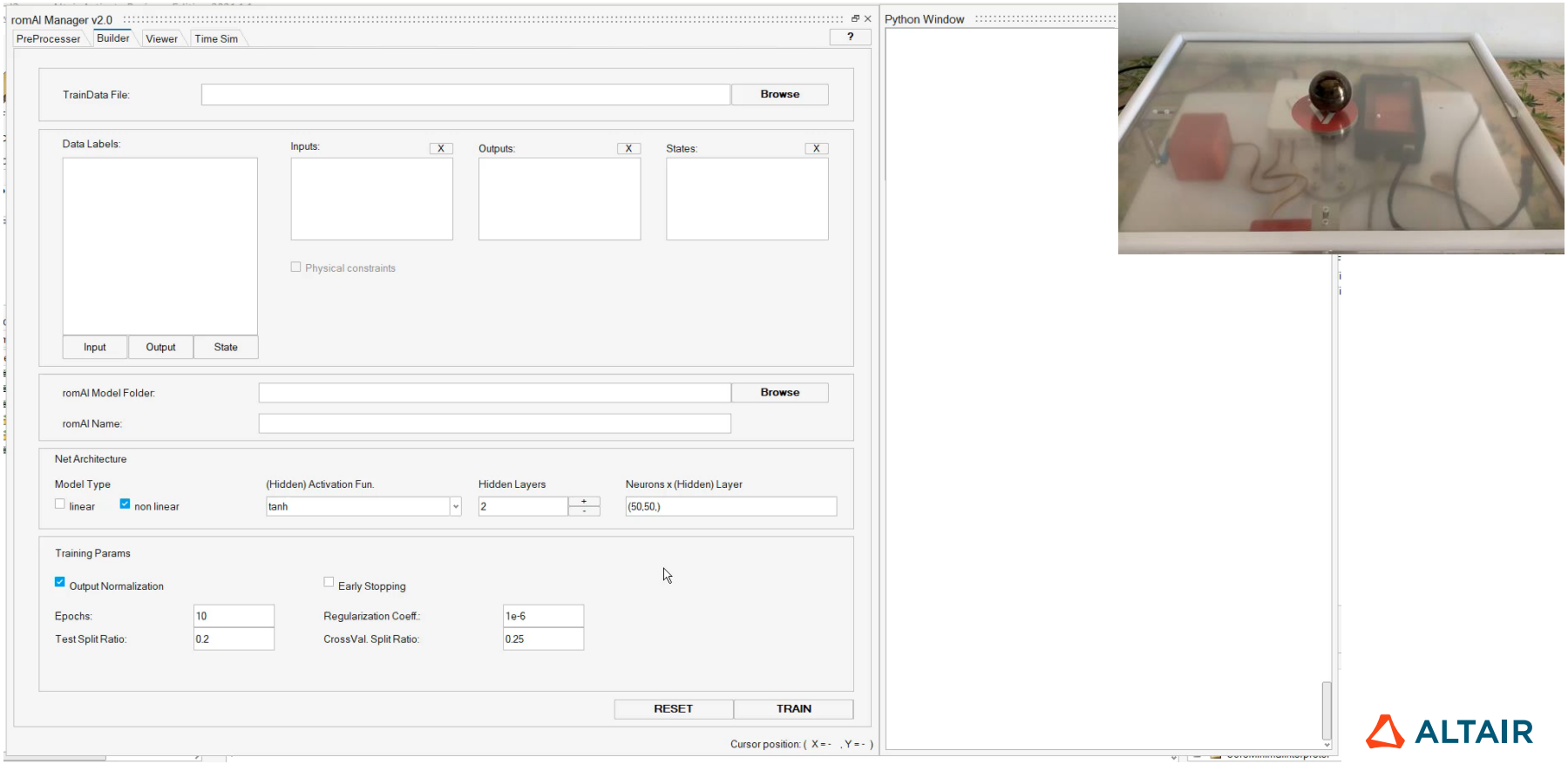
DEM



Battery Test Data



romAI™ generation using Altair Compose®



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USE CASES

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Mechatronic System: Human-Cobot-interaction

Description

GOAL:

- Cobot contact forces do not exceed a certain threshold in case of an impact

REQUIREMENT:

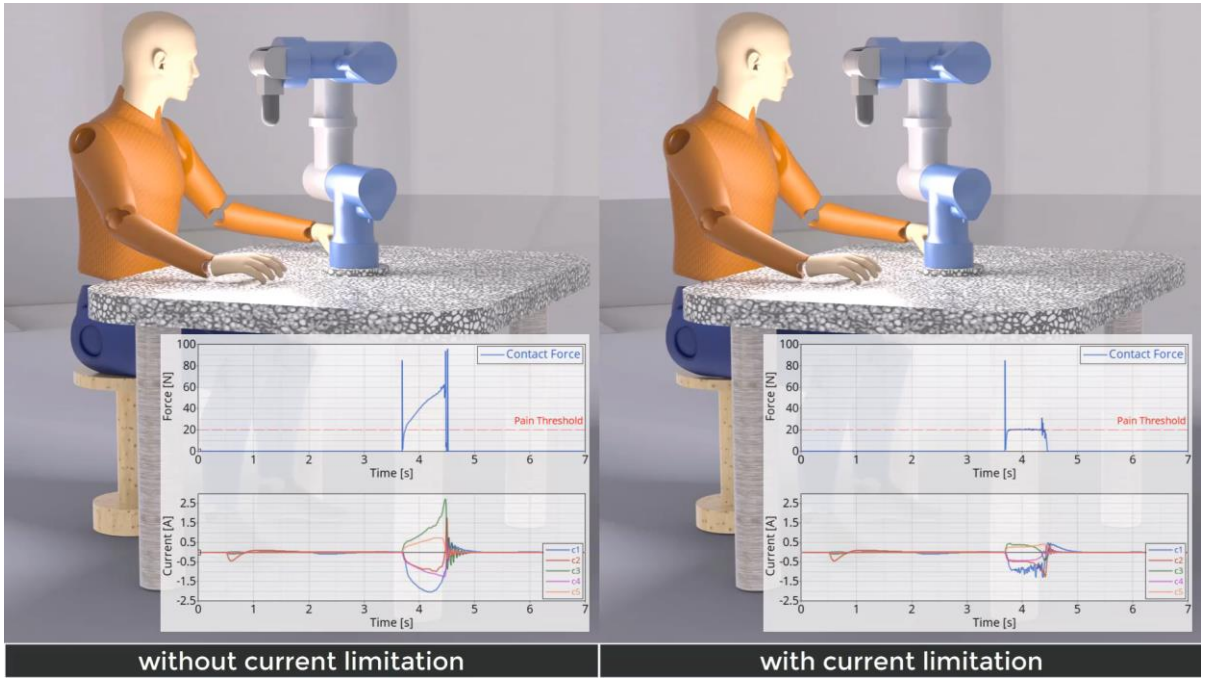
- Accurate model of the contact between the dummy and the cobot

SOLUTION:

- 3D modeling of the plant

Mechatronic System: Human-Cobot-Interaction

Results



- Cobot contact forces do not exceed a certain threshold in case of an impact
- Accurate model of the contact between the dummy and the cobot
- 3D modeling of the plant

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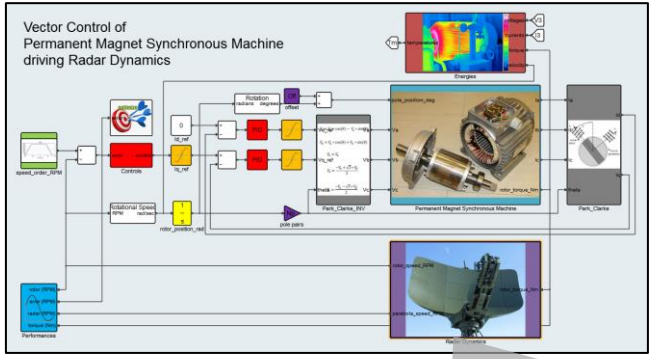
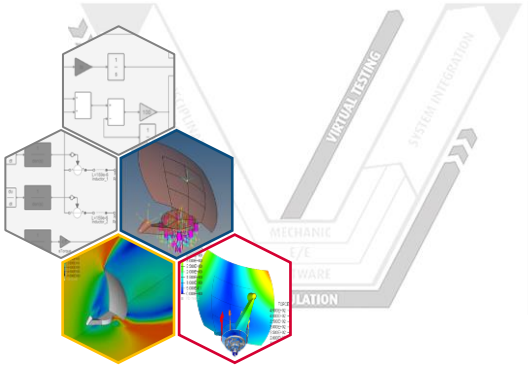
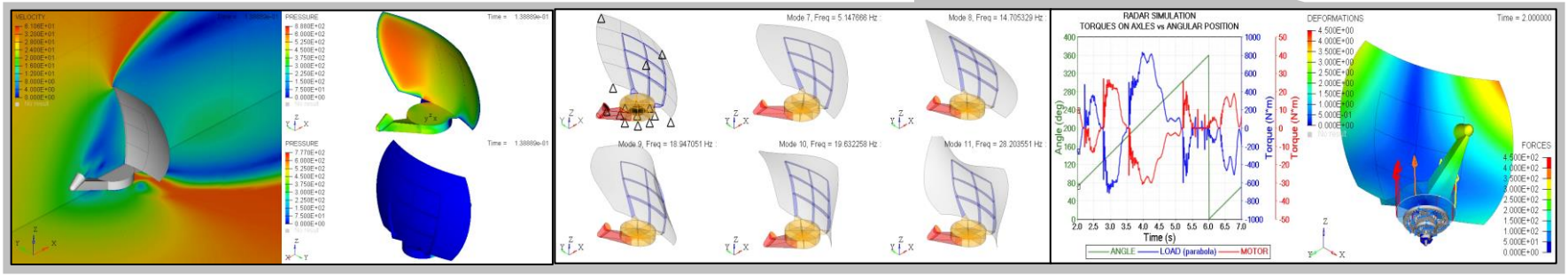
Radar Antenna: (Aero)Dynamics + Vibration

- Level 1:
  - Modelica® + Look-up tables (CFD results)
- Level 2:
  - Modelica® + state matrices (MBS)
- Level 3:
  - MBS co-simulation + aerodynamic loads (CFD)







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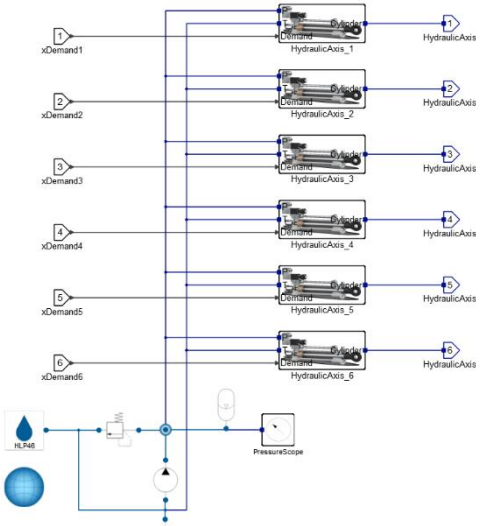
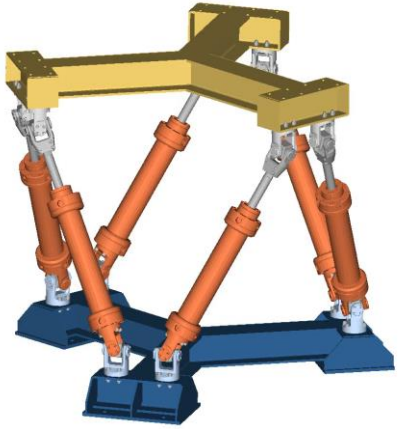
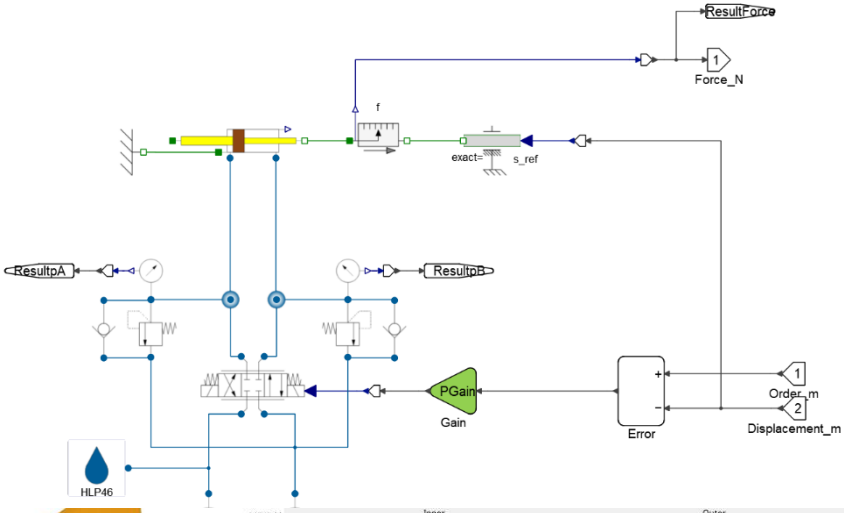
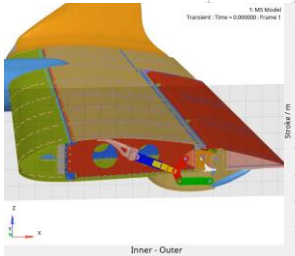
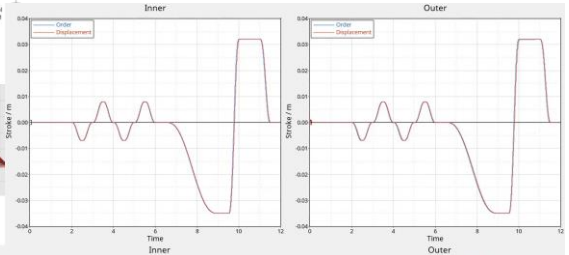
Hydraulically actuated mechanisms

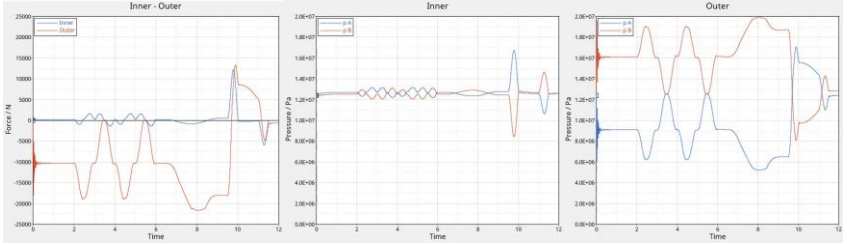


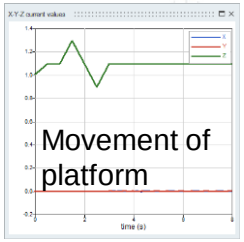


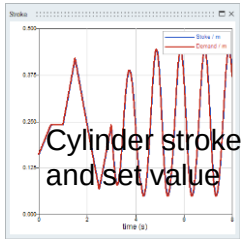


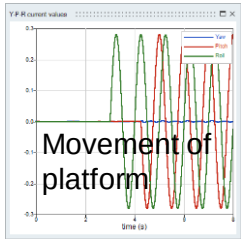


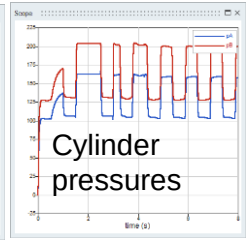












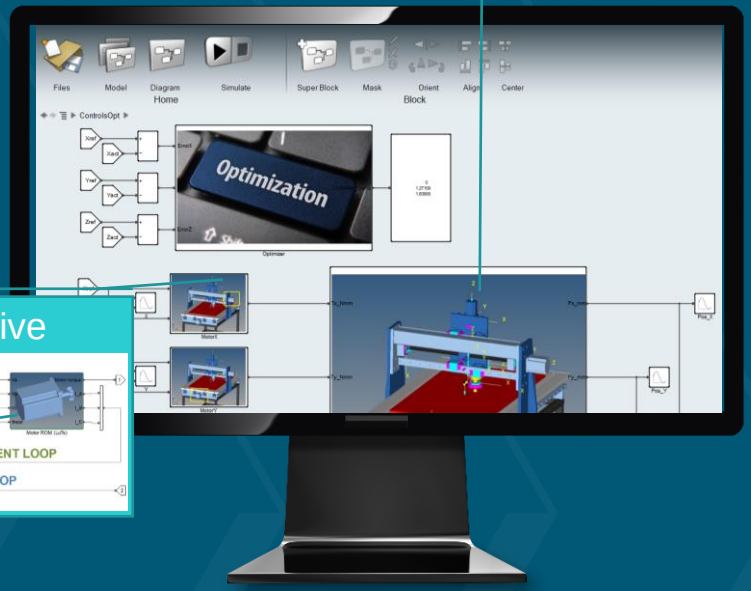
Optimization of a CNC Milling Machine

Improving speed & precision

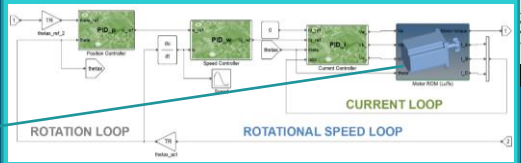
Optimizing the dynamic interaction of multiple system components combining

- 3D Finite Elements Analysis
- Multi-Body Dynamics and
- System simulation

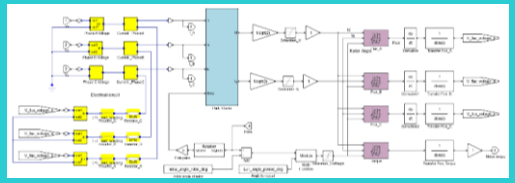
Multi Body Dynamics Model



Cascade Controller Drive



Efficient Motor Model



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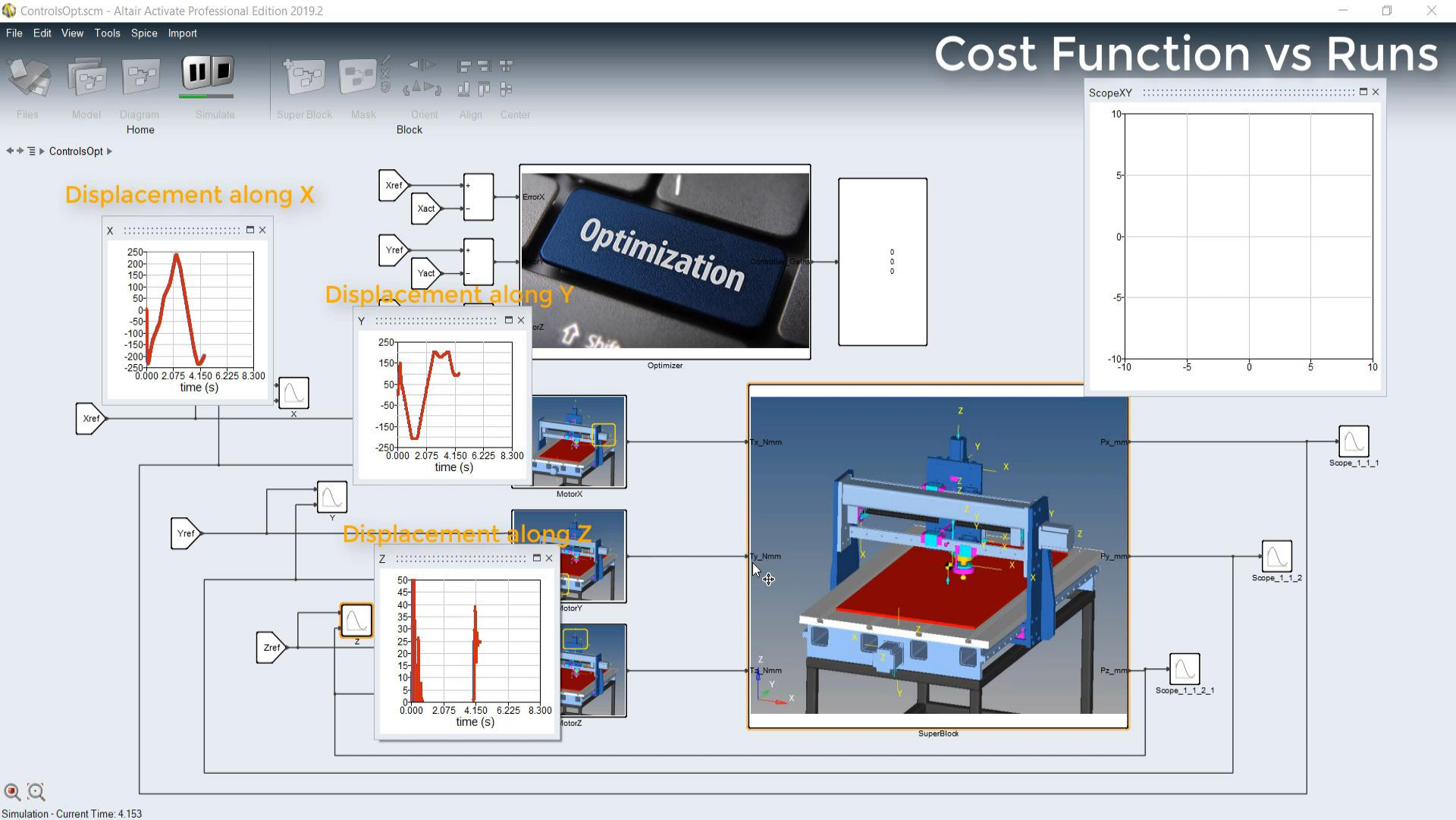
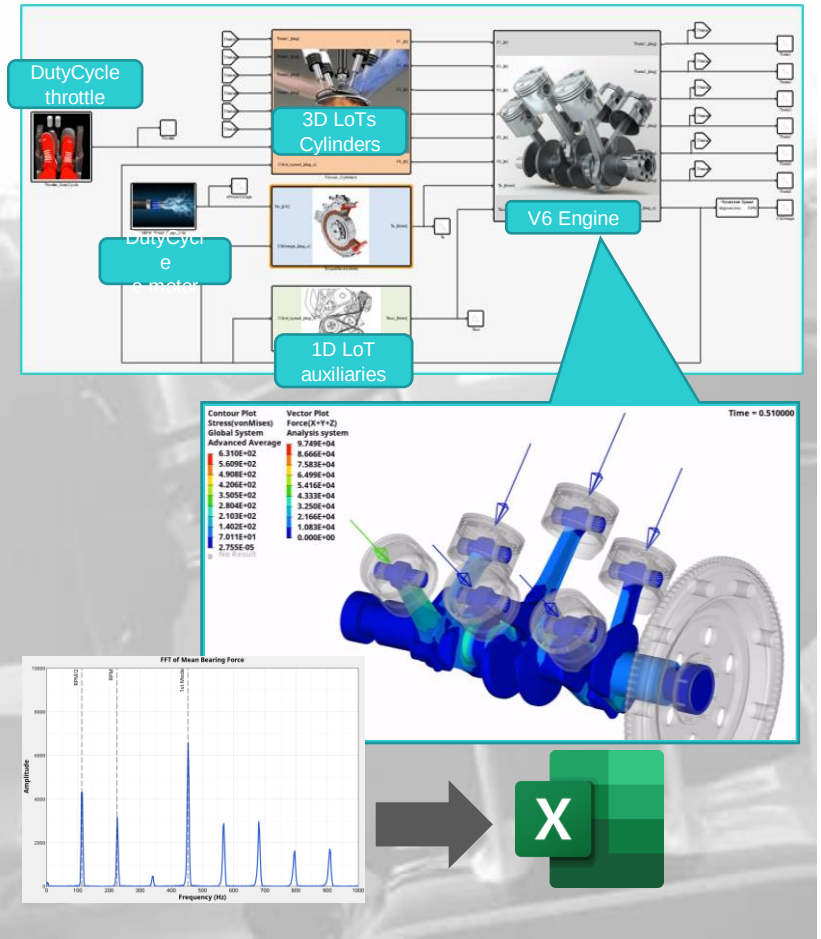

ControlsOpt.scm - Altair Activate Professional Edition 2019.2
File Edit View Tools Spice Import
Files Model Diagram Simulate Super Block Mask Orient Align Center
Home Block
ControlsOpt
Cost Function vs Runs
Displacement along X
Displacement along Y
Displacement along Z
ScopeXY
Optimization
Optimizer
SuperBlock
MotorX
MotorY
MotorZ
time (s)
Simulation - Current Time: 4.153



V6 HYBRID power unit

Challenge

Target conflict between strict budget reductions, more accurate simulation models and democratization of analysis methods

Solution

Simulation environment based on Altair tools with an Excel interface:

- Modular, parametric system model (Activate®)
- Structural 3D analysis of crankshaft and cylinders (MotionSolve™)
- Automated model set-up, simulation, and post processing realizing an Excel interface (Compose®)

Value

- Reduce software spend
- Simplify simulation environment
- Enhance simulation capabilities
- Spread simulation know-how across the company

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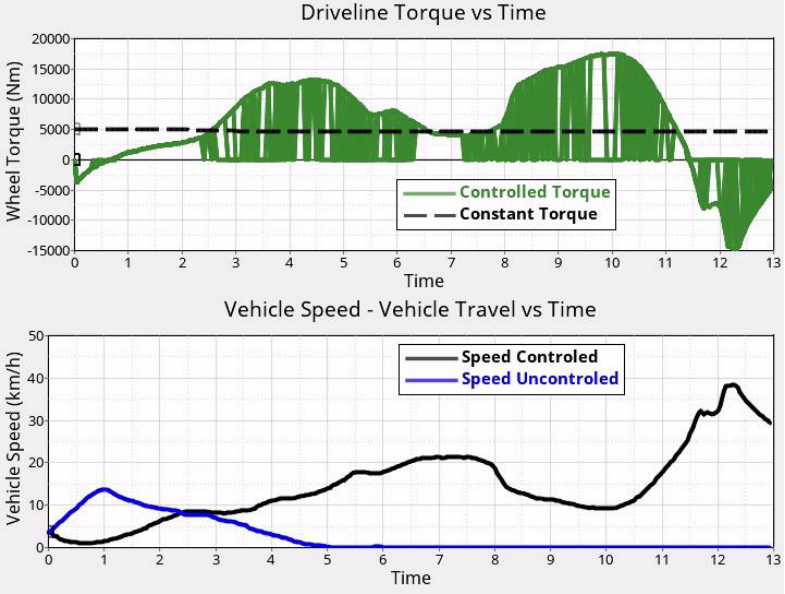
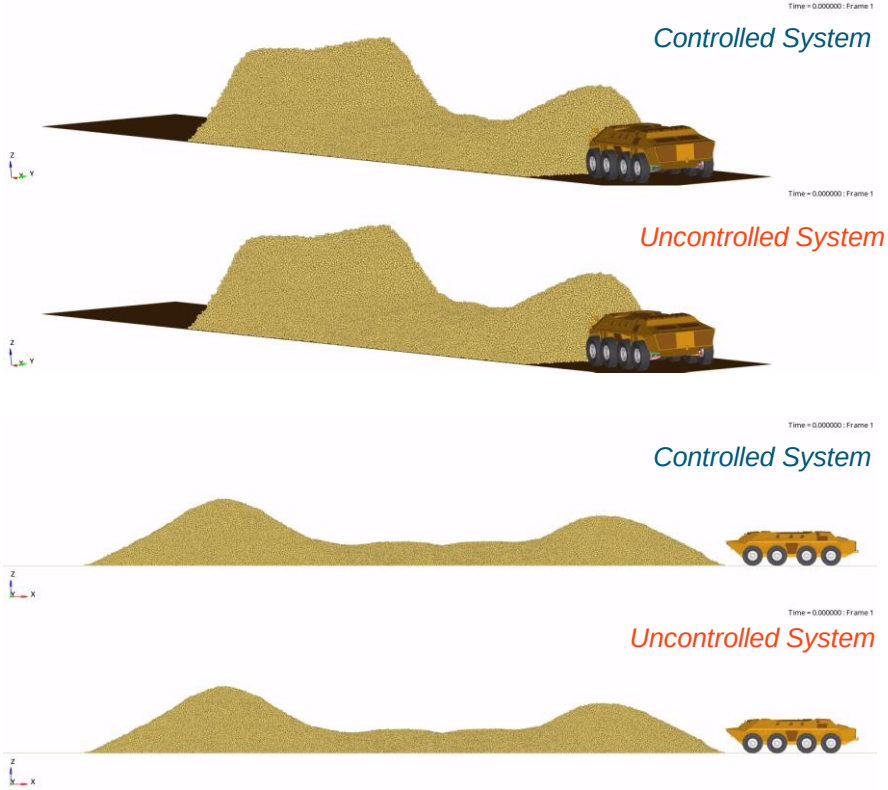
1D-3D Interaction for Traction-Control

Driveline Control Comparison

Driveline control vs Constant Torque (Uncontrolled Driveline)





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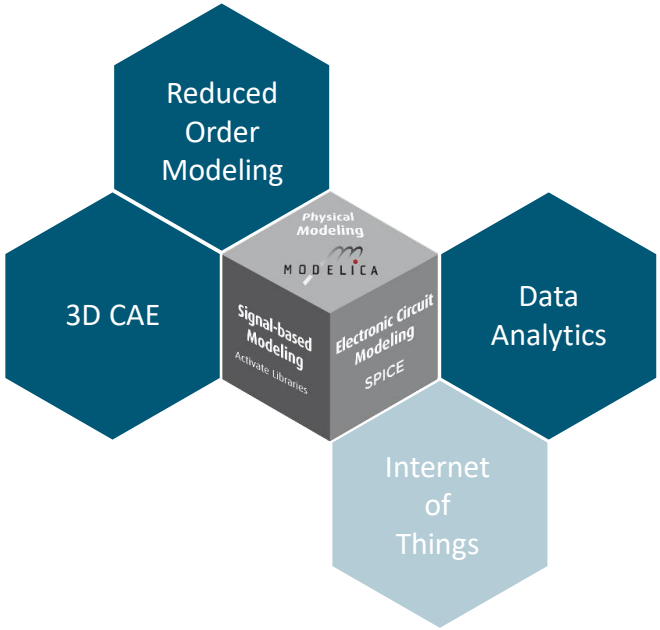
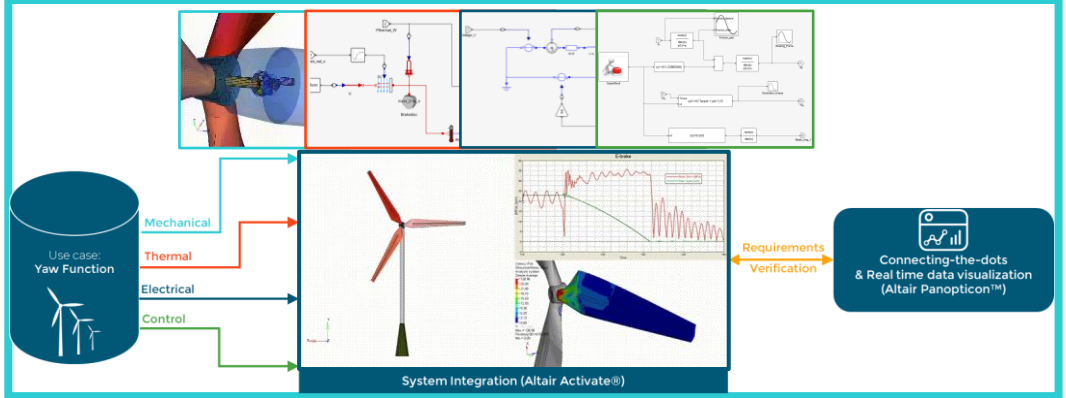
Altair System Integration for Wind Turbines

Helps Break Siloed Mechatronic Product Development



Holistic performance optimization upfront during concept development (Activate®) combined with real-time data visualization & dashboarding (Panopticon™)



AFTER

Benefits:

1. Better teamwork
2. Streamlined Mechatronic product development;
3. Estimated efficiency gain of 6 months
4. Estimated warranty savings of 10%

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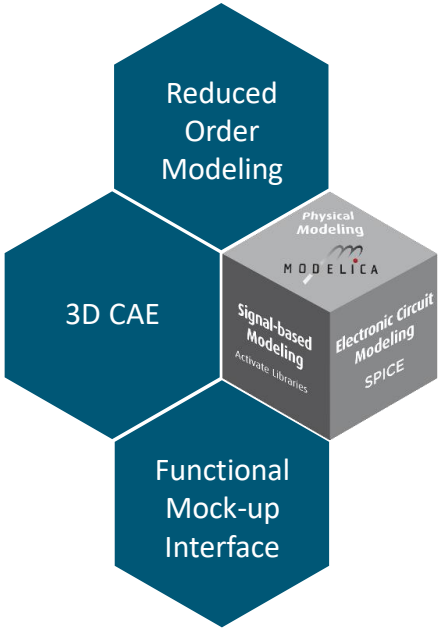
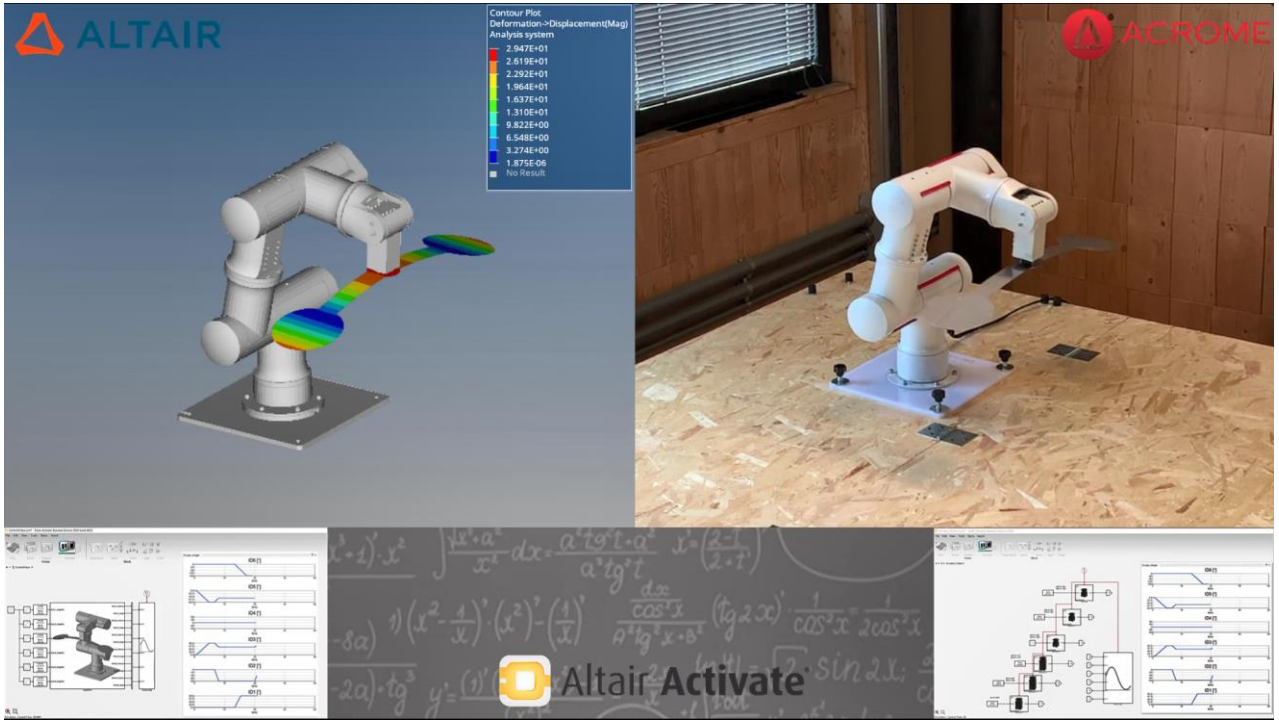
Digital Twin for Mechatronics: Acrobot



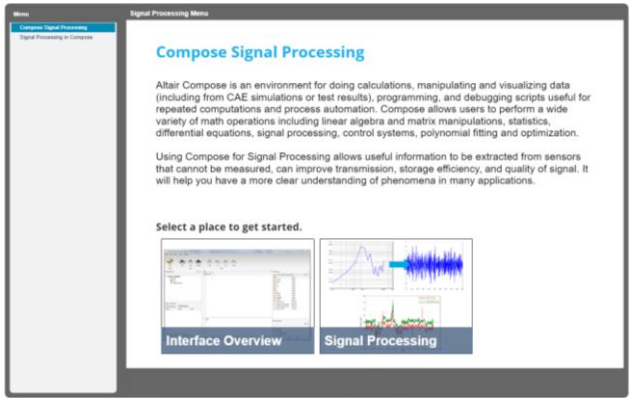


REFERENCES

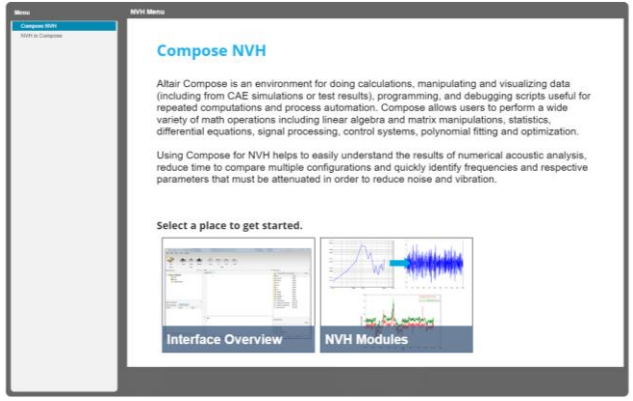
Industrial References

E-Learning Material

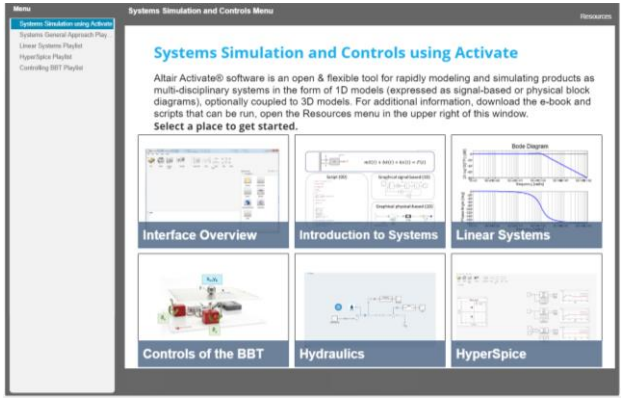
Signals Processing



NVH in Compose



System Simulation & Controls



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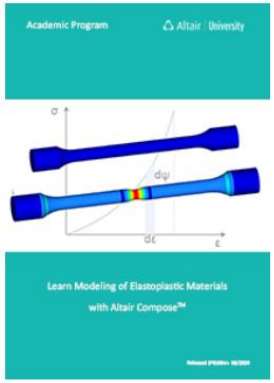
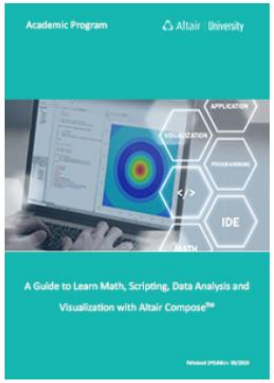
E-Books

Free eBooks

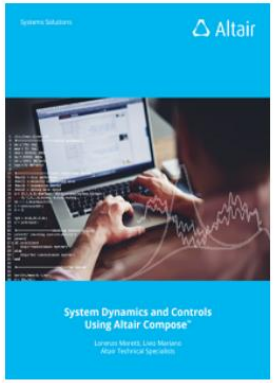
compose Sort



Learn Modeling of Elastoplastic Materials with Altair Compose

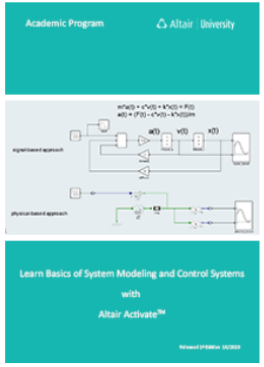


Math, Scripting, Data Analysis & Visualization with Altair Compose



E-book for System Dynamics and Controls Using Altair Compose

activate Sort



Learn Basics of System Modeling and Control Systems with Altair Activate

ALTAIR

Altair as strategic partner for simulation-driven innovation

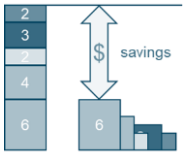
Handling Complexity

- Manage Risks due to Product Complexity
- Optimizing mechatronic product performance holistically as system-of-systems (using physics-based Digital Twins)

Facilitating Teamwork

- Accelerate Time-to-Market
- Breaking down silos between mechatronic disciplines (Mechanical, Electrical, Controls, etc.)

Managing Costs



- Reduce Development Costs
- Streamline Product Development teamwork & tool set, affordably

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Unique Tools for Model-Based Development

https://www.altair.com/systems-modeling-applications/

Products download

connect.altair.com | basicportal.altair.com

Altair MBD Forum

https://community.altair.com/community?id=altair_forums#products

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