100 Use Cases Later:

What AI Has Taught Us About Engineering

Track 1 : Where Physics Meets AI

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Ujwal Patnaik

Sr Director of Product Strategy

26th June 2025, Irvine, California

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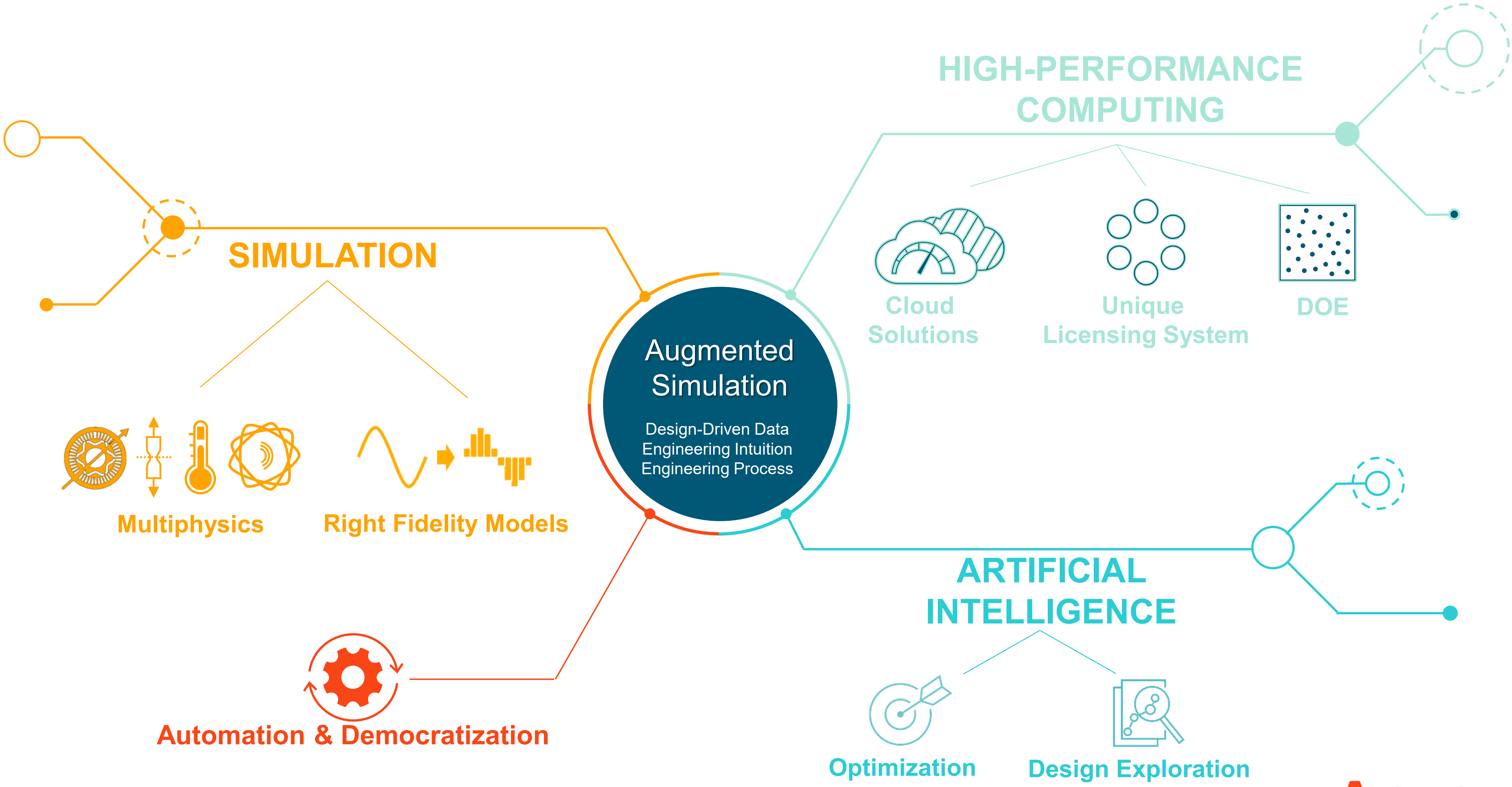
AI Powered Engineering



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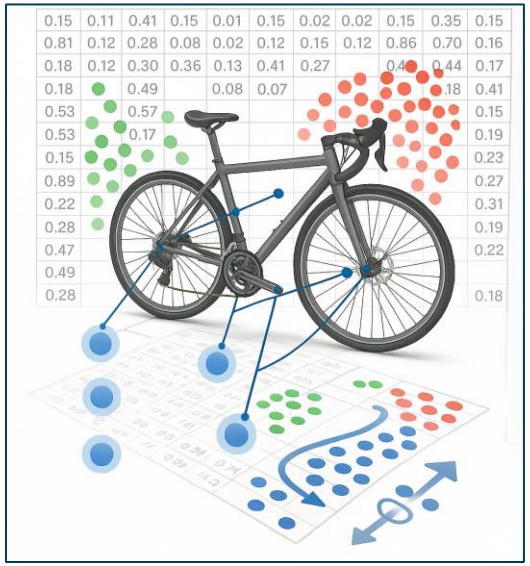
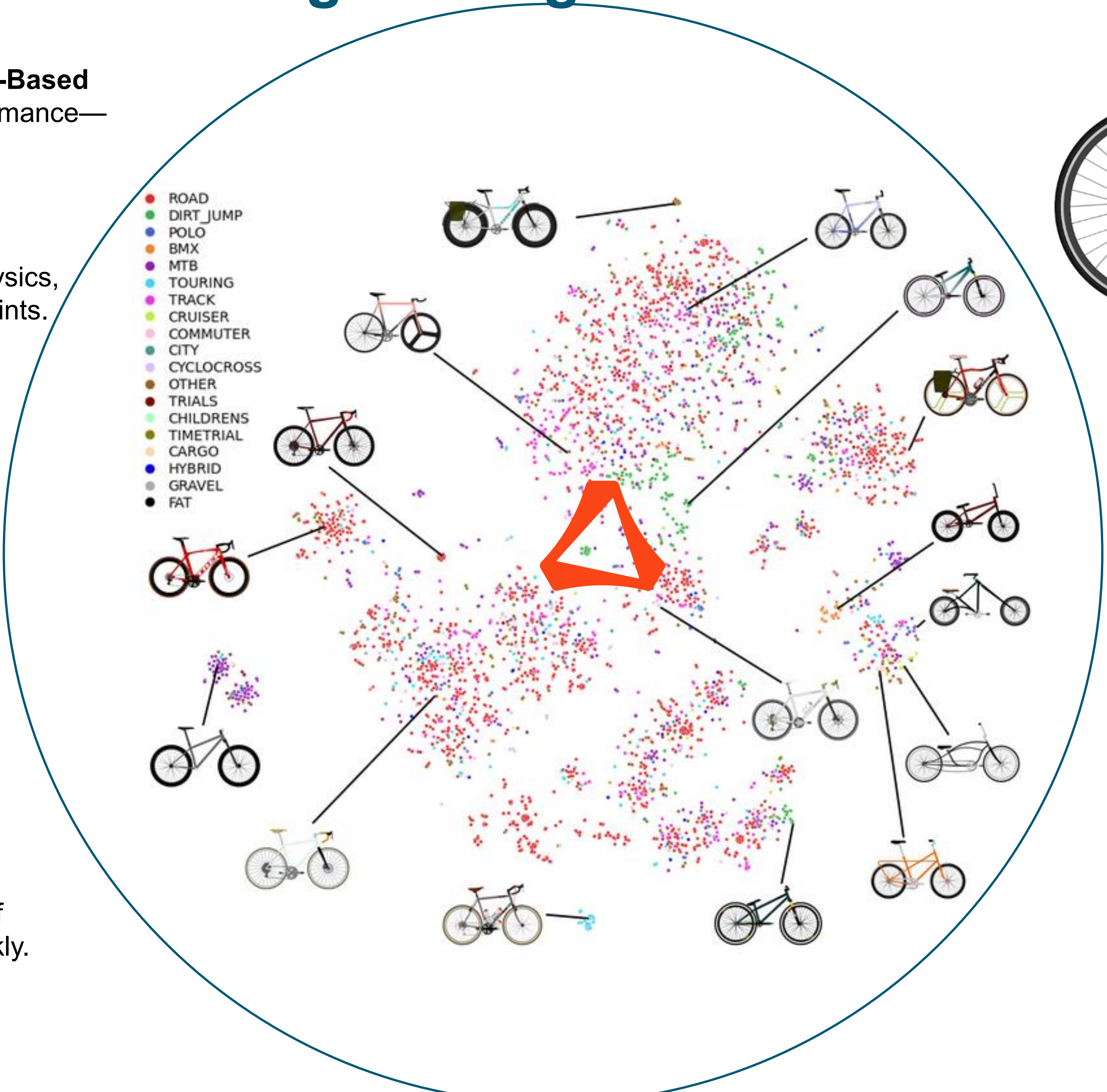
A Concept of AI-Powered Engineering

Performance-Driven, Not Just Similarity-Based
Designs are optimized for real-world performance—not just trained to mimic past examples.

Physics + Constraints Built In
Tools like *Inspire* and *PhysicsAI* embed physics, design rules, and manufacturability constraints.



Massive Design Space Exploration
Enables engineers to explore thousands of high-performing, feasible alternatives quickly.



Simulation-Backed Intelligence
AI integrates seamlessly with FEA, CFD, and MBD for physically valid, production-ready outputs.

Better, Not Just New
Outputs are explicitly optimized for strength, weight, and compliance—delivering true innovation.

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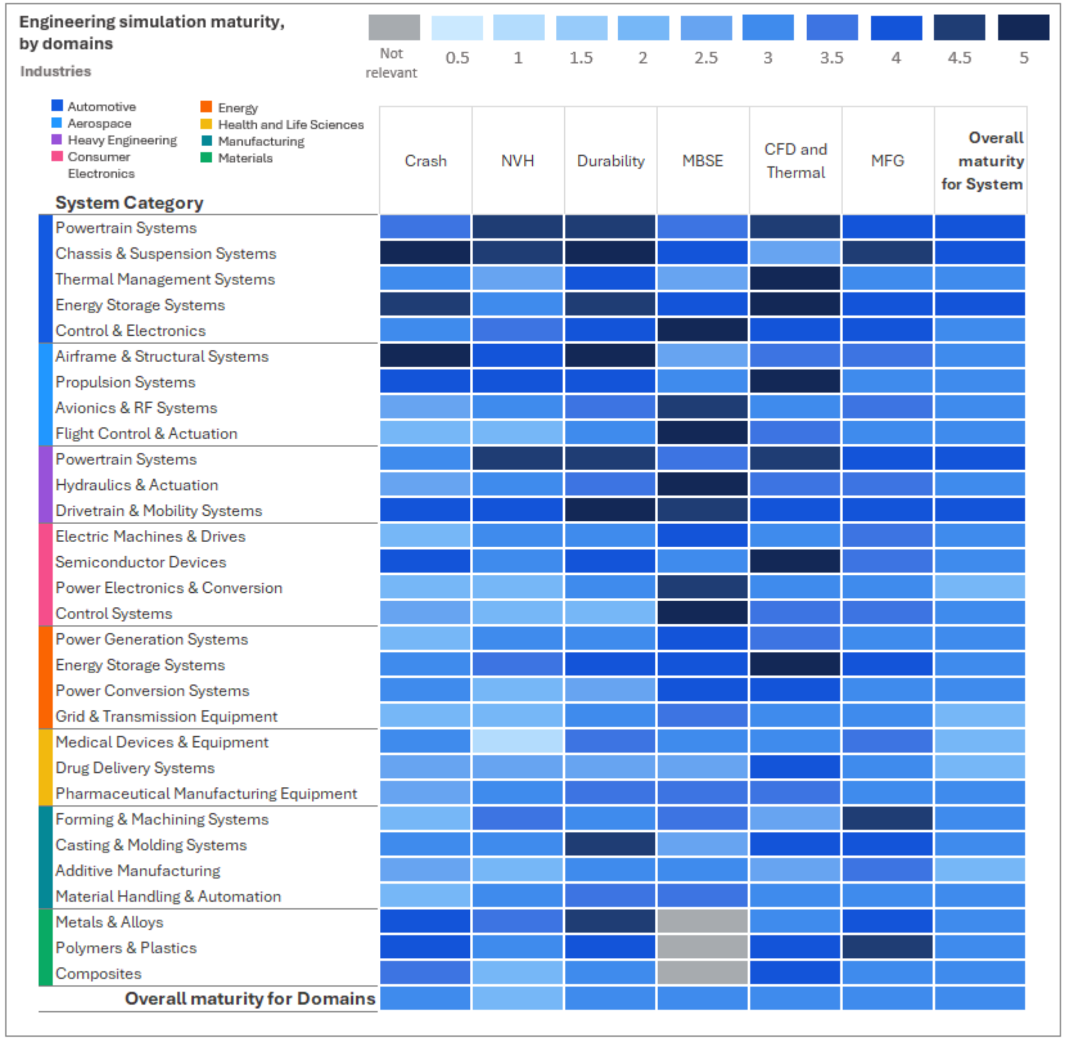
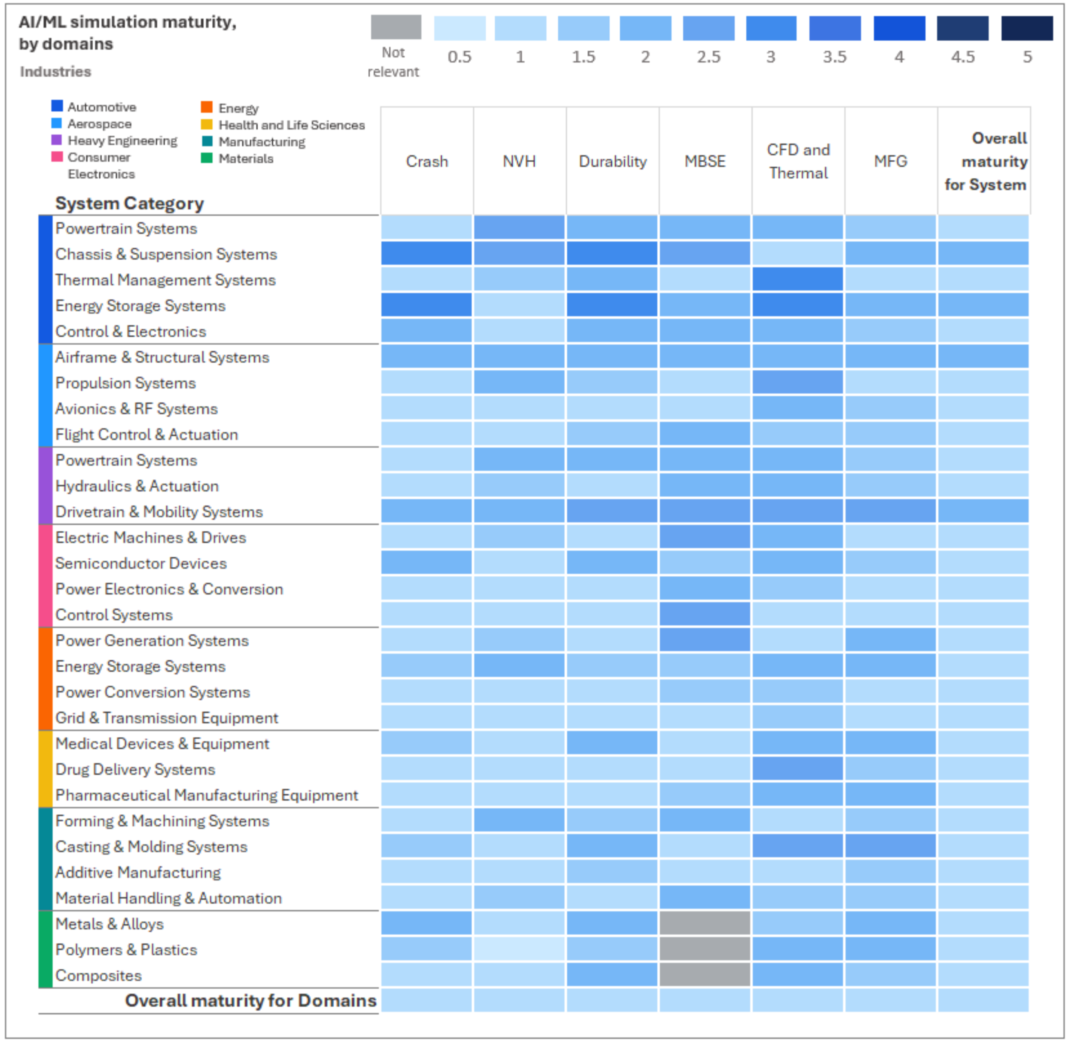
AI-Powered Engineering Maturity: Use Cases

Engineering simulation maturity averages 3.4 across the system



AI/ML simulation maturity averages 1.6 across the system



Courtesy Altair AI Use Cases

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What's in the 100?

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Industries Accounted

7+

Automotive, Aerospace and Defence, Heavy Engineering, Manufacturing, Health and Life Sciences, Consumer Electronics, Energy

Engineering User Personas

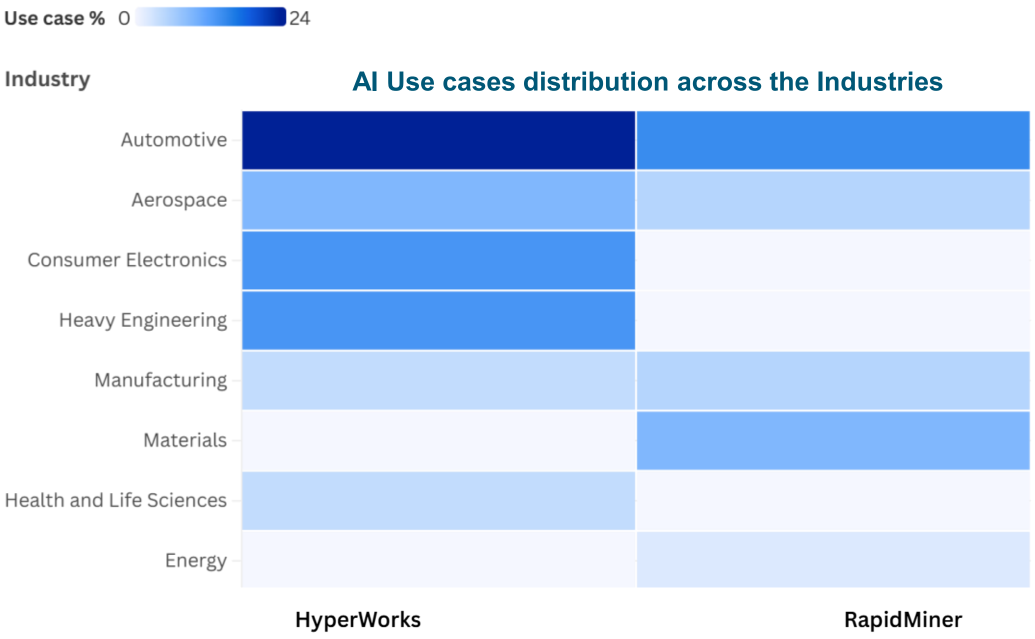
10+

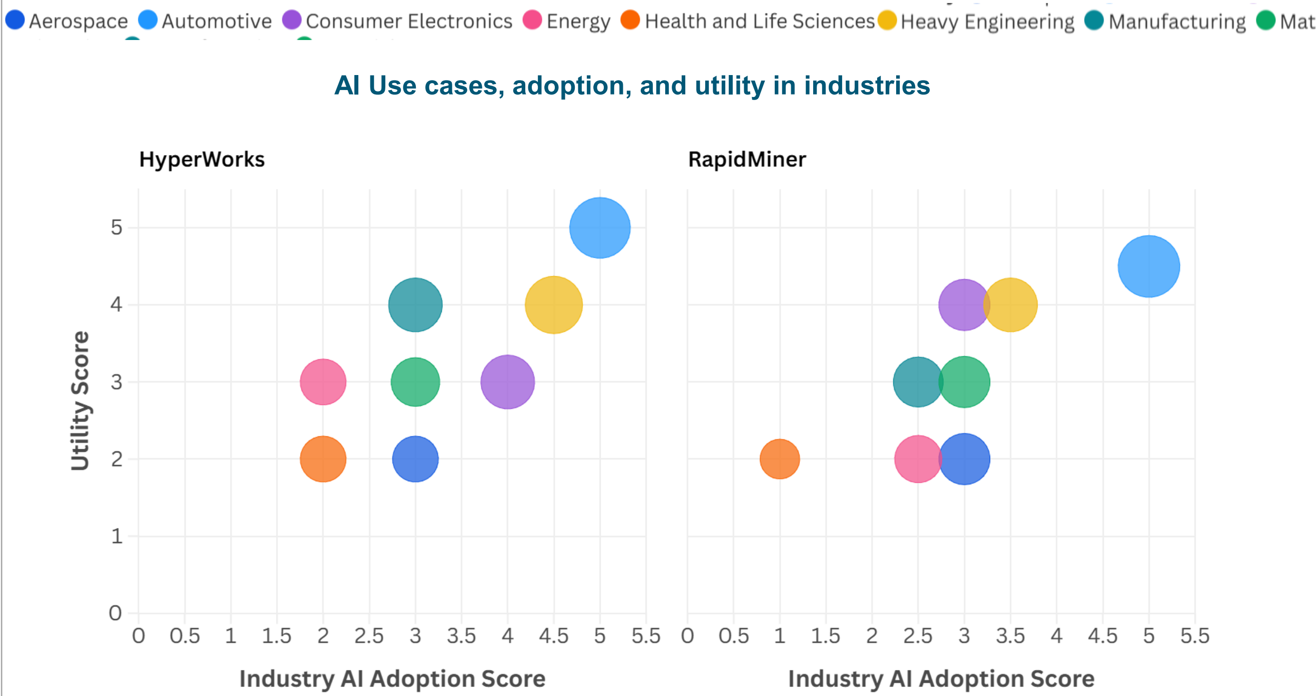
Structural engineers, CFD analysts, Manufacturing experts, Thermal engineers, CAE engineers, Structural analysts, Durability & fatigue engineers, Thermal & CFD simulation experts, AI/ML engineers, Manufacturing process engineers

Adopted at Customer End

74%

Live and deployed at the customer end.





High Impact AI Use Case in the industries

Crash Simulations | Computational Fluid Dynamics | EDA and Electromagnetics | Predictions for failures | MFG Production Decision Making

AI/ML Adoptability Top Reasons

Faster Predictions | Better Accuracy | Lower Costs | Scalability

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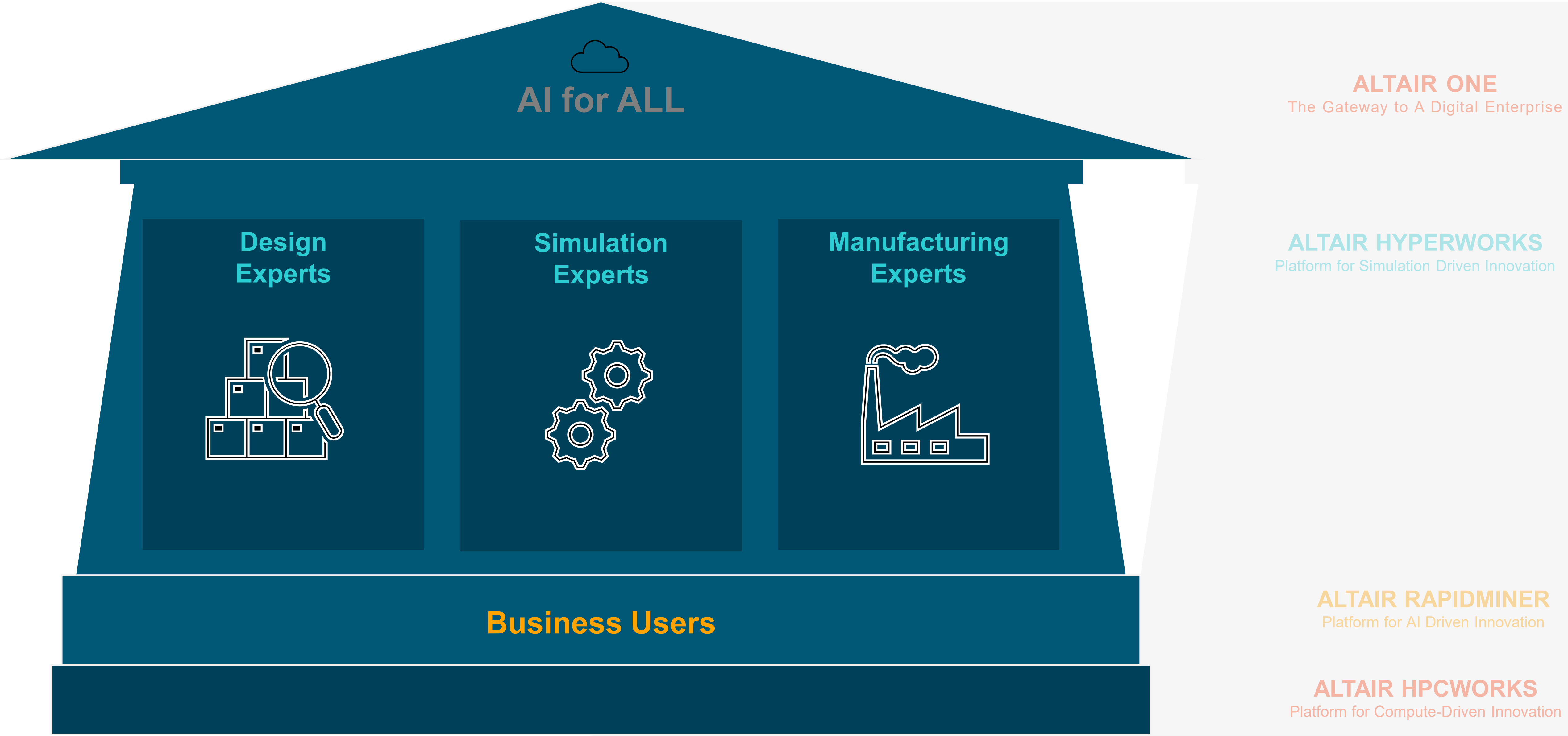

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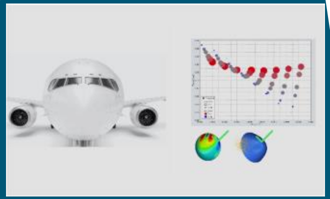
What is going on?

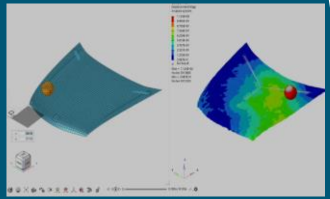
Descriptive Analysis

How sensitive is it ?



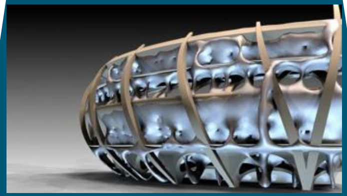
Diagnostic Analysis

Where might it fail ?



Predictive Analysis

What should we do?



Prescriptive Analysis

ALTAIR ONE
The Gateway to a Digital Enterprise

ALTAIR HYPERWORKS
Platform for Simulation-Driven Innovation

ALTAIR RAPIDMINER
Platform for AI-Driven Innovation

ALTAIR HPCWORKS
Platform for Compute-Driven Innovation

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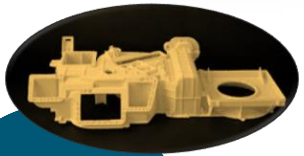
AI-Powered Engineering: Top 10 Use Cases : Review

Predict fatigue life of alloy wheels.

Speed up simulations for excavator.

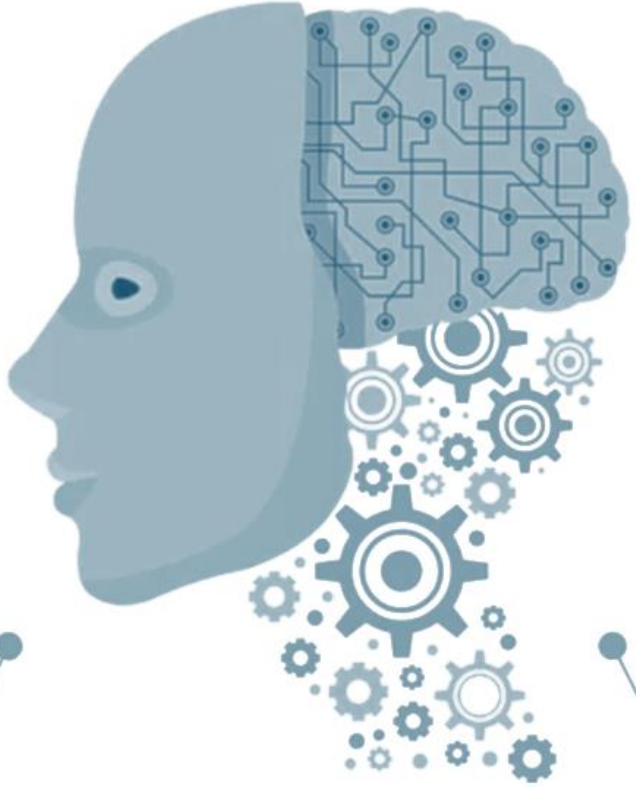


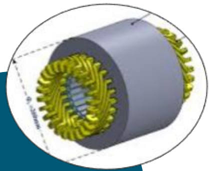
Optimize HVAC for passenger comfort.

Estimate battery pack voltage and health.

Estimate washing machine moisture content.

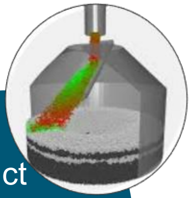
Deploy AI-based virtual sensors for controls.



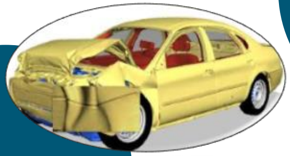


Predict rotor-shaft vibration.

Assess durability with digital twins.

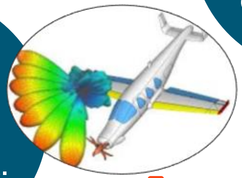


Predict material properties for mixtures.



Predict crashworthiness.

Predict brake-system durability.



Optimize antenna placement.

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Conquer External Aerodynamic Challenges with AI-Powered Physics

Unleash Speed & Accuracy - From 12+ Hours to Minutes with Historical Data & AI

Challenge

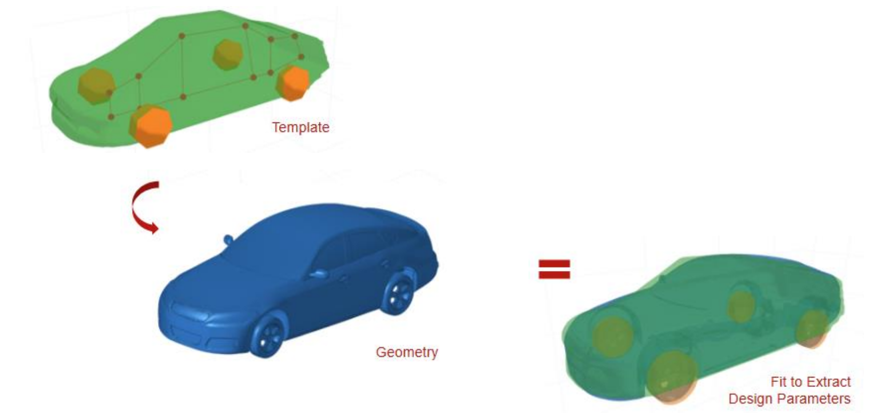
- **Large Model:** Over 2 million elements with extended solver times (12+ hours)
- **Limited Data:** Small training dataset (12 models)

Solution

- **AI-Training:** Train Altair® physicsAI™ on historical simulation data.

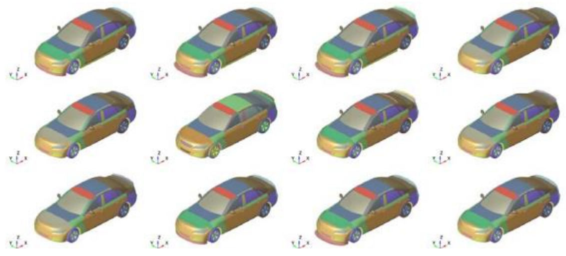
Value

- **Predictive Modeling:** Accurate predictions on new, unseen CAD/CAE model
- **Performance Insights:** Precise aerodynamic performance assessments
- **Time Efficiency:** Slash hours to minutes.

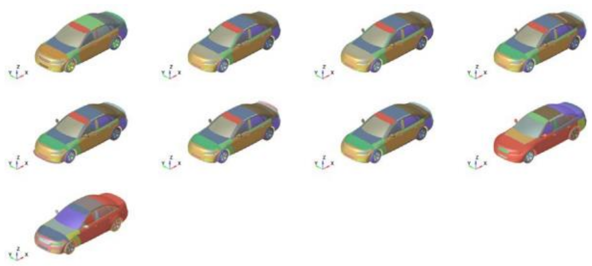


Historical data

Training Data

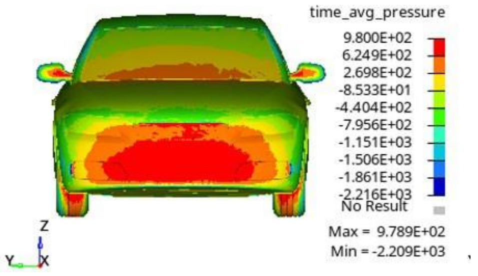


Test Data

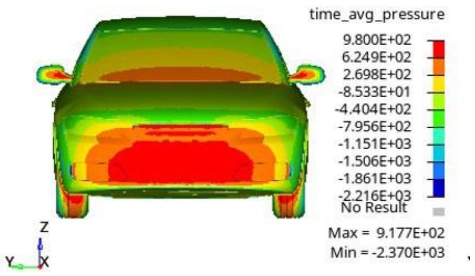


Real-time exploration

ML Runtime 3 min



CFD Runtime 750 min



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HIC Value Predictions

Quick Design Insights for Fewer Iterations and Optimal Resource Utilization

Challenge

- **High Computational Demand:** Simulations are compute-intensive, repetitive, and iterative.
- **Regulatory Requirements:** Even small changes necessitate simulations for verification.
- **Time-Consuming Process:** Iterative verifications are lengthy.

Solution

- **AI and Data Analytics:** Use AI to train models with historical simulation data from various vehicle variants and versions
- **Automated Data Extraction:** Automate the extraction of independent and dependent variables from simulation input and result files
- **ML Enabled Verifications:** Designers and CAE engineers use trained ML models for rapid verifications

Value

- **Faster Verification:** Reduce design verification time through early AI-based verifications and concept evaluations
- **Resource Efficiency:** Decrease the use of expensive resources (software, hardware, and experts)

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NVH Performance Assessment

Data-Driven Strategy for Quick NVH Performance Assessment and Decision-Making

Challenge

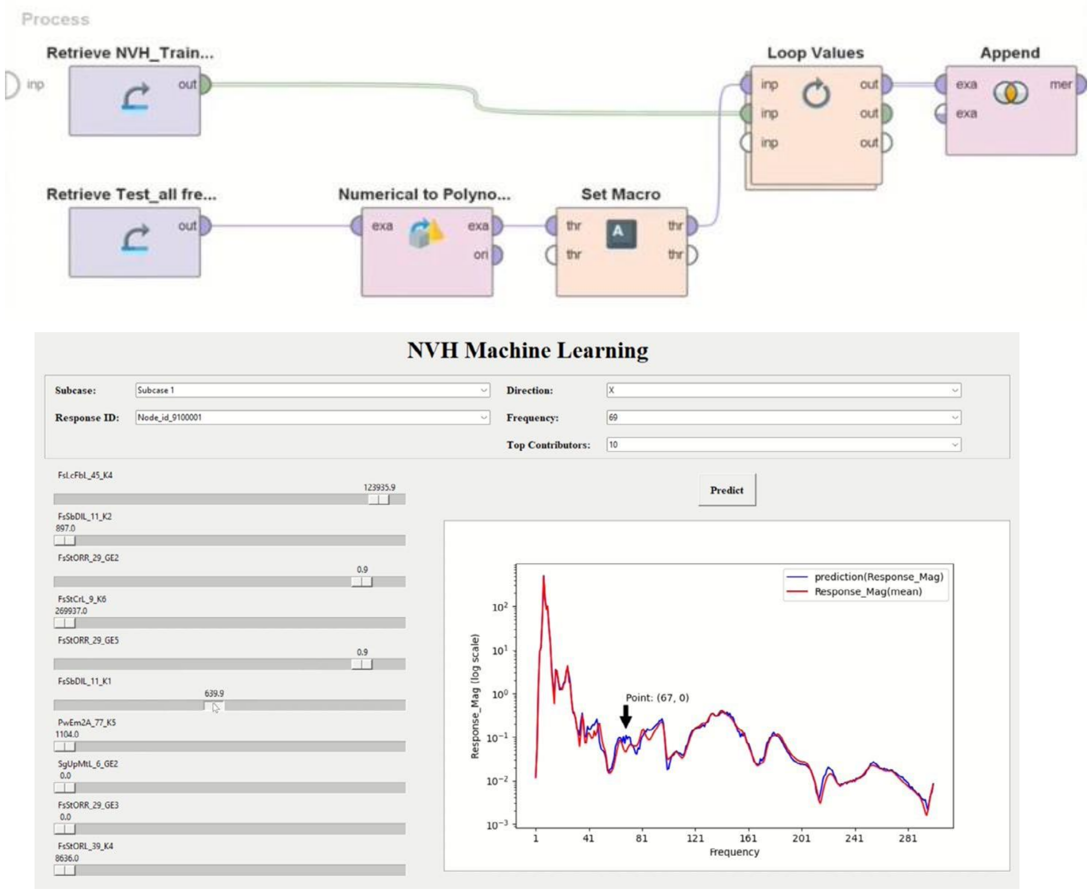
- **Early NVH Detection:** Addressing NVH issues early is vital for brand image, especially with fleet electrification
- **Design Impact:** Quickly analyze NVH performance by altering design variables to ensure structural reliability

Solution

- **Data-Driven Analysis:** Use data and ML to create an application for understanding the effects of design variables on NVH performance
- **No-Code Implementation:** Leverage no-code ML models and interfaces to analyze NVH metrics 100x faster than traditional methods

Value

- **Early Issue Detection:** Enhance brand image by addressing NVH issues early in the design stage
- **Accelerated Analysis:** Speed up NVH performance analysis and decision-making
- **User-Friendly Tools:** Provide a no-code application for efficient NVH metric analysis and improved product lifecycle



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Improving Passenger Thermal Comfort Simulations

Calculating Cabin Temperatures Through CFD-Based ROMs for System Simulations

Challenge

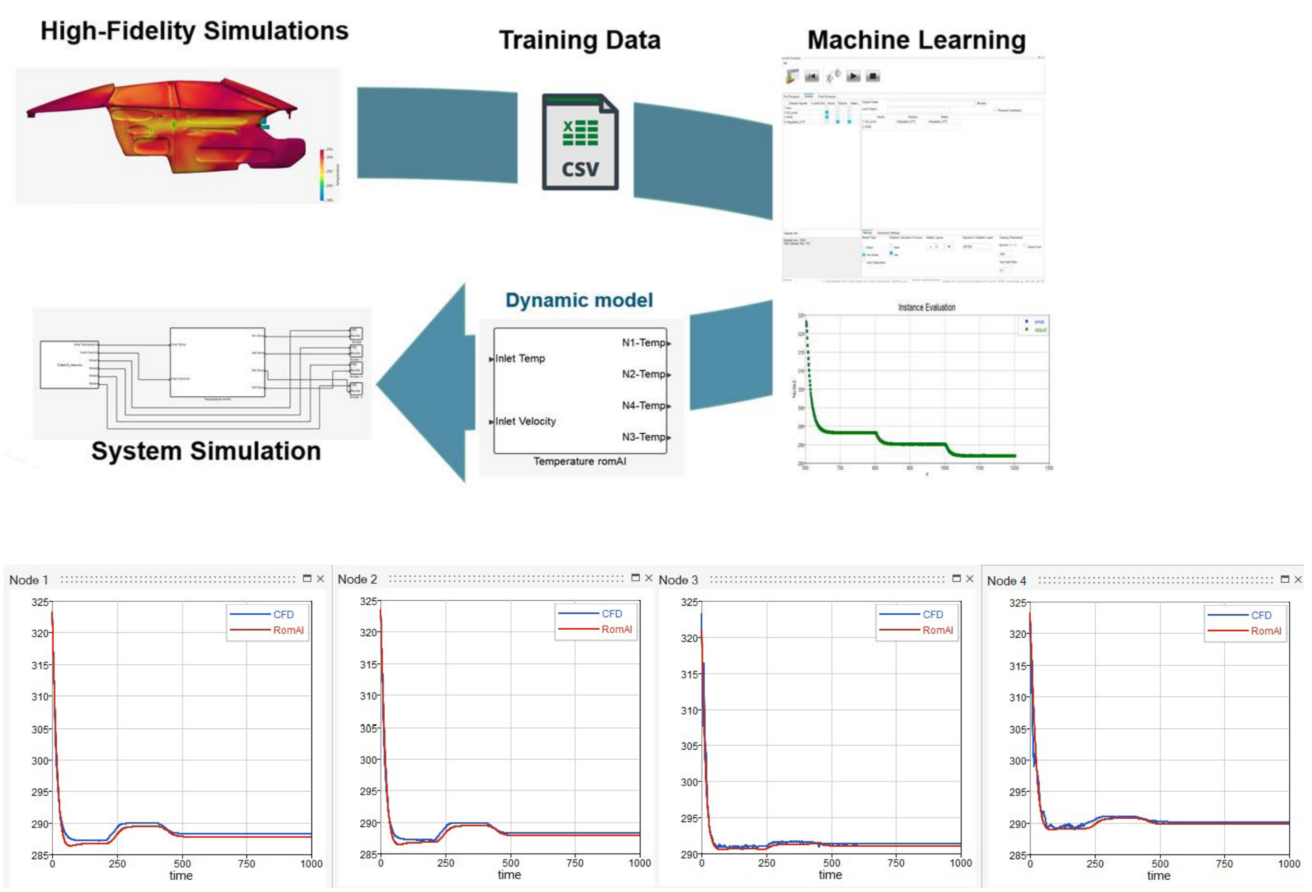
- **Complex Thermal Dynamics Integration:** Difficulty in real-time coupling of CFD and system-level simulations
- **Simulation Model Fidelity:** System simulation model lacks accuracy when using equations
- **Extended Computational Time:** Long run time of CFD simulations required for romAI data collection

Solution

- **Comprehensive Data Gathering:** Run CFD simulations to collect detailed data
- **Advanced Model Development:** Build Altair® romAI™ models using dynamic and static ROMs
- **Seamless Integration:** Deploy romAI models in Altair® Twin Activate™ for system simulation

Value

- **Real-Time Insights:** Achieve real-time coupling of CFD and system simulation for immediate feedback
- **Improved Precision:** Increased accuracy in system simulation leads to informed design decisions
- **Faster Turnaround:** Significantly reduced CFD run times speed up the development process



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Battery Analytics: Life (SoH) Prediction

Leverage field data to determine a battery's state of health and remaining useful life

Challenge

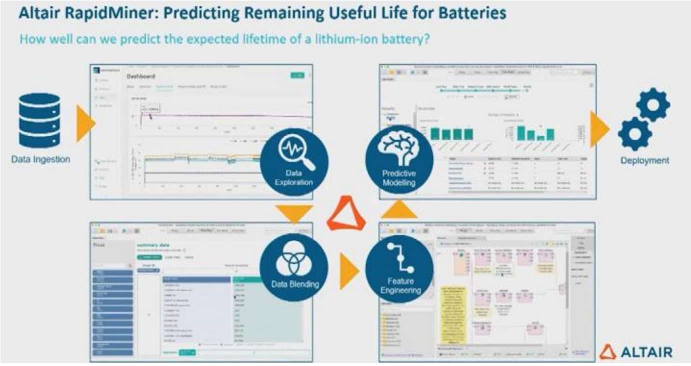
- **Data Utilization:** Use field data to predict battery RUL and SoH
- **Environmental Influence:** Account for environmental and load conditions
- **Measure Battery Life:** Challenging to measure battery capacity accurately in real-time, crucial for RUL assessment

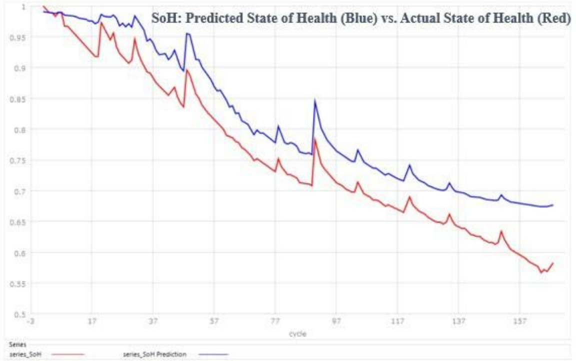
Solution

- **SoH Prediction:** Create a model to forecast battery RUL using data
- **Real-Time Adaptation**: Implement models that adjust in real-time to environmental and operational conditions

Value

- **Battery Optimization:** Assess and optimize battery life for improved performance
- **Fleet and Asset Management:** Boost uptime and manage warranty and value proactively





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Real-Time AI Monitoring for Smart Manufacturing

Overcoming Process Challenges in Injection Molding with AI/ML Diagnosis and Improvement

Challenge

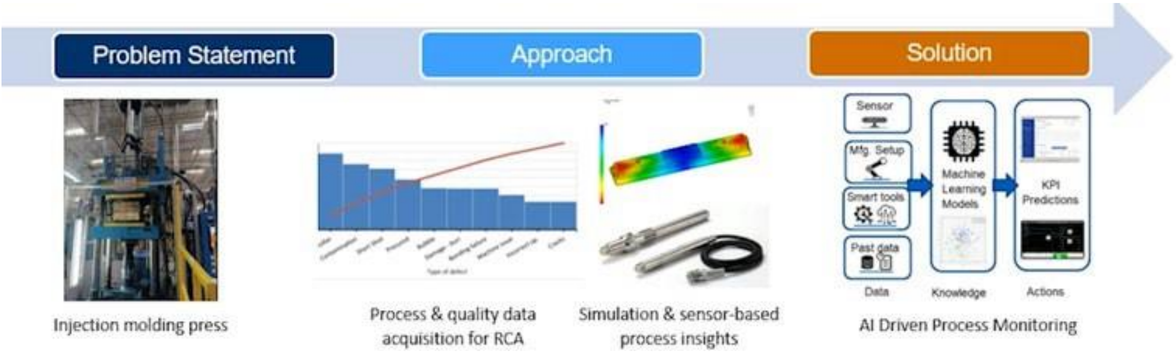
- **Quality Issues:** Frequent defects of manufactured parts
- **Efficiency Gaps**: High cycle times and excessive waste
- **Process Complexity:** Huge number of parameters making diagnosis difficult

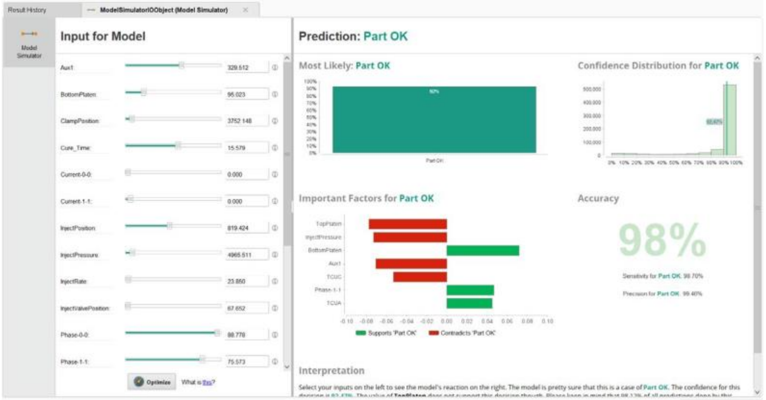
Solution

- **Real-time Monitoring:** Using sensors and AI for continuous process adjustments
- **Predictive Analytics:** ML algorithms optimize settings to prevent defects
- **Automated Adjustments:** Dynamic system responses based on AI insights

Value

- **Quality Improvement:** Reduction in defects and higher product quality.
- **Operational Efficiency:** Decreased cycle times and waste
- **Cost Savings:** Reduced downtime and operational expenses





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Estimation of the Remaining Moisture Content in Cloths During Operations

Application of AI/ML from Test Data

Challenge

- **RPM Optimization:** Optimize drum RPM in spin cycles to enhance water and energy efficiency

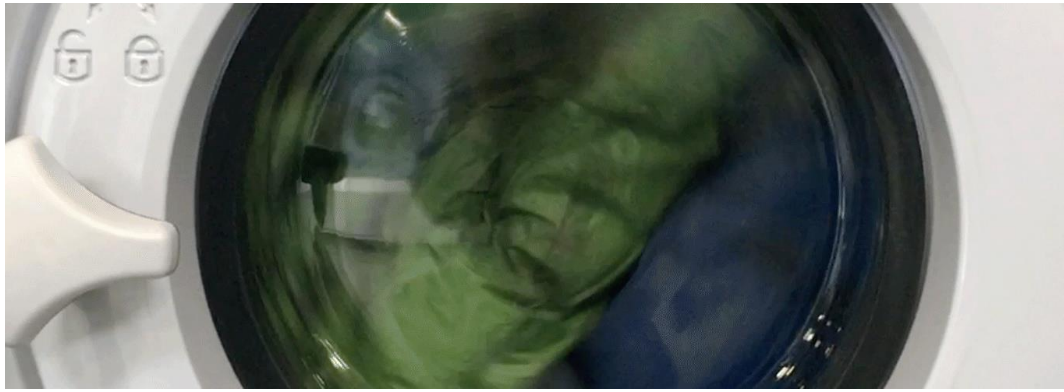
Solution

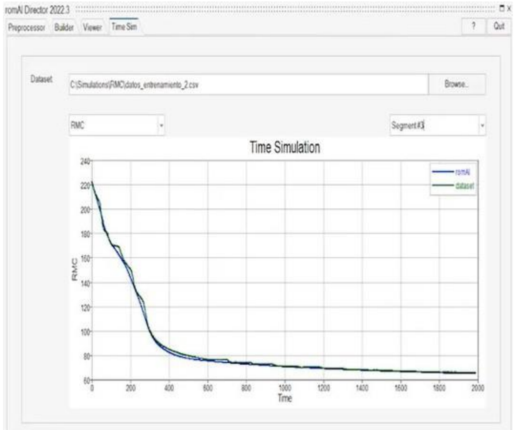
- **Dynamic Modeling:** Deploy Altair® romAI™ for dynamic model creation from minimal tests, enabling effective prescriptive analysis on moisture retention in clothes over time

Value

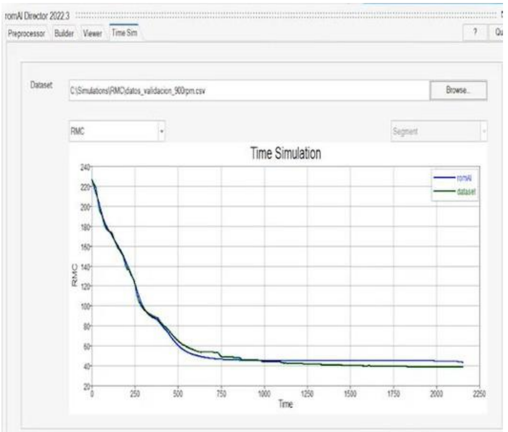
- **Enhanced Accuracy:** Model accuracy is superior even outside the bounds of the training data

- **Operational Efficiency:** Code generation allows for embedding the dynamic model directly into the washing machine, enhancing operational efficiency and resource management





Model results for training data



Model results for test data out of training bounds

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Accelerating Fan Design with AI-Driven Simulation

Overcoming Pre-Processing Bottlenecks and Solver Limitations

Challenge

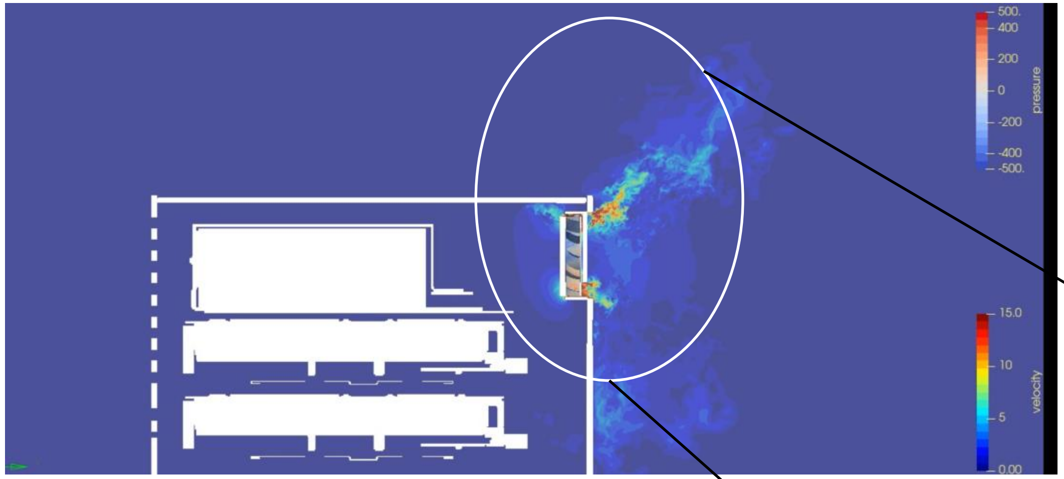
- Traditional CFD pre-processing is highly time-consuming, particularly for geometry simplification and mesh generation.
- Every design modification requires repeating manual steps, slowing down iteration cycles.
- Historical designs and test data are difficult to reuse due to non-parametric formats.
- Evaluating new concepts relies on computationally expensive solvers, often taking hours or even days.

Solution

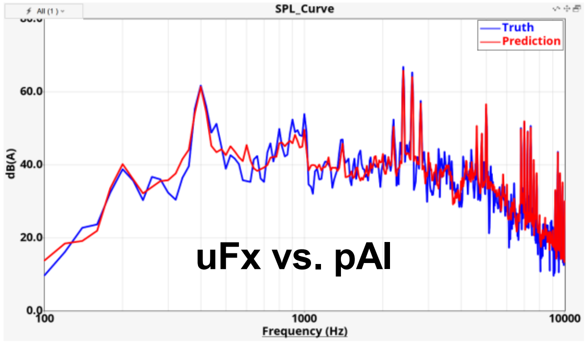
- uFX LBM automates and accelerates pre-processing, efficiently handling complex geometries with minimal manual input.
- PhysicsAI enables use of non-parametric data—such as manually edited geometries and historical SPL curves—for model training.
- The PhysicsAI prediction engine delivers performance KPIs in seconds, providing rapid feedback to designers.

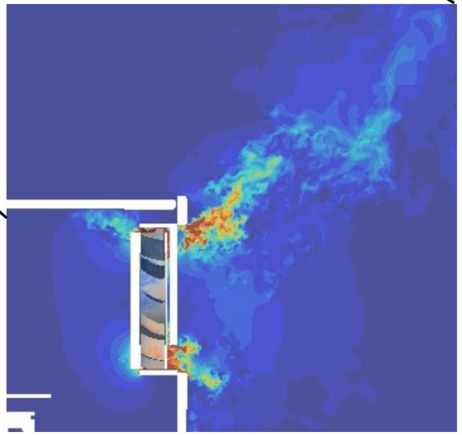
Value

- uFX LBM cuts pre-processing time by up to 80%, significantly accelerating design workflows.
- PhysicsAI achieves 3000x faster performance evaluation compared to traditional solvers.
- Enables fast, early-stage design assessments, supporting more design iterations and better-informed decisions.



Fan Surface Pressure & Flow Velocity





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Accelerating RCS Evaluation Using ML for Different Aircraft Designs

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Geometric Deep Learning for Predictive Radar Signature Modeling

Challenge

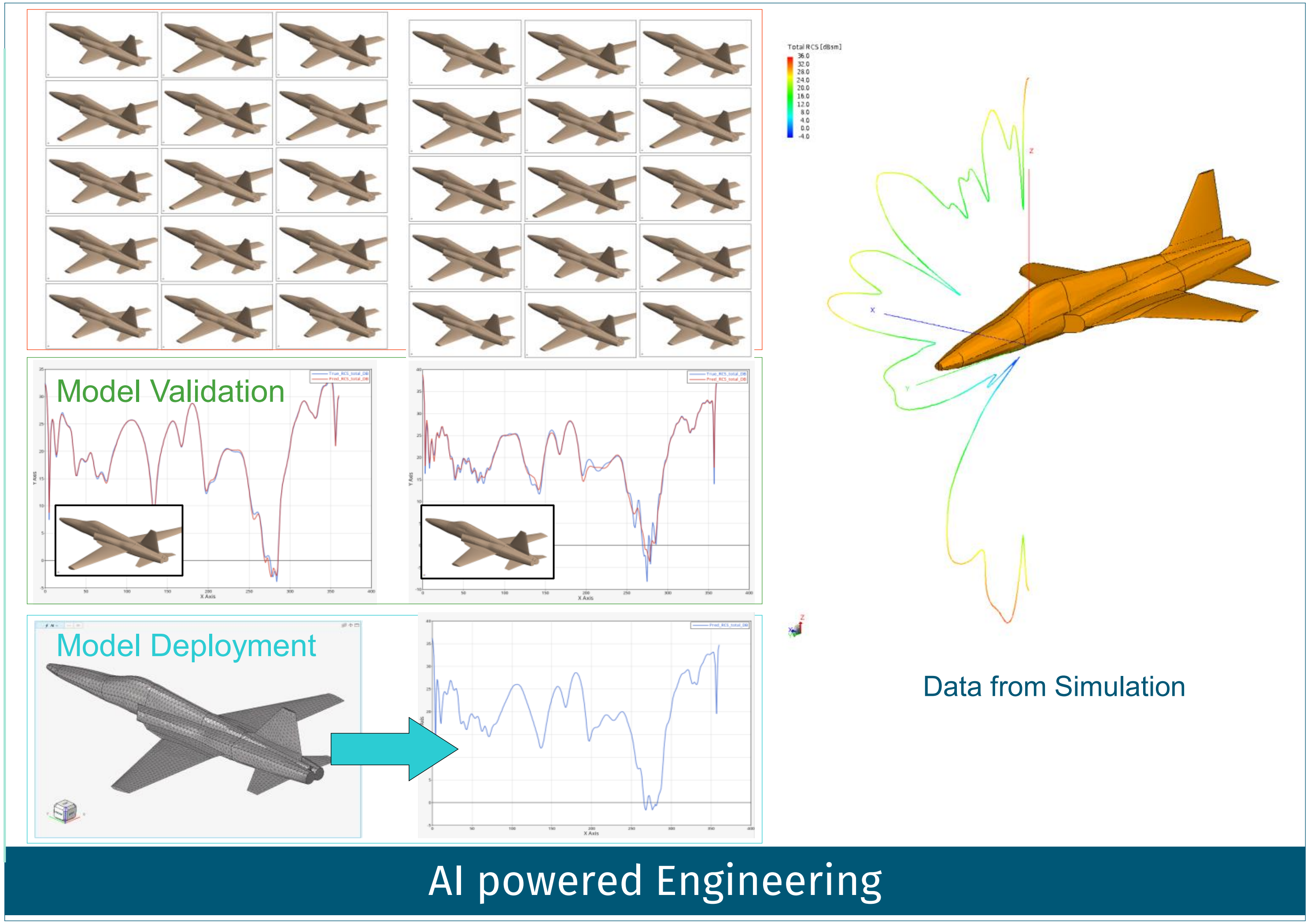
- Radar Cross Section (RCS) simulations are computationally intensive, as they must account for numerous incidence angles and frequencies.
- Late-stage design modifications can significantly increase development time and cost due to the need for repeated simulations

Solution

- Leverage simulation data from early development phases or historical data from predecessor aircraft.
- Use Altair physicsAI to train a geometric deep learning model with Feko simulation outputs and geometric data.
- Split the dataset into training and test sets to validate model accuracy.
- Apply the validated model to predict RCS for new aircraft designs.

Value

- Real-time RCS estimation for new designs using machine learning models.
- Significant reduction in the number of required simulations, especially during final development stages.



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Enabling Collaborative Product Development through Democratized Simulation Intelligence

Leveraging Altair One as a Unified Gateway for Data-Driven Engineering Across Stakeholders

Challenge

- Multiple stakeholders involved across the product development lifecycle.
- Tools and workflows remain fragmented and siloed.
- Lack of a unified platform for cross-functional collaboration.
- Difficulty in scaling and deploying solutions across cloud and on-prem environments.

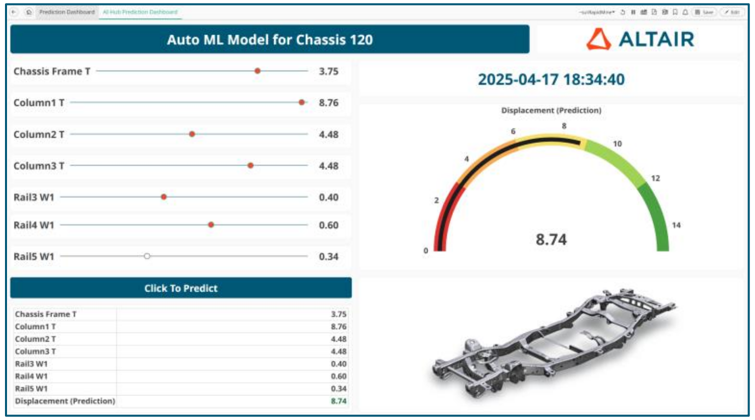
Solution

Altair One serves as a unified access gateway, enabling a hybrid integration of Altair's tools tailored for different roles in the product lifecycle:

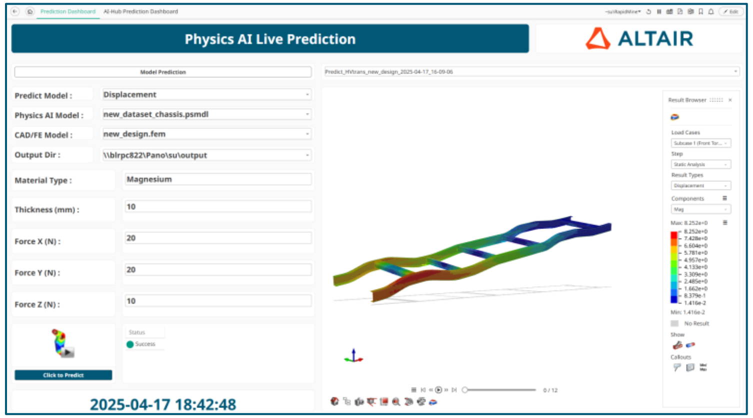
- Altair HyperWorks is used for metadata extraction and accurate physics prediction, enhanced by PhysicsAI to deliver intelligent insights.
- RapidMiner supports exploratory data analysis (EDA) and advanced predictive modeling, empowering data-driven decisions early in the development cycle.
- Altair Panopticon, integrated within Altair One, offers a rich, interactive dashboard interface to visualize simulation outcomes, global KPIs, and incorporate real-time user inputs.

Value

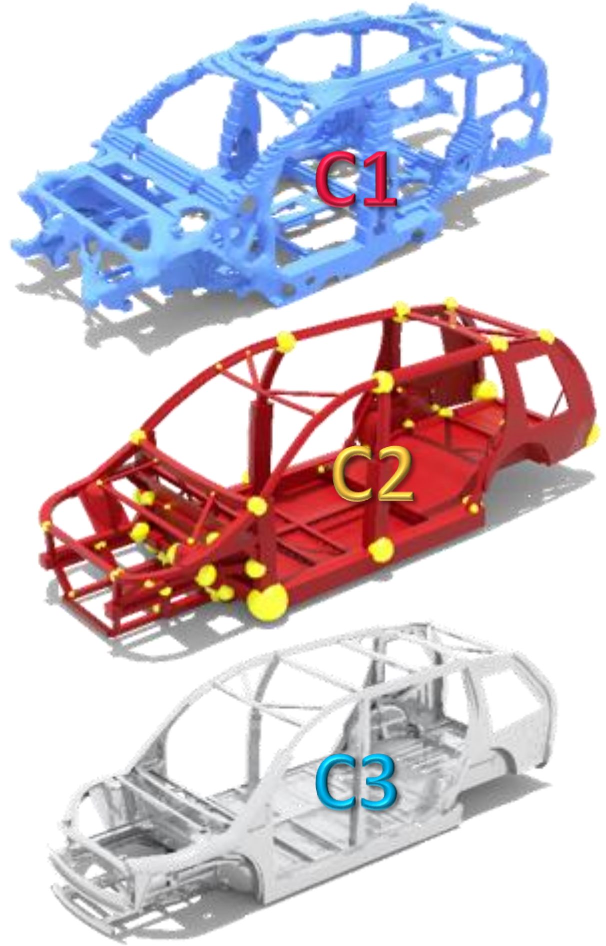
- Seamlessly manage simulation and testing data.
- Leverage HPC capabilities for intensive computation.
- Predict physical behaviors and assess global KPIs collaboratively.
- Enable consistent access to insights through a centralized platform.



Prediction using RapidMiner



Prediction using physicsAI



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Enabling Real-Time Digital Twins for Robot Arms with romAI

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Overcoming Physical and Budgetary Constraints through Simulation-Driven Virtual Sensors

Challenge

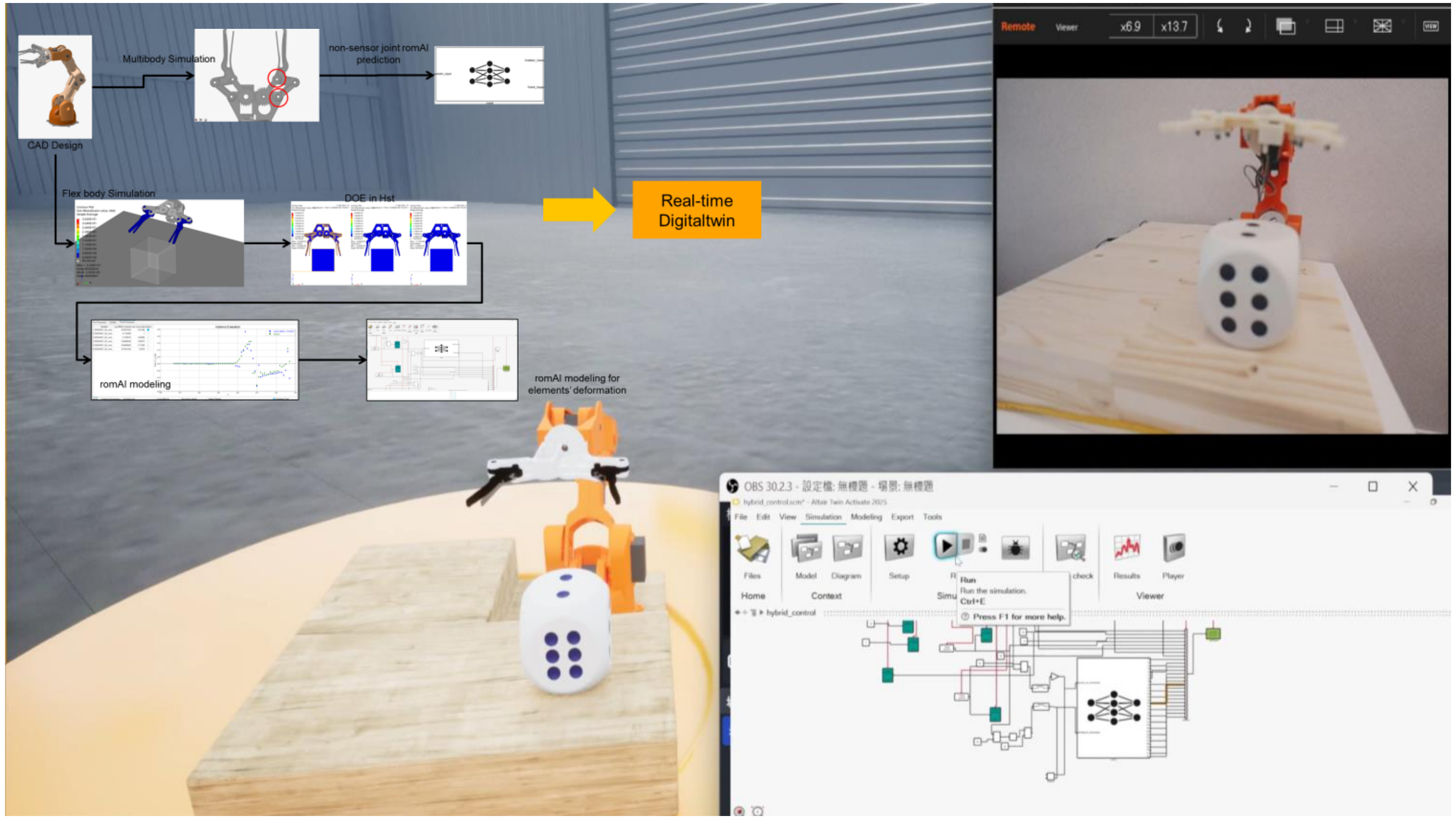
- Real-time digital twin implementations for robot arms often consider only rigid body dynamics, with flexible body integration still absent from most industrial applications.
- Retrofitting existing machines with physical sensors is highly complex and often infeasible.
- Organizations typically lack the time and budget required for extensive on-site testing and calibration.

Solution

- romAI enables rapid prediction of CAE (Computer-Aided Engineering) simulation results, combined with high-end rendering for immersive, real-time visualization.
- Simulation data is leveraged to generate virtual sensors that replicate the behavior of physical ones—without hardware installation.
- A broad range of real-world operating conditions can be replicated digitally for robust testing and validation.

Value

- Achieve a true real-time digital twin experience enriched by CAE-based insights.
- Seamless integration with advanced rendering engines enhances usability and engagement.
- Scalable across various industries—no need for physical sensors or extensive testing on production lines.



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Data-Driven Design from Material to Manufacturing

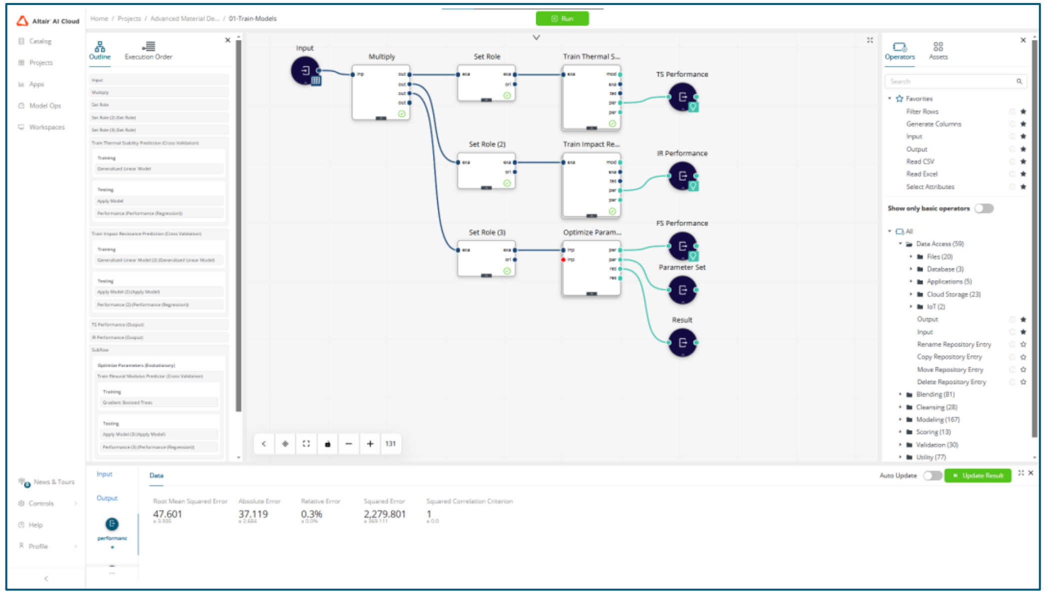
Combine machine learning and optimization to reduce development time, cut costs, and discover higher-performing materials.

Challenge

- Iterative material design and testing cycles are slow and time-consuming.
- Running large numbers of design evaluations is resource-intensive.
- It's unclear when a material is truly optimal – or if performance targets could be exceeded.

Solution

- Used Altair® RapidMiner® to build predictive models from historical material data via visual workflows.
- Integrated Altair® HyperStudy® to run multi-objective optimization and quickly identify new candidate materials.
- Analyzed trade-offs between competing properties and identified candidates similar to known materials.



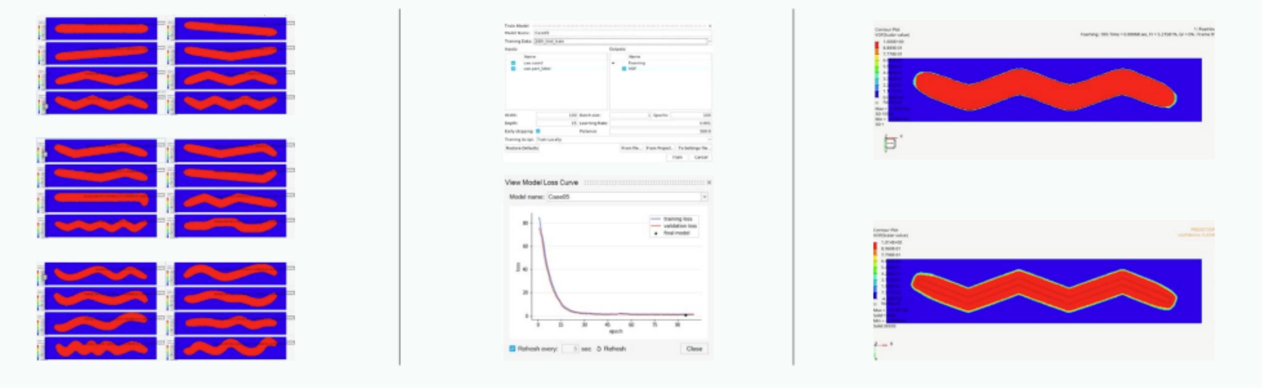
Enable faster design decisions with rapid, accurate epoxy dispensing prediction using real process data

Challenge

- Epoxy dispensing and spread analysis directly affects quality and manufacturability in display equipment.
- Complex CFD simulations are slow – especially for small, intricate designs – delaying early process validation.

Solution

- Simulated epoxy spread behavior using Altair® Inspire™ PolyFoam across multiple dispense paths.
- Used those results to train an Altair® PhysicsAI™ model that predicts epoxy flow and spread under production conditions.
- Enabled real-time exploration of new dispensing strategies without rerunning FEM simulations.



physicsAI: Real-time Prediction

Draw Dispense Path → FEM Preparation → physicsAI Prediction

※ Real-time prediction is possible for the various dispensing patterns

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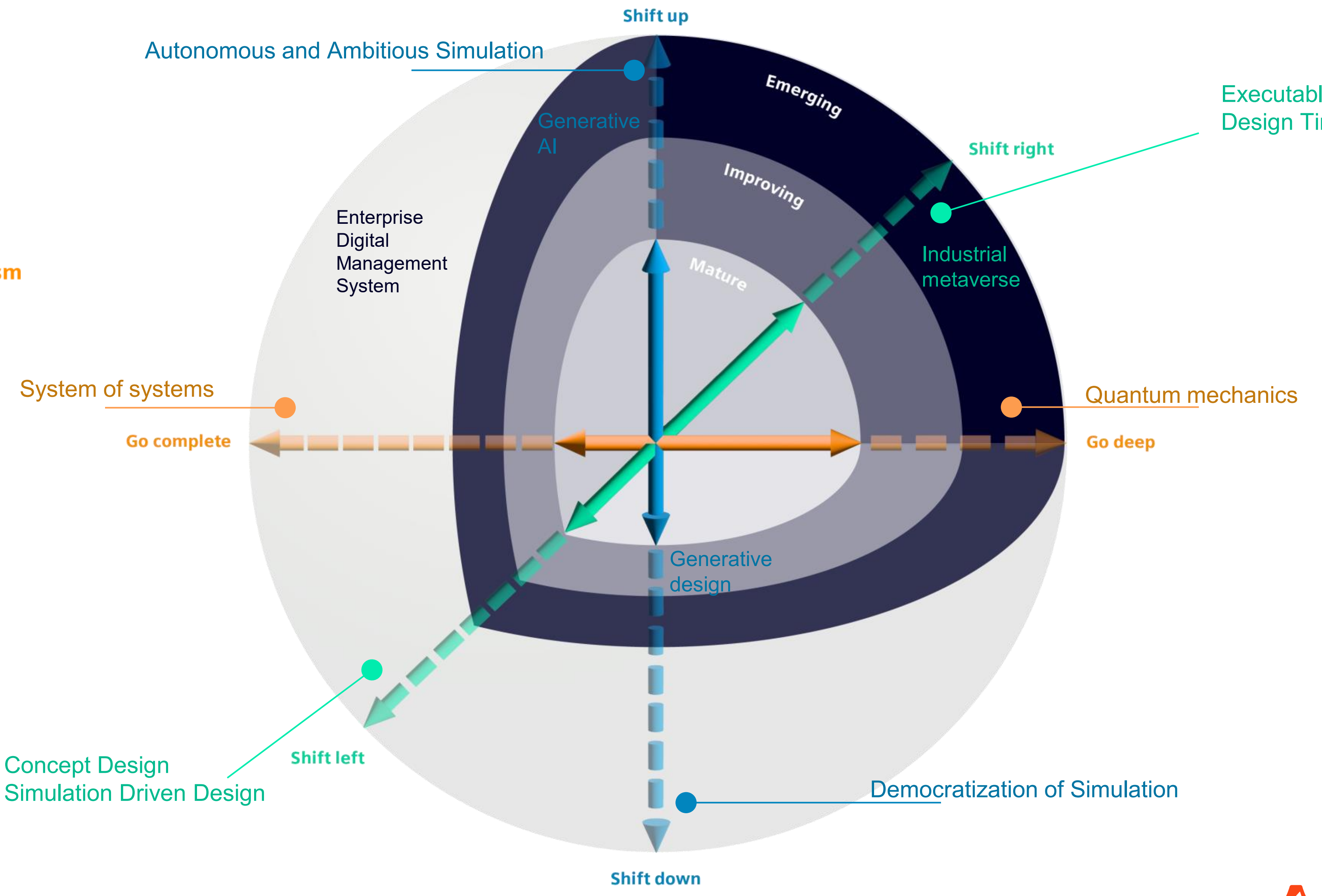
The Future of Design and Simulation Technology

- Horizon 1: User Profile
- Horizon 2: Life Spanning
- Horizon 3: Complexity & Realism



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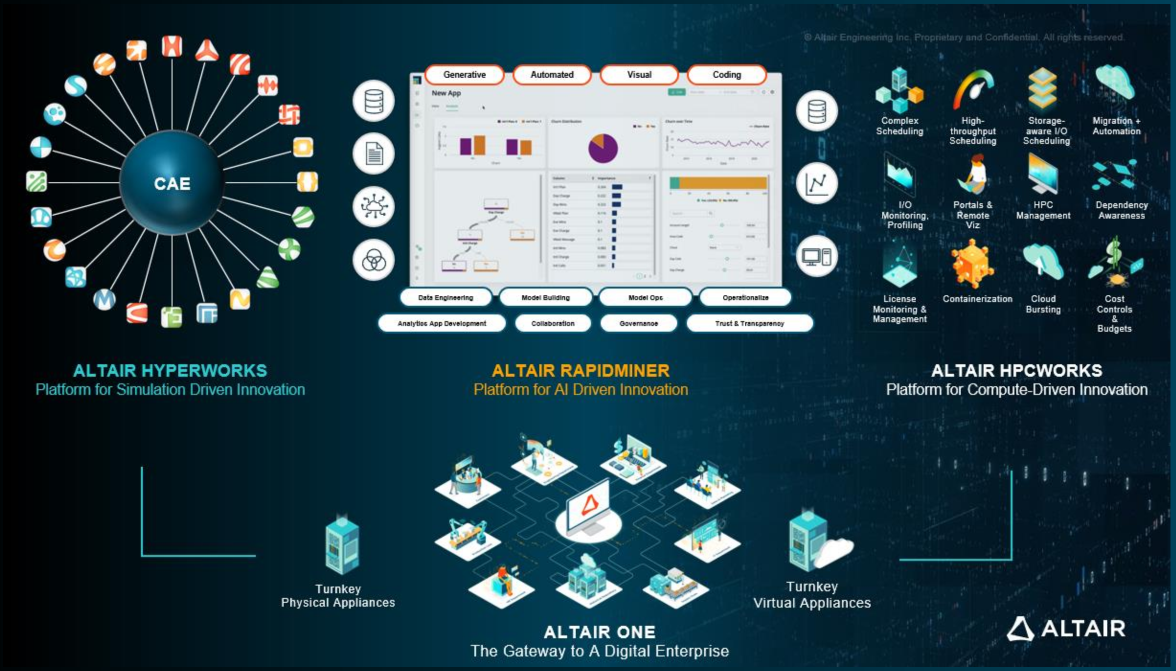
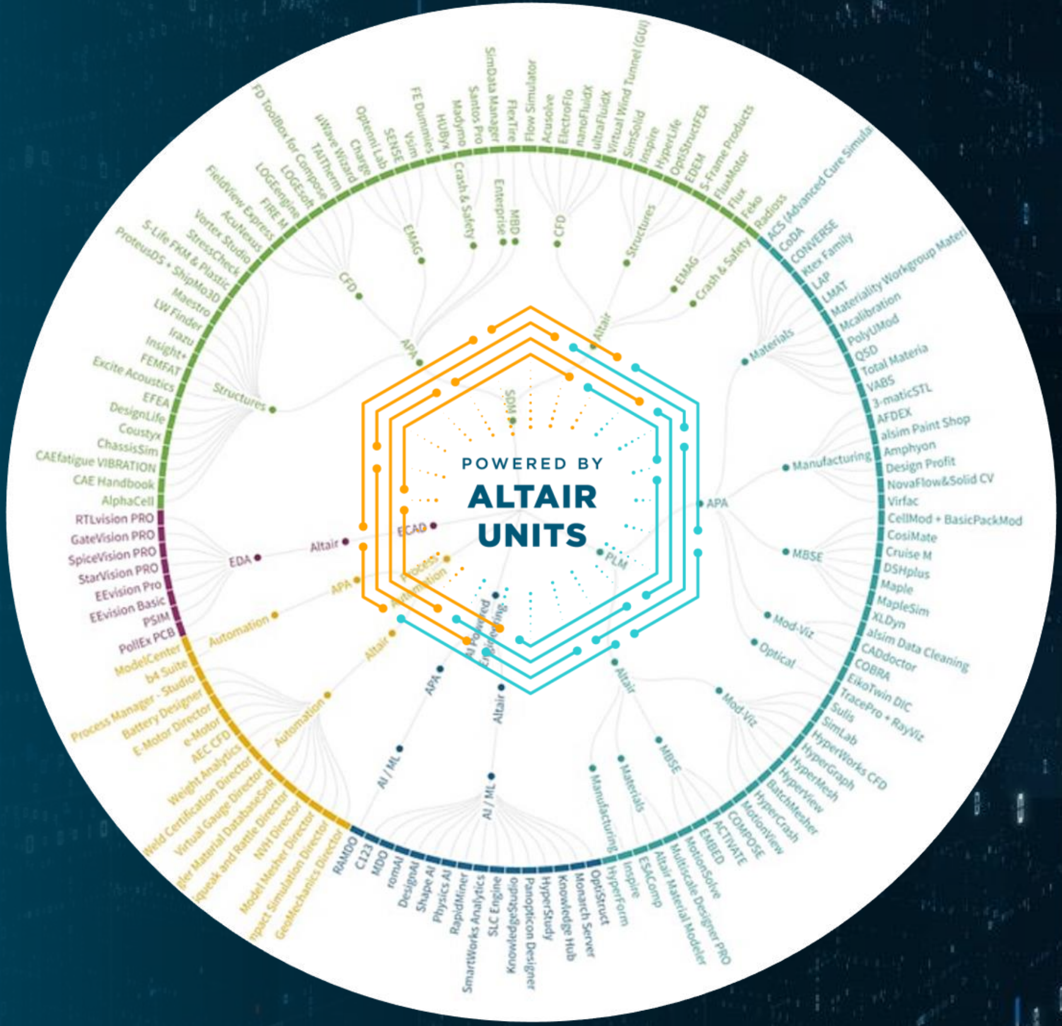
The Platform for Simulation-Driven Innovation





Thank you!