ALTAIR

100 AI-Powered Engineering Use Cases

Everything Solvable

Contents

Background

This convergence of simulation and data analytics not only promises to revolutionize how engineers operate but also holds the potential to transform digital information into tangible digital assets. Altair's commitment to assisting organizations in navigating this digital transformation journey underscores its role as a catalyst for change in the engineering domain, fostering a culture of innovation and progress.

By bridging the gap between the world of simulation and the realm of data analytics, Altair is poised to deliver actionable insights that transcend organizational silos, empowering engineers to make strategic decisions that drive business growth and operational excellence. As organizations embark on this digital transformation journey, Altair stands as a trusted partner, guiding them towards a future where data is not just a resource but a strategic asset that fuels success and propels them towards new frontiers of engineering excellence.

Introduction

The engineering landscape is undergoing a paradigm shift, driven by the rapid integration of Artificial Intelligence (AI). From design and development to testing and maintenance, AI is ushering in unprecedented efficiencies and capabilities. This ebook examines 100 compelling use cases of AI-powered engineering, demonstrating how this technology is transforming our approach to engineering the world around us. For newcomers to AI-powered engineering, we recommend our companion e-guide, “AI for Engineering: Your Roadmap to Getting Started,” which provides practical advice and foundational insights for adopting AI in your organization.

All new AI use cases are marked with a NEW icon.

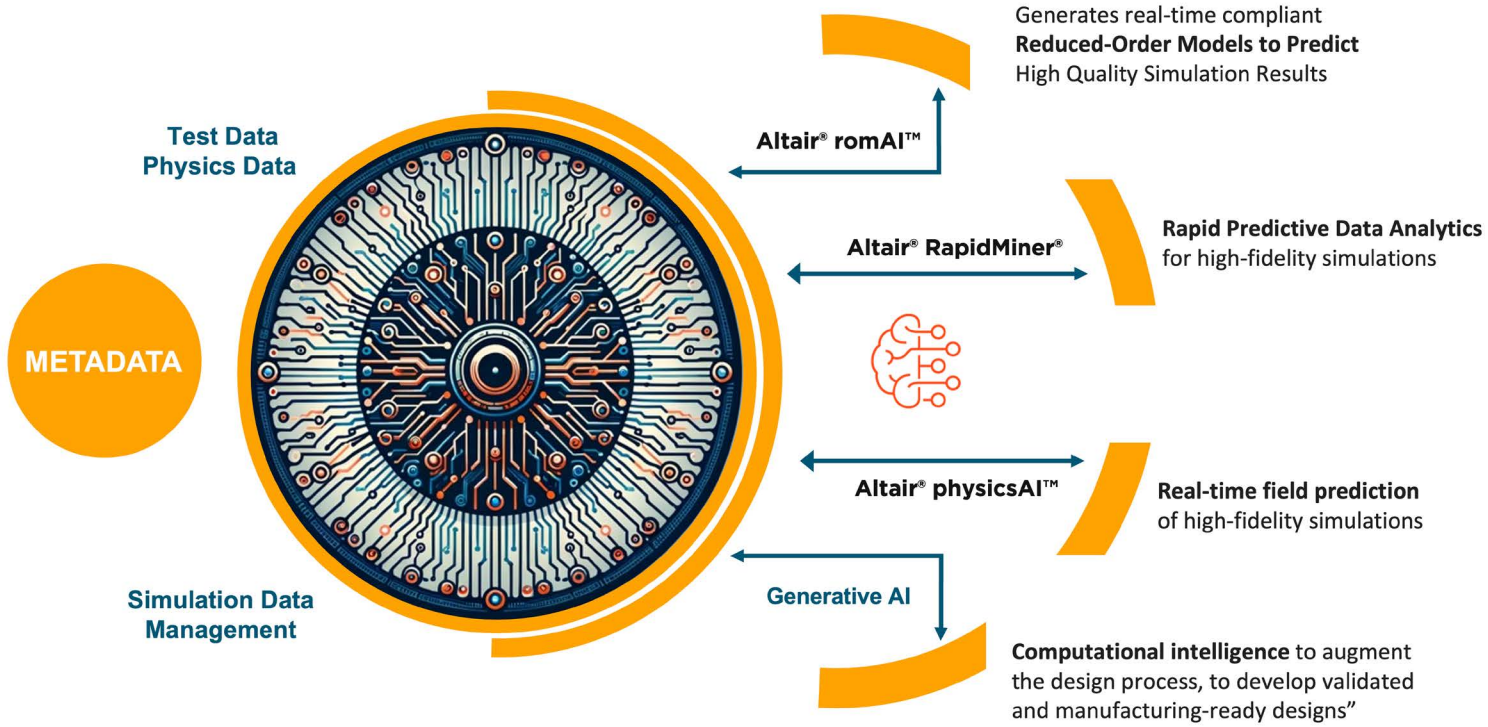
How to Use This Book

This ebook isn't just a collection of problems and solutions – it's a springboard for your next breakthrough. Dive into these 100 real-world use cases, each showcasing the transformative power of AI. Explore how AI is used to conquer challenges, and discover how you can replicate that success.

Don't just read – be empowered! See these applications as blueprints, inspiring you to tackle your own unique challenges and propel your engineering projects to new heights.

Altair's flexible, unit-based licensing empowers you to go beyond these 100 inspiring use cases. This innovative model grants access to all the essential AI tools. No need to worry about acquiring individual licenses – you have everything you need at your fingertips to conquer not just the present, but the future of AI-powered engineering.

Everything solvable. Ask anything. Solve everything.



AI-Powered Product Lifecycle: From Conceptualization to End-of-Life Management

The incorporation of AI in engineering transforms traditional product development into a streamlined, dynamic process

- **Conceptualization and Design:** In the early stages of product development, leveraging AI enables teams to analyze and interpret existing data to shape initial concepts. For instance, an automotive company might use AI to select optimal materials for the vehicle's body that balance weight, durability, and cost, such as choosing between different grades of steel, aluminum, or composites based on predicted performance and environmental impact.

- **Detailed Design and Prototyping:** As designs progress towards prototyping, AI tools, equipped with fast physics predictions, analyze potential outcomes of design choices, predicting performance under various conditions.
  An aerospace company could use AI to simulate airflow over a new wing design, predicting how small changes affect lift and drag, thereby optimizing the design before any physical prototypes are constructed.

- **Testing and Optimization:** During the testing phase, AI facilitates a deeper understanding of test results, identifying why certain designs may not meet expectations. For example, a consumer electronics manufacturer might use AI to analyze why a new smartphone model overheats under certain conditions, allowing engineers to quickly adapt the design and cooling solutions.

- **Manufacturing and Maintenance:** In the final stages, AI assists in refining manufacturing processes and predicting maintenance needs. A machinery manufacturer could employ AI to predict when CNC machines are likely to fail or require maintenance, scheduling preemptive servicing that minimizes downtime and maintains production quality.

- **End-of-Life Management:** AI continues to play a vital role as products approach their end of life. It helps in predicting the optimal timing for product retirement and facilitates the efficient recycling or repurposing of materials. For example, in the electronics sector, AI can help companies determine the best process for dismantling used smartphones and recovering valuable materials like gold and copper efficiently.

This seamless integration of AI across all stages not only accelerates the development cycle but also enhances the quality and sustainability of products. By adopting AI-powered engineering, businesses can transform how they design, develop, maintain, and responsibly retire their products, ensuring they are prepared to meet future challenges and market demands.

Altair: Your Preferred AI-powered Engineering Partner

Altair stands as a beacon of advanced AI-powered engineering solutions, seamlessly integrating best-in-class simulation, artificial intelligence (AI), high-performance computing (HPC), and data analytics to provide a market-leading user experience. Built on an open and programmable architecture, our tools offer unprecedented flexibility and control, allowing users to push the boundaries of innovation. Leveraging our deep expertise in computational science, Altair serves as a strategic partner, uniquely equipped to tackle the toughest engineering challenges and drive groundbreaking innovations.

Our platform supports the full spectrum of AI integration—augmenting, embedding, and enabling AI within engineering workflows. This democratizes technology through intuitive, no-code/low-code analytics and AI workflows, making advanced capabilities accessible to all engineers. We structure our AI-powered engineering tools around four fundamental pillars: Descriptive, Predictive, Causal, and Prescriptive Analysis. Each pillar is designed to empower engineers with the intelligence needed to tackle modern challenges and seize new opportunities. This holistic approach optimizes every project phase, fostering innovation and driving excellence in all engineering endeavors.

By providing the essential data backbone for AI enterprises, Altair not only supports but accelerates the journey towards digital transformation, ensuring that every solution is both innovative and actionable.

- **Descriptive Analysis:** Go beyond traditional data interpretation with Altair's AI-powered tools that simulate and model current conditions and historical data. Understand product behavior under varied scenarios to make data-driven decisions efficiently.
- **Predictive Analysis:** Anticipate future challenges and opportunities with our sophisticated predictive tools. By modeling the potential behavior of products under various conditions, these tools help you forecast future stresses and deformations, ensuring your designs are both innovative and robust.
- **Causal Analysis:** Dive deeper into the 'why' with causal analysis. Altair's AI algorithms analyze changes in behavior and performance, revealing the underlying causes of stress increases and component failures. This insight allows for more informed decision-making and enhanced design optimization.
- **Prescriptive Analysis:** Shape the future by not only predicting outcomes but also advising on the best course of action. Our prescriptive tools suggest concrete steps to improve performance or mitigate risks, turning potential issues into opportunities for innovation.

Through this ebook, we invite you to explore the countless possibilities that AI brings to engineering, all demonstrated through Altair's market leading technologies and expertise.

Automotive Use Cases

Overcome Complexity in Bracket Design

Automated physics predictions streamline design processes, reducing time and improving efficiency

Challenge

- The dataset contains a wide variety of topologies, adding complexity to the design process

Solution

- Automatically grouped data using Altair® HyperMesh®
- Trained Altair® PhysicsAI™ on historical simulation data for fast physics predictions

Value

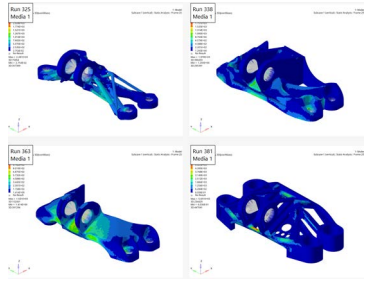
- Predict results for unseen CAD/CAE models, speeding up design iterations and cutting development costs
- Eliminate silos by sharing knowledge across categories, driving continuous improvement and innovation

Dataset generated by: MIT DSL, http://digitalstructures.mit.edu/

Historical data

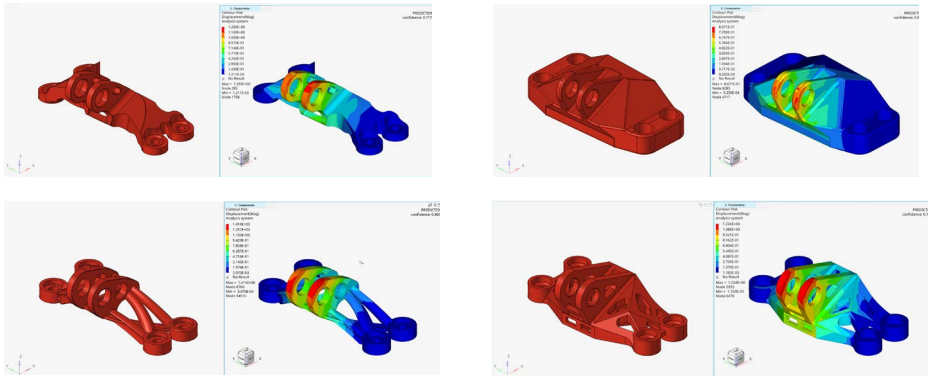
Training Data

Test Data



Real-time exploration

CAD Data



Conquer External Aerodynamic Challenges

AI-trained models, using limited historical data, reduced solver times from 12+ hours to minutes for large models with over 2 million elements

Challenge

- Large model with over 2 million elements, leading to solver times exceeding 12 hours
- Limited training data, with only 12 models available for analysis

Solution

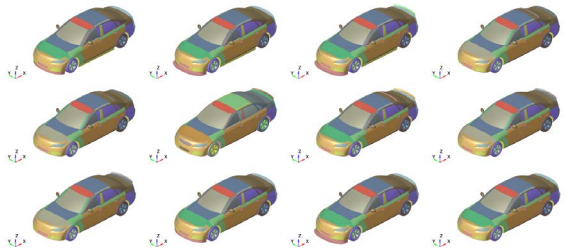
- Trained Altair® PhysicsAI™ on historical simulation data to develop predictive modeling for accurate insights on new, unseen CAD/CAE models

Value

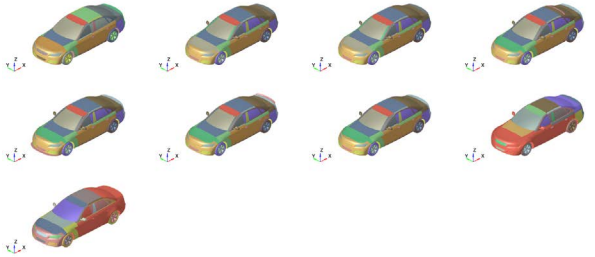
- Achieved reliable predictions for new, unseen CAD/CAE models, improving decision-making
- Gained precise insights into aerodynamic performance, enhancing design efficiency
- Dramatically reduced solver times from hours to minutes, accelerating development cycles and speed to market

Historical data

Training Data

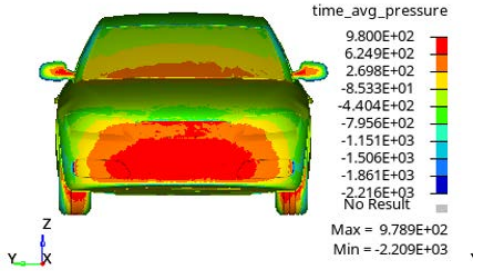


Test Data

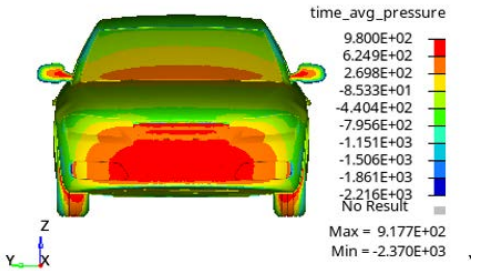


Real-time exploration

ML Runtime 3 min



CFD Runtime 750 min



Hood Impact Analysis

AI-powered simulations reduced analysis time and provided accurate predictions for unseen designs

Challenge

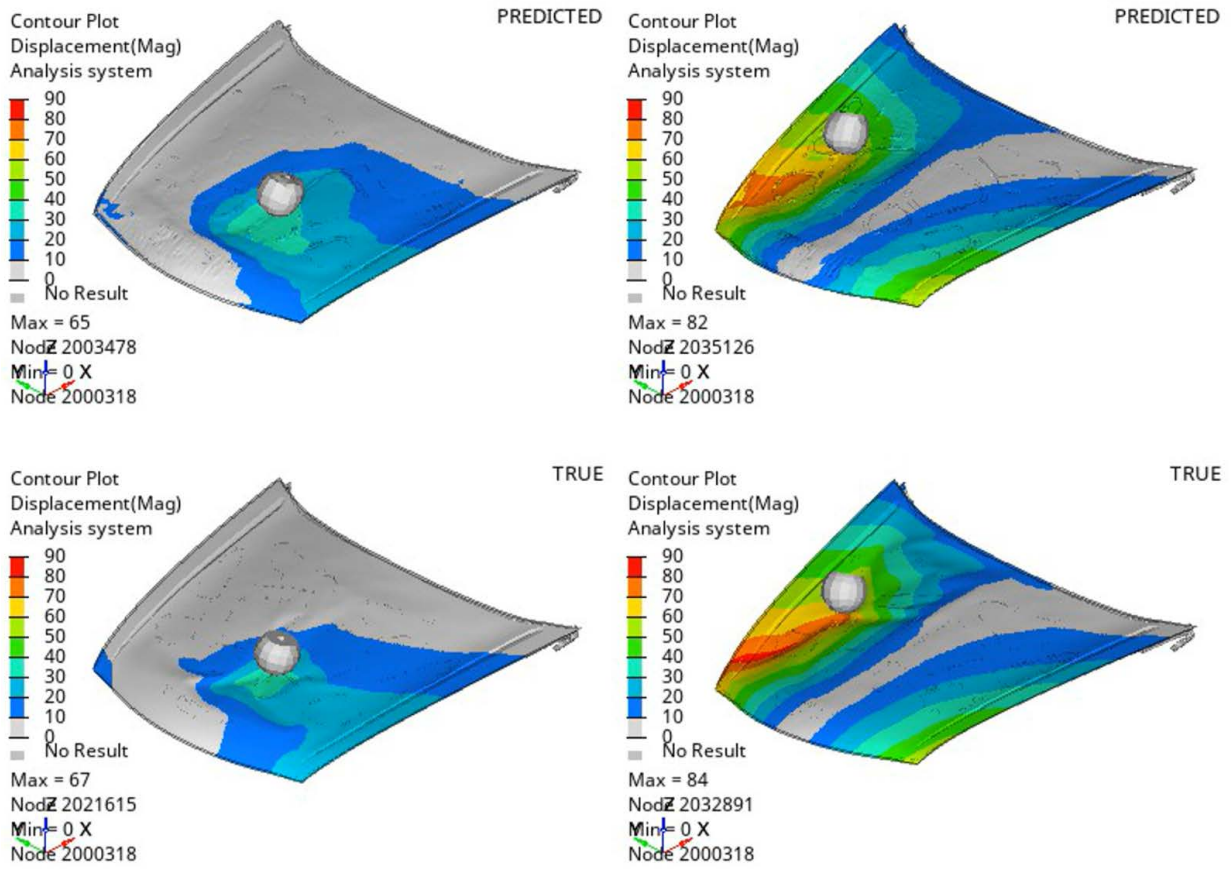
- There were multiple variable impact points that needed to be analyzed
- Large deformation simulations were required for transient behaviors, adding complexity

Solution

- Altair® PhysicsAI™ was trained on extensive simulation data to deliver accurate physics predictions

Value

- The model provided highly accurate predictions for new, unseen CAD/CAE models, improving decision confidence and reducing the risk of costly errors
- Predictions were delivered in seconds, not minutes, dramatically increasing analysis efficiency and accelerating time-to-market for new designs



Detect NVH Performance Issues Early

Machine learning and no-code tools accelerate NVH performance assessments, enabling faster and more informed decision-making

Challenge

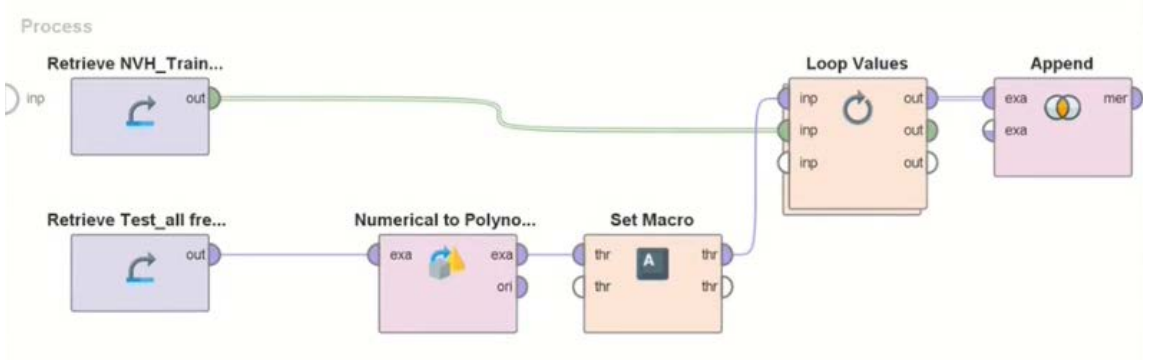
- Difficulty in detecting NVH issues early, which risks brand reputation, especially with the shift toward fleet electrification
- Need for faster NVH performance analysis to assess design variables and ensure structural reliability

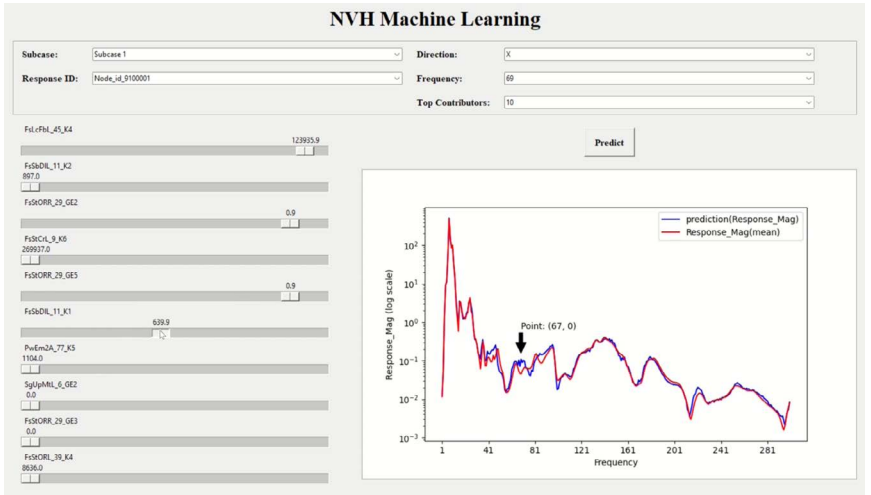
Solution

- Used data and machine learning to create an application for understanding the effects of design variables on NVH performance
- Leveraged no-code machine learning models and interfaces to analyze NVH metrics 100x faster than traditional methods

Value

- Early detection of NVH issues strengthens brand reputation and enhances product quality
- Faster NVH analysis accelerates decision-making and reduces development cycles
- User-friendly, no-code tools improve workflow efficiency and extend the product lifecycle





Headlamp Leveling Test for AIS 008

Predictive modeling and data-driven strategies transform the vehicle testing process, accelerating compliance checks

Challenge

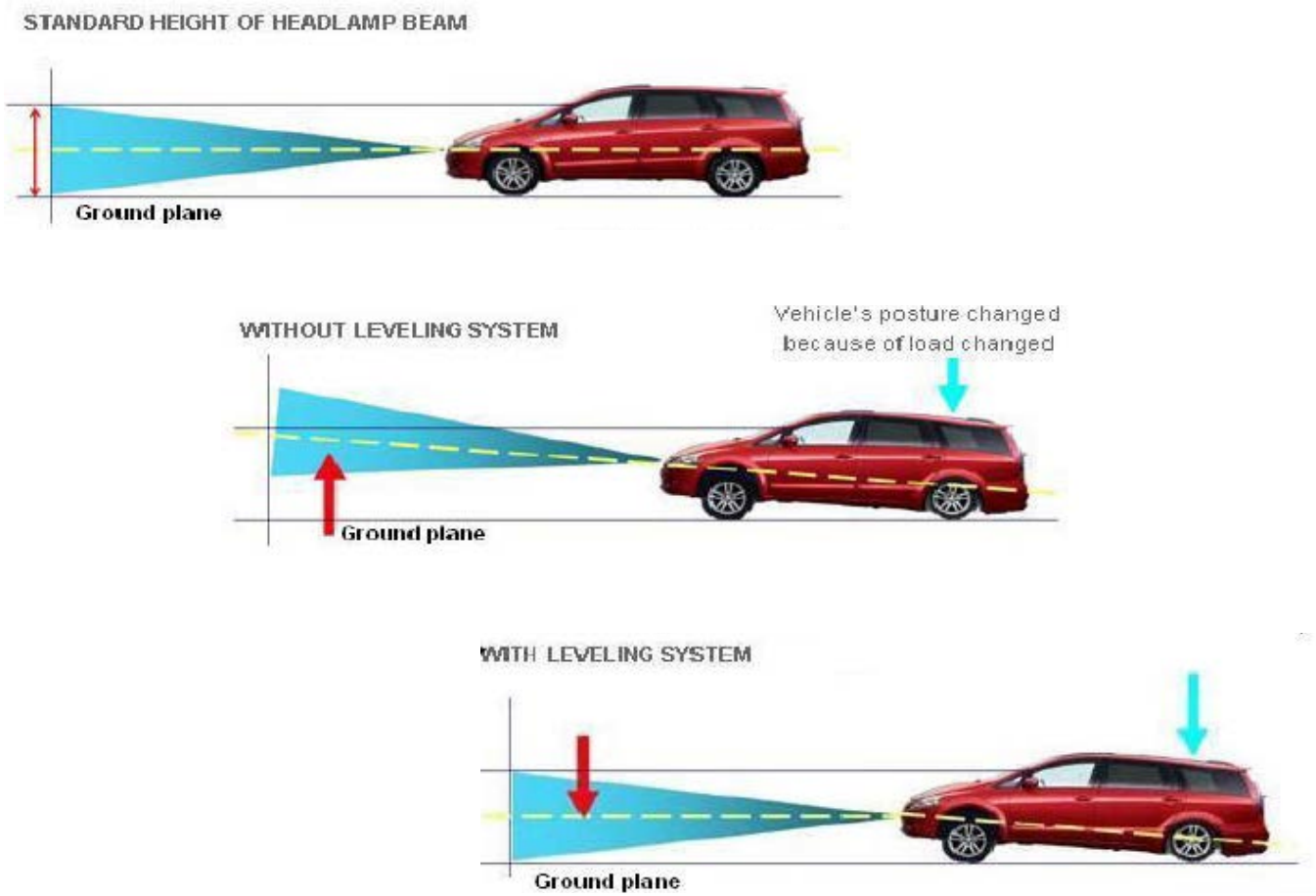
- Headlamp checks (AIS 008) at the testing stage involve time-consuming physical vehicle loading with dead weights

Solution

- Trained ML regression models using historical data to select the most accurate predictive model
- Deployed an ML-based sensitivity simulator for more efficient analysis
- Integrated the final model into a user-friendly dashboard for testing the output on new vehicle parameters

Value

- Streamlined the headlamp compliance process, significantly reducing time
- Improved decision-making with precise, data-driven predictions for faster adjustments
- Simplified parameter testing and adjustments with easy-to-use dashboard access



Data-Driven Digital Twin for Optimized HVAC System Performance

Vehicle telemetry and field data are used for HVAC system usage analysis and failure classification, enhancing reliability and performance

Challenge

- Understand HVAC usage patterns and customer behavior across different conditions
- Optimize control settings to adapt to various operational scenarios
- Diagnose and resolve system failures through effective root cause analysis

Solution

- Created a digital twin using data from operational vehicles or systems (test or in-service) to represent the physical HVAC system
- Used predictive analysis to forecast HVAC system conditions and optimize performance
- Applied root cause analysis to identify and resolve system failures with data-driven insights

Value

- Informed decision-making throughout development, leading to improved outcomes
- Enhanced HVAC system efficiency and performance, driving operational improvements
- Enabled iterative development through continuous feedback, ensuring long-term product success

Predict Battery State of Health and Remaining Useful Life

Field data and real-time models ensure accurate predictions of battery life and performance under various conditions

Challenge

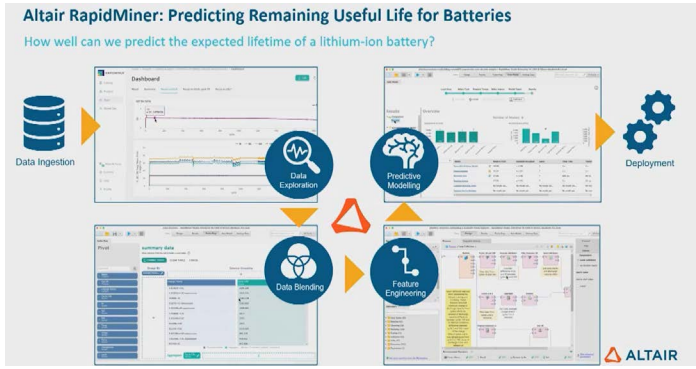
- Predict battery remaining useful life (RUL) and state of health (SoH) using field data
- Account for environmental and operational conditions that affect battery performance
- Accurately measure battery capacity in real-time, which is crucial for RUL assessment

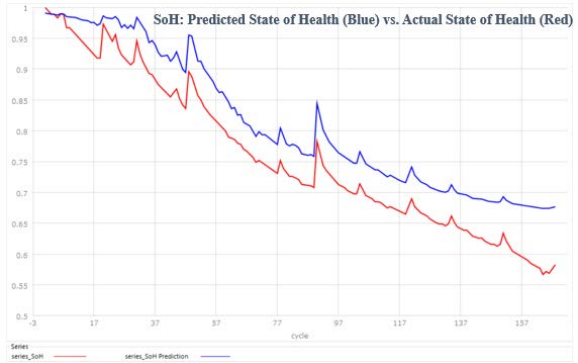
Solution

- Developed a model to forecast battery RUL using data-driven insights
- Implemented real-time adaptive models to account for changing environmental and operational conditions

Value

- Optimized battery performance for extended life and efficiency
- Enhanced fleet and asset management by improving uptime and proactively managing warranties





Improve Passenger Thermal Comfort Simulations

CFD-based ROMs enable real-time coupling with system simulations for accurate cabin temperature predictions

Challenge

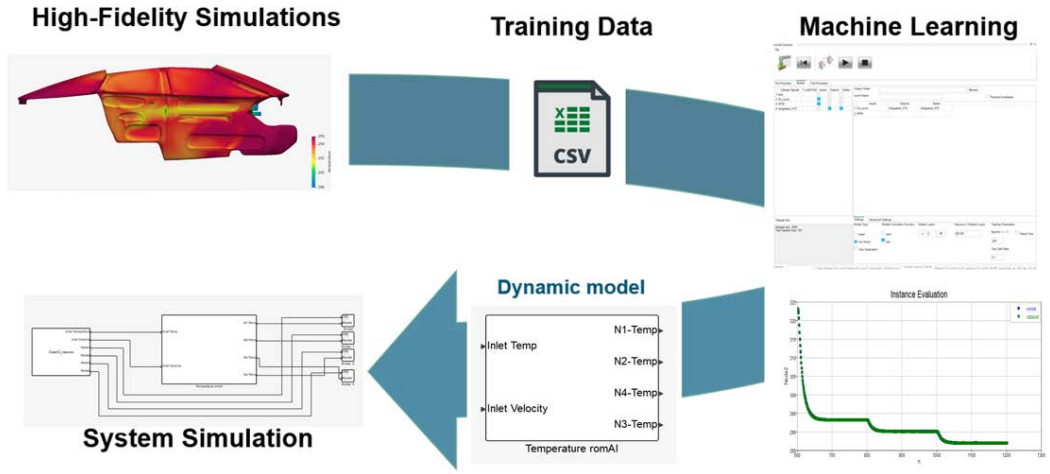
- Difficulty in achieving real-time coupling between CFD and system-level simulations
- System simulation models lack accuracy when relying on equations alone
- Long computational times are required for CFD simulations, slowing down romAI data collection

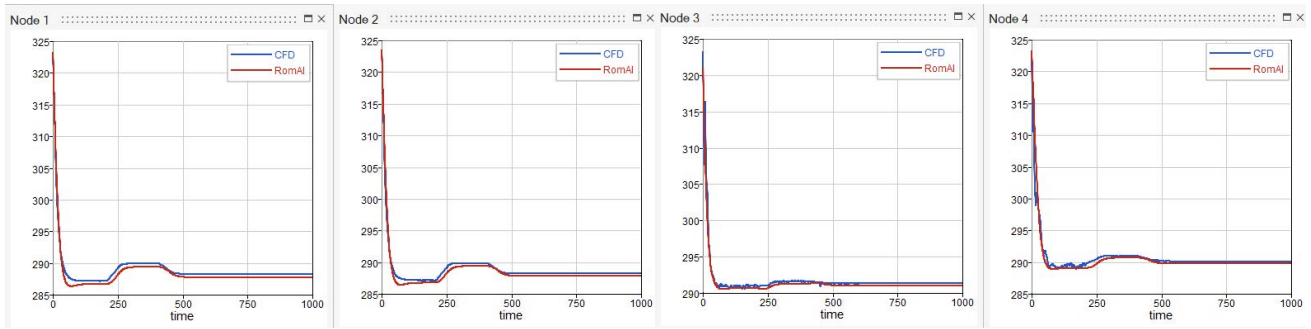
Solution

- Conducted comprehensive CFD simulations to gather detailed data
- Developed advanced Altair® romAI™ models using dynamic and static ROMs for improved simulation fidelity
- Seamlessly integrated romAI models into Altair® Twin Activate™ for efficient system simulation

Value

- Enabled real-time coupling between CFD and system simulations, providing immediate insights
- Improved precision in system simulations, leading to more informed design decisions
- Significantly reduced CFD run times, accelerating the overall development process





Rattle Performance Optimization

Optimizing design parameters to reduce automotive rattle using machine learning

Challenge

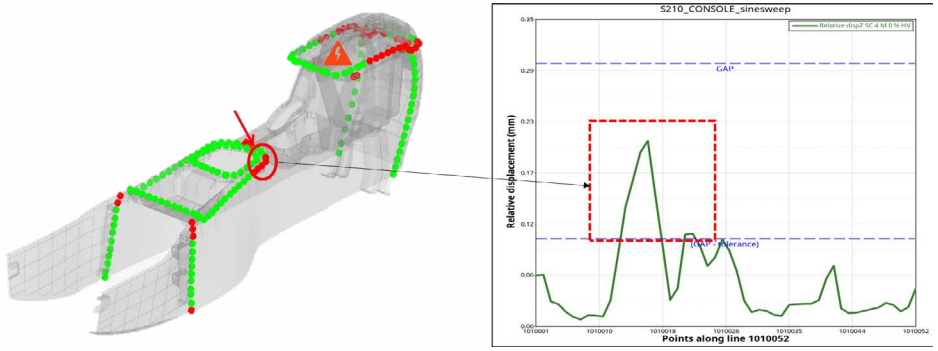
- Rattle noise reduces customer satisfaction, increases warranty claims, and damages brand loyalty
- Numerous interdependent design variables influence rattle performance
- Difficult to efficiently minimize or eliminate rattle noise using traditional optimization methods

Solution

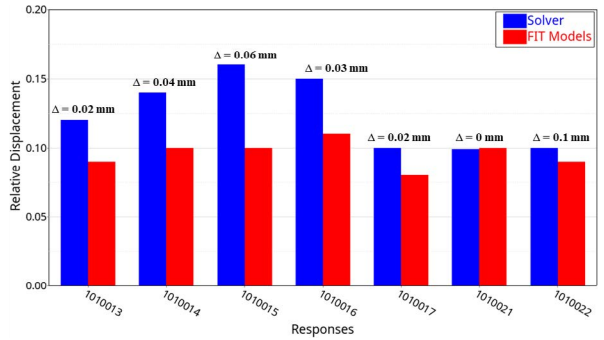
- Used a DOE to identify the most influential design parameters related to rattle
- Trained machine learning to accurately capture rattle behavior across a range of design configurations
- Optimized design parameters using machine learning models to find an optimal solution

Value

- Quickly evaluated performance across a much larger design space compared to traditional methods
- Achieved solver-level accuracy with ML-driven models,ensuring trustworthy results without heavy computational cost
- Completed multi-objective optimization in seconds, accelerating design cycles and reducing physical testing needs



		Train Data Set 450 Runs	Cross Validation	Test Data Set 50 Runs
Label	Fit Type	I R^2	X R^2	R^2
Response point 1010013	RBF	1.0000000	0.9975378	0.9980220
Response point 1010014	LSR	0.9987685	0.9981937	0.9785362
Response point 1010015	MLSM	0.9998621	0.9982932	0.9987690
Response point 1010016	RBF	1.0000000	0.9983203	0.9991771
Response point 1010017	RBF	1.0000000	0.9984200	0.9991467
Response point 1010021	LSR	0.9998034	0.9996656	0.9952576
Response point 1010022	RBF	1.0000000	0.9991528	0.9992151



Real-Time Battery Monitoring for 2-Wheeler

Digital twins and virtual sensors predict battery health and performance metrics, providing real-time insights without physical sensors

Challenge

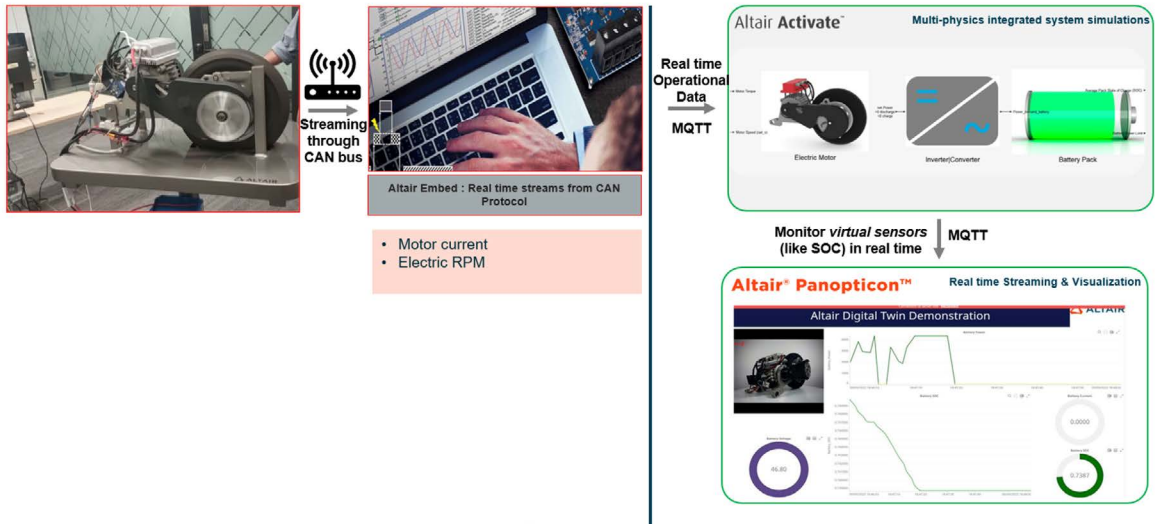
- Develop a digital twin capable of monitoring supplier-procured batteries in real time without the use of physical sensors

Solution

- Created physics-based digital twins of the battery pack, utilizing real-time sensor data
- Collected motor current and RPM data in real time using IoT sensors from the physical asset
- Connected a 1D physics-based digital twin model to predict key battery performance indicators (SOC, SOH, voltage, current).
- Enabled in-service monitoring, streaming and visualizing all battery KPIs in real time

Value

- Achieved continuous real-time monitoring of critical battery KPIs, reducing the reliance on costly physical sensors
- Provided data-driven insights that enabled proactive maintenance and optimization, minimizing downtime
- Lowered operational costs by reducing the need for physical sensors, streamlining battery management, and improving overall system efficiency



HIC Value Predictions for Design Optimization

AI-driven predictions provide quick insights, reducing design iterations and optimizing resource utilization

Challenge

- Simulations are highly compute-intensive, requiring significant resources for repeatable and iterative processes
- Small design changes demand new simulations for verification to meet regulatory requirements
- Iterative verifications are time-consuming, delaying the overall development process

Solution

- Applied AI and data analytics to train models using historical simulation data from multiple vehicle variants
- Automated the extraction of both independent and dependent variables from simulation input and result files
- Enabled designers and CAE engineers to leverage trained ML models for rapid verifications and faster feedback

Value

- Significantly reduced verification time by applying AI-based models early in the design process, allowing quicker concept evaluations
- Lowered costs by reducing reliance on expensive software, hardware, and expert resources, streamlining the verification process

Thermodynamic Analysis of Linear Actuator Time Constants

CFD-based ROMs provide faster and accurate insights into actuator performance across spring configurations

Challenge

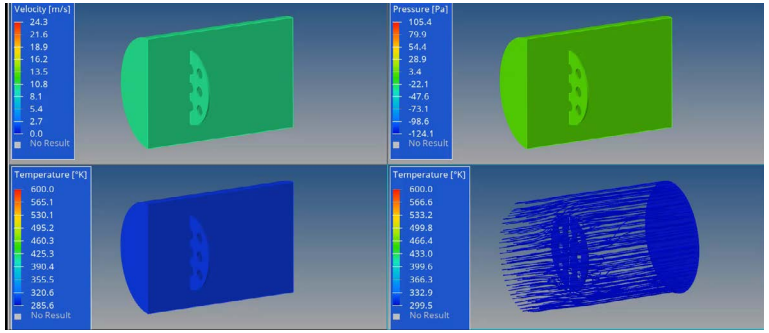
- Time-consuming analysis when studying the time constant of a linear actuator across different spring configurations
- Complexity in accurately modeling thermo-fluid dynamics for various spring configurations
- Difficulty integrating dynamic models into system-level simulations efficiently

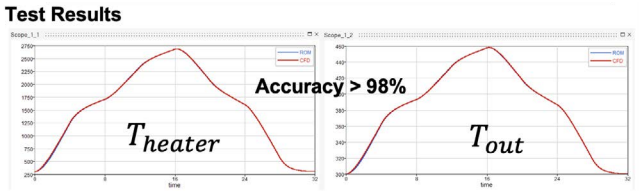
Solution

- Generated training and test data using Altair® AcuSolve®
- Built dynamic ROMs using Altair® romAI™ for improved simulation speed
- Integrated the ROMs with the controller in system-level simulations using Altair® Activate®

Value

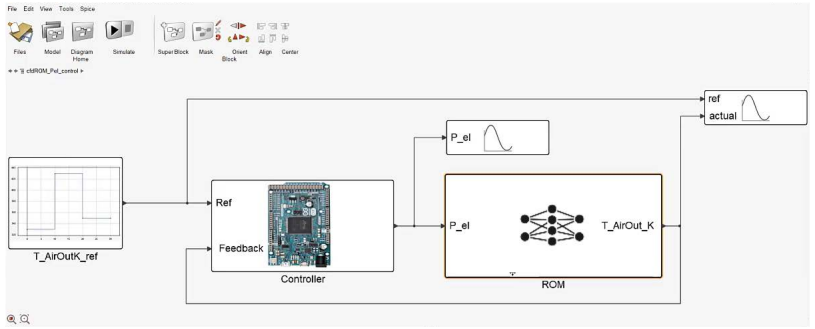
- Achieved extreme efficiency, reducing simulation run time from 6800s to 1s
- Maintained accuracy greater than 98% compared to high-fidelity simulations
- Reduced the need for multiple transient CFD simulations, requiring only one to generate the necessary training data





SPEC	CFD FULL MODEL	DYNAMICAL ROM
Physical time [s]	32	32
Core	28	1
CPU Time [s]	~6800	1*

* Neural Nets Training time: ~300 [s]



Optimize Battery Pack SoC and Voltage in Real-Time

Real-time Power Hardware-in-the-Loop (HIL) Delivers Precise Insights into State of Charge (SoC) and Voltage, Driving Improved Efficiency and System Reliability

Challenge

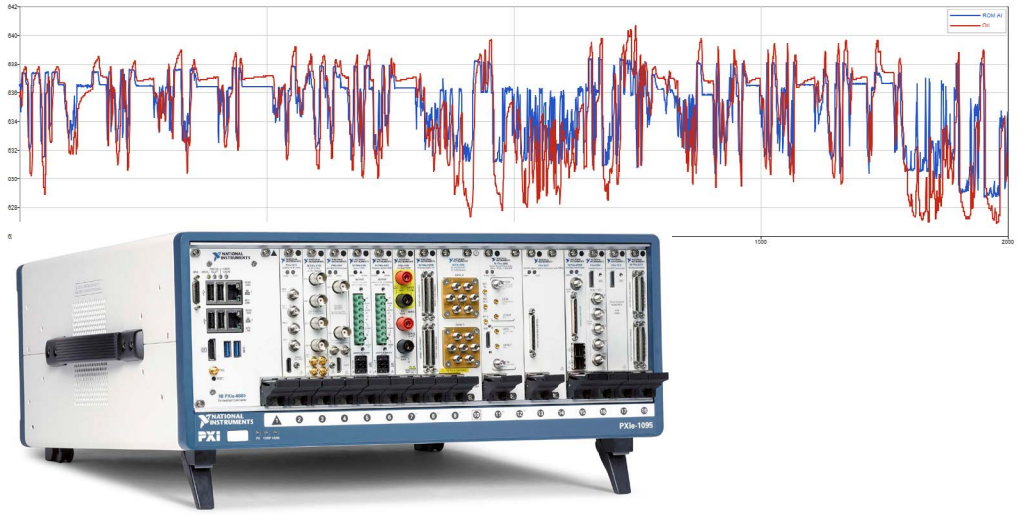
- Achieve real-time simulation with a 1ms time step
- Integrate vehicle, powertrain, and motor models
- Verify accuracy against real-world field test data

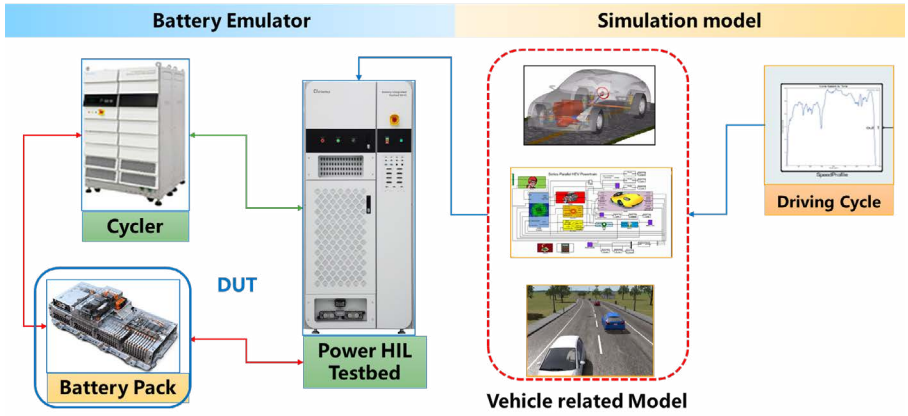
Solution

- Developed battery model using Altair® romAI™ for accurate real-time simulation
- Generated Linux FMU for real-time application on the NI PXI system
- Integrated the BEV template with Altair® FluxMotor® LUT model for comprehensive vehicle simulation

Value

- Achieved 98% accuracy in predicting battery performance, enhancing reliability
- Enabled real-time application, making it suitable for any vehicle-related customer
- Delivered complete solution for BMS controller testing, ensuring complete system validation





Identify Root Causes of Two-Wheeler Warranty Claims

Root cause analysis automates the processing of large, multi-year datasets, forecasting potential issues and scaling to handle rising data volumes, improving product quality and minimizing claims

Challenge

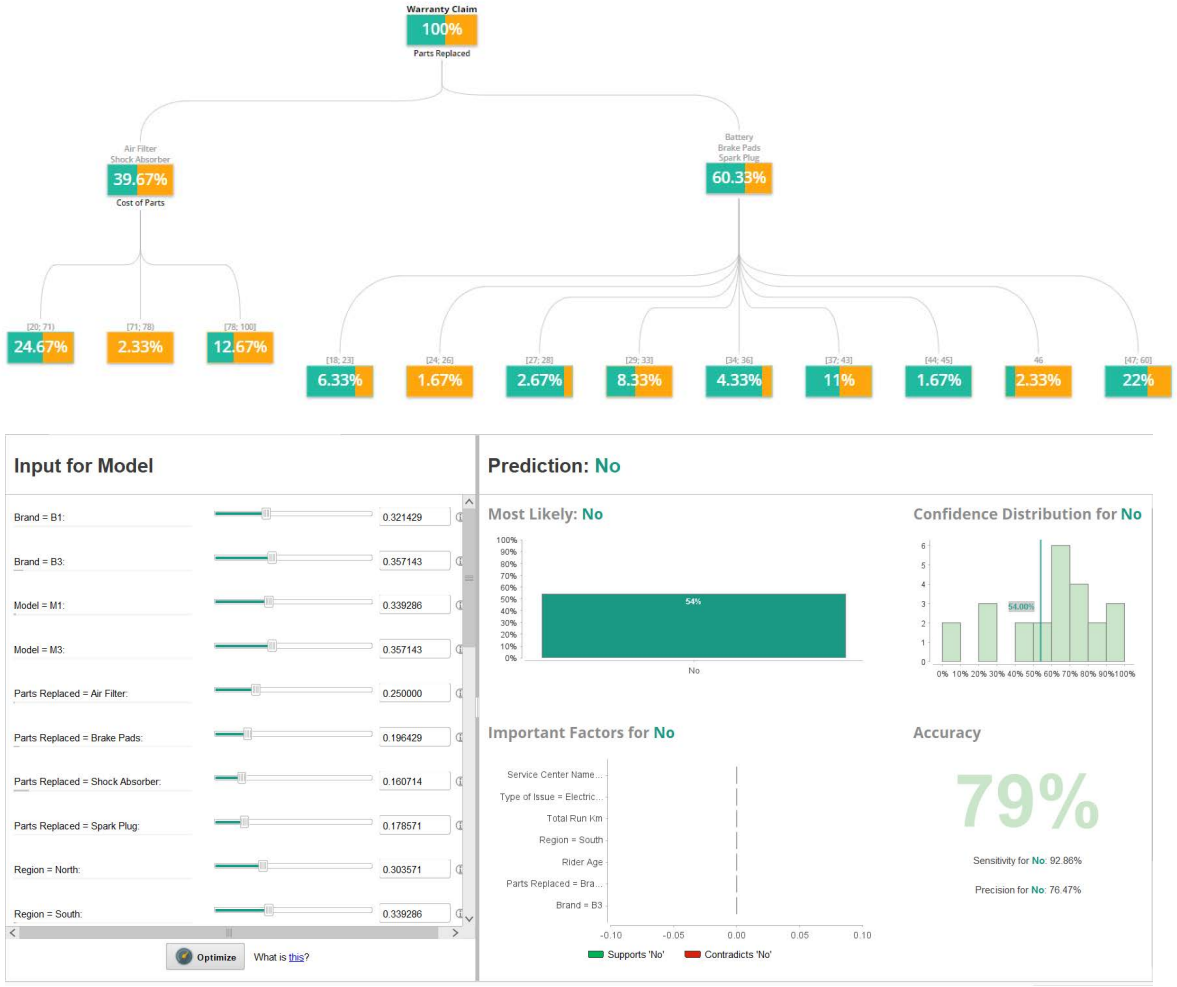
- Manual analysis of large, multi-year datasets is constrained by data complexity and volume, slowing processing and delaying critical insights
- Increasing volumes of warranty data strain manual processes, driving up operational costs and limiting scalability
- Manual analysis introduces risks, from data entry mistakes to missed patterns, jeopardizing reliability and increasing the risk of costly disruptions

Solution

- Automated the processing of warranty datasets, reducing manual effort and accelerating insights
- Forecasted potential warranty issues based on historical data, enabling preventive measures
- Scaled to manage increasing volumes of warranty data, meeting growing business demands

Value

- Accelerated response times, enhanced product quality, and personalized customer experiences
- Optimized inventory by predicting parts replacement needs, reducing excess stock and associated costs
- Proactive analytics reduce warranty claims, free up resources for revenue generation, and increase profitability



Optimize Exhaust Silencer Design for SPL Reduction

AI modeling, supported by simulation and shape morphing, predicts SPL and optimizes silencer design for improved performance

Challenge

- Unclear how to integrate advanced AI technologies into existing product development processes for better results
- Difficulty in achieving effective SPL reduction through traditional exhaust silencer design methods

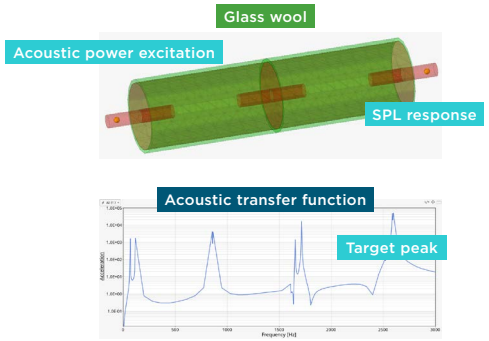
Solution

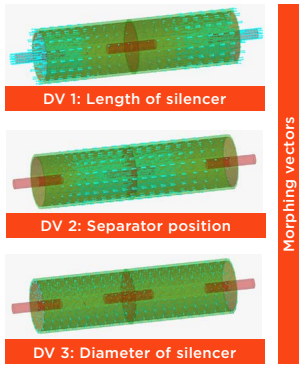
- Solved SPL calculations using Altair® OptiStruct®
- Applied morphing techniques to change the silencer shape
- Created a training dataset with Altair® HyperStudy®
- Developed an AI model with Altair® RapidMiner® and identified the optimal silencer size using the optimization feature

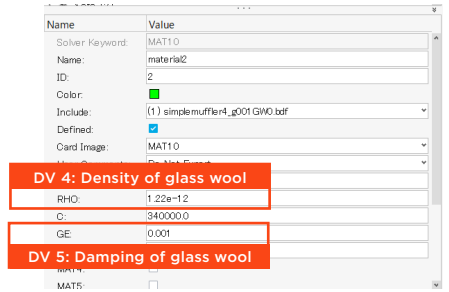
Value

- Leveraged RapidMiner's optimization function to obtain an improved silencer size, resulting in better performance and efficiency
- Identified additional applications for AI in product development, increasing its impact and utility across the organization

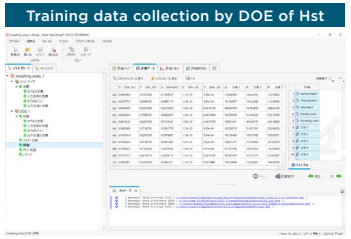
Analysis & Optimization Condition

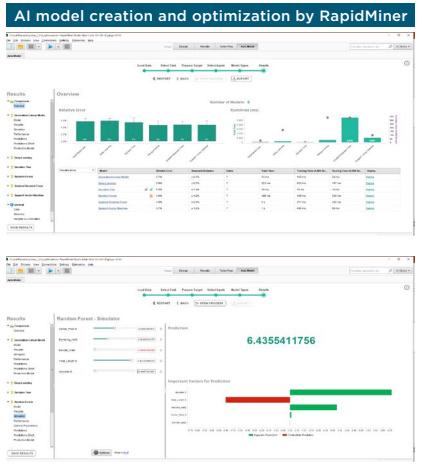


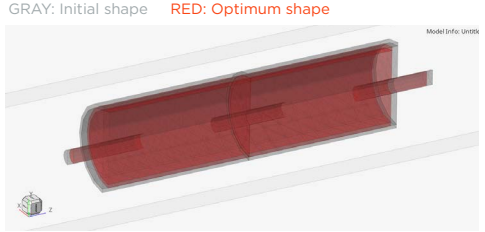


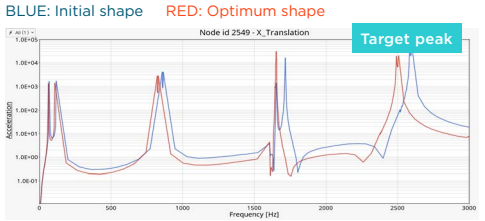


AI/ML Model Creation and Optimization by RapidMiner









Accelerate 3D-CFD Simulation for Optimized HVAC Flow Distribution

AI and 1D modeling accelerate 3D-CFD simulation, delivering faster and more accurate HVAC performance optimization and enhancing overall system efficiency

Challenge

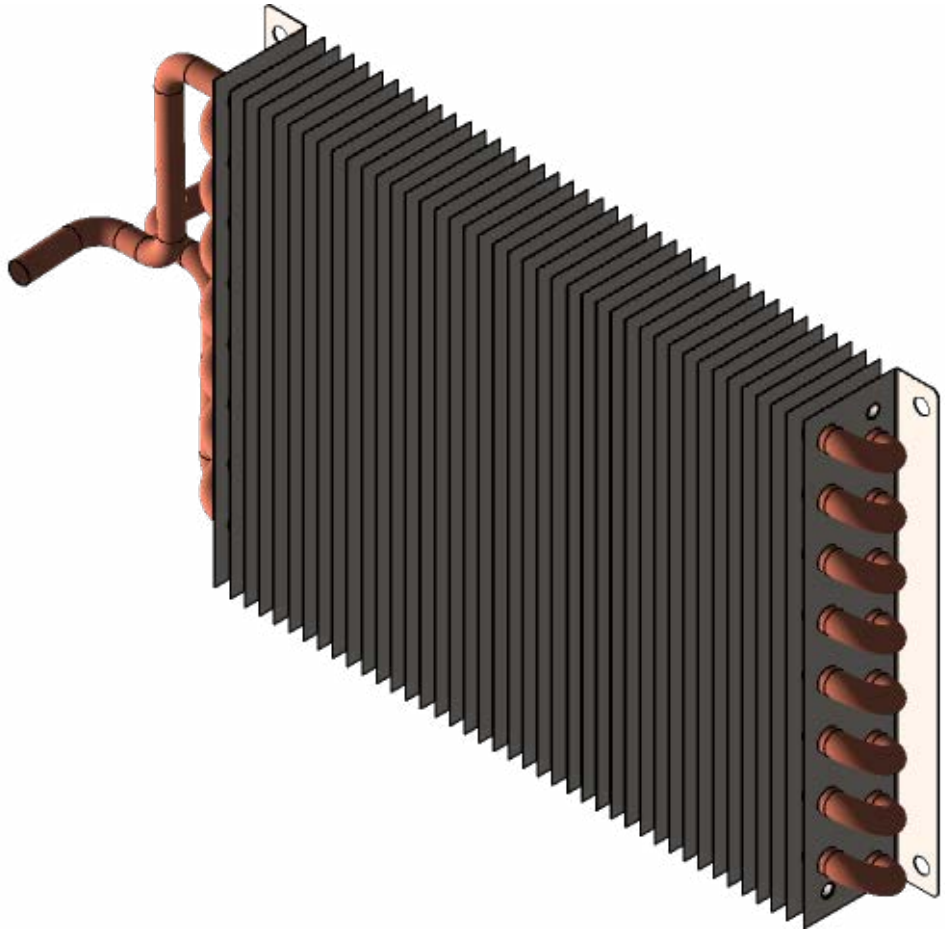
- Resolve vehicle-wide functional deficiencies that require detailed 3D distribution by using AI to reduce computationally intensive 3D-CFD simulations into a streamlined 1D model

Solution

- Reduced the DOFs of output velocity distributions using Singular Value Decomposition in OML
- Employed Altair® romAI™ to predict singular values based on input flow and operating modes
- Recovered the output velocity distributions using a matrix product block in Altair® Twin Activate™
- Exported the FMU containing the ROM from Twin Activate for integration into a 1D HVAC simulation

Value

- Achieved high-accuracy and rapid 1D HVAC simulations, reducing simulation time and accelerating the design process, resulting in significant cost savings and faster time-to-market



Predict EV Gearbox Thermal Behavior and Oil-Gear Heat Transfer

AI-powered ROM and particle-based simulations predict oil-gear HTC and heat transfer from RPM and oil fill levels, reducing computational time and providing accurate predictions for 4000+ gearbox scenarios

Challenge

- Assess the cooling effect of oil on gears and predict the overall thermal behavior of the gearbox to ensure optimal performance
- Manage the complexity of a gearbox parameter space with 4000+ scenarios, encompassing RPMs, oil fill levels, inclination angles, and operating temperatures
- Reduce computational time (~8 hours per run with 2 GPUs) for each Altair® nanoFluidX® simulation

Solution

- Characterized the system using simulation data from a fractional factorial DoE to develop a dynamic ROM that predicts the global HTC
- Conducted particle-based fluid dynamic simulations with nanoFluidX based on RPM and oil levels specified by the fractional DoE
- Developed a non-linear ROM using Altair® romAI™ to reproduce dynamic HTC behavior during operations, with integration into GT-Suite for reuse

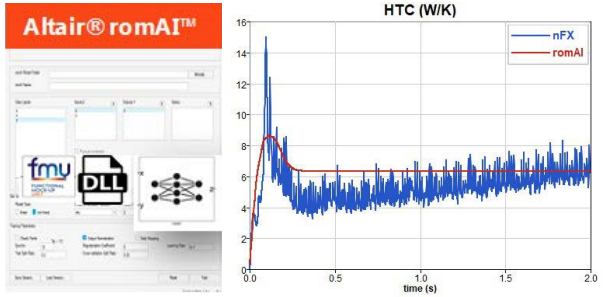
Value

- Achieved a 130,000x increase in speed, significantly reducing time to insights
- Ensured highly accurate predictions for dynamic system behavior, improving decision-making and operational efficiency
- Minimized simulation requirements, lowering computational costs by avoiding a full factorial approach

nanoFluidX High Fidelity Simulations

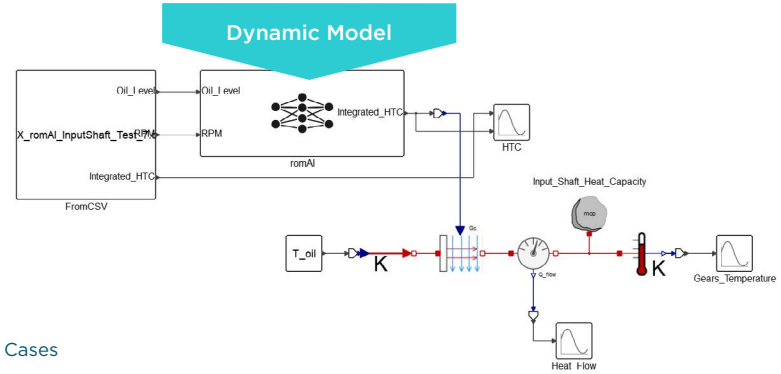
Training Data

romAI Machine Learning



Dynamic Model

1D System Simulation



Rapidly Evaluate New Hood Frame Design Concept

Historical data and AI-powered physics predictions reduce time to assess stress and displacement, enabling quicker evaluations for new hood frame concepts

Challenge

- Engineers must evaluate multiple design concepts rapidly, but traditional FEA methods take too long for comprehensive modeling and simulation, slowing decision-making and product development timelines

Solution

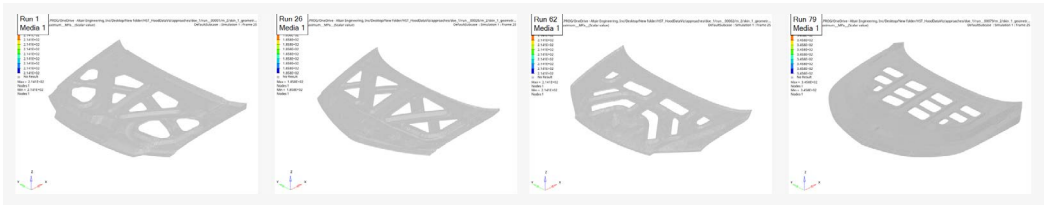
- Leveraged historical data from 10,000+ hood frames, with geometries represented as surface meshes (STL files) and performance metrics from structural mechanics generated through FEA in CSV format
- Applied advanced physics predictions with Altair® PhysicsAI™ using STL and CSV data for rapid evaluations
- Used transfer learning to apply insights to new hood frame design concepts

Value

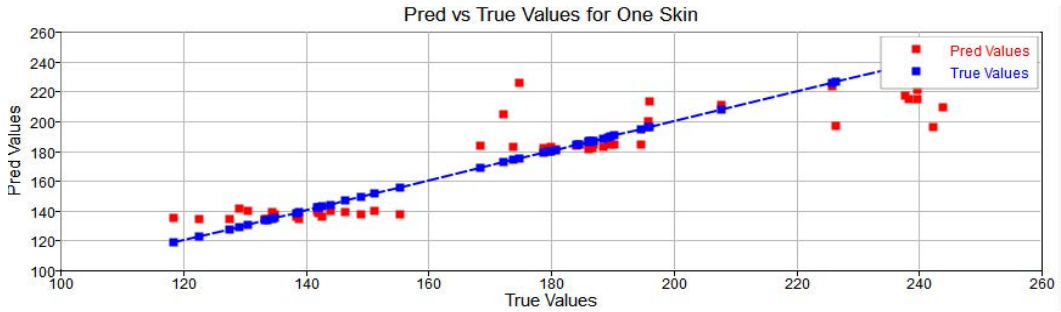
- Delivered fast predictions of maximum stress and displacement, accelerating the design comparison process
- Improved ease of access, usage, and post-processing in Altair® HyperMesh®, enhancing efficiency through streamlined workflows

Dataset generated by: OSU DDML, https://mae.osu.edu/ddml

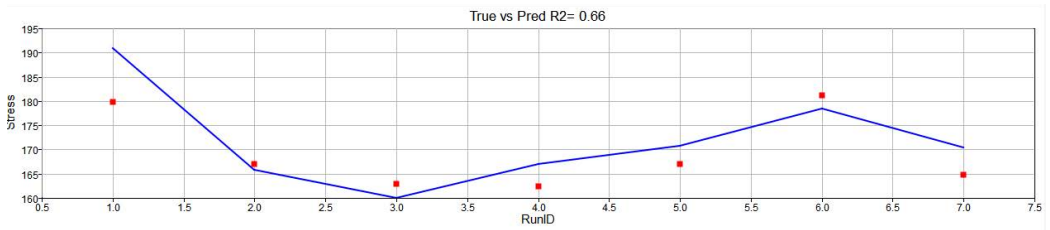
Sample Data



PhysicsAI vs Solver Results



Transfer Learning for New Program



Optimize Airbag Validation for Faster, Cost-Effective Design and Testing

Leverage AI-powered simulation to optimize airbag designs, reduce computational costs, and accelerate validation processes with high accuracy

Challenge

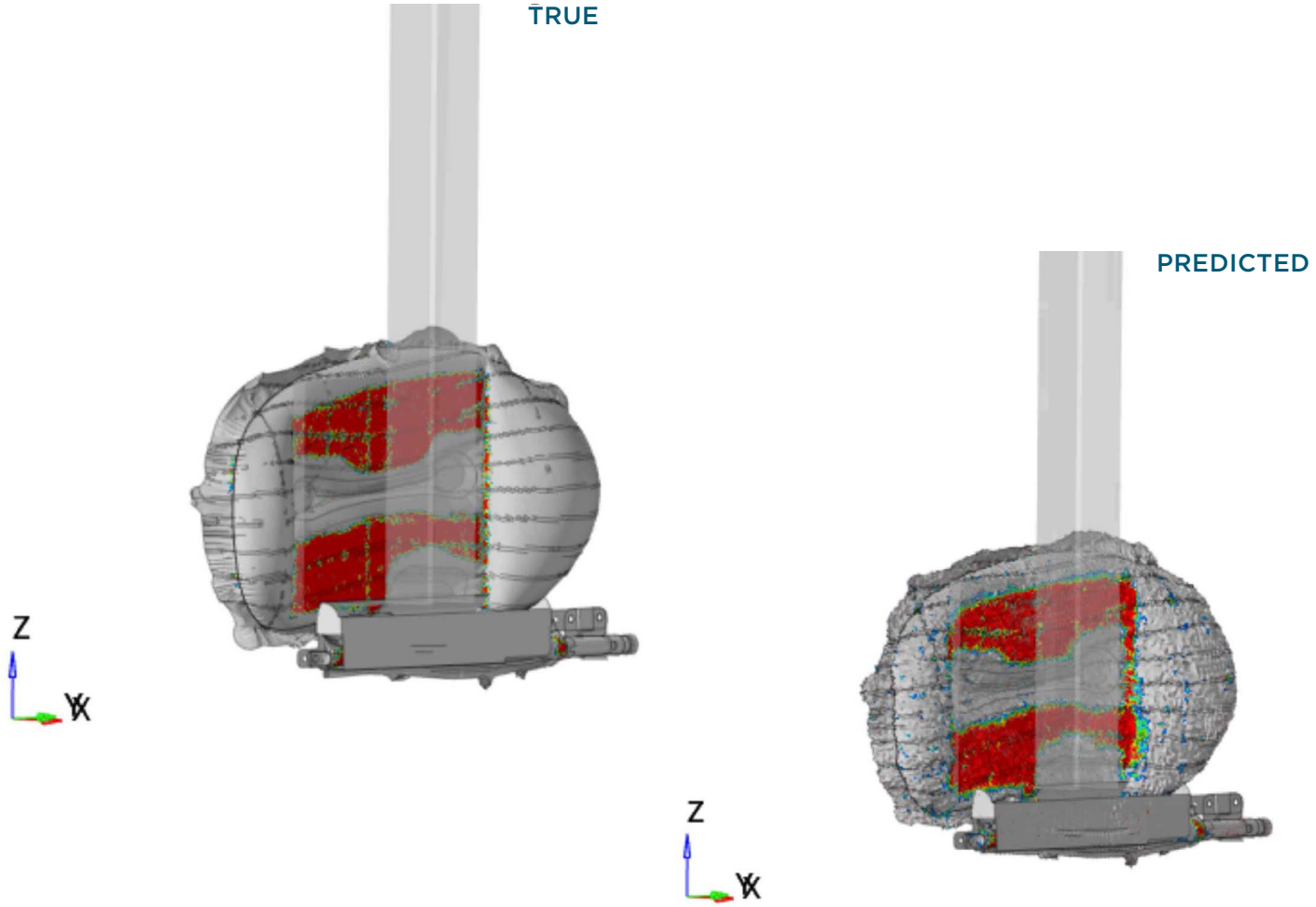
- Airbag validation is critical for ensuring proper airbag function during crash events
- Traditional methods for designing and validating HAB behavior are time-consuming and computationally expensive
- Analyzing vast data across scenarios delays design validation and product development

Solution

- Altair® PhysicsAI™ optimized airbag design by analyzing datasets and predicting behavior across test scenarios
- Predicted airbag contact/interactions with a pendulum test scenario, focusing on the breadth and width of the impactor plate as variant's within the DOE
- Trained a PhysicsAI model using 56 runs (47 training, 9 validation), providing accurate predictions with reduced computational time

Value

- Replaced a 2-hour, 64-CPU simulation with an ML model delivering results in under 30 seconds, cutting costs and time while achieving strong correlation between true and predicted results for high accuracy and precise design decisions
- Extending to predict acceleration, geometry, mass inflow, and leakage, optimizing design processes and efficiency



Faster Exploration of Motorcycle Handlebar Designs for Improved Ergonomics

AI-powered physics predictions leveraging historical data significantly reduce development time, allowing faster design exploration for improved rider comfort and performance

Challenge

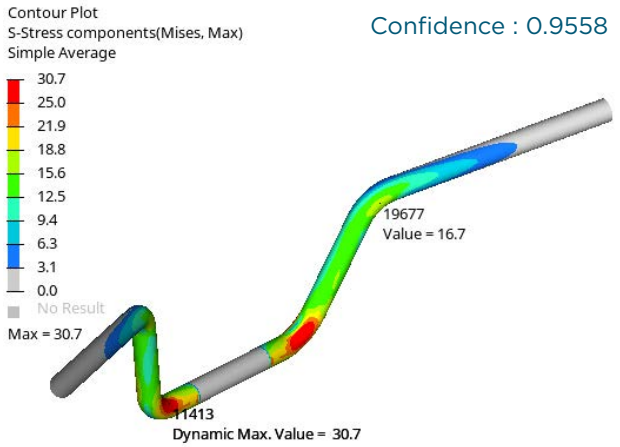
- The handlebar is critical to a motorcycle's ergonomics, affecting rider effort, cornering, and overall comfort
- Traditional methods for building and simulating handlebar designs are time-consuming, limiting opportunities for design exploration

Solution

- Leveraged Altair® PhysicsAI™ to accelerate physics predictions, utilizing simulation data for faster, more efficient design evaluations

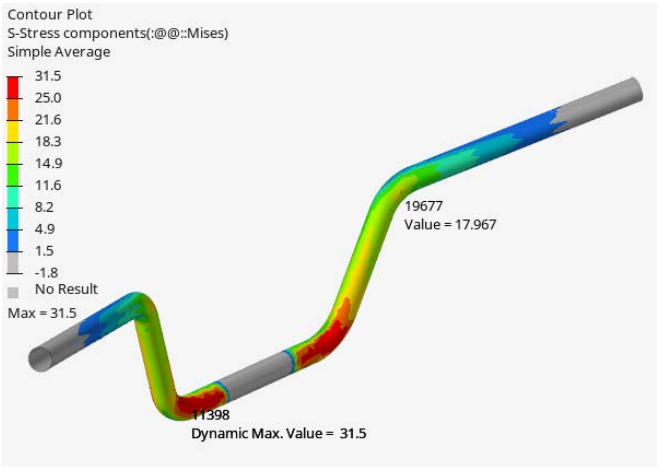
Value

- Significantly reduced product development time, enabling quicker iterations and innovation
- Maximized the utilization of skilled resources, allowing engineers to focus on refining designs instead of long simulations
- Accelerated design exploration, providing faster insights into multiple handlebar concepts for improved performance and ergonomics



Confidence : 0.9558

PhysicsAI: 10 seconds



Solver: 1 hour

Riding Postures

Z Bar — Low Z Bar — Tracker Bar — Drag Bar

Faster Design Exploration of Crash Boxes for Enhanced Safety

AI-powered physics predictions and synthetic data generation drastically reduce simulation time, enabling faster design iterations and improved performance

Challenge

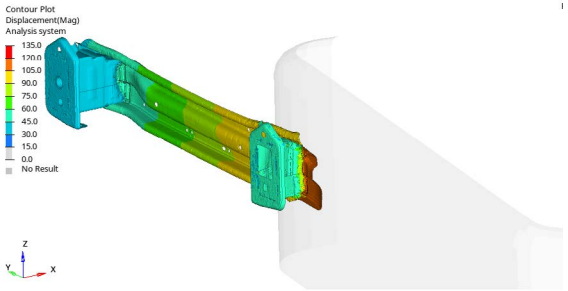
- Crash box simulations require up to 14 hours, making rapid design exploration and iteration impractical
- Extended simulation times limit opportunities for innovation and performance optimization

Solution

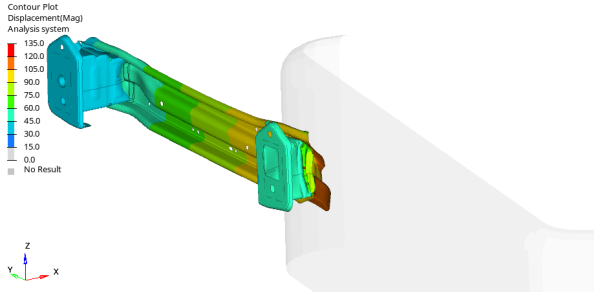
- Generated synthetic data using Altair® HyperStudy® to efficiently support design variations
- Trained an AI model using Altair® PhysicsAI™, leveraging simulation data to enable faster physics predictions and drastically reduce simulation time

Value

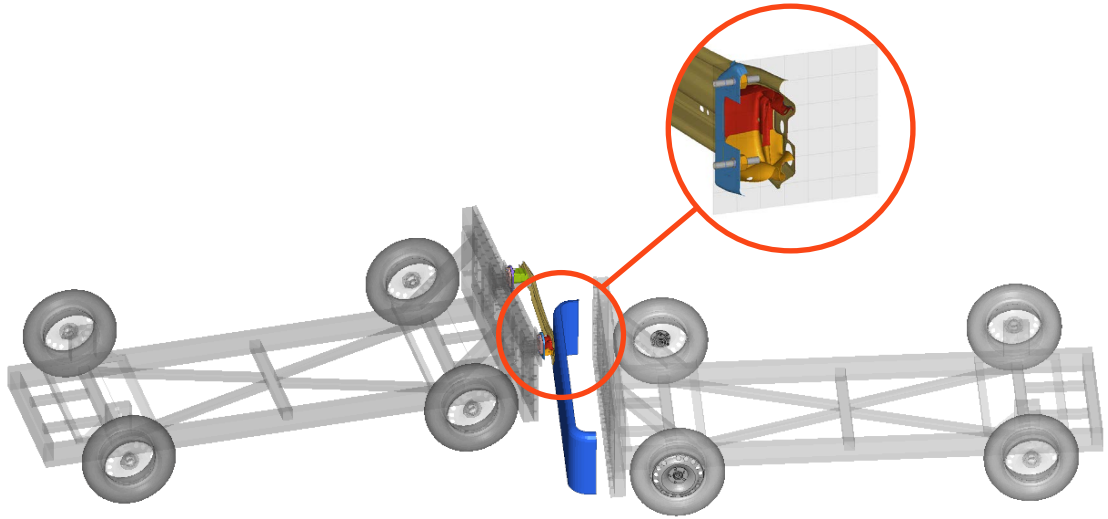
- Reduced simulation time from 14 hours to just 10 seconds, allowing faster evaluation of highly nonlinear transient behavior
- Simplified access, usage, and post-processing through the flexibility and interoperability of the Altair® HyperWorks® platform
- Enabled rapid design exploration, fostering more innovative and efficient crash box designs



PhysicsAI: 10 seconds



Solver: 14 hours



NEW

Speed-up Crash Analysis and Optimization

Predict a five-star, automotive crash ratings before any prototype hits the road – or wall

Challenge

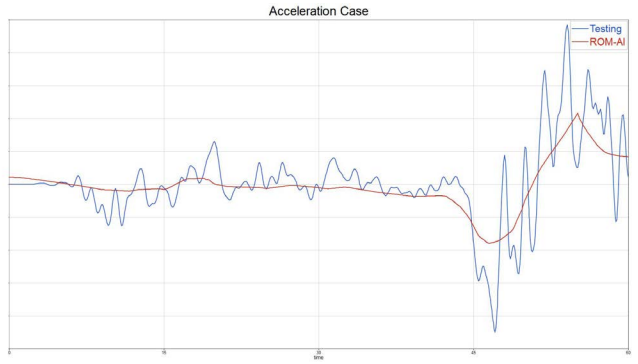
- Optimize thickness of multiple surfaces while ensuring crashworthiness and occupant safety
- Side impacts involve intricate interactions between vehicle structures, interior components, and occupants. Accurately simulating these scenarios is challenging due to nonlinear material behavior and complex contact dynamics.

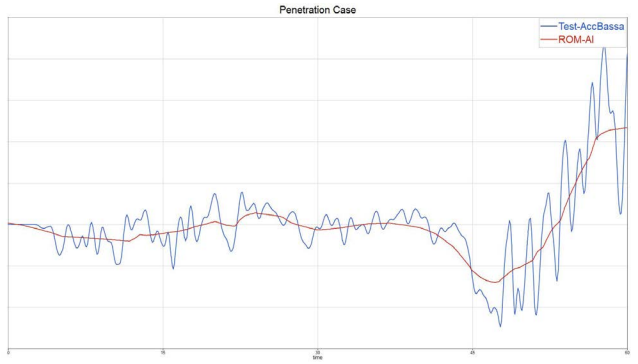
Solution

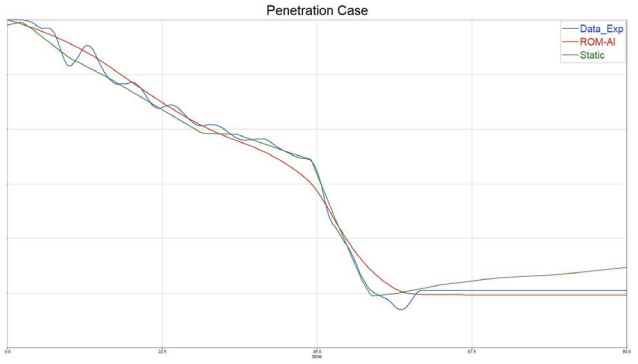
- Ran a fractional factorial DoE using Altair® Radioss® to simulate crash events
- Trained a dynamic, non-linear ROM with Altair® romAI™ to predict crash response across design variants

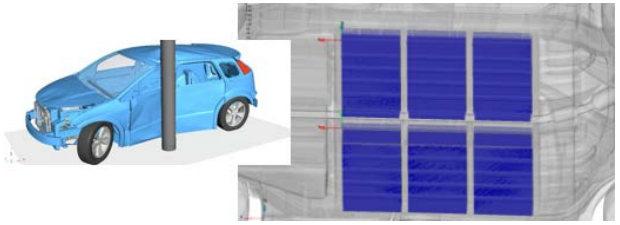
Value

- Reduced runtime from dozens of hours to seconds
- Enabled rapid design optimization and crashworthiness assessment
- Achieved more accurate results than static ROMs for dynamic crash behavior









NEW

Crash Optimization with AI-Based ROMs

Reduce CPU time and run hundreds of crash scenarios overnight using Altair® romAI™

Challenge

- Crash simulations are highly non-linear and computationally expensive, making design optimization difficult

Solution

- Trained a ROM with Altair® romAI™ to learn and replicate complex crash behavior

Value

- Cut simulation runtime from hours to minutes
- Generated hundreds of crash outcomes in a single night
- Enabled accurate, large-scale crash design optimization with 95%+ precision

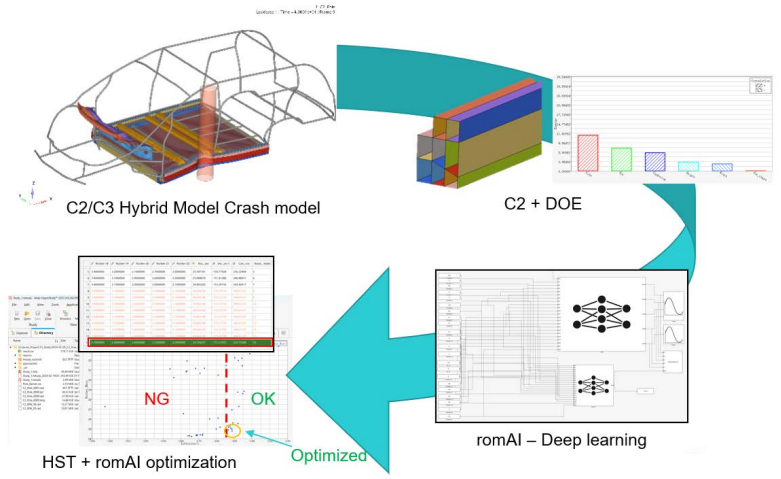
40+ TIMES

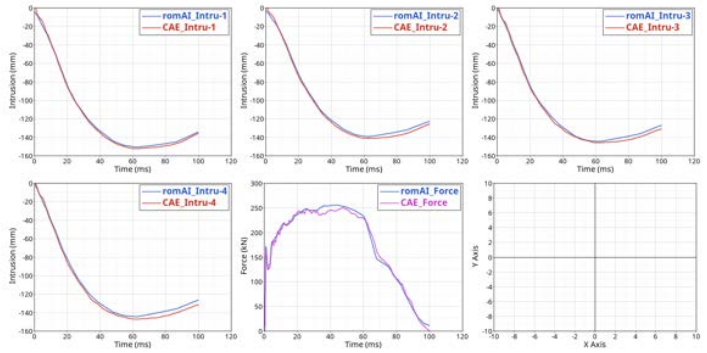
TIME SAVING

95%+

ACCURACY

romAI





Optimized Validation
romAI vs. CAE

NEW

Rapid HVAC Design Optimization for Vehicle Cabins

Replace 3D CFD with AI ROMs to test control strategies in seconds

Challenge

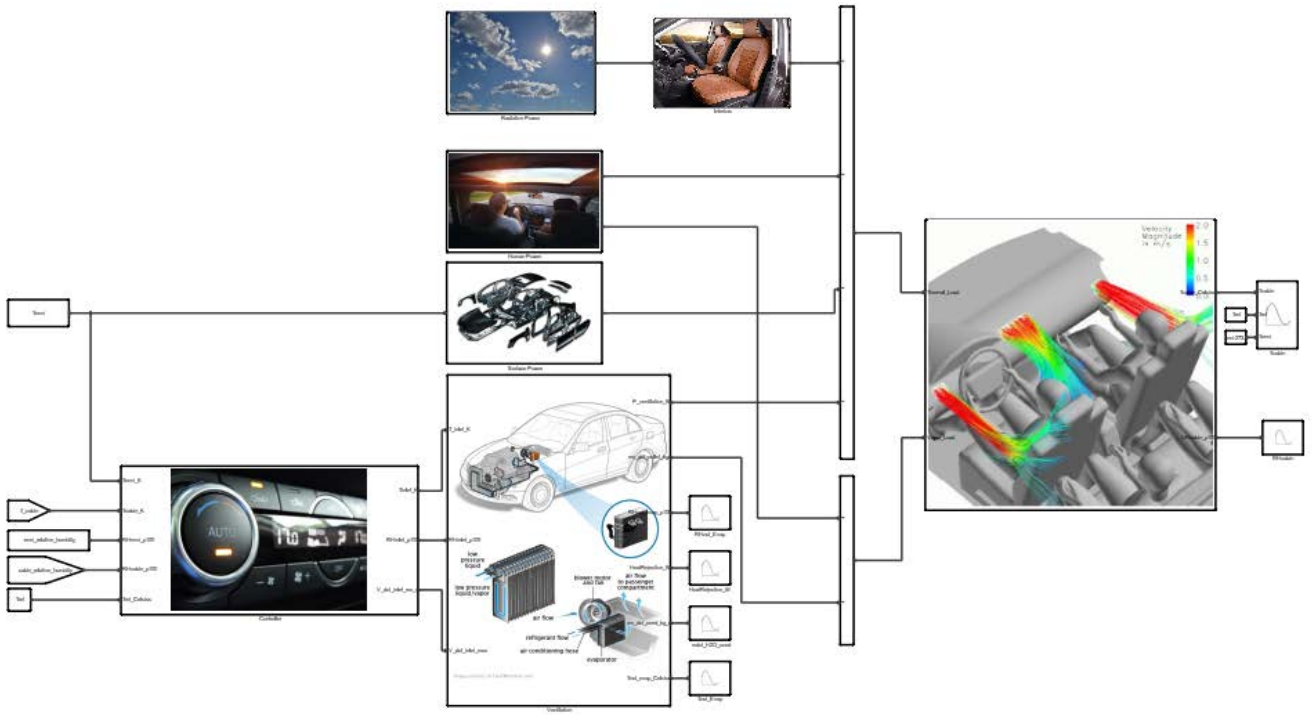
- Optimize airflow and thermal comfort within vehicle cabins
- Reduce simulation time while testing multiple HVAC control strategies

Solution

- Modeled the HVAC system using 1D and 3D data to represent full vehicle airflow
- Created a dynamic ROM of the cabin's thermal environment using Altair® romAI™
- Replaced 3D CFD in the HVAC circuit with the ROM for faster simulation and iteration

Value

- Cut HVAC simulation runtime from tens of hours to seconds
- Maintained accuracy with <1.2 °C difference vs. CFD results
- Delivered better performance than Gaussian regression for high delta-T scenarios (e.g., 4.4 °C)



NEW

Digital Twin of a Bracket Using Minimal Sensor Data

Predict stress and load at critical points with AI and just two strain gauges

Challenge

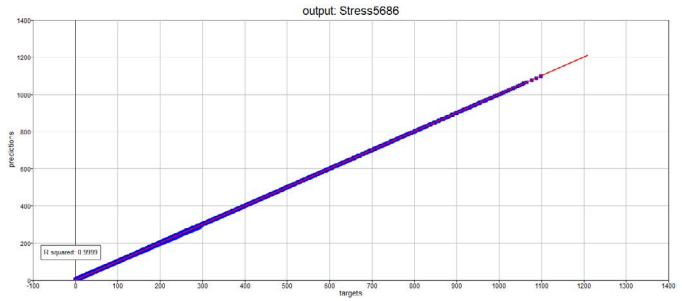
- Accurately assess bracket stress and load using only two strain measurements
- Minimize the number of physical sensors while maintaining prediction fidelity

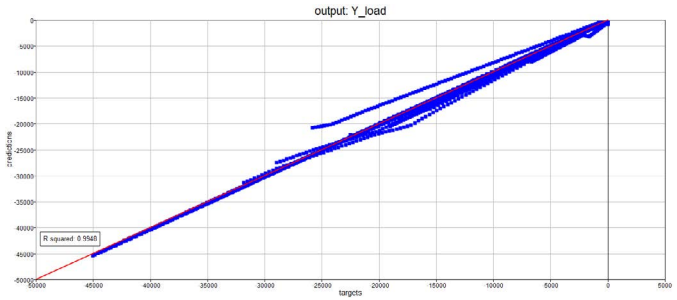
Solution

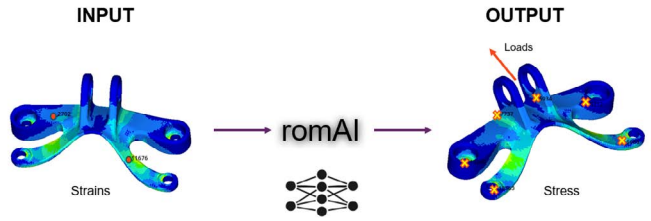
- Built an FEA model in Altair® OptiStruct® to simulate stress/strain under known loads
- Created a ROM in Altair® romAI™ from the FEA data
- Used Altair® Twin Activate® to apply the ROM and estimate full-field stresses from limited strain input

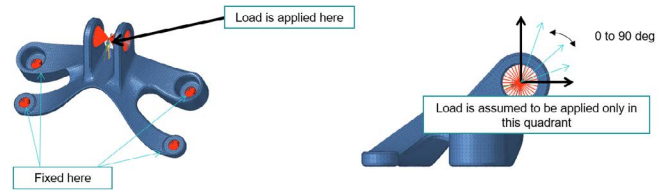
Value

- Achieved >95% accuracy using only two measured strain values
- Enabled real-time performance monitoring with just one FEA model
- Reduced sensor count while maintaining high-quality digital twin predictions









NEW

Cluster Simulation Hotspots for Better Training Data

Improve AI model quality by curating large simulation datasets through feature extraction and clustering

Challenge

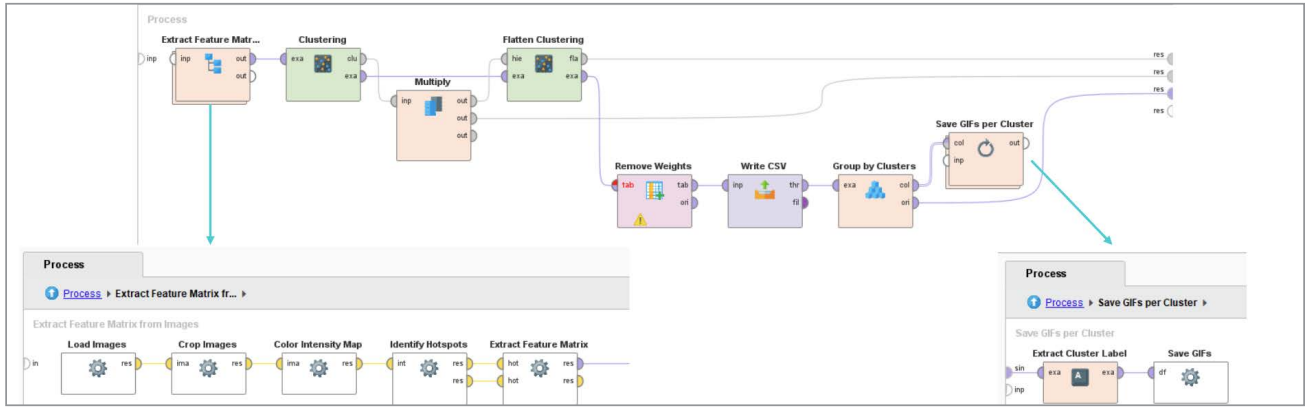
- Simulation datasets are massive and difficult to manage efficiently
- High dimensionality makes it hard to identify patterns or reduce redundancy
- Poorly curated data can bias AI models and reduce predictive performance

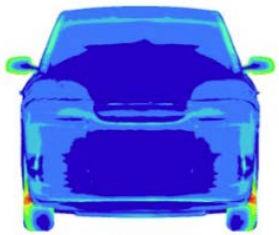
Solution

- Focused curation efforts on performance variation in simulation results, rather than geometric differences
- Extracted hotspot features (e.g., count, location, intensity) from simulation data using Altair® RapidMiner®
- Transformed results into 2D image representations to reduce dimensionality while preserving key behaviors
- Applied clustering in RapidMiner to group similar simulations and enable structured, scalable dataset creation

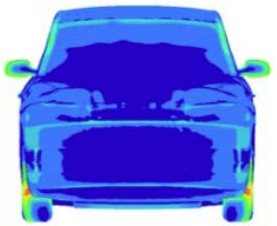
Value

- Accelerated AI adoption by delivering cleaner, better-structured training data for downstream use in tools like Altair® PhysicsAI™
- Reduced engineering time and effort by automating simulation data prep and organization
- Enabled scalable AI initiatives through structured datasets that support faster, more confident decision-making

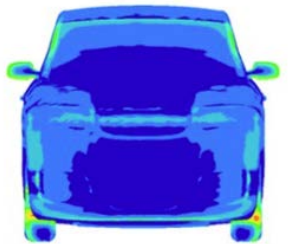




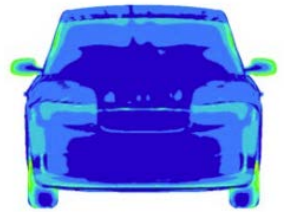
Cluster 1:
Flatter windshield design with zero/one hotspot



Cluster 2:
Slightly elevated windshield with two hotspots



Cluster 3:
Highly elevated windshield with more than 4 hotspots



Cluster 4:
Moderately elevated windshield with 3/4 hotspots

NEW

Predicting Thermal Runaway in Batteries

Use experimental data and physics-constrained deep learning to model battery fire risk in minutes

Challenge

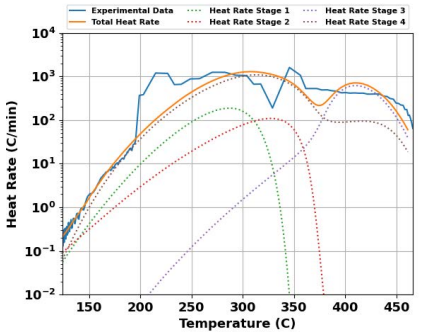
- Thermal runaway, triggered by a single overheating cell, can lead to explosive battery fires, posing serious risks to EV safety and reputation
- EV manufacturers face strong commercial pressure to accurately simulate thermal runaway and validate battery safety early in development
- Traditional methods rely on empirical curve-fitting and trial-and-error, making them slow, expensive, and too imprecise for modern design needs

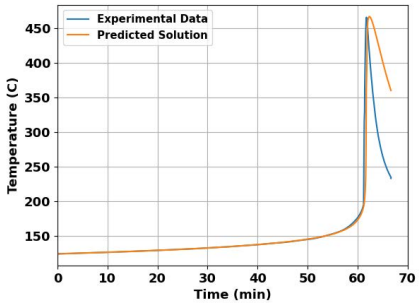
Solution

- Built a physics-constrained Neural ODE model trained on experimental calorimetry data to learn the behavior of thermal runaway
- Structured the model architecture to follow governing equations, enabling physically meaningful and highly accurate predictions
- Used deep learning and backpropagation to detect sudden temperature spikes, with the model optionally integrated into Altair® AcuSolve® for system-level simulation

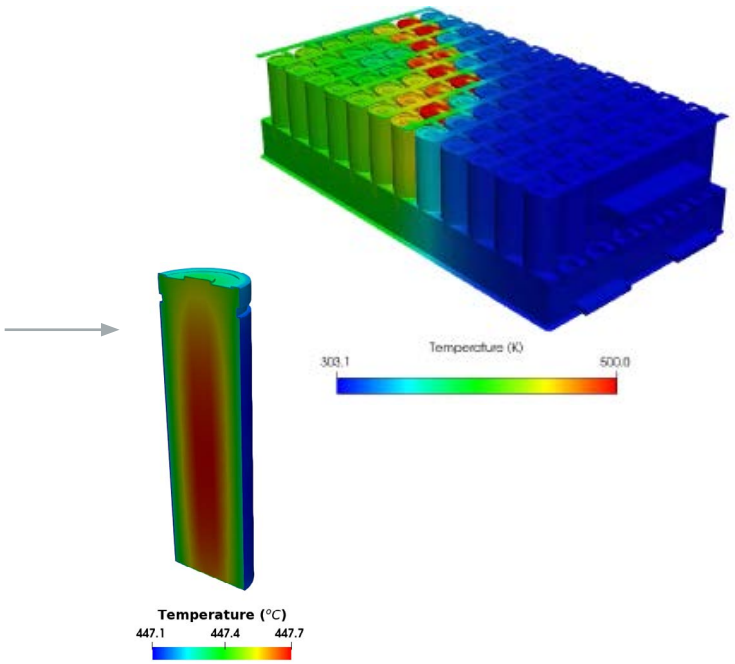
Value

- Accurately predicted thermal runaway across diverse battery abuse scenarios
- Cut modeling time from hours to minutes with automated training
- Enabled faster, safer, and more cost-effective design iteration





Physics-constrained AI model learns from data



Simulate thermal runaway

NEW

Weld Quality Detection

Automated vision-based inspection powered by Altair® AI Edge™ and integrated IoT monitoring

Challenge

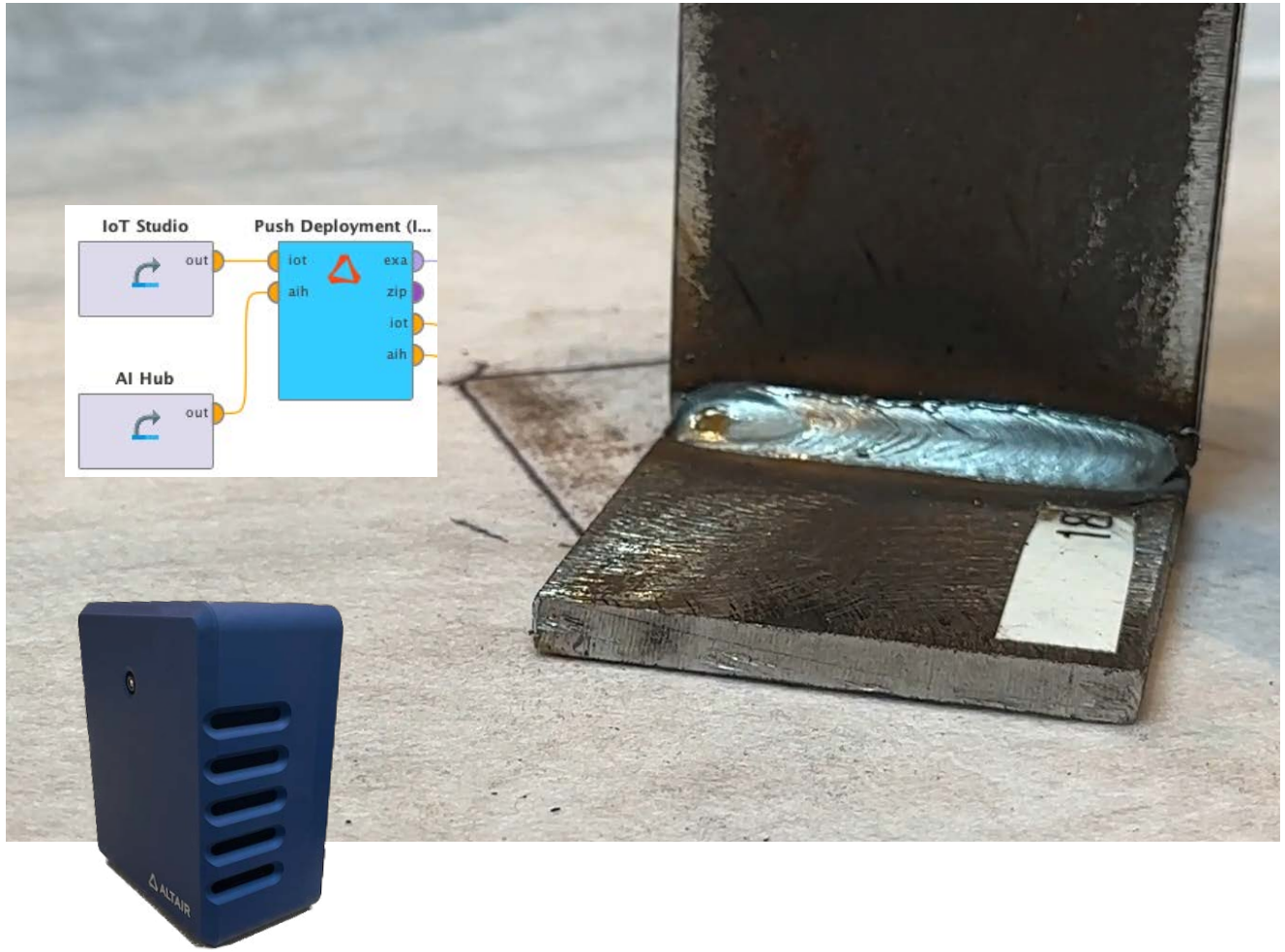
- Manual weld inspection is time-consuming and difficult to scale
- Unstructured image data presents challenges for automated defect detection
- Identifying and diagnosing weld defects requires complex root cause analysis

Solution

- Deployed AI Edge device to create a full end-to-end vision-based weld inspection system
- Integrated with Altair's AI and IoT solutions to capture, score, and stream imagery from the production line
- Enabled real-time defect classification at the edge through drag-and-drop AI model deployment
- Provided centralized monitoring of AI Edge devices via a cloud-native IoT interface

Value

- Reduced inspection time and manual labor through real-time, automated weld quality checks
- Improved product consistency and traceability with centralized quality data across edge devices
- Shortened production cycles by accelerating defect detection and root cause analysis



NEW

Rapid Structural Simulation of Ladder Chassis Design for NVH Domain

AI-driven modal analysis for rapid prediction of natural frequencies and mode shapes in chassis development

Challenge

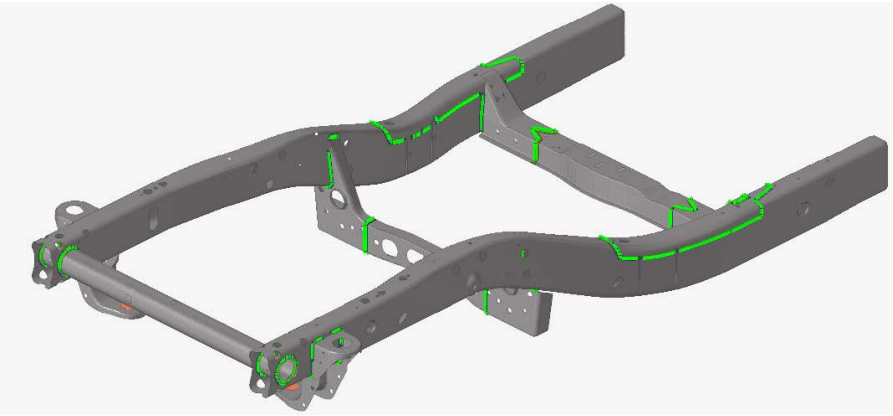
- Traditional CAE simulations for modal analysis are time-intensive, slowing early-stage design decisions
- Engineers need fast, accurate predictions of natural frequencies and mode shapes to iterate quickly

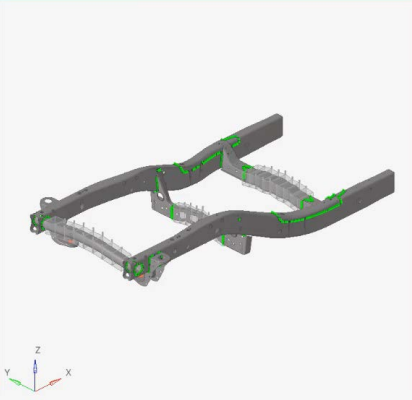
Solution

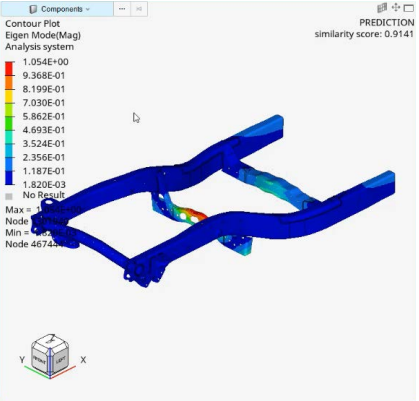
- Generated synthetic datasets using Altair® HyperStudy®, varying chassis thickness and shape within manufacturable limits
- Trained an Altair® PhysicsAI™ model on curated simulation results to rapidly predict vibrational behavior for new designs

Value

- Enables real-time prediction of structural behavior for new design changes
- Reduces computational cost and supports faster decision-making during product development
- Enhances early-stage design by providing actionable insights on vibrational performance







NEW

Enabling Collaborative Product Development through Democratized Simulation Intelligence

Leveraging Altair One® as a unified gateway for data-driven engineering across stakeholders

Challenge

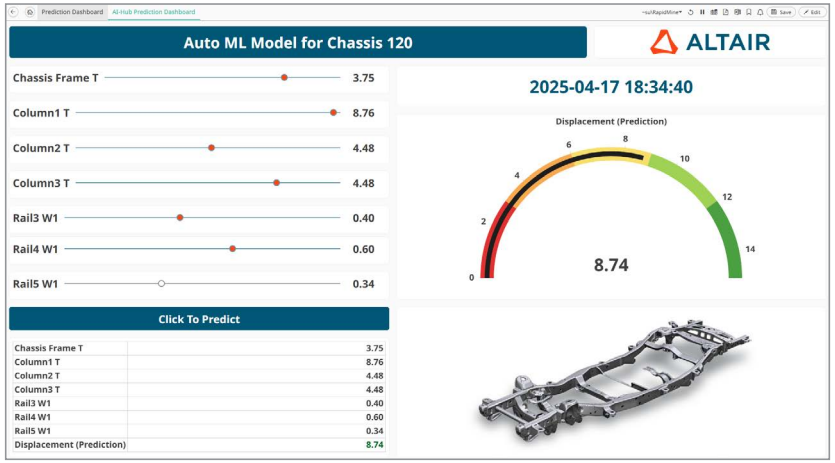
- Multiple stakeholders contribute across the product development lifecycle, but tools and workflows remain siloed.
- Collaboration is limited by the lack of a unified platform for cross-functional collaboration.
- Scaling and deploying solutions across cloud and on-prem environments is complex and inconsistent.

Solution

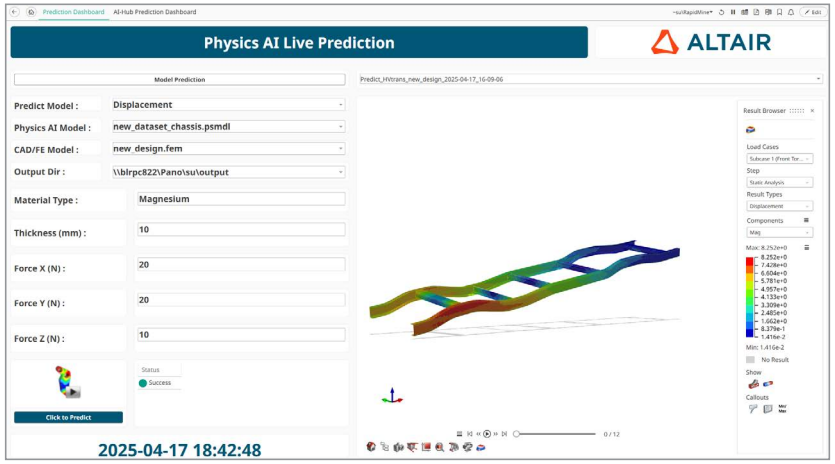
- Altair One serves as a unified access gateway, enabling a hybrid integration of Altair's tools tailored for different roles in the product lifecycle.
- Altair® HyperWorks® is used for metadata extraction and accurate physics prediction, enhanced by Altair® PhysicsAI® to deliver intelligent insights.
- Altair® 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

NEW

Inventory Management with AI for Leading OEM Supply Chain

Reducing cost, emissions, and stock disruptions with part-level safety stock intelligence

Challenge

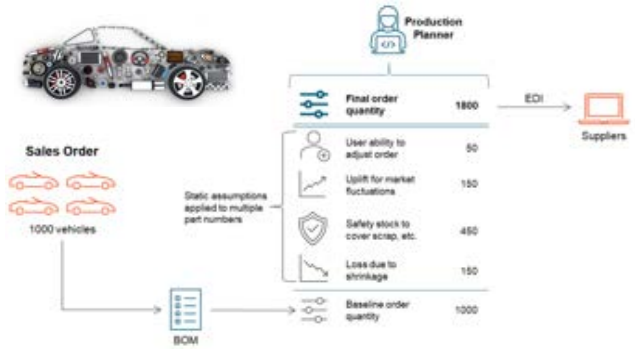
- Inventory safety stock levels were set manually, based on fixed rules and planner experience—not on real-world demand or supplier variability
- Sourcing spanned 9,500+ parts with lead times ranging from hours to 13 weeks across local, regional, and global suppliers
- Resulted in excess stock, emergency shipments, missed orders, and inconsistent inventory reviews — leading to cost overruns and carbon-intensive logistics

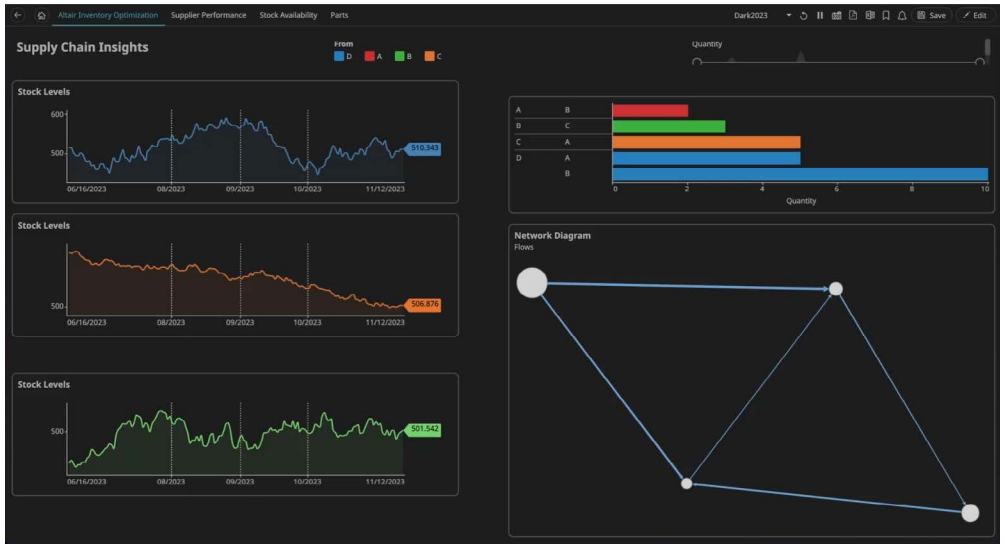
Solution

- Used Altair® RapidMiner® to build an AI model that analyzes demand patterns, lead times, and shipping conditions to forecast part-level ordering needs
- The software gives the ability to dynamically optimize safety stock parameters and weekly ordering schedules – replacing static rules with intelligent recommendations

Value

- Potential to save 15% of costs by eliminating excess safety stock and manual safety buffers
- Improve service levels with fewer missed orders, last-minute expedites, and production delays
- Contribute to sustainability goals by reducing air freight emissions tied to reactive logistics decisions





Heavy Engineering Use Cases

Optimize Excavator Bucket Designs for Improvement in Filling Efficiency

AI-powered co-simulation accelerates design iterations, leading to a 20% improvement in bucket filling capacity and the ability to compare multiple design variants in under a minute

Challenge

- Optimizing the bucket shape for particle filling during the excavator's digging cycle is critical for performance
- Traditional methods are time-consuming, requiring multiple shape changes and new simulations for each iteration

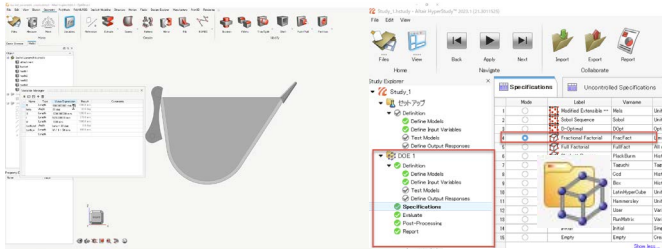
Solution

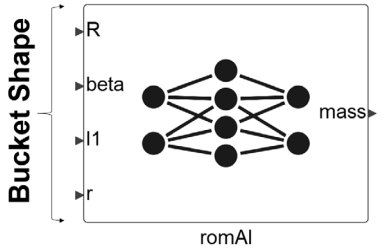
- Leveraged the co-simulation between Altair® MotionSolve® and Altair® EDEM™ to simulate the full multibody excavator, including flexible components, interacting with granular material/particles
- Created a parametric bucket shape using Altair® Inspire™ sketching and parametric features for flexible design iterations
- Automatically updated the bucket's parametric geometry for each run of the DoE, feeding it into the MotionSolve-EDEM co-simulation, facilitated by Altair® HyperStudy®
- Trained a Reduced-Order Model (ROM) using DoE results with Altair® romAI™, ready for fast optimization within Altair® Twin Activate™

Value

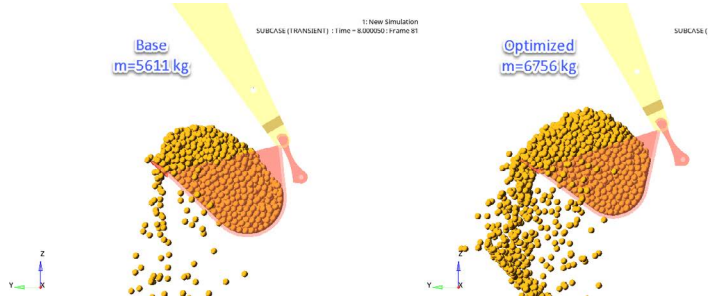
- Achieved a 20% improvement in bucket filling mass compared to the original design
- Enabled comprehensive optimization, comparing dozens of design variants in less than 1 minute

Full 3-D model (~1 hour)





Accurate ROM (~1 s)



Fast optimization (~1 min) > + 20% fill gain

ALTAIR

Enhance Tractor Performance and Accuracy in Real-Time Hardware Simulations

Turn high-fidelity 3D DEM simulations into an efficient and accurate deep learning based ROM model deployed for a real-time hardware application

Challenge

- Modeling real-time plow-soil interaction forces and integrating them into the full tractor simulation requires accurate, dynamic data and seamless integration.
- Traditional methods struggle to provide the real-time feedback for realistic performance predictions

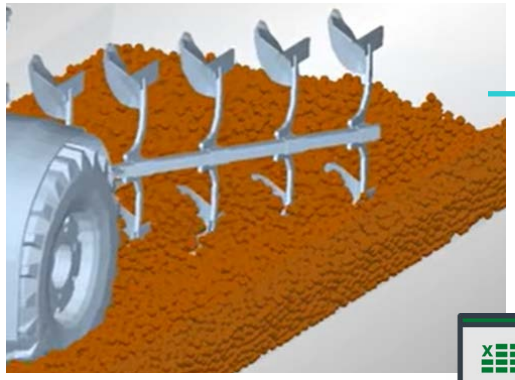
Solution

- Ran high-fidelity DEM simulations in Altair® EDEM™ to develop a real-time compliant ROM, leveraging Altair® romAI™ and Altair® Twin Activate™ to accurately estimate plowing forces under various conditions
- Integrated the ROM with real-time hardware, including a driver-in-the-loop system, for enhanced simulation accuracy

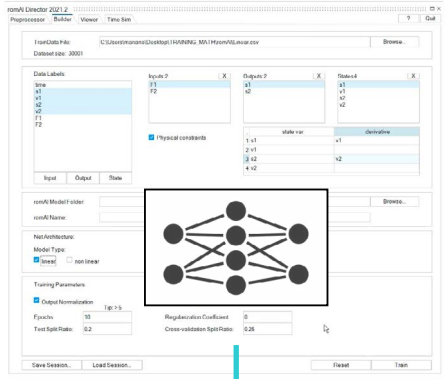
Value

- Simulated a more realistic plowing experience, improving accuracy for better decision-making and performance evaluation
- Provided a better estimation of consumption, facilitating more efficient tractor operations

EDEM



romAI
Twin Activate



Real-Time
Hardware

Real-Time Health Monitoring for Critical Components in Heavy Equipment

Utilizing AI/ML-powered digital twins and virtual sensors to monitor the state of health (SoH) in real-time, enabling anomaly detection, failure prevention, and improved maintenance efficiency

Challenge

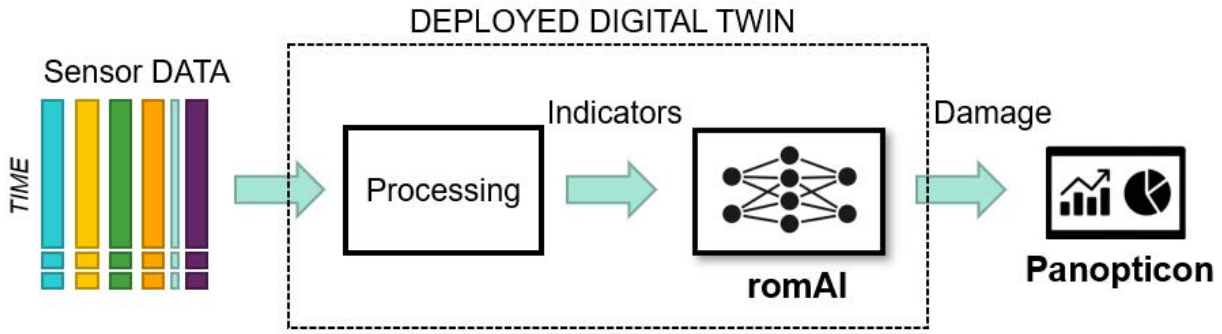
- Accurately estimating the state of health (SoH) of critical components in real-time using sensor data such as accelerations and pressures is essential to avoid failures and reduce downtime

Solution

- Developed real-time compliant virtual sensors that accurately predict the SoH using Altair® romAI™ and Altair® Twin Activate™. These virtual sensors can be deployed on edge devices or cloud platforms for continuous monitoring

Value

- Gained a deeper understanding of system damage behavior under various operating conditions
- Improved anomaly detection and failure prediction, enabling proactive measures to prevent breakdowns
- Enabled more effective predictive maintenance planning, reducing downtime and improving overall operational efficiency



Faster Full Vehicle Dynamics Analysis for Leaf Spring Suspension

AI-generated ROM reduces simulation time by 31x, speeding up vehicle dynamics analysis while maintaining accuracy through comprehensive leaf spring data integration

Challenge

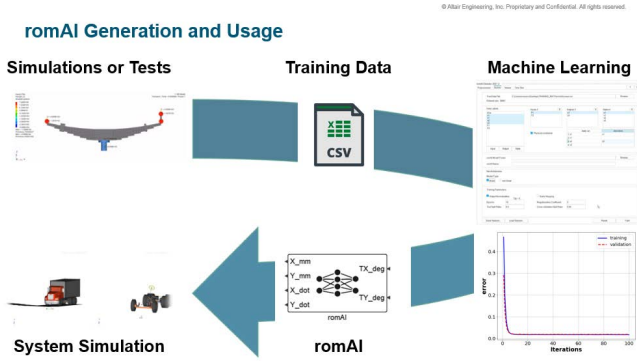
- Traditional system-level simulations for full vehicle dynamics are time-consuming, hindering the ability to quickly evaluate and optimize performance

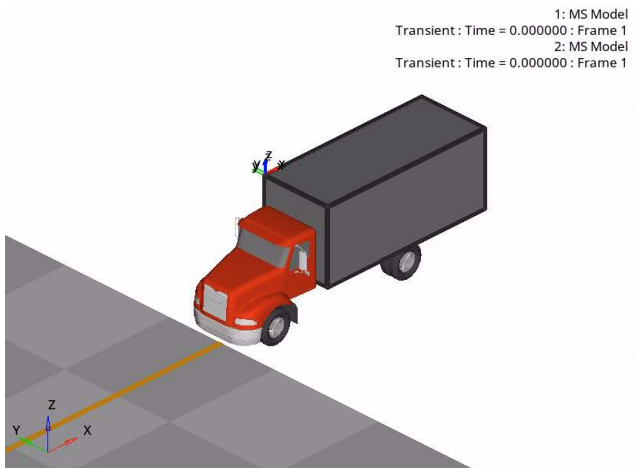
Solution

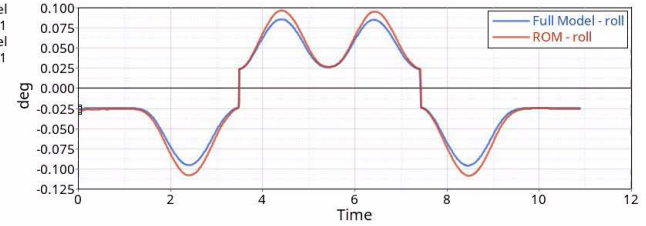
- Generated training and test data for the leaf spring suspension using the Leaf Spring Builder in Altair® MotionView®
- Created a ROM for the leaf spring suspension using Altair® romAI™
- Simulated the full vehicle dynamics, incorporating the ROM for faster analysis, using Altair® MotionSolve®

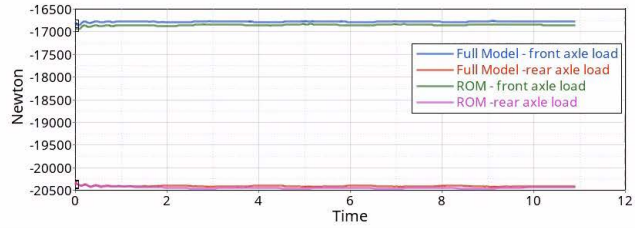
Value

- Achieved a 31x reduction in runtime (from 992 seconds to less than 32 seconds), significantly speeding up vehicle dynamics analysis and enabling quicker design iterations
- Ensured good accuracy of the solution, with visual comparisons demonstrating reliable results and supporting faster decision-making









Reduce Rotor Power Consumption for Animal Feed Systems

High-fidelity DEM solver and AI-generated ROM reduce simulation time from 8 hours to 3 seconds with over 98% accuracy

Challenge

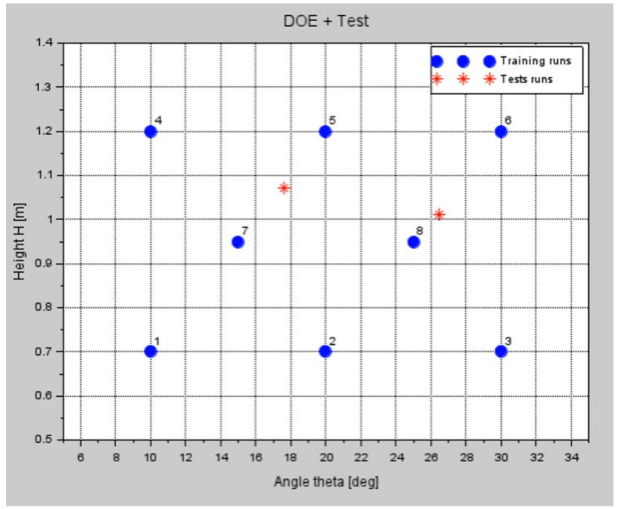
- Reduce the rotor power consumption of a mixer used for feeding systems

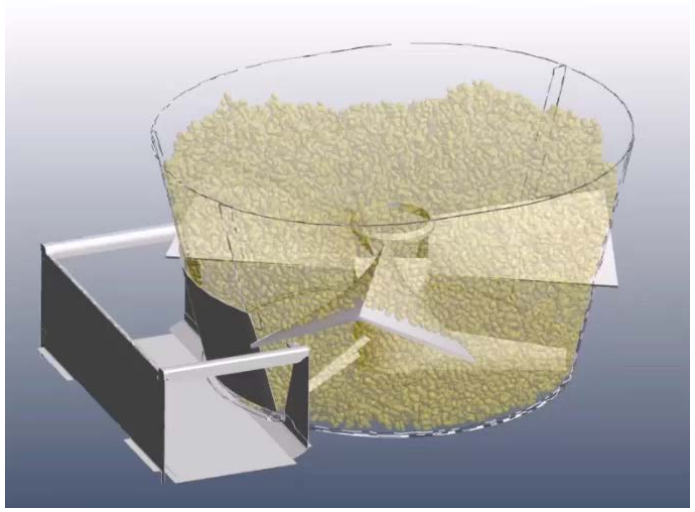
Solution

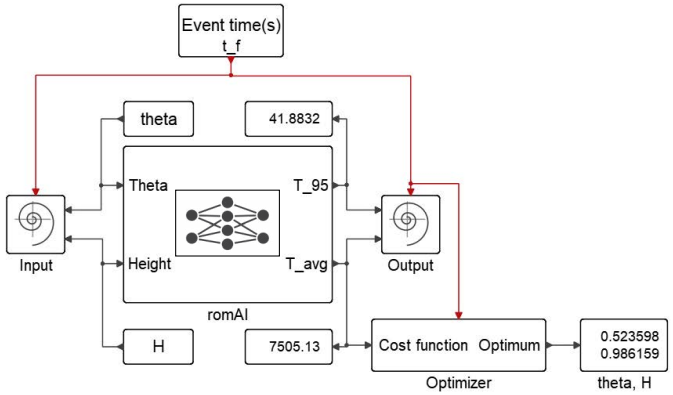
- Optimized a complex non-linear system using Altair® EDEM™ high-fidelity DEM solver, drastically reducing simulation time while maintaining accuracy through Altair® romAI™ technology

Value

- Reduced simulation run time from 8 hours to 3 seconds, enabling rapid design optimization
- Achieved over 98% accuracy compared to high-fidelity simulations, ensuring reliable outcomes for all configurations identified with the ROM







	C_M [Nm]	T_{95} [s]
ROM	7505.1	42.2
FOM	7690.8	41.7
Erreur relative	-2%	1%

Accelerate System-of-Systems Simulations for Wheel Loader Optimization

AI-generated ROM reduces simulation time by 34x, enabling faster analysis of vehicle dynamics, control systems, and granular material interactions with over 98% accuracy

Challenge

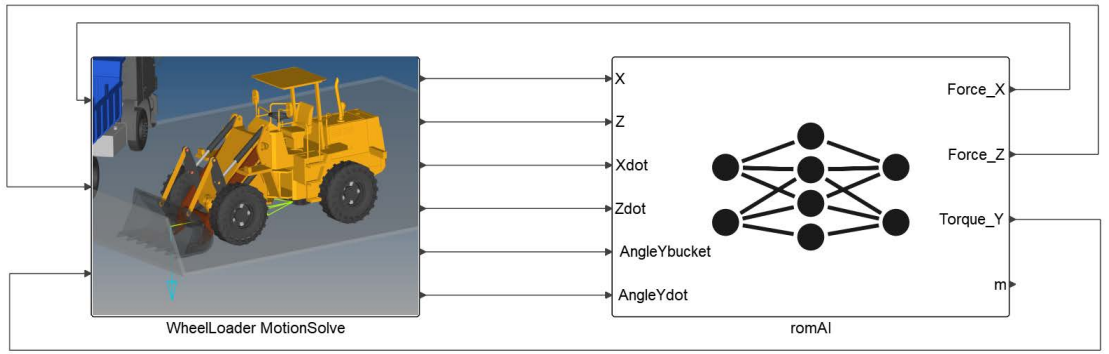
- Accelerate system-of-systems simulations for vehicle dynamics, control systems, and material interactions in a wheel loader to allow for further optimization analysis, addressing the computational cost of simulating granular material dynamics

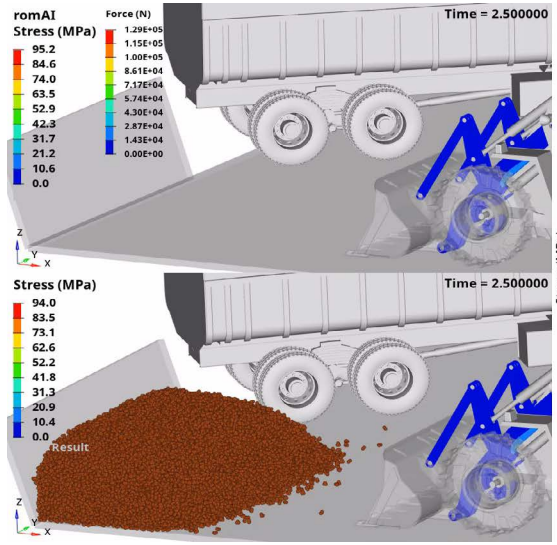
Solution

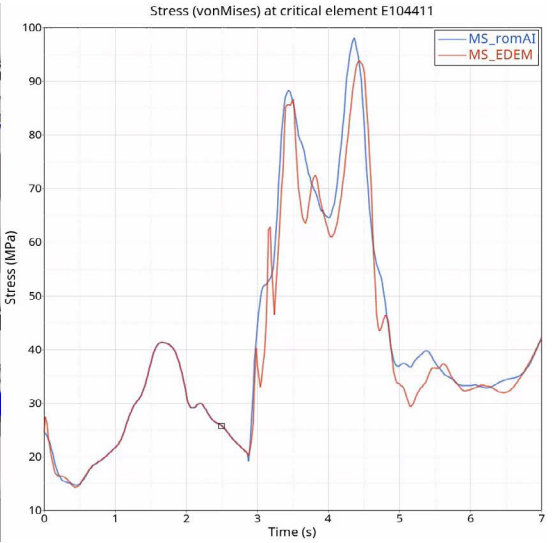
- Developed a high-fidelity, co-simulation model with Altair® MotionSolve® for vehicle dynamics, Altair® Twin Activate™ for control and actuation, and Altair® EDEM™ for handling the granular material dynamics of the particles and the interaction forces between the bucket of the wheel loader
- Created a ROM with Altair® romAI™ to reduce simulation time while maintaining accuracy

Value

- Accurately estimated reaction forces between the bucket and granular material using a dynamic Reduced-Order Model (ROM)
- Achieved a 34x reduction in simulation runtime, decreasing it from 680 seconds to just 20 seconds
- Maintained over 98% accuracy, compared to high-fidelity simulations







NEW

Faster Fertilizer Design with Accurate Uniformity Prediction

Optimized spreader geometry using deep learning trained on simulation and test data

Challenge

- Even fertilizer spread is essential for optimal growth, yield, and reduced pollution
- Uneven distribution causes crop damage, waste, and environmental issues
- Traditional methods are slow and require CAE expertise to test each design iteration

Solution

- Trained a deep learning model on historical, test, and DEM simulation data to predict distribution uniformity from geometry alone
- Used Altair® PhysicsAI™ and Altair® HyperStudy® to optimize spreader design without requiring simulation for each iteration

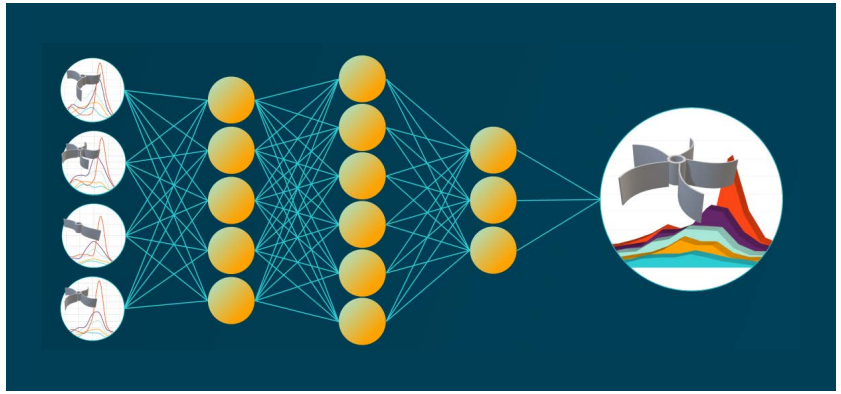
Value

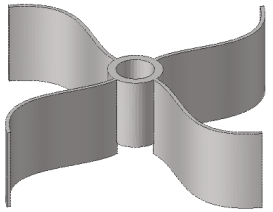
- Predicted CV in 6 seconds with >90% accuracy – 520× faster than CAE
- Eliminated need for repeated simulation, enabling faster design cycles without CAE expertise

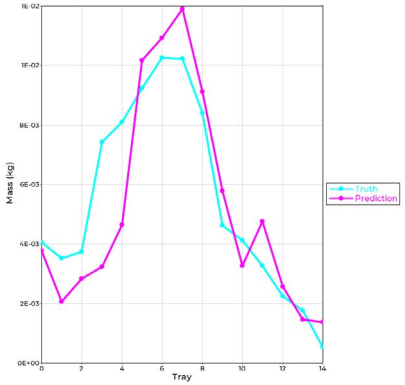
6 SEC
TO CALCULATE CV

520x
FASTER THAN CAE

>90%
ACCURACY







NEW

Evaluate Time Constant Dynamics of a Linear Actuator in Seconds

Perform accurate time constant analysis 3600× faster than full simulation using a dynamic ROM

Challenge

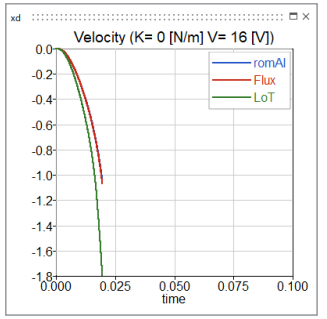
- Time constant analysis is slow, taking up to an hour per simulation
- Traditional methods don't easily capture nonlinear electromagnetic effects, limiting accuracy
- Changing actuator springs requires rerunning costly full simulations, slowing innovation

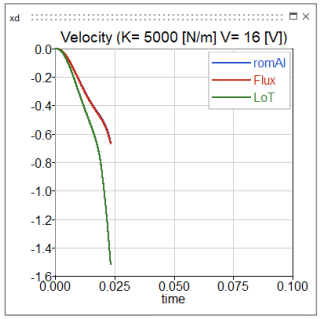
Solution

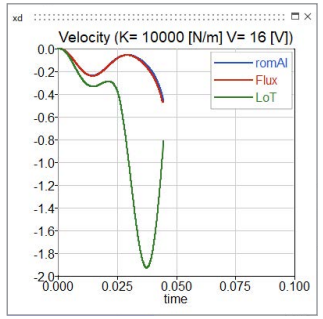
- Generated training and test data for electromagnetic behavior using Altair® Flux®
- Created a dynamic Reduced-Order Model of the electromagnetic dynamics using Altair® romAI™
- Integrated the ROM with mechanical dynamics in Altair® Twin Activate® for full system evaluation

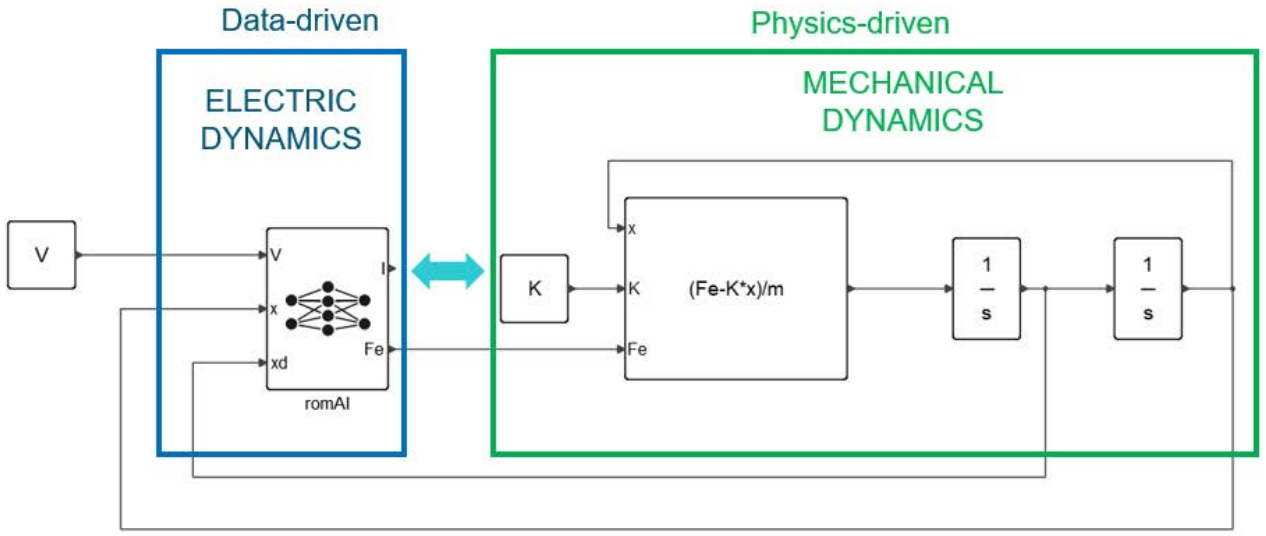
Value

- Reduced runtime from 1 hour to 1 second, enabling fast evaluation of design changes
- Delivered >98% accuracy compared to high-fidelity simulation
- Delivered more accurate system response than lookup tables by learning the influence of eddy currents from high-fidelity training data









NEW

Accelerate Time Constant Simulation of a Solenoid Valve

Create a fluid-dynamic ROM to reduce simulation time from 18 hours to 1 second with high accuracy

Challenge

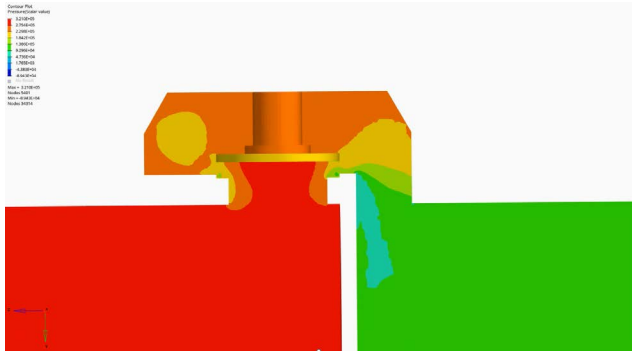
- Multi-physics simulations (fluid, mechanical, electrical) are too slow for quick time constant evaluation
- Existing methods struggle to balance speed and accuracy, especially during the transient phase

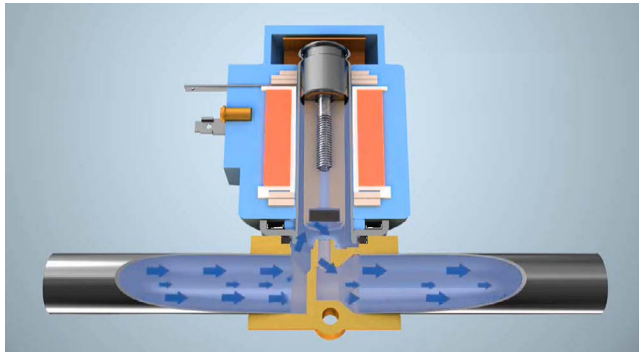
Solution

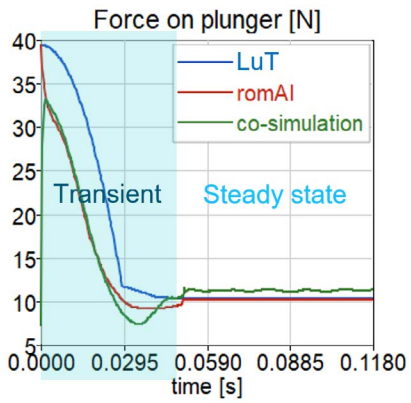
- Generated a dynamic ROM of the fluid dynamics using Altair® romAI™
- Integrated the ROM with mechanical and electrical dynamics for full-system evaluation

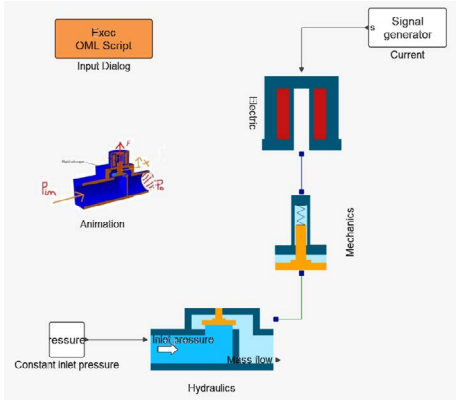
Value

- Reduced simulation time from 18 hours to 1 second
- Achieved >98% accuracy compared to high-fidelity simulation
- Modeled the transient phase more accurately than lookup-table methods









NEW

Model Defeaturing for Faster Simulation Prep

Automate feature removal using decision trees trained on labeled CAD geometry

Challenge

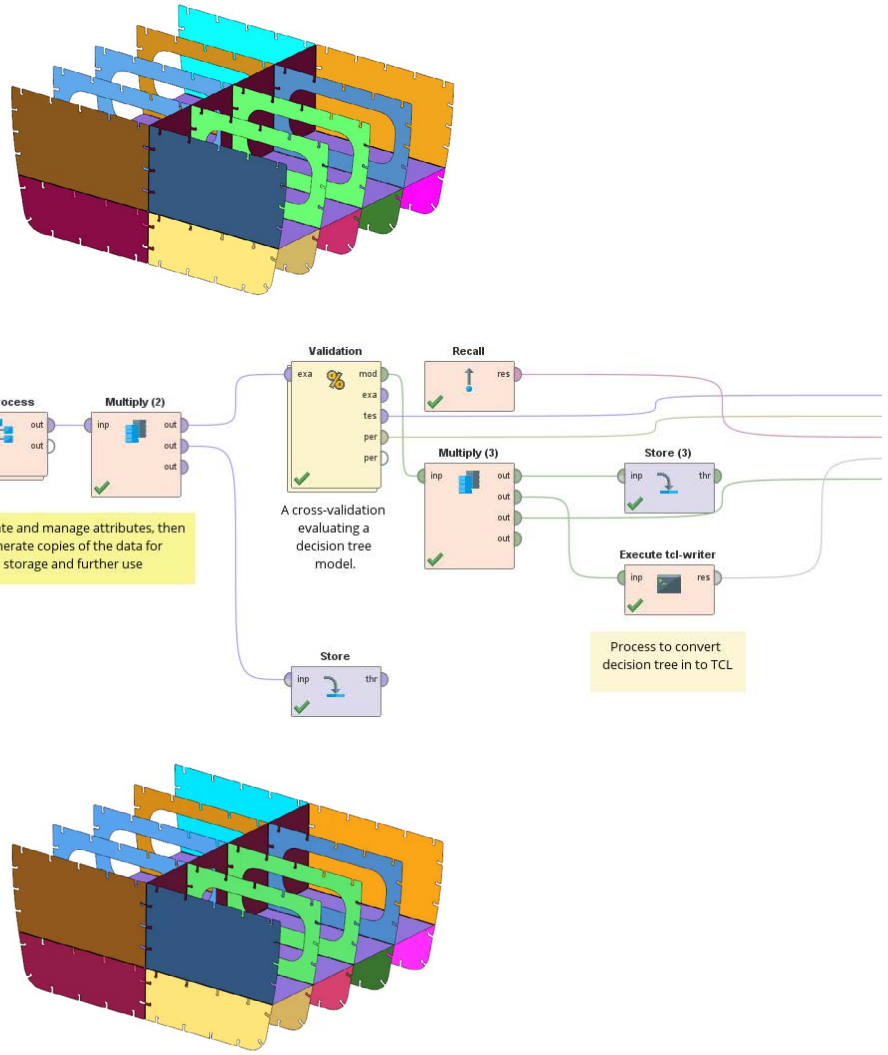
- Large CAD models include inconsistent or non-standard features that disrupt simulation workflows
- No reliable way to automatically identify and remove unwanted geometry
- Manual scripting approaches are time-consuming, inconsistent, and require expert input

Solution

- Labeled existing model lines with feature metadata to guide removal decisions
- Exported relevant line data from Altair® HyperMesh® to capture geometric and contextual attributes
- Built a decision tree model using Altair® RapidMiner® that classifies lines for defeaturing automatically

Value

- Cut model cleanup time significantly, accelerating simulation prep and design cycles
- Supports reuse and adaptation across product lines through retrainable workflows
- Lightweight integration into existing processes using standard scripting (TCL/Python)



NEW

Optimization of Implicit Modelled Heat Exchanger

PhysicsAI-driven modeling for efficiency prediction

Challenge

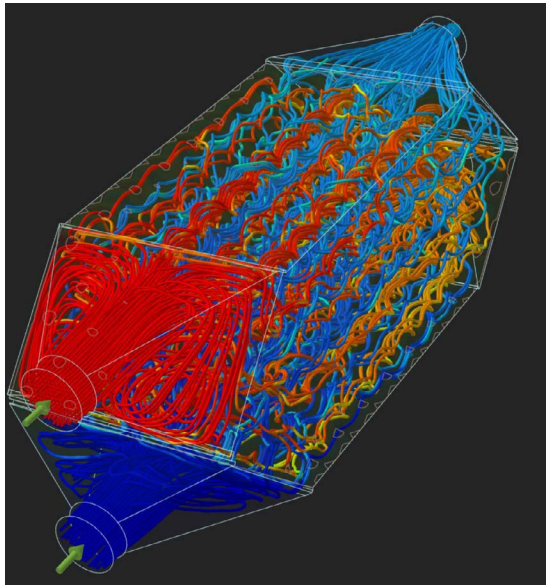
- CFD analysis (meshing) is difficult for CAD designs using implicit geometry.
- Optimizing heat exchanger efficiency is complex and time-consuming.
- Understanding the relationship between design variables is important for performance improvements.

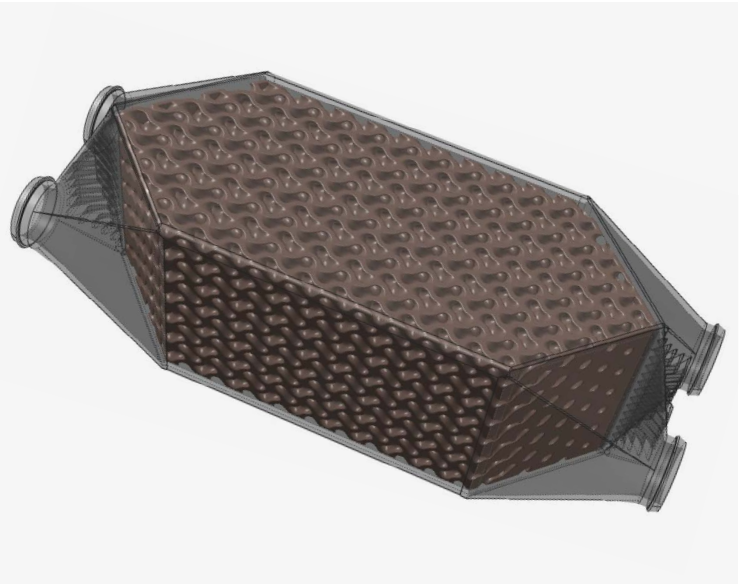
Solution

- Altair® Inspire™ was used to model implicit geometry, set up CFD, and run AI-based analysis in a single environment.
- Parameterized the CAD geometry based on field data and defined boundary conditions accordingly. Explored various combinations to analyze the relationship between geometry, fields, and BCs.
- Integrated AI-driven machine learning models to calculate efficiency in newly developed CAD models.

Value

- Streamlined product development by integrating Altair tools into a unified simulation workflow.
- Increased heat exchanger efficiency by no less than 12% through a targeted design optimization process.
- Accelerated optimization cycles by approximately 24× by utilizing Altair® PhysicsAI™ for rapid performance evaluation.
- Improved design decision-making through sensitivity analysis of key variables impacting system performance.





Aerospace and Defense Use Cases

Optimize Aircraft Skin-Stringer Design

AI/ML-driven simulations improve structural strength and streamline the early design phase

Challenge

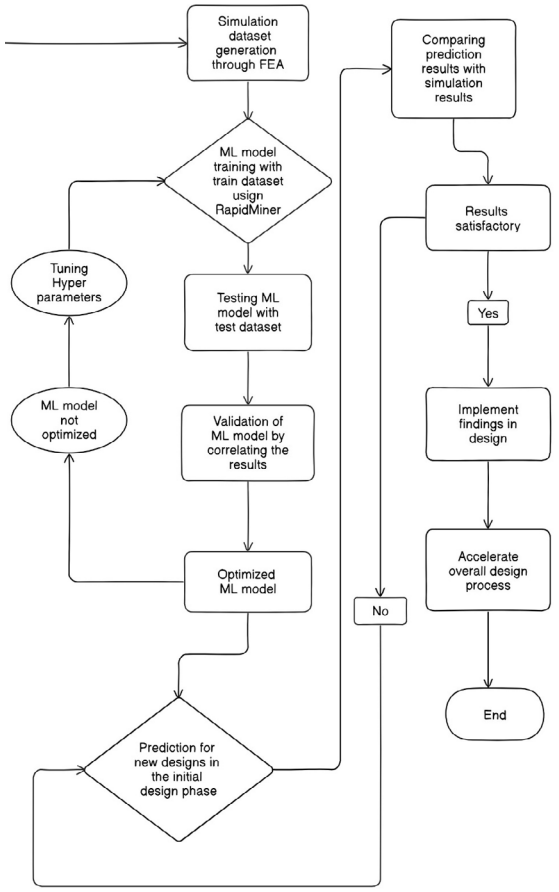
- Designing airplane skin requires advanced knowledge and complex calculations to ensure structural integrity
- Excessive bending poses a risk of buckling, which can lead to potential failure
- Frequent inspections are necessary to catch issues early and maintain safety standards

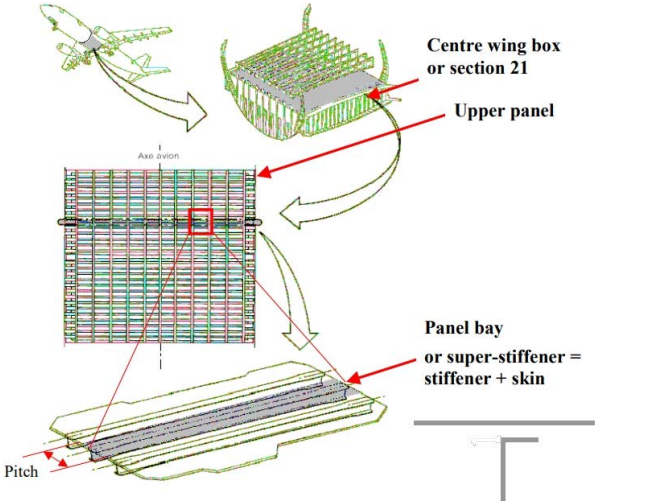
Solution

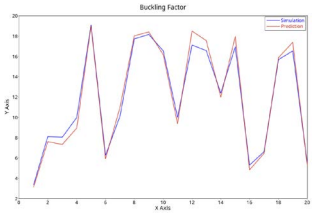
- Advanced CAE tools allow for comprehensive structural analysis, enabling faster and more accurate designs
- AI/ML optimization predicts and improves design efficiency, reducing both time and costs
- Predictive maintenance ensures safety by using data-driven insights from historical performance to schedule maintenance

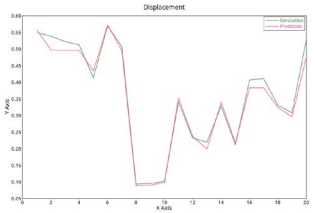
Value

- Rapidly identify optimal airplane skin designs, reducing development time and speeding up time to market
- Leverage AI/ML to create stronger, more efficient airplane skins, driving data-backed decision-making for superior performance
- Automate tasks and detect issues early, minimizing downtime and significantly reducing operational costs









ALTAIR

Multi-disciplinary Avionic System Optimization

AI-powered ROMs and optimization enhance design efficiency and boost system reliability, increasing MTBF by up to 600%

Challenge

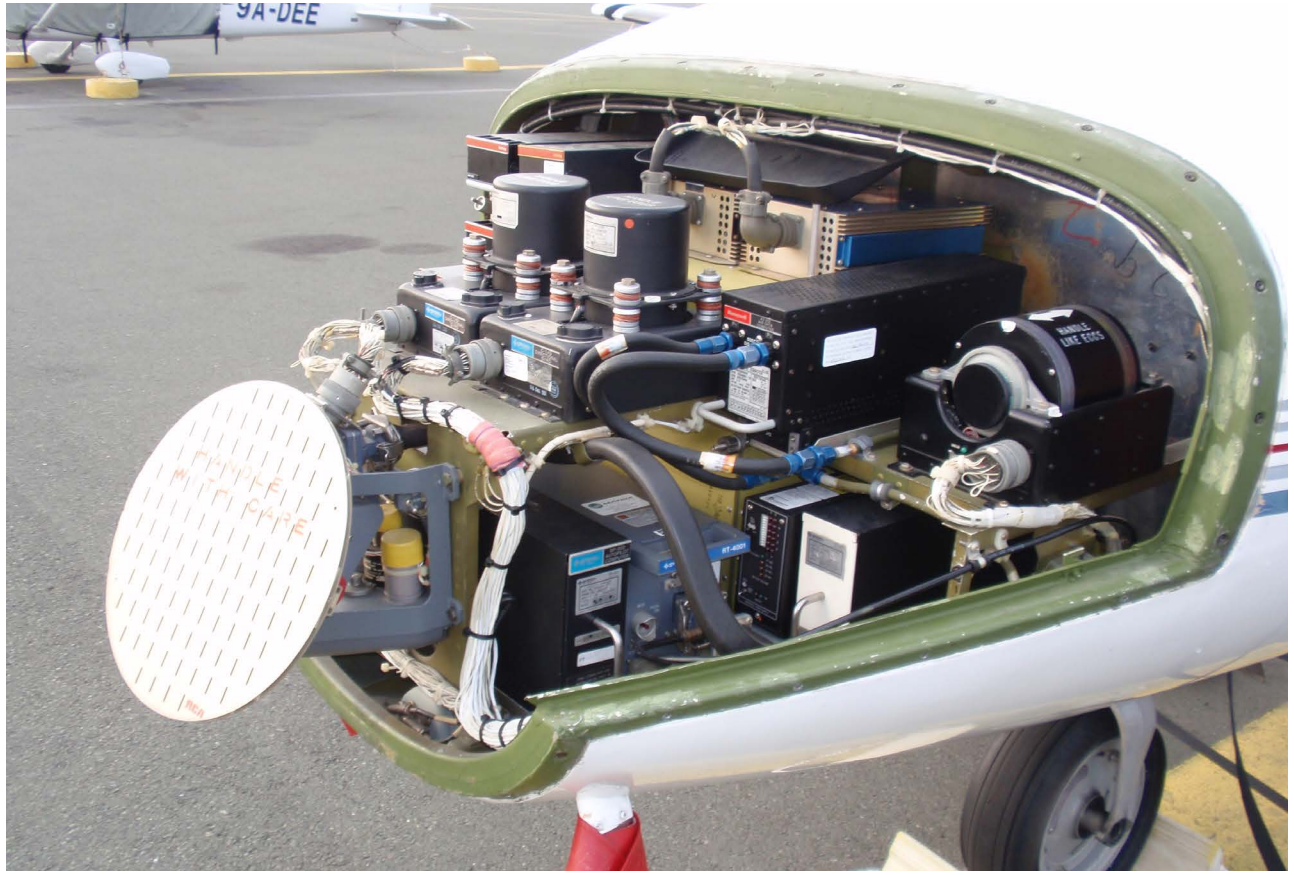
- Complex multi-disciplinary interactions required for modeling and optimization
- Numerous constraints make multi-disciplinary optimization difficult to achieve
- Computationally intensive simulations create bottlenecks in the design process.

Solution

- Created highly efficient and accurate ROMs (up to 10x faster and >99% accuracy) using Altair® romAI™
- Seamlessly integrated the ROMs into the existing workflow for smoother operations
- Performed constraint optimization across disciplines using Altair® HyperStudy®

Value

- Increased reliability with up to 600% improvement in Mean Time Between Failures (MTBF).
- eved energy efficiency gains, improving Environmental Control System power efficiency by up to 6%.



Von Dtom - Eigenes Werk, CC BY-SA 3.0

Strength Verification for Airworthiness Certification

AI/ML-Driven ROMs for Fast, Accurate Verification and Enhanced Design Confidence

Challenge

- Quickly verify airworthiness specifications across various gust profiles and altitude levels to meet stringent requirements

Solution

- Developed highly accurate dynamic ROM using Altair® romAI™ from a single high-fidelity transient simulation

Value

- Achieved verification accuracy of over 99%, ensuring reliability in decision-making
- Accelerated the verification process by up to 10x, reducing time to market
- Provided deeper insights into physical behavior, improving confidence in the design process

Compare Aerodynamic Performance of Airfoil Designs

CFD and ROM-based methods deliver faster, more accurate airfoil analysis

Challenge

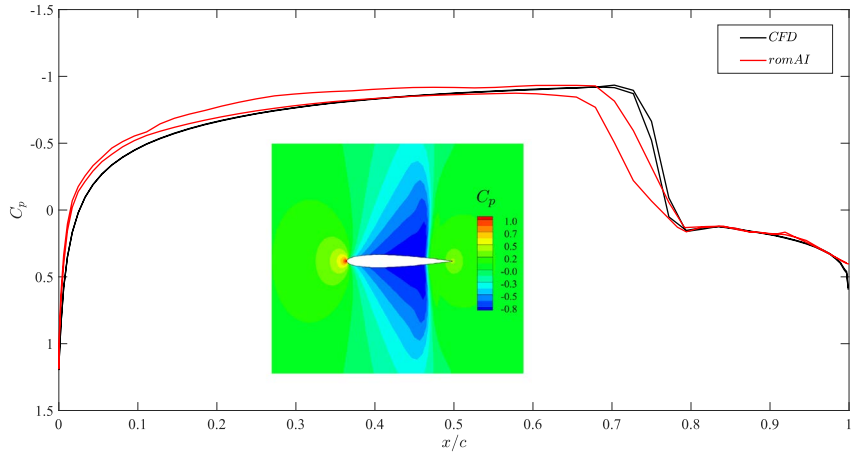
- Traditional CFD simulations for multiple airfoil designs are time-intensive and require significant computational resources
- Difficulty in assessing coefficient variation for different airfoil designs in transonic and inviscid flow
- Challenges in managing and comparing large datasets from various airfoil designs

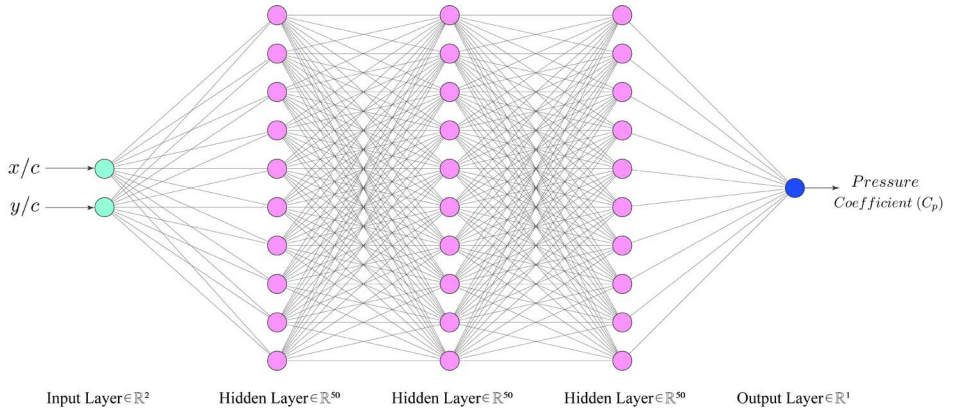
Solution

- Conducted CFD simulations to collect training and test data
- Created a ROM to estimate the pressure coefficient of an airfoil based on its design
- Applied ROMs to efficiently and accurately compare coefficient variations across multiple airfoil designs, enabling faster evaluations

Value

- Reduced simulation time from 140s to less than 3s, allowing faster design iterations and quicker decision-making
- Improved data management and analysis, improving efficiency in handling multiple airfoil designs and reducing operational bottlenecks
- Delivered reliable results with excellent generalization for modeling complex aerodynamic behaviors, minimizing risks and enhancing design confidence





Real-Time RCS Analysis for Faster, More Accurate Measurements

Simulated data and AI-powered models reduce time to perform RCS analysis, enabling quicker and more accurate evaluations for cruise missile simulations

Challenge

- Performing RCS measurements in real-time is expensive and time-consuming
- Calibration errors can introduce inaccuracies into measurements
- Developing an AI/ML model for RCS analysis requires significant effort in creating extensive datasets. To streamline this, a cruise missile model was simulated at various incident angles using Altair® Feko®

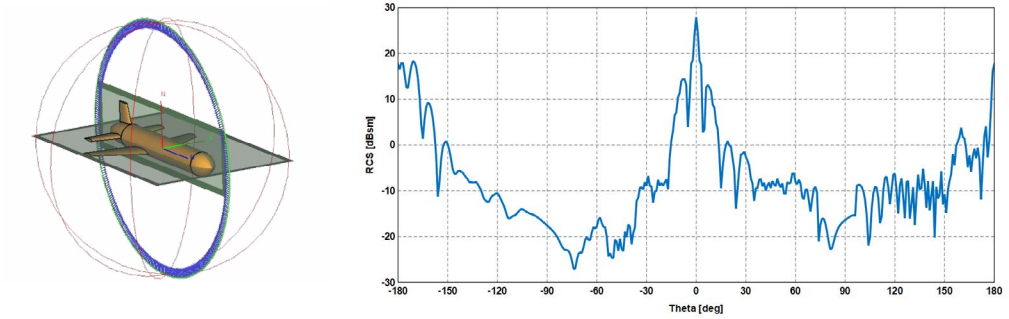
Solution

- Automated the process using AI/ML models, leveraging minimal measurement data to determine the maximum step size for training and using simulated data for testing
- Saved resources and time by using the RL-GO asymptotic solve method for data extraction, achieving strong agreement with RCS between solvers. This method was selected over full-wave solvers, which are more resource-intensive and time-consuming
- Forecasted RCS accurately with a minimal step size using the proposed model

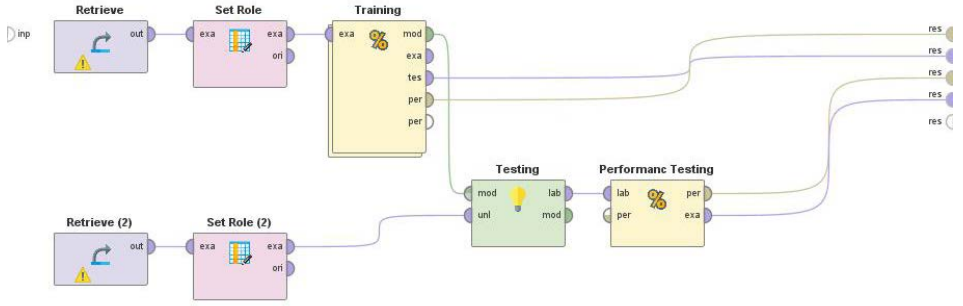
Value

- Achieved faster, more precise results than actual measurement scenarios, saving time and costs
- Eliminated calibration errors in measurement scenarios for greater reliability

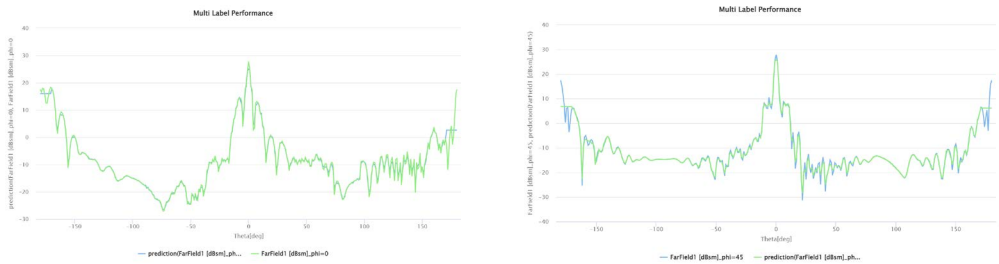
Cruise Missile Model and RCS Results - Feko



ML Workflow - Rapid Miner



Simulated Results with GBT ML Model - Rapid Miner



Optimize Antenna Performance Across Frequency Bands

Machine learning models optimize 5G antenna design by reducing simulation time, ensuring performance optimization, and accelerating time-to-market

Challenge

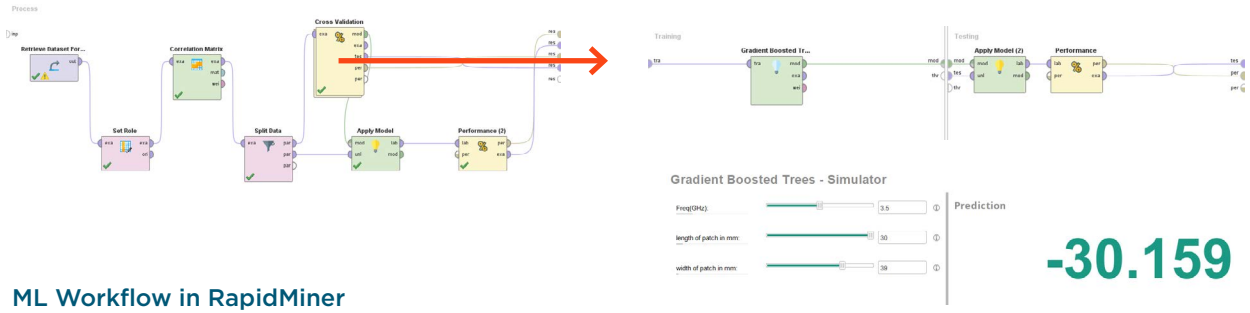
- 5G antennas operate across sub-6GHz and mm-wave frequency bands, where typical antenna design structures are simulated to optimize parameters such as S-parameters, gain, and bandwidth, while maintaining miniaturized dimensions
- Structuring the dataset for ML optimization is challenging due to the complexity of capturing diverse design variables and conditions for accurate antenna performance

Solution

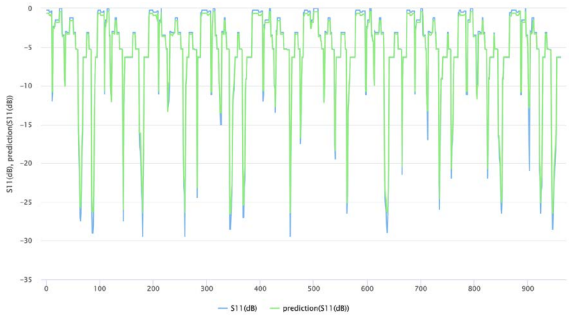
- Developed an ML model to optimize 5G antenna performance for specific frequency bands, focusing on S-parameters, gain, and bandwidth
- Built a robust dataset of 5G antennas and their performance characteristics, enabling the model to recommend the best antenna for optimal performance across the target frequency range
- Used Altair® RapidMiner® auto-run model to generate initial results, which were then refined into a trained ML model with optimized hyperparameters for target frequency band

Value

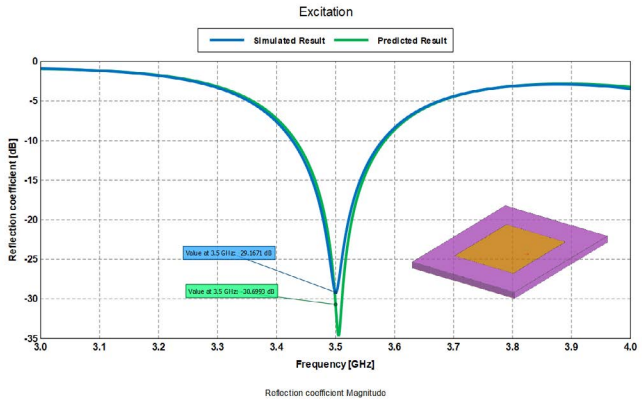
- Ensured accurate selection and performance optimization for 5G antennas
- Achieved peak 5G antenna performance within the target frequency band, reducing simulation time and costs for faster development cycles



ML Workflow in RapidMiner



Optimized results with GBT Algorithm in RapidMiner



Comparison of Simulated and Predicted Reflection Coefficient (dB)

NEW

Virtual Sensors Estimate Critical Load and Strain Data

Built from physical measurements and AI models to reduce sensor count and improve coverage in real time

Challenge

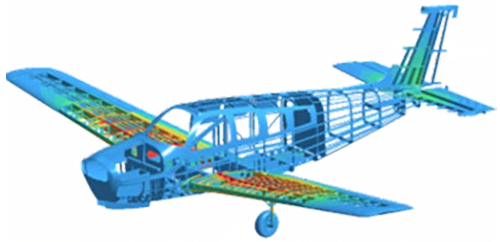
- Capturing key performance data requires many physical sensors, which can be costly, intrusive, and hard to place effectively

Solution

- Used Altair® AI Studio to optimize the number and position of physical sensors
- Trained Altair® romAI™ to act as real-time virtual sensors using physical measurements
- Delivered critical load and strain estimates during operation

Value

- Reduced physical sensors without losing insight
- Enabled real-time virtual sensing for key performance data
- Lowered instrumentation costs and improved system understanding

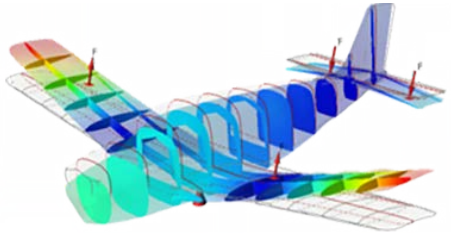


N strains

Altair® RapidMiner®

Best strain gauges locations

Loads Estimation



6 SEC

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NEW

Estimate the Temperature of a Turbine at Different Locations

Create virtual sensors using ROMs trained on simulation data to estimate temperature distributions inside turbines

Challenge

- Measuring temperature distribution inside a turbine is difficult due to limited sensor access and harsh conditions
- Physical testing across all operating scenarios is impractical and expensive
- Lack of internal data limits the ability to assess performance, plan maintenance, or detect anomalies

Solution

- Trained Altair® romAI™ models on simulation data to estimate temperature at key locations inside the turbine
- Used the models as virtual sensors to replace or supplement physical measurements in real time

Value

- Gained deeper insight into turbine behavior during operation
- Enabled earlier detection of anomalies and potential failures
- Improved maintenance planning with predictive, data-driven insights

Source: https://en.wikipedia.org/wiki/Honeywell_HTF7000

NEW

Accelerated Evaluation of Aircraft Wing Designs

Replace repetitive structural analysis with high-speed AI-driven predictions across aerofoil variations

Challenge

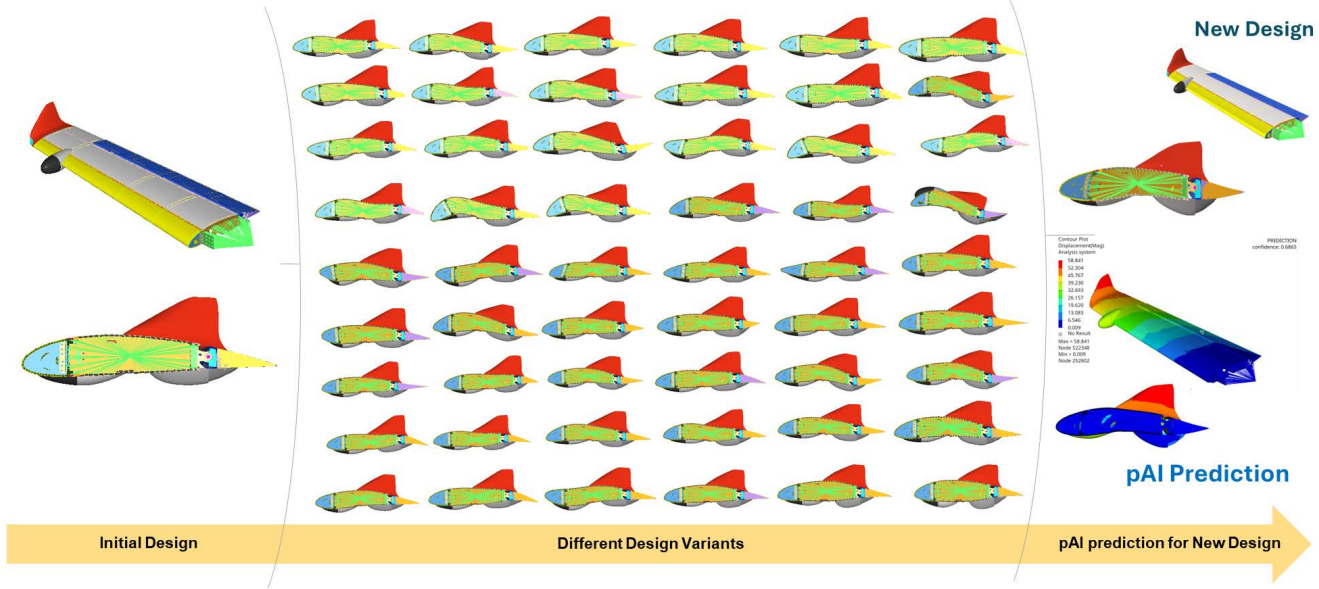
- Assessing the performance of different airfoil structures is time-consuming and repetitive
- Manual setup makes it difficult to maintain consistency across design iterations

Solution

- Used structural simulation results to train an Altair PhysicsAI model for predicting wing performance
- Captured design-performance relationships across a range of airfoil geometries
- Applied the trained model to automate evaluation of new designs without manual setup

Value

- Reduced evaluation time by 50× – from traditional runtime to just 15 seconds
- Maintained 98% accuracy compared to full structural simulations
- Enabled rapid iteration of new wing designs, accelerating development cycles and improving time to decision



NEW

Smarter Aircraft Wing Assembly Starts with Automated Parts Classification

AI-driven classification of ribs, spars, and other parts reduces manual sorting and speeds up wing assembly

Challenge

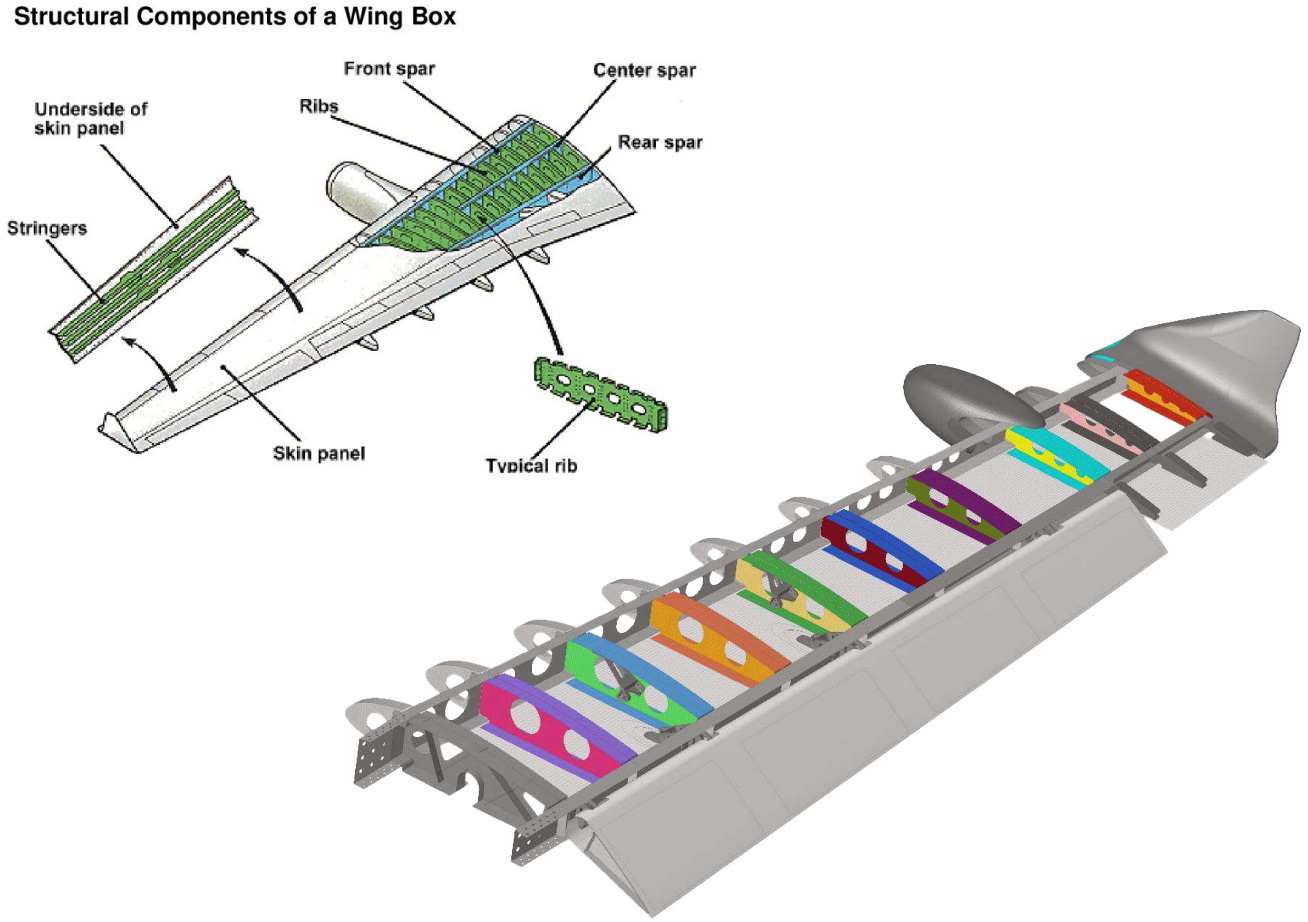
- Modeling aircraft wing assemblies is complex and time-intensive, especially when managing large volumes of CAD data
- Accurate modeling depends on identifying subpart types (ribs, spars, stringers, and more) early in the process
- Manually segregating parts from CAD is repetitive, error-prone, and slows overall productivity

Solution

- Collected CAD data from 10 existing aircraft models to train an Altair ShapeAI classifier to recognize standard wing parts
- Applied the trained model to new aircraft designs to automatically identify parts
- Integrated the classifier into the automated modeling workflow to accelerate early-stage wing assembly setup

Value

- Cut classification time from 3 hours to under 2 minutes – freeing engineers to focus on higher-value work
- Increased modeling throughput and reduced bottlenecks in early-stage wing assembly design
- Scaled part classification consistently across programs, improving standardization and team productivity



NEW

Rapid Dent Analysis for Aircraft Engine Nacelles

Building a lightweight Digital Twin for dent-related stress prediction and structural diagnostics using AI-enhanced modeling

Challenge

- Lip skin dents reduce aerodynamic efficiency and increase fatigue risk
- Traditional FEA takes ~4 hours per case, limiting responsiveness during inspection
- Manual meshing and setup make maintenance, repair, and overhaul (MRO) turnaround inconsistent and time-intensive

Solution

- Built an AI model using Altair® PhysicsAI™, trained on CAD and FEM data from 40+ real-world dent cases
- Used physics-informed deep learning to predict dent-induced stress without meshing or manual setup

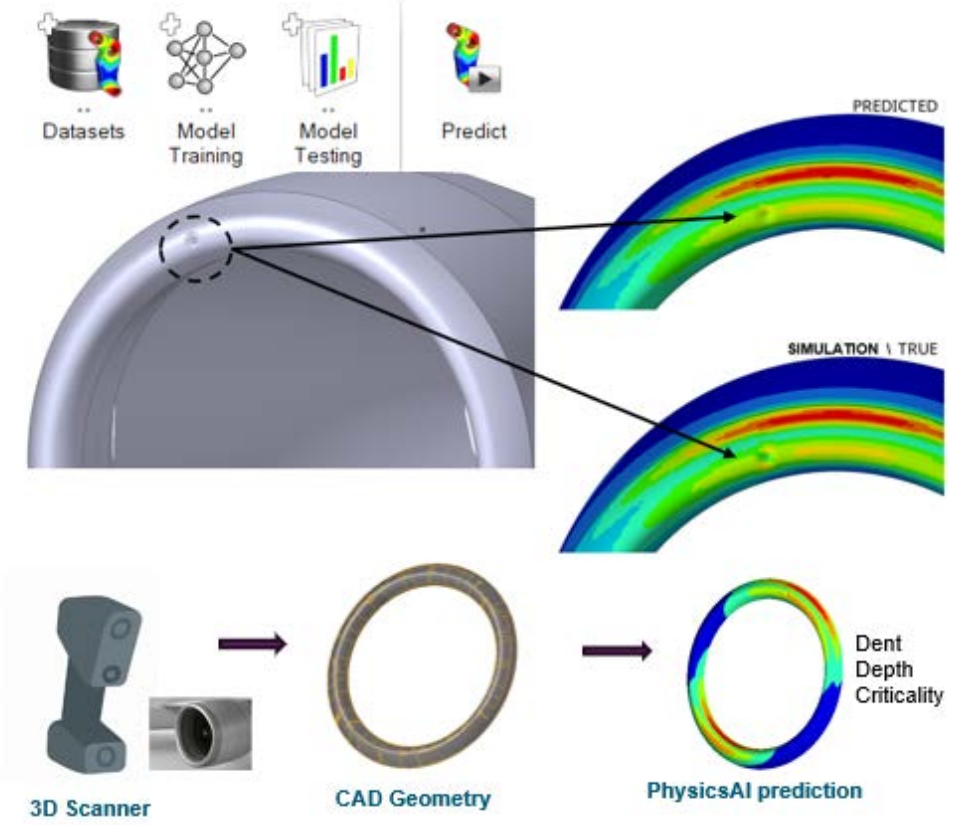
Value

- Cut dent analysis time from ~4 hours to 20 seconds, accelerating MRO decision-making
- Achieved 95% reduction in simulation time with 85% prediction accuracy, maintaining confidence in results
- Scaled assessment workflow across 40+ real-world cases, supporting digital twin and 3D scanning initiatives

85%
PREDICTION ACCURACY

95%
REDUCTION IN SIMULATION TIME

40
DENT CASES



NEW

Accelerate RCS Evaluation Across Aircraft Design Variants

Accelerate radar cross section analysis using geometric deep learning trained on simulation and historical data

Challenge

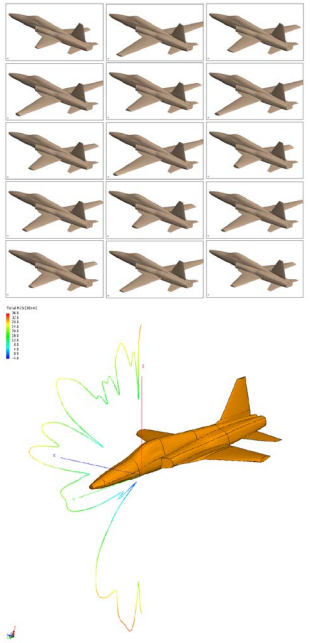
- Radar cross section (RCS) simulation is time-consuming, requiring numerous angles and frequencies to assess detectability
- Late-stage design changes trigger costly re-simulations that delay program timelines

Solution

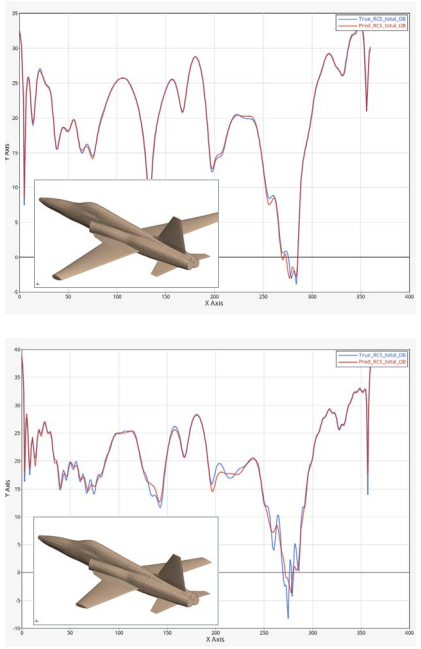
- Built predictive models using historical and early-phase simulation data from predecessor series
- Trained Altair® PhysicsAI™ on Altair® Feko® simulation results using geometric deep learning to learn shape–RCS relationships
- Split data into training and test sets to validate model accuracy
- Deployed validated prediction model to accelerate evaluation of new aircraft designs

Value

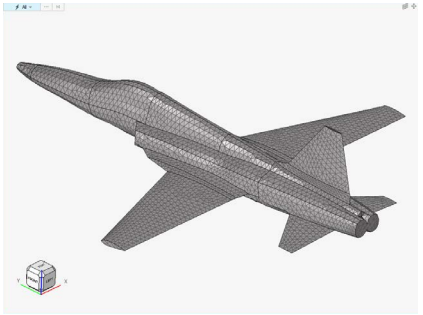
- Faster design cycles with instant RCS predictions to support late-stage changes
- Lower simulation costs by reducing reliance on compute-intensive CAE
- Shorter program timelines through earlier RCS validation and fewer bottlenecks

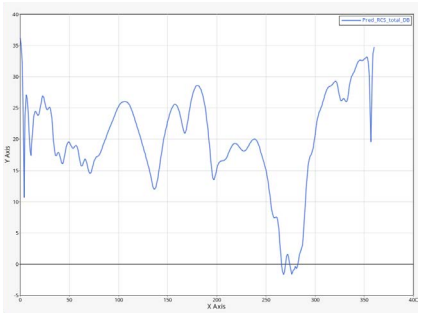


Data from simulation



Model Validation





Model Deployment

Electronics / Energy Use Cases

Predict Remaining Moisture Content in Clothes During Operations

AI/ML models applied to test data improve accuracy and efficiency in real-time moisture estimation

Challenge

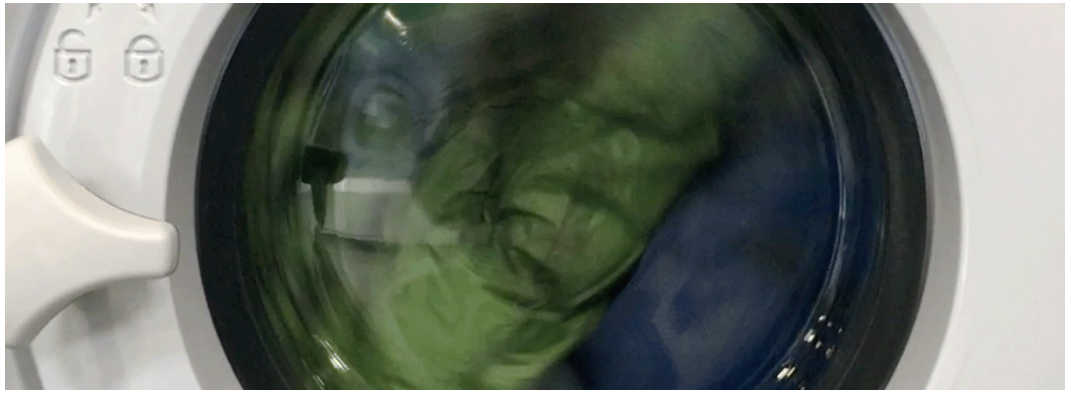
- Optimize drum RPM in spin cycles to enhance water and energy efficiency

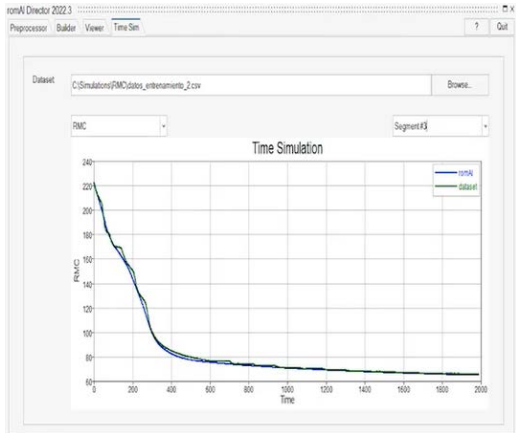
Solution

- Altair® romAI™ was deployed to create dynamic models from minimal tests, enabling effective prescriptive analysis of moisture retention in clothes over time

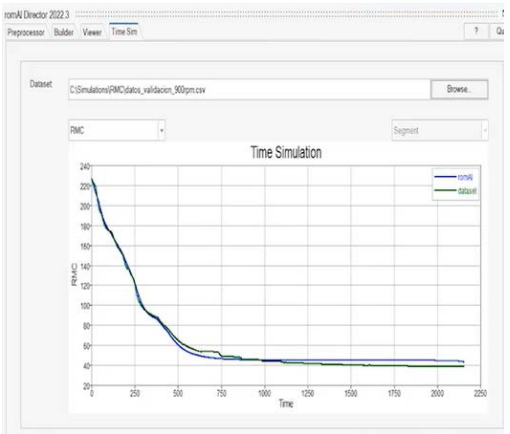
Value

- Achieving high model accuracy even outside the training data range ensures consistent and reliable performance, reducing costly errors
- Integrating the dynamic model directly into the washing machine boosts operational efficiency, leading to significant resource savings and reduced operating costs





Model results for training data



Model results for test data out of training bounds

Estimate Linen Weight for Resource Efficiency in Washing Machines

AI/ML models created a virtual sensor to optimize water and energy consumption

Challenge

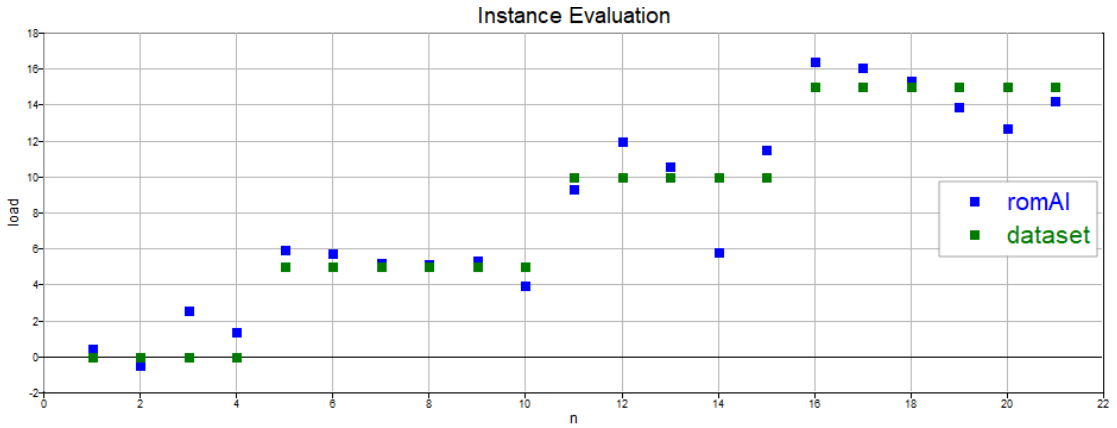
- Reduce water and energy consumption in washing machines

Solution

- A virtual sensor was created to estimate the dry weight of linen using AI/ML models based on sensor data

Value

- Significant energy and water savings were achieved
- The solution has the potential to be deployed in hardware, enabling the virtual sensor to be integrated directly into washing machines



Smart Grid Energy Management for Transformer Health

AI-layered multi-agent systems enable predictive health management, improving grid reliability and transformer lifespan

Challenge

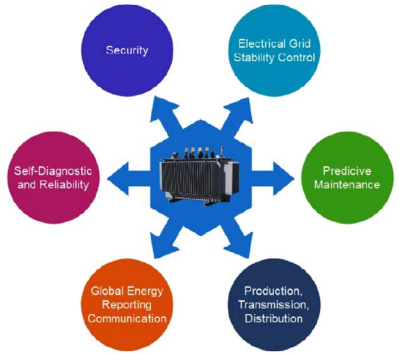
- The integration of distributed energy resources and storage systems complicates grid management, posing challenges at various grid stages
- A need for automation in identifying and categorizing transformer failures, including bushing, oil preservation, and core issues

Solution

- Deployed an AI-based system using smart sensors to analyze transformer health, incorporating diagnostic algorithms, Health-Index, and Life-Loss estimations

Value

- Improved system stability and reduced downtime through accurate prediction and diagnosis of failures
- Lowered costs and extended equipment life by streamlining maintenance strategies



Optimize Heat Pump Controllers

AI-powered modeling and virtual testing combined with data processing and controller optimization increased heat pump efficiency by over 8%

Challenge

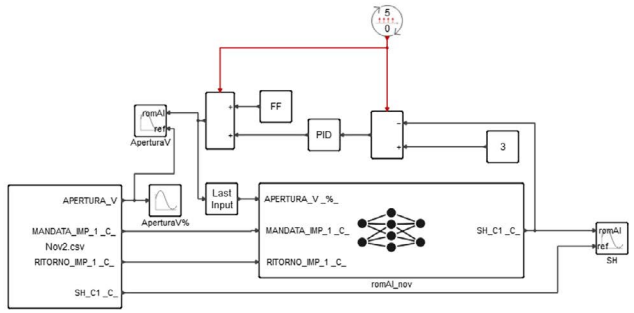
- Optimizing the controller of electro-valves used in heat pumps across various building types

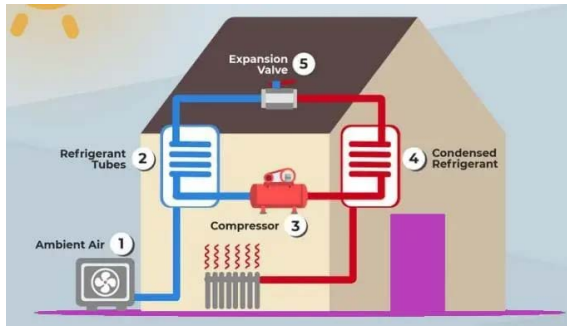
Solution

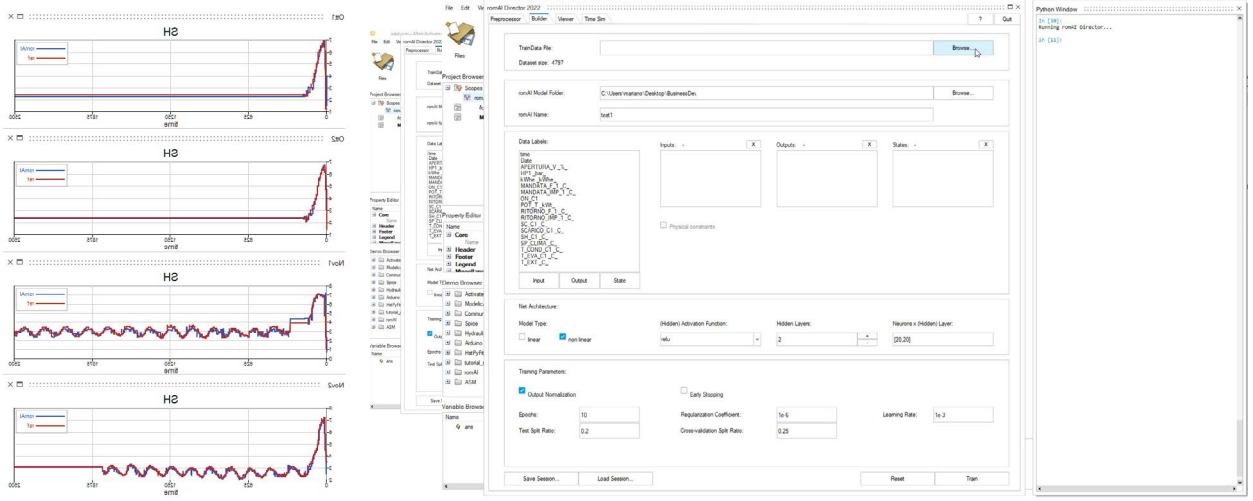
- An accurate model of the heat pumps was identified using Altair® romAI™, enabling virtual testing of different control strategies
- Field data was automatically processed and adjusted for training/testing, extracted from the IoT platform, using Altair® Monarch®.
- The identified ROM model was hosted, and the optimized controller was designed using Altair® Activate®.

Value

- Heat-pump efficiency was increased by over 8%, leading to significant energy savings







ALTAIR

Temperature Evaluation of Altair® ElectroFlo™

CFD simulations and physics predictions provide accurate temperature predictions across fan configurations, improving design accuracy and reducing development time and costs for electronic consoles

Challenge

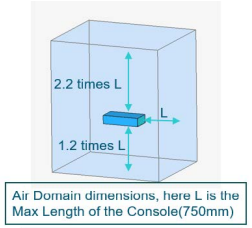
- Optimize thermal management by predicting and controlling temperature distribution for various fan openings and heat source positions in an electronic console

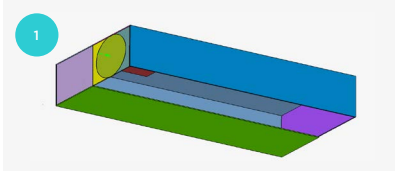
Solution

- Performed CFD iterations by varying fan locations and openings on the console's front and bottom faces, calculating max and min temperatures on the chip and console to build a comprehensive dataset
- Trained an Altair® PhysicsAI™ model using CFD data to predict temperatures in new design configurations

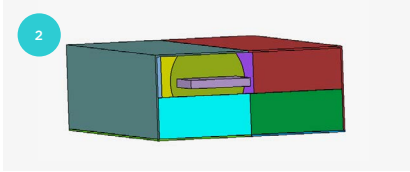
Value

- Delivered fast and accurate predictions (98% accuracy) for new design configurations, reducing costly iterations, time-to-market, and computational costs
- Enabled early design exploration, allowing for informed decisions earlier in the development process and seamlessly integrating AI into workflows to minimize disruptions and operational costs

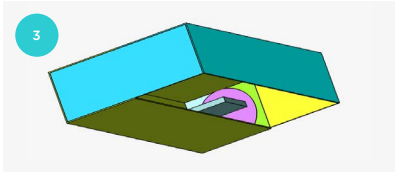




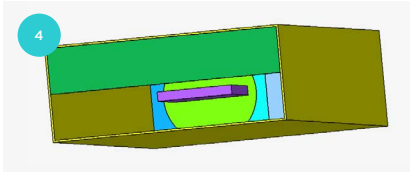
First Half Opening at Bottom face



First Half Opening at Front Face

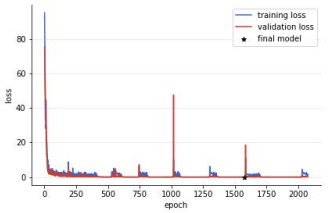


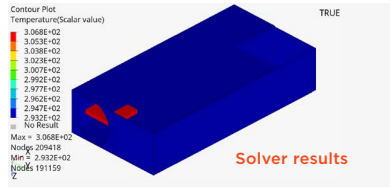
Second Half Opening at Bottom face

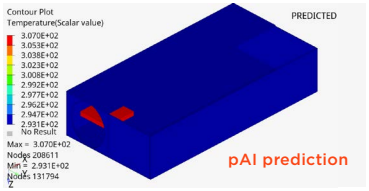


Second Half Opening at Front Face

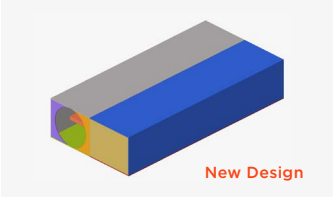
Testing

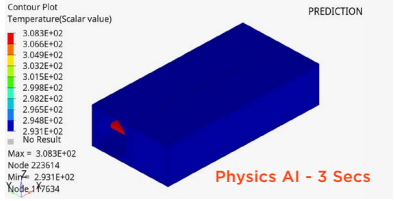


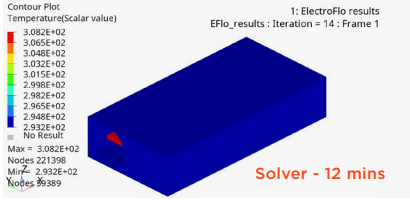




Prediction







Load Forecasting for Smart Buildings

Forecasting models streamline energy usage, prevent blackouts, and improve infrastructure planning across building zones and operational conditions

Challenge

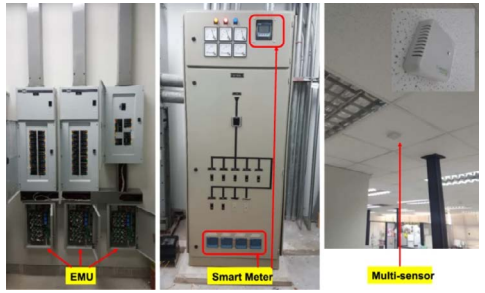
- Address energy demand fluctuations and manage complex consumption scenarios across different building zones and load types under various weather and operational conditions in a Smart Building
- Manage large datasets of electricity consumption and indoor environmental measurements of a commercial building

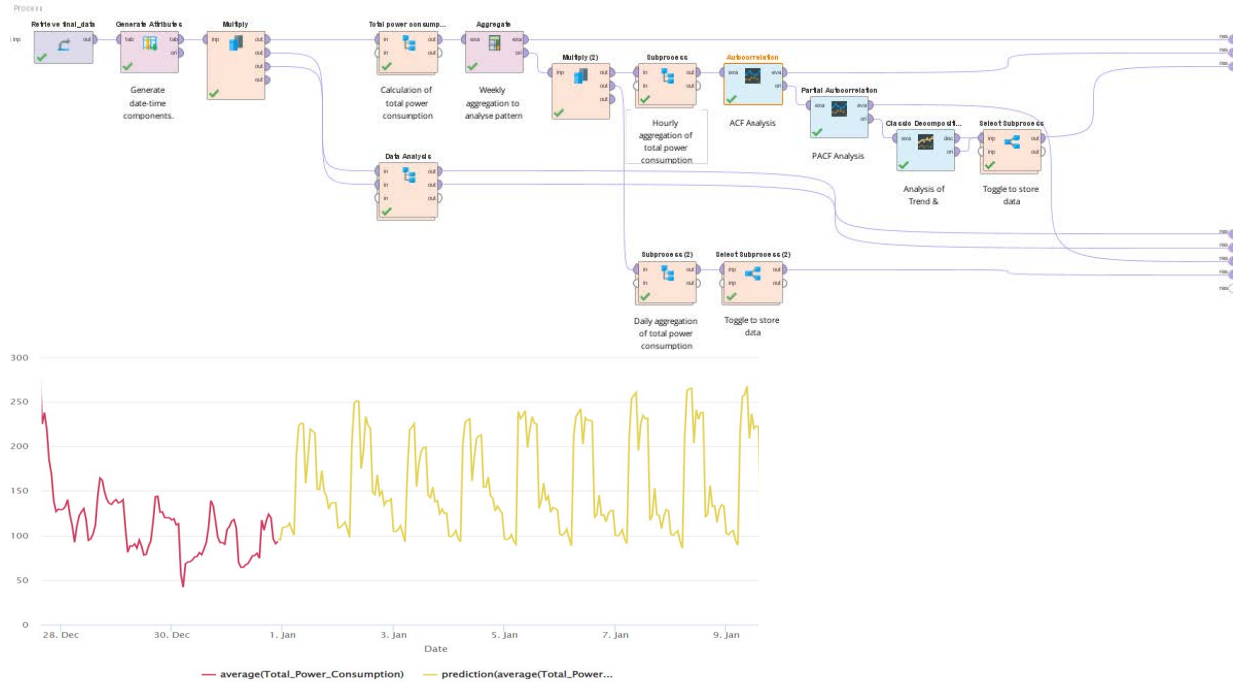
Solution

- Developed forecasting models for electricity consumption across multiple appliances under varying conditions, supporting applications such as zone, floor, and building-level load forecasting, indoor thermal modeling, simulation validation, demand response algorithm development, and anomaly detection

Value

- Minimized the risk of costly electricity blackouts by preventing overloads
- Optimized energy usage, leading to reduced operational costs and improved efficiency
- Enabled smarter planning for electricity infrastructure, ensuring scalability and future-proofing for different building zones





Predict Rotor Speed and Angle for Sensorless PMSM Control

AI-powered ROM and system-level simulations improve sensorless control accuracy, enhancing motor performance predictions and efficiency

Challenge

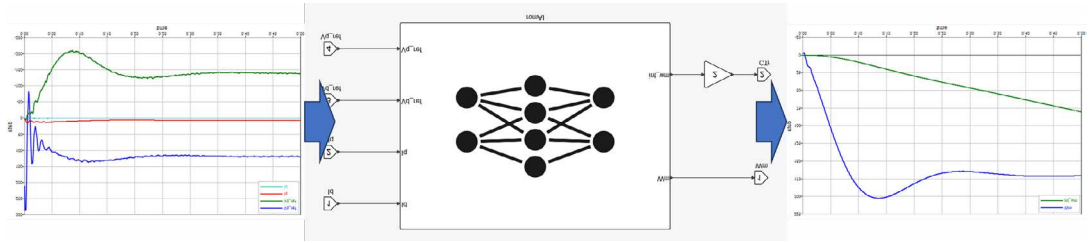
- Predict angular velocity and rotor angle based on DQ motor currents and DQ reference voltages for a Permanent Magnet Synchronous Motor (PMSM)

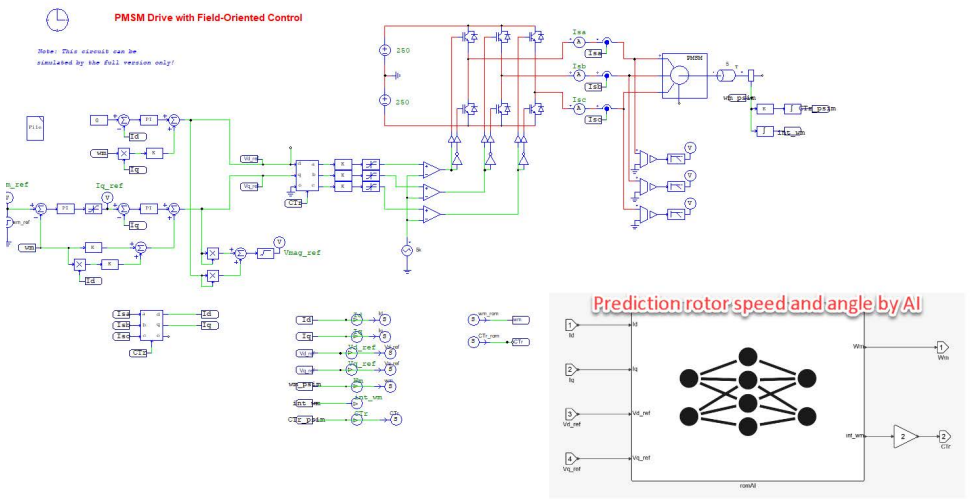
Solution

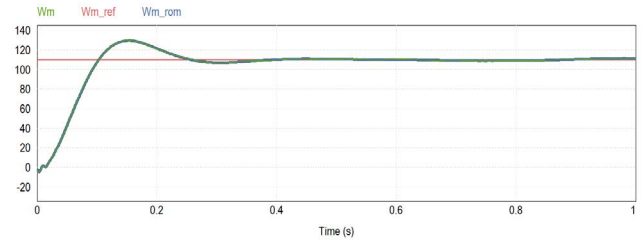
- Used Altair® PSIM™ for motor control and power electronics in PMSM
- Integrated and simulated the system between the power electronics and ROM using Altair® Twin Activate™
- Created reduced order motor models with Altair® romAI™
- Ran the DoE for the PSIM model using Altair® HyperStudy®.
- Pre-processed results data for romAI using Altair® Compose®

Value

- Ensured precise motor control by minimizing discrepancies between predicted and actual rotor speed, leading to improved system reliability
- Enhanced operational efficiency by integrating the ROM, reducing the need for complex physical models and simulations







NEW

Accelerate E-Motor Multiphysics Design

Accelerate geometry optimization by predicting multiphysics performance with AI-trained models

Challenge

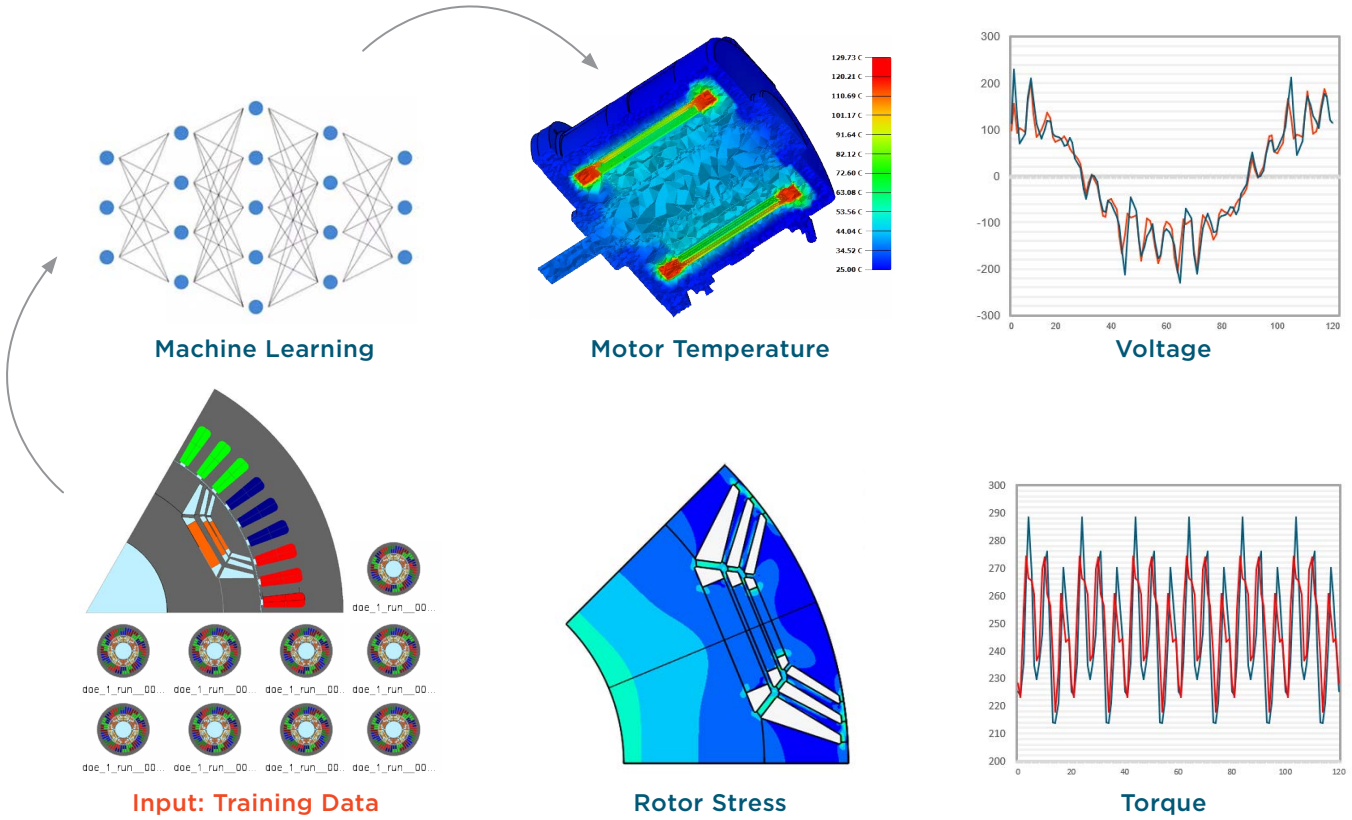
- Optimizing e-motor geometry requires analyzing performance across multiple physics domains
- Each simulation domain (e.g., thermal, electromagnetic, structural) uses different tools and data
- Running multiple FEAs per design is time-consuming and computationally expensive

Solution

- Trained machine learning models on simulation results (e.g., temperature, torque, voltage, stress)
- Predicted multiphysics performance of new geometries without rerunning FEAs
- Integrated the AI models into an optimization loop to identify higher-performing designs faster

Value

- Predicted motor behavior for new geometries instantly
- Cut simulation time by 15× for rapid design exploration
- Delivered better designs by exploring more options within the same timeframe



NEW

Faster, More Accurate Induction Motor Modeling

Generate reliable efficiency maps across wide operating conditions using ROMs

Challenge

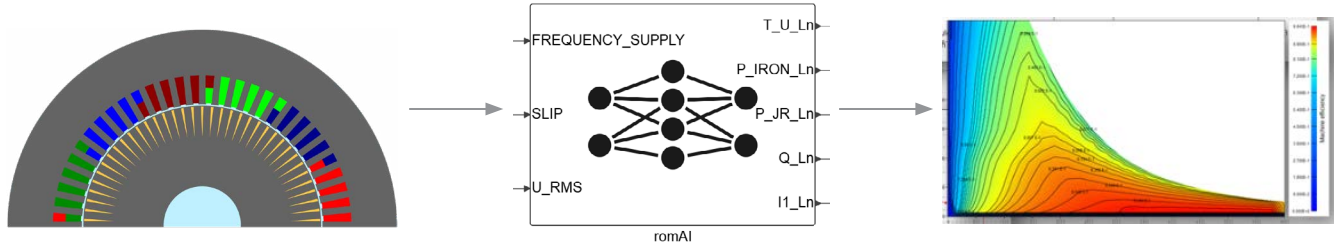
- Long simulation times slow down induction motor design workflows
- Accurate efficiency calculations require many operating points, increasing compute demands

Solution

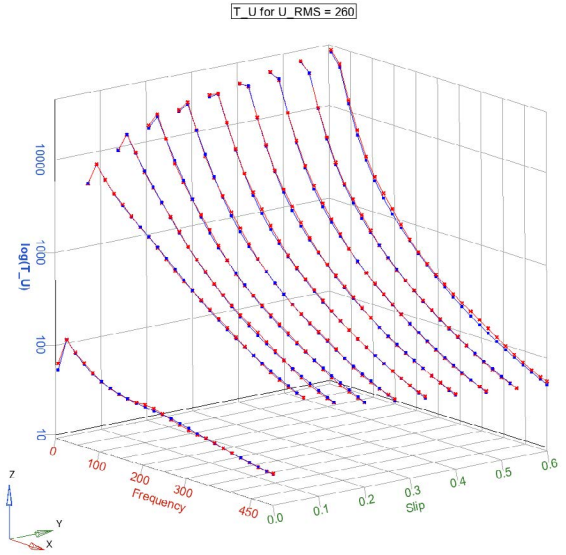
- Ran electromagnetic FEA simulations to generate training data across a range of operating points using Altair® Flux®
- Trained a ROM with this data in Altair® romAI™ to capture nonlinear motor behavior
- Used the ROM to rapidly compute power balance and generate detailed efficiency maps

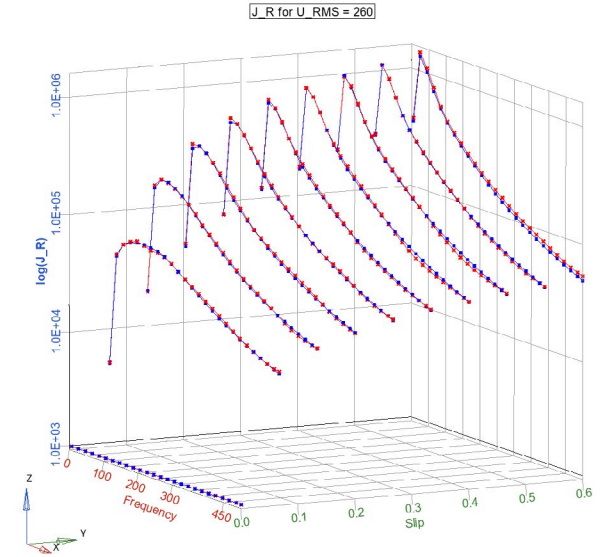
Value

- Simulated over 7,000 operating points in just 2 seconds, down from 10 hours using full FEA
- Achieved high accuracy with less than 5% average deviation from detailed simulations
- Enabled rapid design iterations with trustworthy performance prediction



Flux romAI Equivalent Motor Model





Flux romAI

ALTAIR

NEW

Speed Up Power Converter Simulations

Build AI-based ROMs from simulation data for faster-than-real-time performance

Challenge

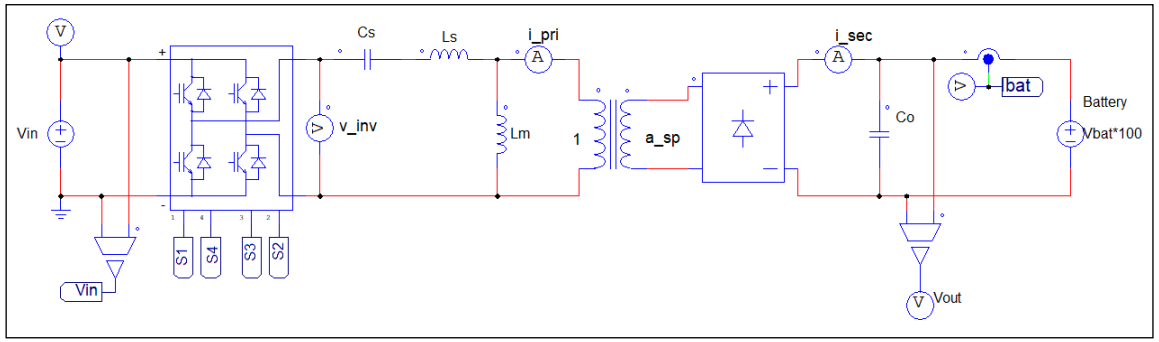
- Detailed PSIM simulations of power converters are computationally expensive and slow
- Simulations often require modeling multiple converter topologies, increasing runtime complexity

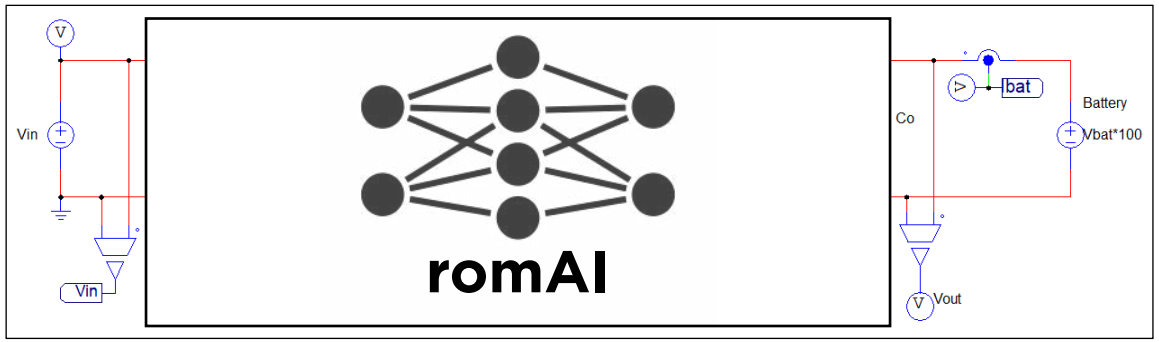
Solution

- Used Altair® PSIM™-generated data to train AI-based ROMs with Altair® romAI™
- romAI replicates converter behavior with high accuracy, enabling real-time and parallel simulations

Value

- Achieve faster-than-real-time results using lightweight surrogate models
- Simulate multiple converter configurations simultaneously to evaluate load-sharing
- Accurately predict I/O current dynamics and thermal behavior with a fraction of the computation





NEW

Accelerate Stability Analysis in Grid-Connected Converter Systems

Predict transient behavior and thermal losses faster to support renewable energy integration

Challenge

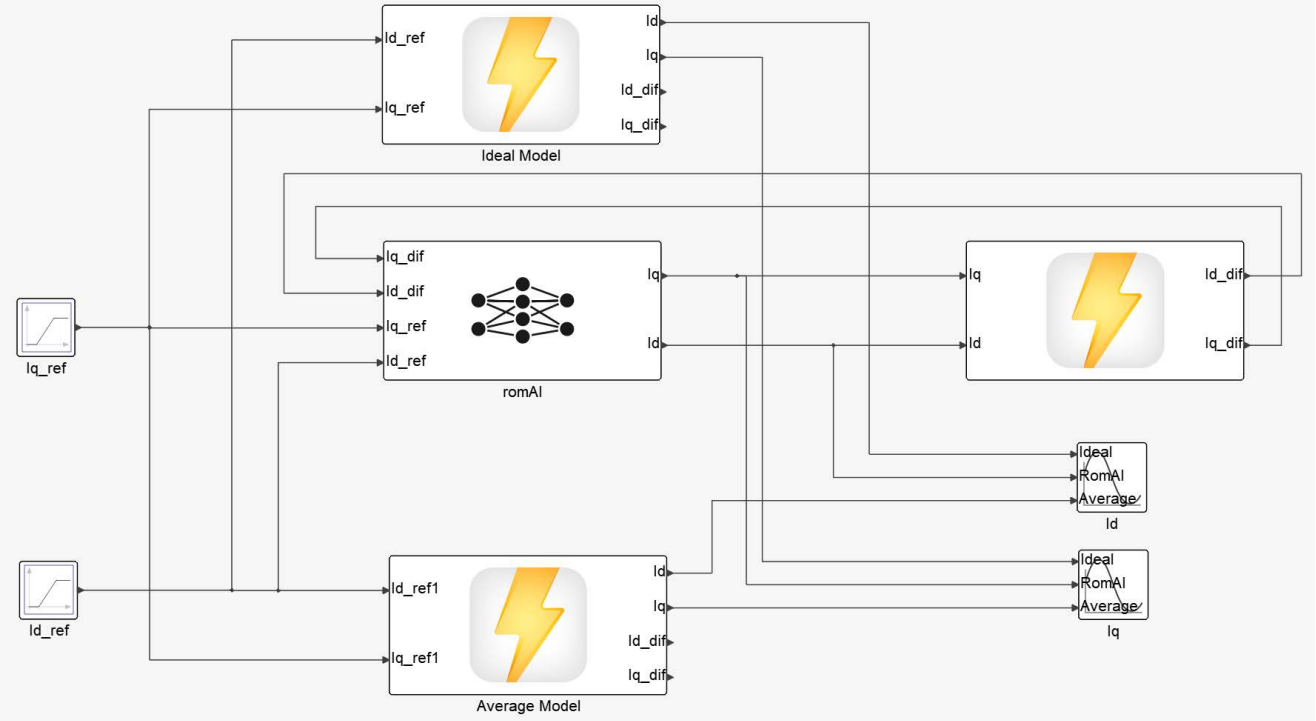
- Rising renewable adoption adds more converters to the grid, even in residential areas
- Converter interactions introduce transient instability and thermal loss risks
- Traditional simulations are too slow for large, multi-converter systems

Solution

- Simulated converter behavior using Altair® PSIM™ to capture transient and thermal effects
- Trained an Altair® romAI™ model to replicate responses and predict performance for new scenarios
- Enabled fast, repeatable stability checks without full re-simulation

Value

- Delivered transient and thermal predictions in seconds
- Scaled analysis to systems with many connected converters
- Reduced simulation time while preserving result accuracy



NEW

Accelerate Electric Motor Design Generation

Generative AI transforms performance specs into validated electric motor concepts in hours, not weeks

Challenge

- The competitive e-motor market demands faster development cycles, but traditional optimization methods, based on fixed specs, often fall short of delivering peak motor performance
- Frequent design iterations increase computational costs and engineering time, slowing innovation and time-to-market

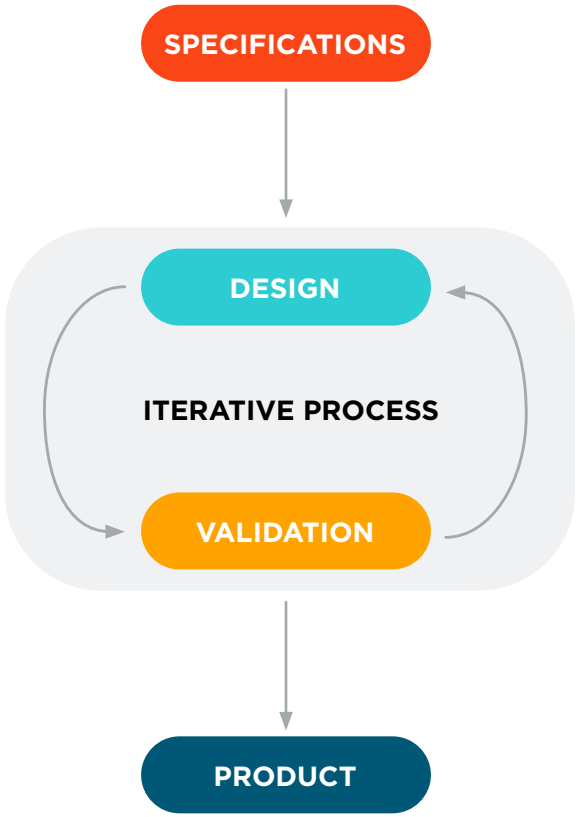
Solution

- Produced synchronous motor pre-designs directly from target performance specifications using generative AI
- Integrated the solution into Altair® AI Studio and Altair® AI Cloud to streamline design exploration, validation, and deployment

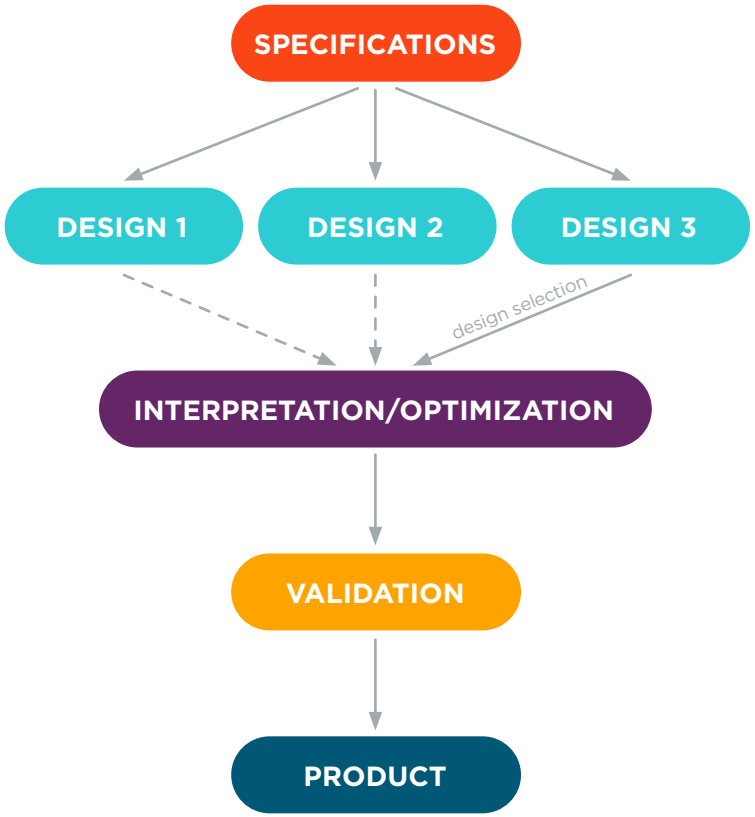
Value

- Faster design cycles and reduced engineering effort accelerate product development
- Lower computational cost and quicker go-to-market improve efficiency and ROI
- Broader design exploration drives more innovative, high-performance motor designs

Traditional Approach



GenAI Approach



NEW

Crash and Impact Testing on the Star Wars™ AT-ST™ Walker

Accelerate complex crash simulations by 166x, reducing cost and time through learned physical behavior

Challenge

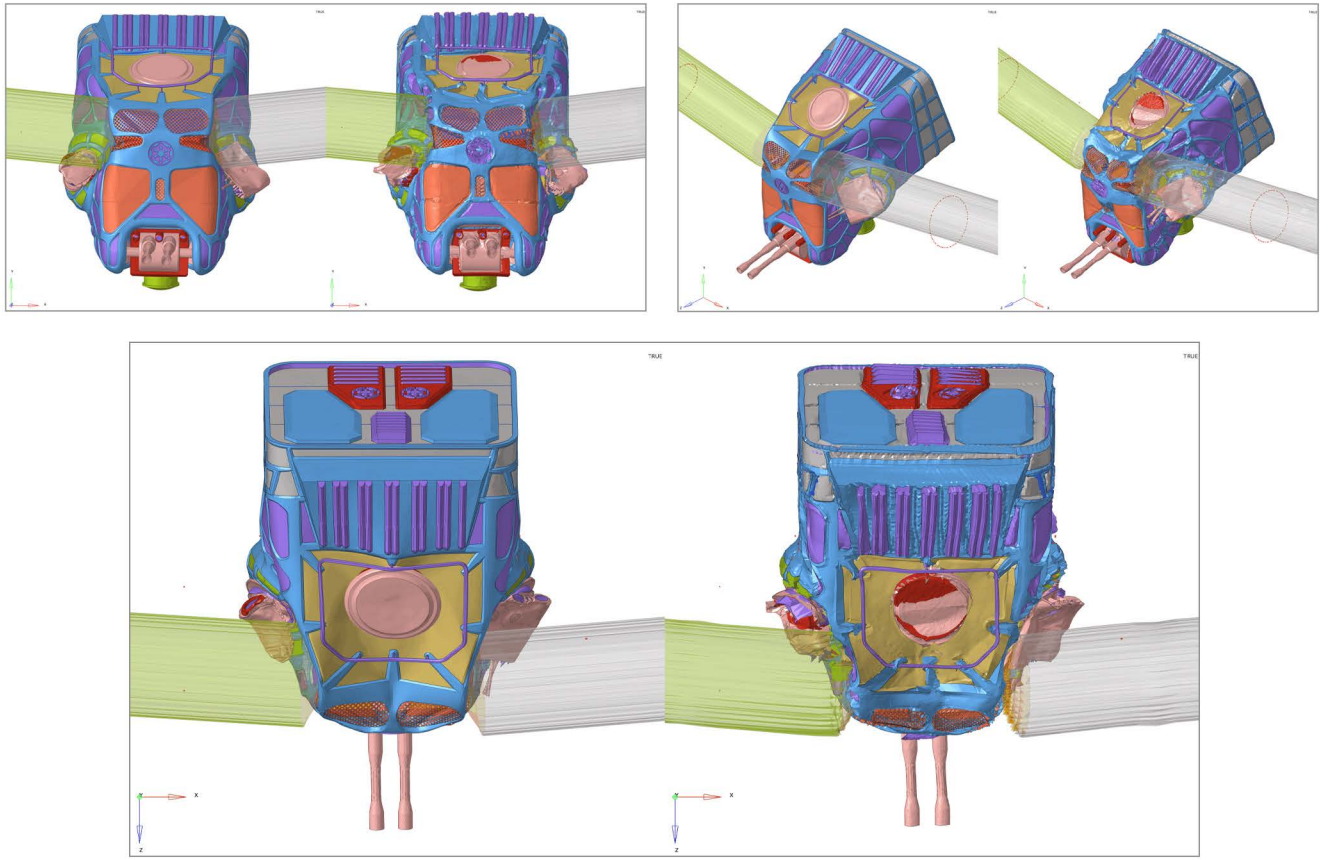
- Transient events like crash, impact, and drop are highly nonlinear and localized
- Traditional simulations require significant compute time and cost
- Difficult to explore design alternatives using full finite element (FE) runs

Solution

- Trained a Altair® PhysicsAI™ model using the initial DOE simulations
- Modeled explicit dynamic behavior for faster prediction
- Demonstrated using the complex geometry of the Star Wars AT-ST walker

Value

- Reduced prediction time from 72 minutes to 26 seconds (166x faster)
- Enabled rapid design iteration with minimal additional compute, lowering simulation cost while maintaining high-fidelity accuracy



NEW

Optimize Fan Acoustics

Use geometric deep learning models trained on CFD and test data to rapidly predict fan acoustic behavior

Challenge

- Traditional CFD-based fan acoustics analysis requires complex and time-consuming simulation setup
- Testing for sound pressure levels demands specialized equipment and environments
- High computational costs limit the number of design iterations that can be practically evaluated

Solution

- Combine pre-existing CFD simulations and test data to train a model of acoustic performance
- Generated an Altair® PhysicsAI™ model in minutes using the prepared dataset
- Used the trained model to estimate SPL and evaluate multiple fan designs in seconds, enabling rapid comparison of acoustic performance across geometries

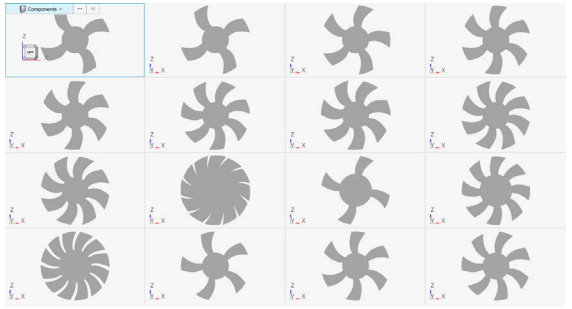
Value

- Reduced acoustic evaluation time by over 360x, accelerating design cycles for noise-sensitive components
- Enabled data-driven selection of optimal fan configurations without additional simulations or testing
- Delivered 98% prediction accuracy, supporting confident early-stage decisions and reducing reliance on physical prototypes

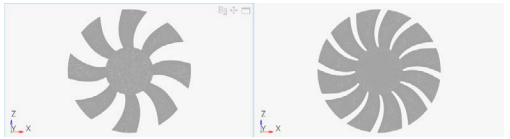
360x
FASTER

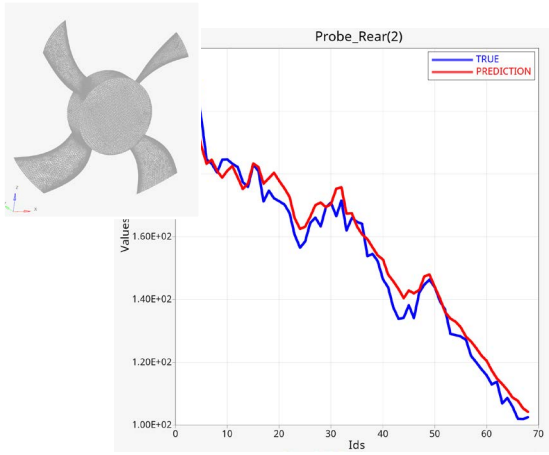
98%
ACCURATE

Training Data



Test Data





NEW

Accelerating PLC Code Development

Agentic AI workflow using multi-agent LLMs to generate and validate Structured Text from natural language

Challenge

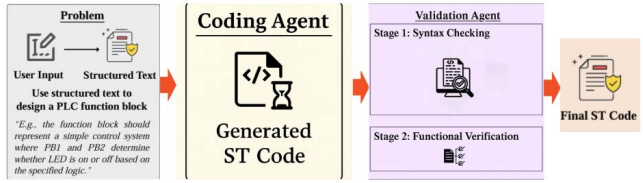
- Manual PLC programming in Structured Text (ST) is slow, error-prone, and difficult to scale
- No standardized tools exist for validating code accuracy or translating human instructions into reliable, executable PLC logic

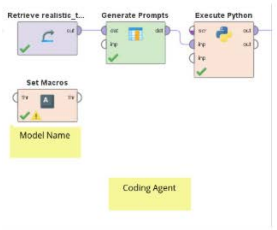
Solution

- Used LLMs such as GPT-4, Qwen2.5-Coder, Llama, and Codestral to translate natural language prompts into ST code
- Deployed a multi-agent architecture combining coding and validation agents for end-to-end automation
- Verified functional and syntactic accuracy using the RuSTy compiler

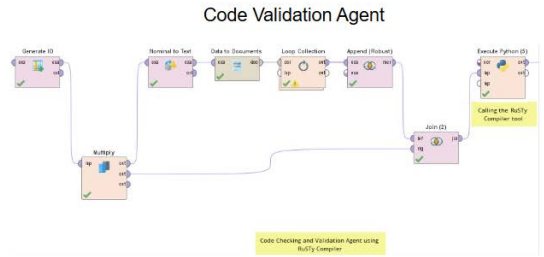
Value

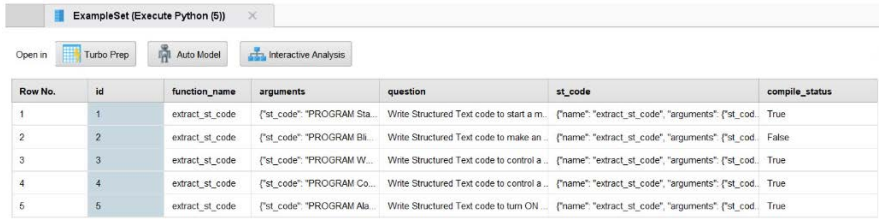
- Accelerates PLC development with accurate, automated code generation
- Reduces reliance on specialized programmers, enabling broader team collaboration and faster iteration





Coding Agent





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Material and Manufacturing Use Cases

Detect Steel Sheet Defects

AI-powered object detection enhances steel quality by identifying surface defects in real-time

Challenge

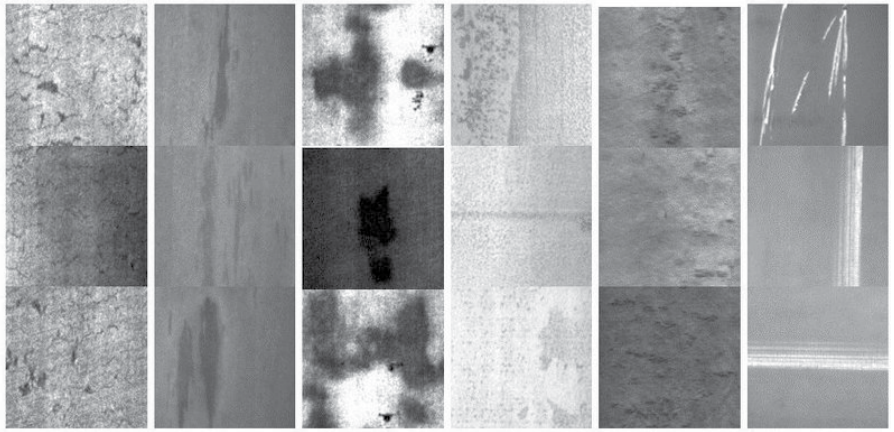
- Ensuring consistent steel quality is difficult and impacts both product costs and processing precision
- Poor steel quality negatively affects the accuracy of subsequent processing steps
- High part rejection rates result in significant financial losses

Solution

- Computer vision was used to detect and classify defects in steel sheets
- The trained model was integrated into a dashboard for real-time analysis and inferencing

Value

- Steel quality control was improved, reducing costs and enhancing processing accuracy
- Part rejections and associated financial losses were minimized
- Real-time defect detection and analysis were made more efficient through a user-friendly dashboard



Operational Digital Twin for Sheet Metal Forming

AI-driven insights from Altair® romAI™ improved control and reduced waste by over 15%

Challenge

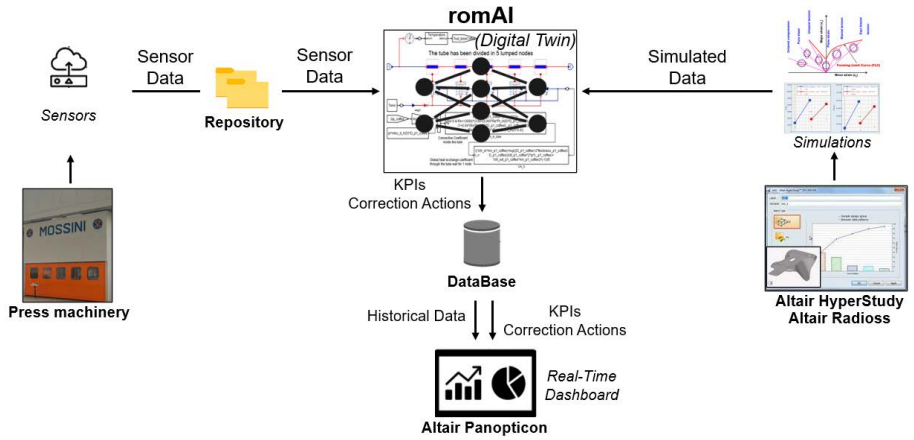
- Identify causes of divergence from nominal conditions in the sheet metal forming process

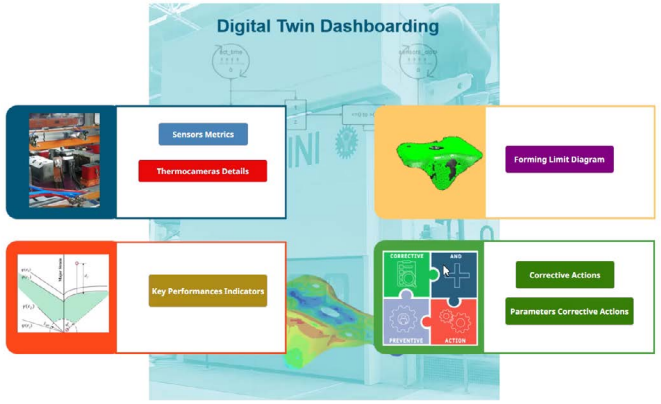
Solution

- Built an operational Digital Twin for monitoring and improvement with Altair® romAI™
- Trained ROM with simulation data to analyze sensor data and identify the causes of divergence
- A real-time dashboard was used for monitoring and providing actionable information.

Value

- Improved process control enabled more consistent quality and reduced downtime, directly impacting operational efficiency
- Waste production was reduced by over 15%, delivering significant cost savings and boosting overall profitability





Accelerate What-If Analysis for Sheet Metal Forming

Enhanced ROM techniques improve efficiency and reduce run times for faster decision-making

Challenge

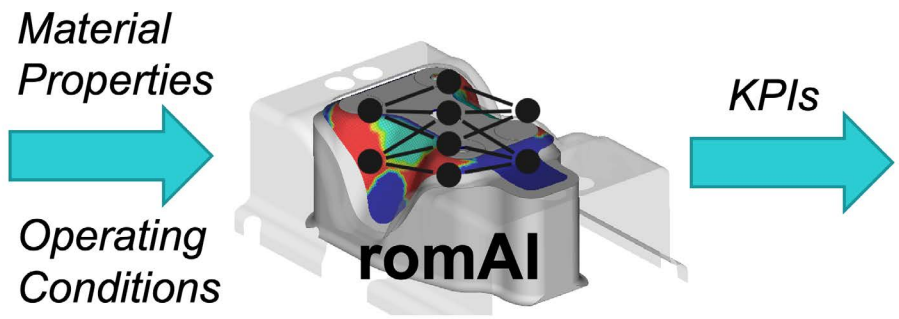
- Quickly understanding the variation of KPIs as a function of material properties and operating conditions, such as pad force and die friction

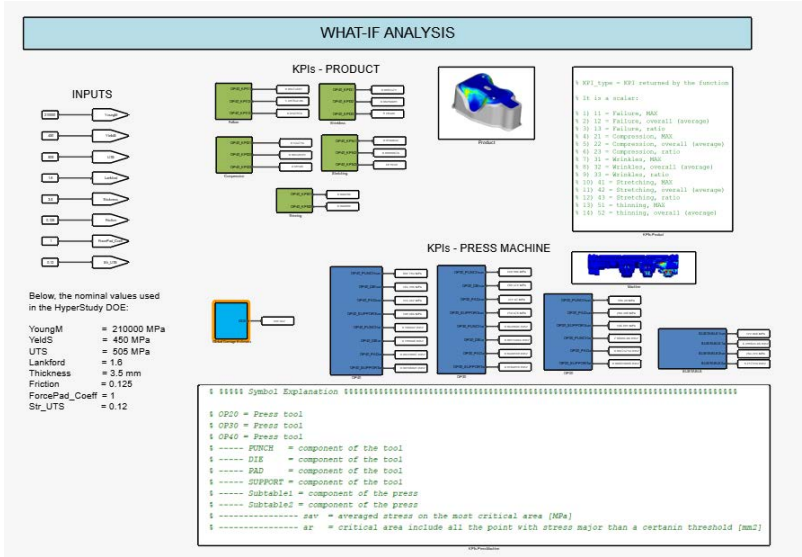
Solution

- High-fidelity modeling of the forming process was achieved using Altair® Radioss®
- Training and test data were automatically generated with Altair® HyperStudy® and Altair® Compose®, applying a fractional DOE (MELS) to Radioss simulations, and KPIs were calculated automatically with Compose
- ROMs for KPI estimation were generated using Altair® romAI™
- ROMs were hosted with Altair® Activate®, calculating KPIs for both the product and the press machine, facilitating efficient what-if analysis

Value

- Run time was reduced from 4 hours to 1 second, enabling fast and easy what-if analyses





ALTAIR

Address Process Challenges in Injection Molding with Real-Time AI Monitoring

AI/ML diagnosis and optimization reduce defects and improve process efficiency

Challenge

- Frequent defects in manufactured parts are impacting overall quality
- High cycle times and excessive waste are creating inefficiencies in the process
- A large number of parameters are making diagnosis and process optimization difficult

Solution

- Real-time monitoring through sensors and AI enabled continuous adjustments during the process
- Machine learning algorithms optimized settings to proactively prevent defects
- Automated adjustments allowed dynamic system responses based on AI-driven insights

Value

- Significant reduction in defects lead to improved product quality
- Enhanced operational efficiency with decreased cycle times and reduced waste
- Lower downtime and operational expenses resulted in considerable cost savings

Crash-Optimized Megacasting Design for Enhanced Performance

AI/ML-driven response surface methods (RSM) streamline crash optimization and integrate lightweighting strategies

Challenge

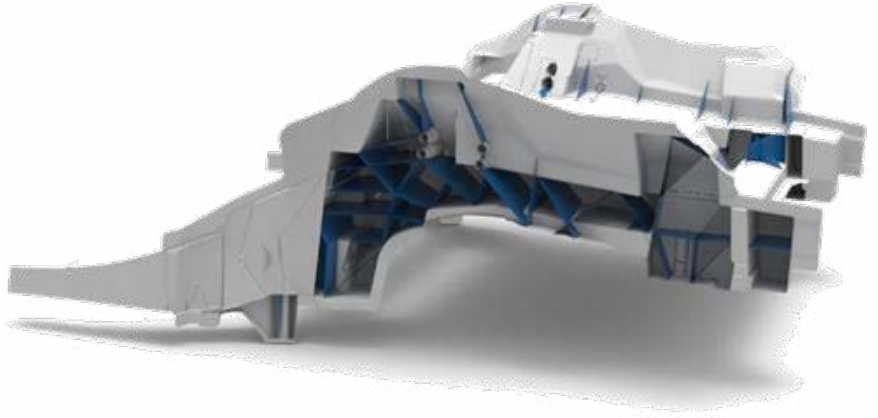
- Complex design challenges in megacasting manufacturing, requiring intricate analysis
- Processing large volumes of simulation data to identify optimal solutions
- Meeting sustainability goals by developing lighter products with superior performance across multiple disciplines (crash, NVH, etc.)

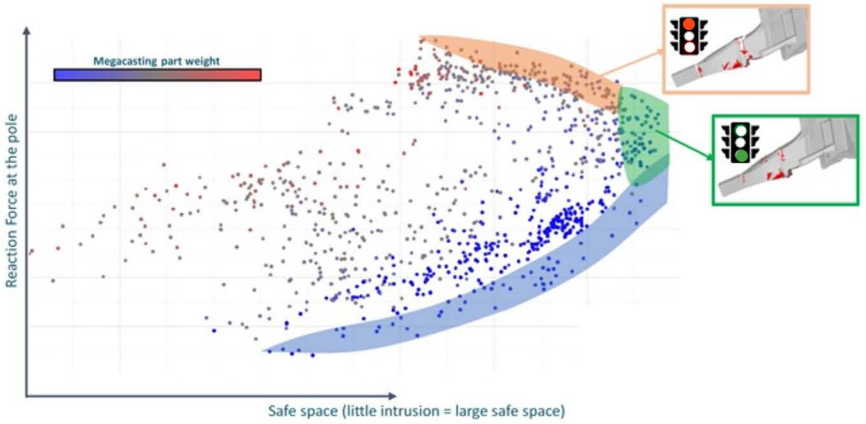
Solution

- Employed multidisciplinary design exploration to assess both design requirements and manufacturability across various concepts
- Leveraged AI/ML clustering to identify top-performing designs and optimize selection
- Applied lightweighting strategies through structural optimization to maximize energy absorption, minimize deformation, and avoid ruptures

Value

- Enhanced products' lightweight potential with expanded design flexibility and material properties
- Reduced losses associated with part quality and improved resource utilization
- Accelerated product development for faster speed to market





Predict Real Time Bearing Failure Class

Predictive models and real-time sensor data processing reduce downtime, detect bearing failures early, and optimize inventory management

Challenge

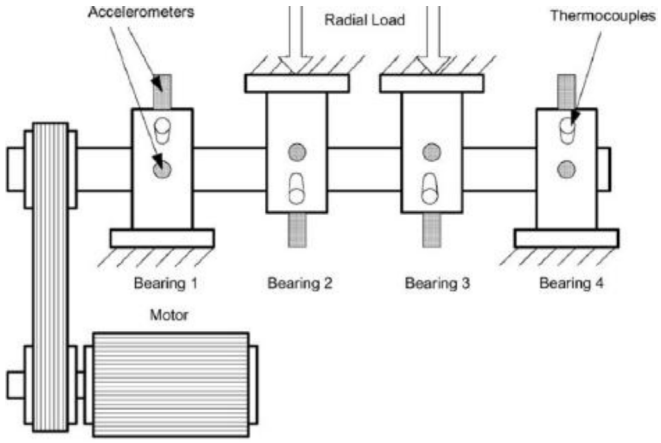
- Downtime and production losses due to various bearing failures, including inner race, outer race, roller issues, and complete breakage
- Real-time sensor data requires efficient processing to avoid delays

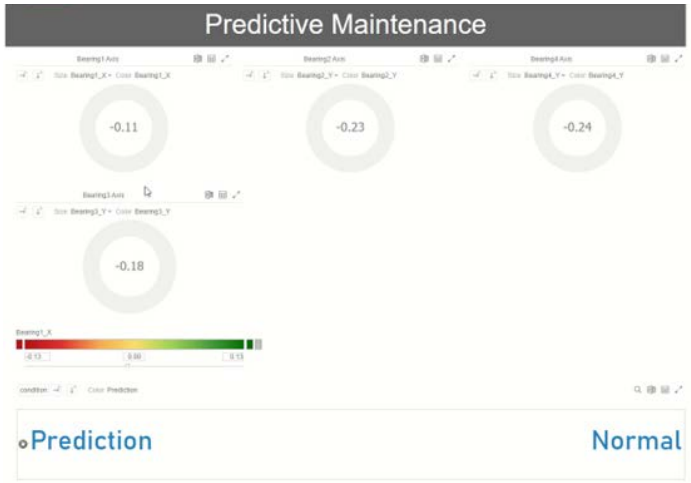
Solution

- Built a predictive model using historical accelerometer sensor data from bearings, enabling real-time condition monitoring and failure prediction
- Connected Altair® Panopticon™ to edge devices via the MQTT Protocol for real-time streaming and visualization of accelerometer data
- Extracted statistical, domain, and visual features from raw accelerometer data to train ML models for failure prediction and classification, proactively addressing potential breakdowns

Value

- Minimized production losses and downtime by preventing unexpected bearing failures and identifying failure types and anomalies early for proactive maintenance
- Optimized inventory and reduced maintenance costs by predicting failures and planning spares usage more effectively





Achieve Consistent Particle Size in Pharma Manufacturing

Real-time data monitoring and machine learning models optimize product quality, reduce waste, and enhance decision-making

Challenge

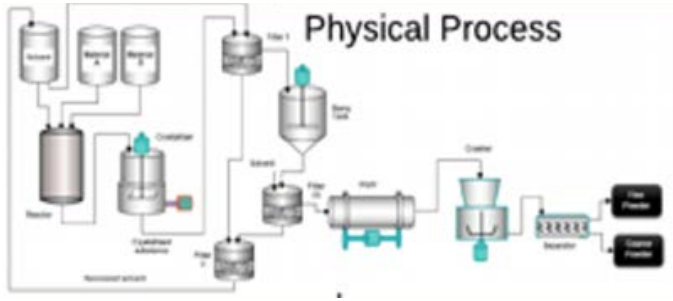
- Meet the 90% fine/coarse particle size requirement, reducing business waste bay minimizing the need to discard/reprocess coarse powder through additional crushing and separation

Solution

- Connected Altair® Panopticon™ to the OPC server, streaming real-time sensor data for process monitoring
- Built an ML model using data from 2,000 batches to predict output quality, deployed it on a real-time dashboard for process monitoring, and prescribed engineers corrective actions for bad batches

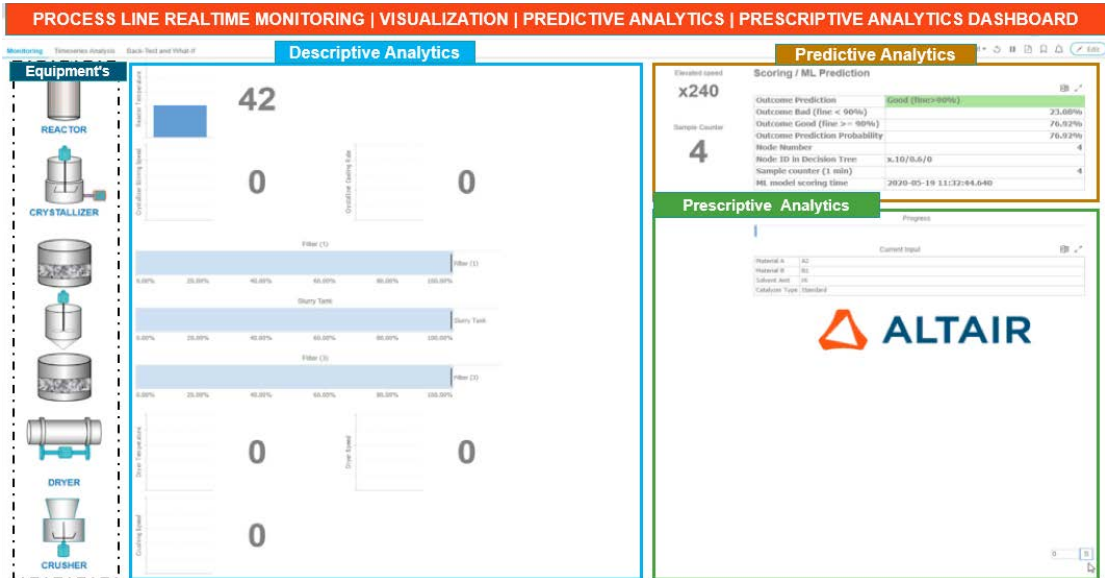
Value

- Enabled real-time anomaly detection and monitoring to prevent issues and reduce downtime
- Predicted product quality early, allowing proactive adjustments to improve efficiency and minimize waste
- Provided operators with back-testing and “what-if” analysis for better decision-making and quality control



Observed variables per batch:

- **Material grade:** Material A (A1, A2), Material B
- **Amount of Solvent used :** High, Low
- **Reactor**: Temperature history, reaction time
- **Crystallizer**: stirring speed, cooling rate, total time
- **Catalyzer Type**: Standard, Enriched
- **Dryer**: speed, temperature history, total time
- **Crusher**: speed, time
- **Output**: % fine powder and % course powder



Physics Predictions for Polyurethane Foaming Design Optimization

AI-powered predictive models reduce the need for HPC, accelerate complex design iterations, and deliver cost-effective solutions for foaming simulations

Challenge

- Multiple design iterations required by engineers, increasing time and effort
- Each design requires a separate, time-consuming simulation run
- Complex designs result in longer computational times
- Foaming simulations are not supported on HPC, limiting speed and efficiency

Solution

- Trained Altair® PhysicsAI™ on historical simulation data from past design iterations
- Predicted design outcomes using PhysicsAI, then ran one final simulation in Altair® Inspire™ PolyFoam to validate a new design
- Confirmed the prediction accuracy of PhysicsAI against traditional foaming simulations

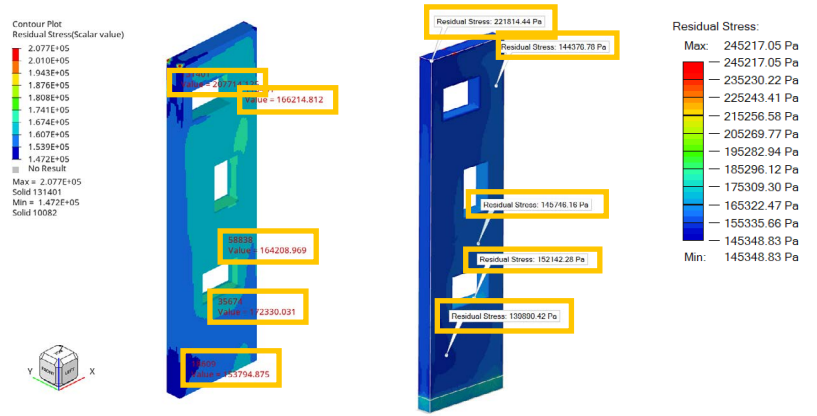
Value

- Eliminates the need for expensive HPC resources, reducing operational costs
- Accelerates design iterations, allowing for faster product development and a quicker time-to-market
- Enables predictive analysis for design changes in seconds to minutes, improving efficiency and freeing up valuable engineering resources

After predicting through PAI, Ran one more simulation in Inspire PolyFoam on a new design

Confirmed the prediction accuracy of PAI against traditional foaming simulation

~0.02 MPa accuracy difference

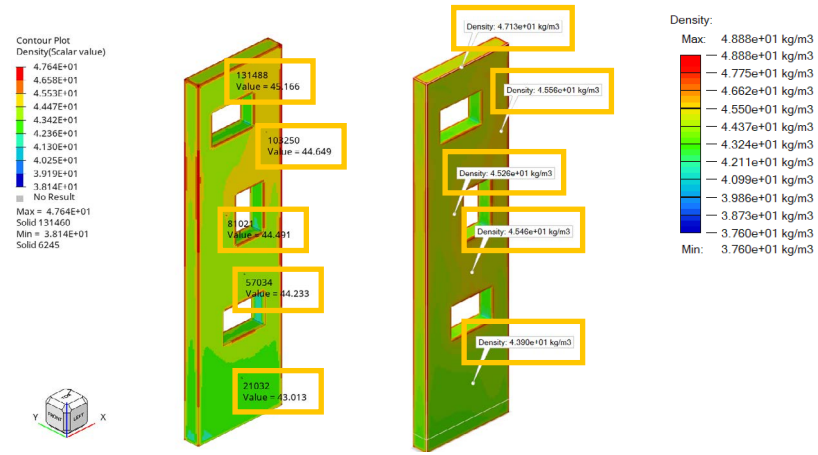


Physics AI Inspire PolyFoam

After predicting through PAI, Ran one more simulation in Inspire PolyFoam on a new design.

Confirmed the prediction accuracy of PAI against traditional foaming simulation

~2 Kg/m3 accuracy difference



Physics AI Inspire PolyFoam

ALTAIR

Faster Development of Optimal Rubber Material Mixtures

ML models trained on historical data improved efficiency, reduced costs, and accelerated discovery of high-performance materials

Challenge

- Developing new rubber mixtures is costly and time-consuming, requiring extensive testing of numerous combinations

Solution

- Historic data from previous experiments and manufactured products was used to train an ML model that predicts the key properties of new material mixtures

Value

- Virtual testing streamlined the development process, reducing time and costs on non-viable mixtures
- Accelerated discovery of optimal material combinations
- Lowered production costs and enabled faster market entry for high-performance materials, ensuring a competitive advantage

Automated Scalable Material Outlier Detection

AI-powered pre-processing identifies anomalies, ensuring cleaner data for reliable material modeling

Challenge

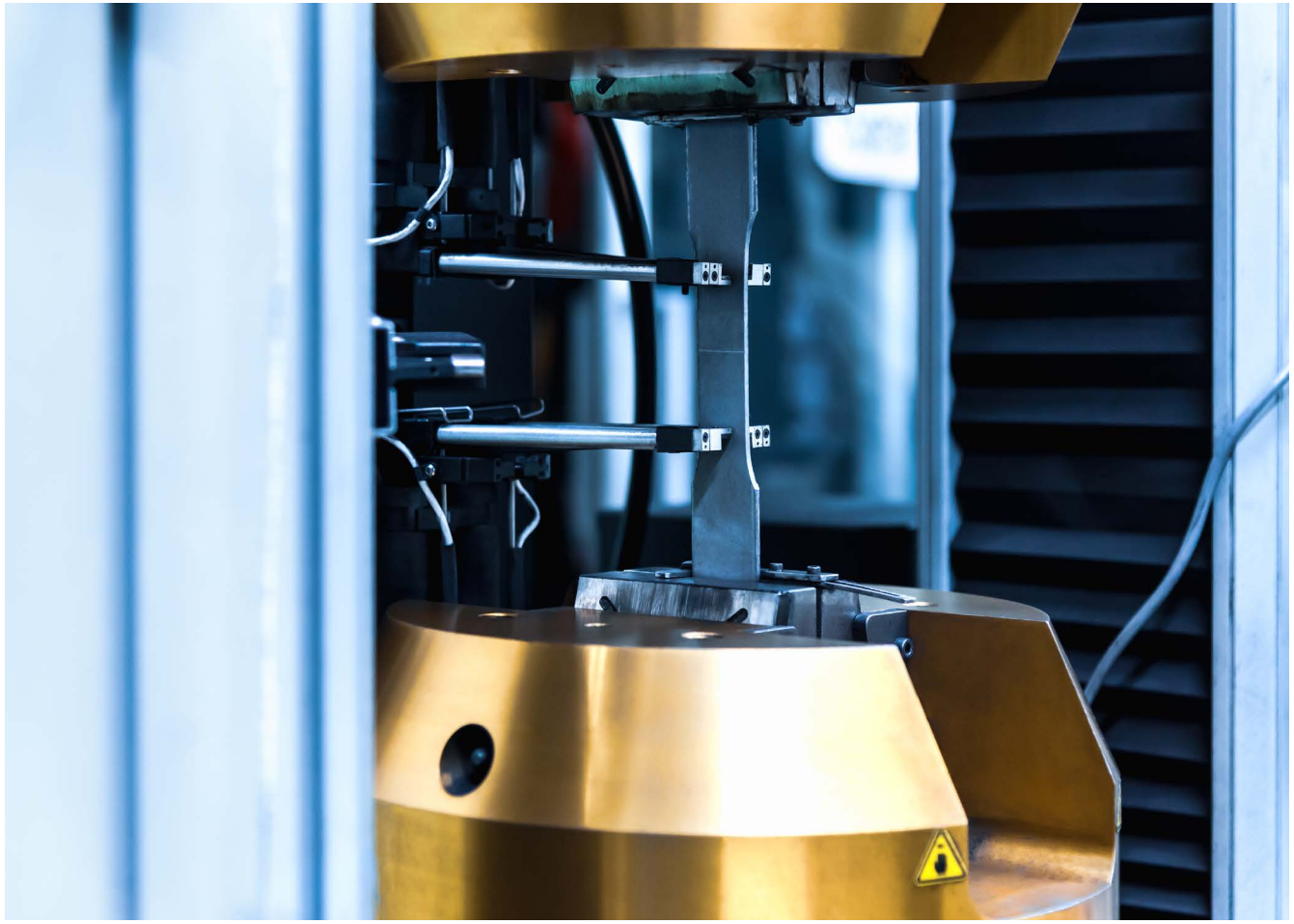
- Raw material data is often noisy and variable, making it difficult to detect true patterns. Effective preprocessing is essential to filter out noise and identify material outliers accurately

Solution

- Data consolidation and transformation were automated, applying unsupervised machine learning techniques, such as K-means clustering, to detect outliers in material data

Value

- Improved test data quality and material model accuracy, ensuring more reliable insights
- Enabled the creation of predictive models with machine learning, driving faster and more informed decision-making
- Reduced reliance on physical testing, shortening lead times, and cutting costs, leading to faster time-to-market



NEW

Instant Formability Predictions for Sheet Metal Design

Predict sheet metal simulation results in seconds using AI-trained models – no full simulation required.

Challenge

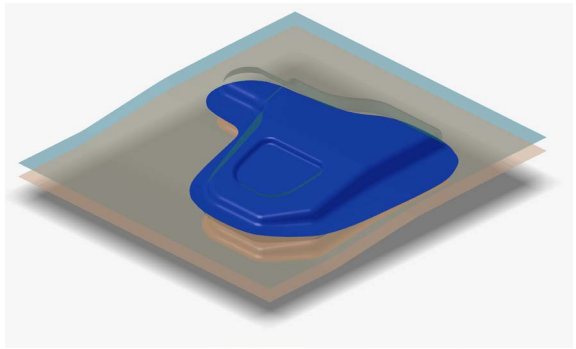
- Sheet metal forming involves complex variables: die geometry, blankholding and drawbead forces, and especially blank size and shape
- After tool design, blank geometry is the key factor in part formability, driven by the contact surface area between the blank and tooling
- Poor blank-to-tool interaction can cause flow issues, resulting in excessive thinning or wrinkle defects

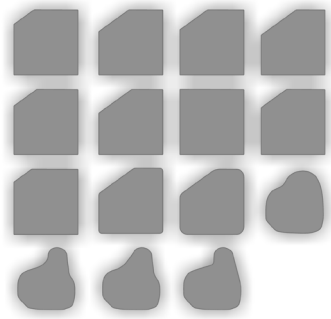
Solution

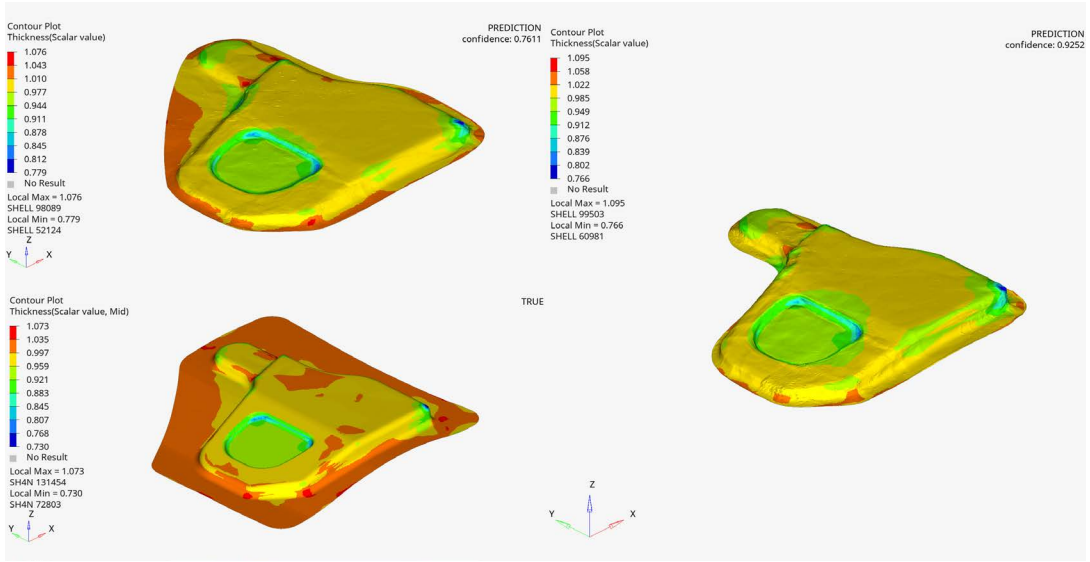
- Trained an AI model on varied blank shapes and sizes using historical simulation data
- Enabled rapid prediction of formability outcomes – including displacement, thickness or plastic strain – for new blank designs
- Supported early blank shape refinement to minimize flow-related defects before committing to full simulations

Value

- Reduced iteration time from hours to seconds, replacing preprocessing and full simulation with AI-based prediction
- Identified formability risks early in the process, enabling fast design exploration with high prediction accuracy
- Freed up simulation resources while accelerating decision-making







NEW

Smarter Manufacturing Decisions with AI-Driven Epoxy Modeling

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
- Fast analysis is essential to keep pace with tight development cycles

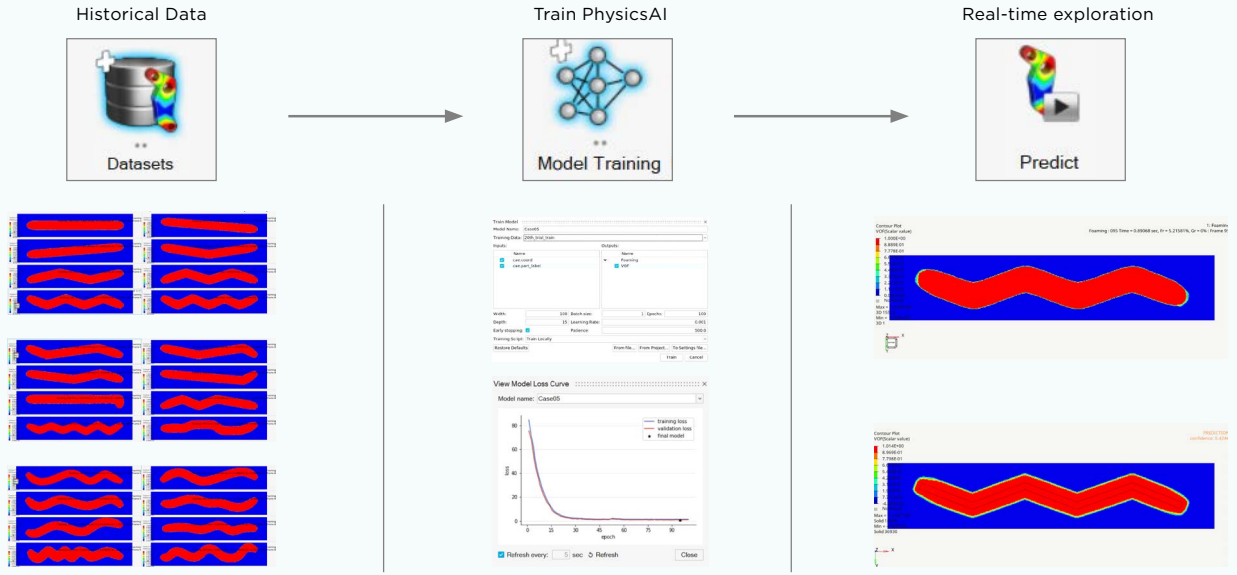
Solution

- 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

Value

- Reduced turnaround from hours to seconds for epoxy pattern validation
- Accelerated early-stage decisions with instant predictions for new dispense paths
- Maintained accuracy by using production-calibrated simulation data

Dispensing Prediction through PhysicsAI



PhysicsAI: Real-time Prediction

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

NEW

New Polymers, Less Testing, Better Results

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

Challenge

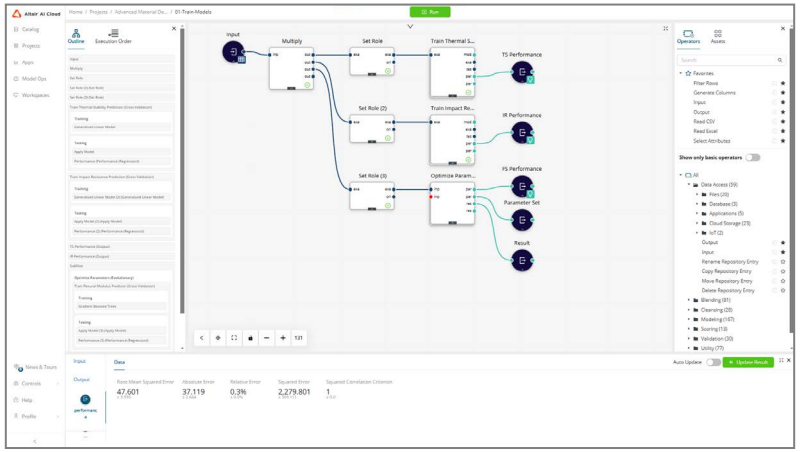
- Iterative material design and testing cycles are slow and time-consuming
- Running large numbers of design evaluations is resource-intensive
- It's unclear when a material is truly optimal – or if performance targets could be exceeded

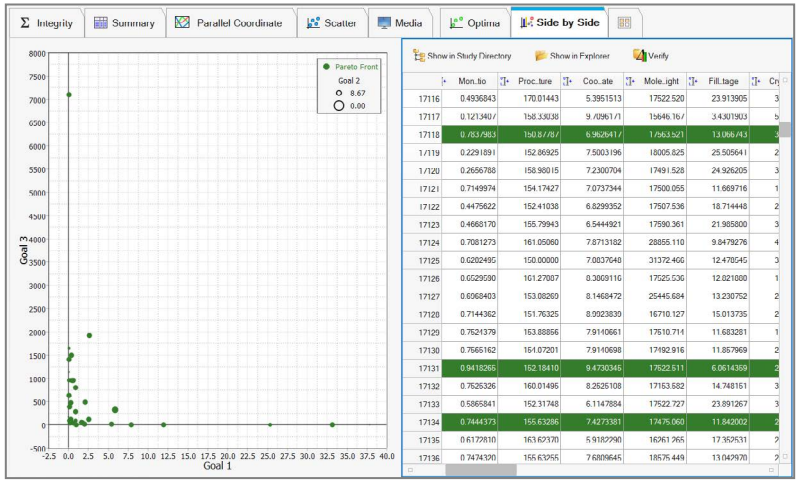
Solution

- 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 to meet requirements
- Analyzed trade-offs between competing properties and identified candidates similar to known materials

Value

- Lowered material development costs by reducing redundant testing.
- Shortened development cycles through automated optimization.
- Delivered higher-performing, more innovative materials
- Improved sustainability metrics without increasing workload





NEW

Accelerate Microstructure Simulation for Battery Compacting

Automating simulation inputs and using ROM predictions cuts time, cost, and manual effort in electrolyte microstructure modeling.

Challenge

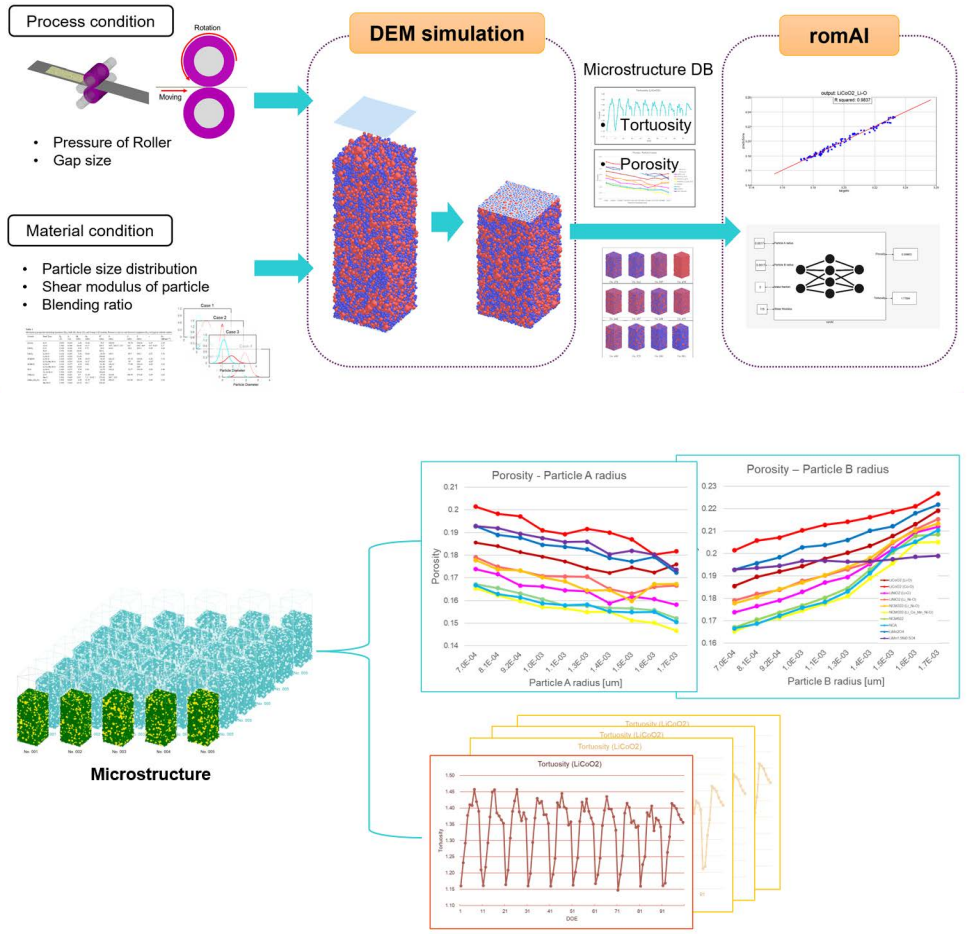
- Building a database of battery electrolyte microstructures is slow because simulation time multiplies with the number of variable cases
- Manually adjusting input variables and running simulations is complex and prone to error
- The size of the dataset makes it difficult to modify simulations during execution or detect outliers efficiently

Solution

- Automated the simulation workflow to enter variable values and run processes without manual intervention
- Used ROM-based prediction to estimate key outputs like porosity and tortuosity from measured data, reducing the number of full simulations needed

Value

- Lowered simulation costs and cycle times, improving overall process efficiency
- Reduced human error by eliminating manual input steps
- Enabled more scalable and reliable results analysis through data-driven predictions



ALTAIR

NEW

Optimize Cast Iron Alloy Design

AI-powered metal casting predicts optimal additive use, reducing costs while meeting high product quality standards using trusted data.

Challenge

- Reducing additive use risks compromising product quality
- Trial-and-error testing is slow, expensive, and inefficient
- Engineers lack quick access to proven performance data for formulation decisions

Solution

- Trained machine learning models on historical manufactured mixture data to predict the minimum additive content needed to meet quality standards
- Ran virtual experiments to narrow down optimal combinations for physical validation
- Leveraged data to access the latest research and proven performance results

Value

- Reduced testing costs by focusing only on the most promising candidates
- Lowered additive consumption without sacrificing quality
- Enabled faster, data-driven decisions using trusted, high-quality application data

NEW

Smart Data for Quality Control in Steel Production

Machine learning predicts quality issues early, reducing waste, energy use, and cost in complex, data-heavy production environments.

Challenge

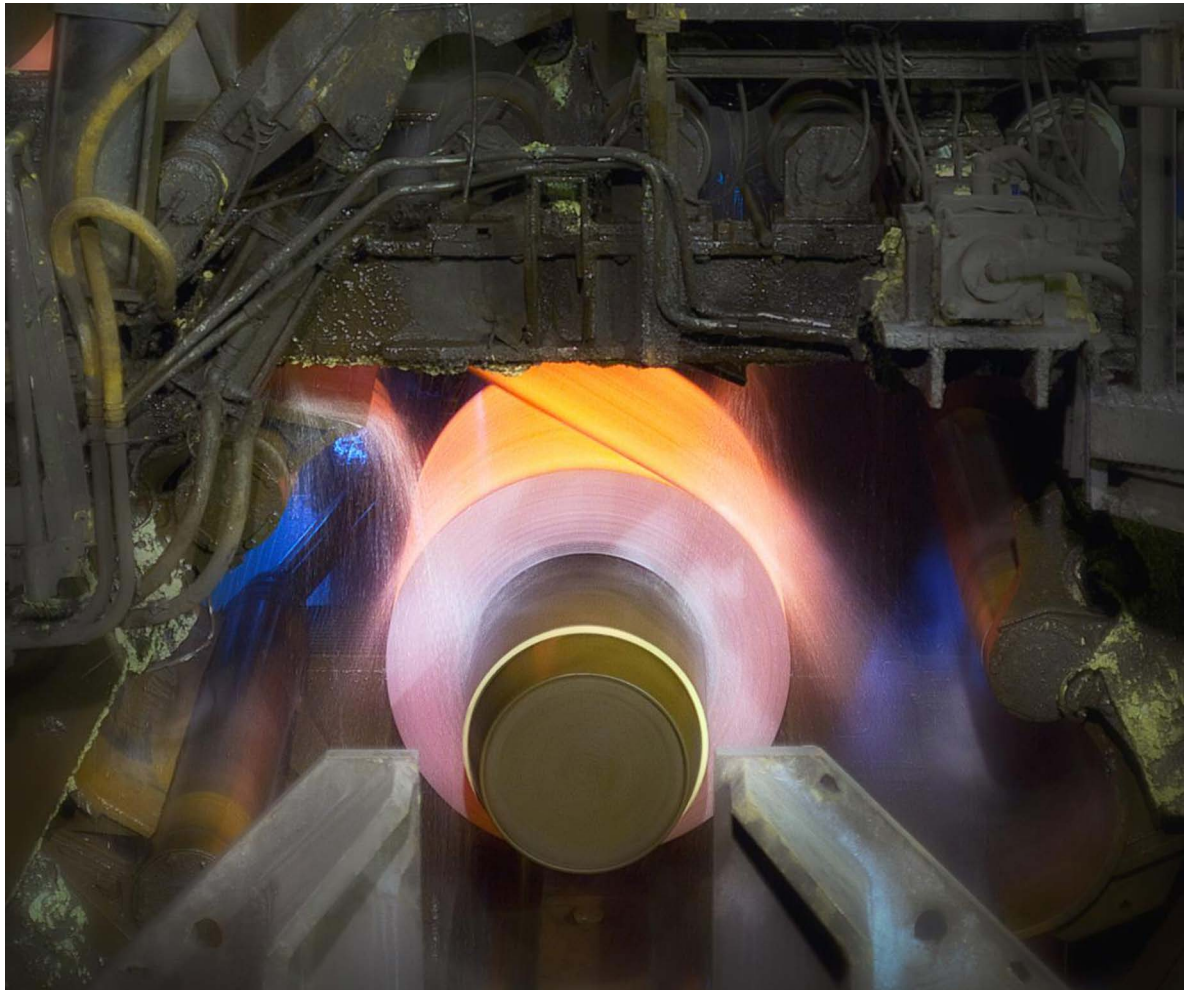
- Steel production is highly variable, producing 10-meter blocks to 2-kilometer rolls
- Hundreds of sensors generate massive volumes of data at 1–10 Hz over years of production
- Managing and extracting actionable insights from this data is an industry bottleneck
- High energy consumption and long lead times increase cost and risk if quality issues aren't detected early

Solution

- Applied machine learning to process and analyze production data in near real-time
- Predicted product quality early in the manufacturing process to enable corrective action
- Integrated predictive insights into existing production workflows for smarter decisions

Value

- Avoided unnecessary processing of defective material, saving energy and cost
- Improved throughput and consistency by catching quality issues earlier
- Enhanced data utilization, unlocking long-term value from existing sensor infrastructure



NEW

Predict Welded Joint Strength Using Machine Learning

Machine learning Deep learning models accelerate strength assessment using material and test data, reducing physical testing and enabling faster, safer vehicle design.

Challenge

- Accurate joint strength assessment is essential for crash safety and structural performance
- Physical testing is costly, time-consuming, and resource-intensive
- Traditional processes raise production costs and slow development cycles

Solution

- Collected ASCII data on chemical composition, product specifications, material grades, and test conditions
- Applied advanced deep learning models to predict joint strength based on these inputs
- Delivered a standardized, accurate prediction workflow usable by both experts and non-experts

Value

- Improved joint strength predictions enhanced crash safety and vehicle performance
- Reduced reliance on physical testing, saving time and cost
- Accelerated design cycles and enabled cross-team collaboration and innovation

NEW

Improving HPDC Efficiency for LCV Door Handles

Reduce design time and material waste using AI-trained models for casting defect prediction and process tuning.

Challenge

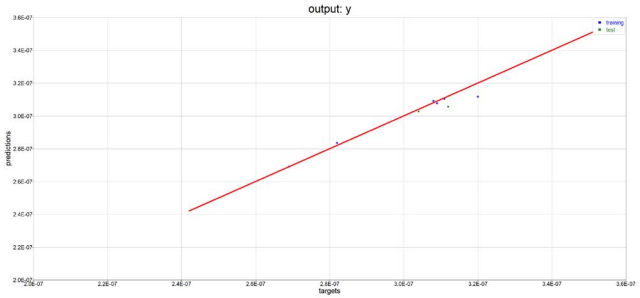
- Traditional casting analysis is slow and resource-intensive, especially when iterating similar part designs
- Lack of process optimization often leads to increased costs and time during production

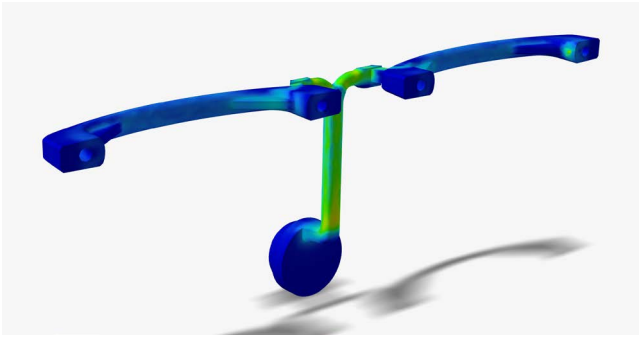
Solution

- Trained Altair® PhysicsAI™ models on historical casting simulation data specific to the LCV door handle to evaluate performance across different gating and runner configurations
- Used Altair® romAI™ to analyze input-output relationships and identify optimal process settings (e.g., gating positions, flow velocity) to achieve desired casting quality
- Applied AI-based predictions to design gating systems that improve fill balance, minimize turbulence and air entrapment, reducing the need for repeated simulation or physical trials

Value

- Enables early identification and prevention of casting defects, lowering production costs and reducing time and material waste
- Optimizes process efficiency with a “right first time” approach, minimizing rework and accelerating product development cycles
- Reduces reliance on costly simulations and physical prototyping through accurate AI predictions, freeing up engineering resources and shortening time to market





NEW

Real-Time Digital Twin for Robotic Arm Simulation

AI-powered virtual sensors and real-time rendering enable a scalable, physics-based digital twin for robotic systems

Challenge

- Real-time digital twin for robot arms, including both rigid and flex body dynamics, has yet to be widely implemented in industrial applications
- Retrofitting physical sensors onto existing equipment is costly and often impractical
- Manufacturers typically lack the time and budget for extensive testing and calibration on the production line

Solution

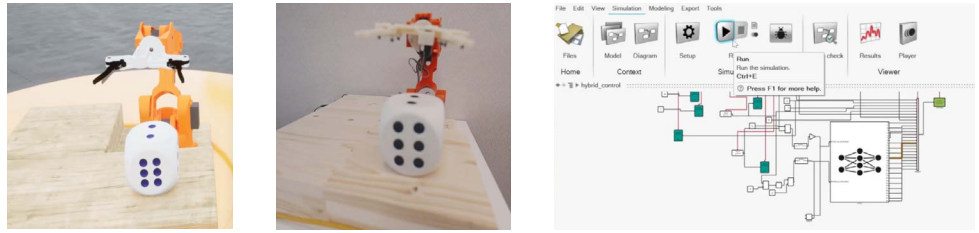
- Simulated rigid and flex body dynamics of the robot arm using Altair® Inspire™ and Altair® Radioss® to generate training data.
- Used Altair® romAI™ to build a reduced order model (ROM) that replicates CAE results in real time
- Deployed the ROM in Altair® Twin Activate® and connected it to a high-end rendering engine for real-time visualization of virtual sensor feedback and system behavior

Value

- Enables real-time design validation and diagnostics without retrofitting physical sensors
- Reduces operational costs by minimizing downtime, testing, and calibration cycles
- Scales across every industrial application to accelerate digital transformation and improve ROI

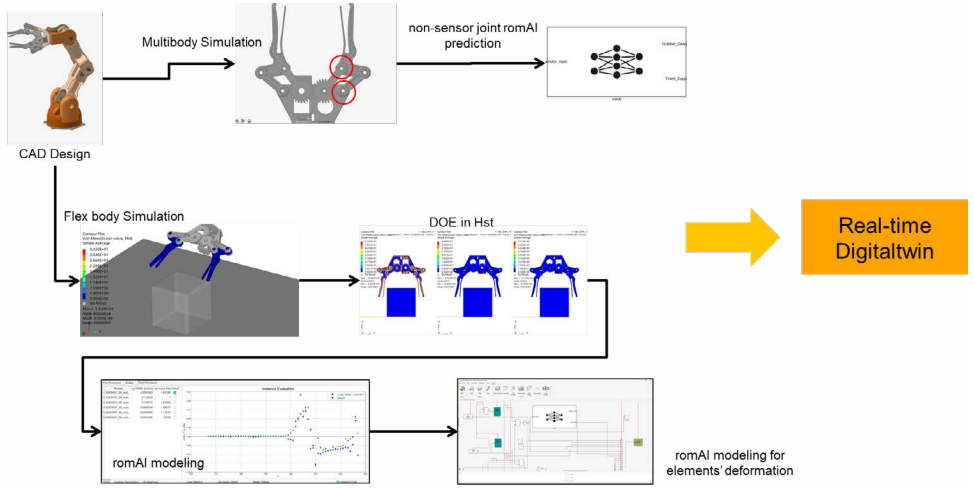
REAL-TIME

DIGITAL TWIN



5+

ALTAIR PRODUCTS INTEGRATED



SCALABILITY

NEW

GenAI Chatbot for Manufacturing & Maintenance Support

LLM-powered assistant for resolving production issues with contextual, real-time responses

Challenge

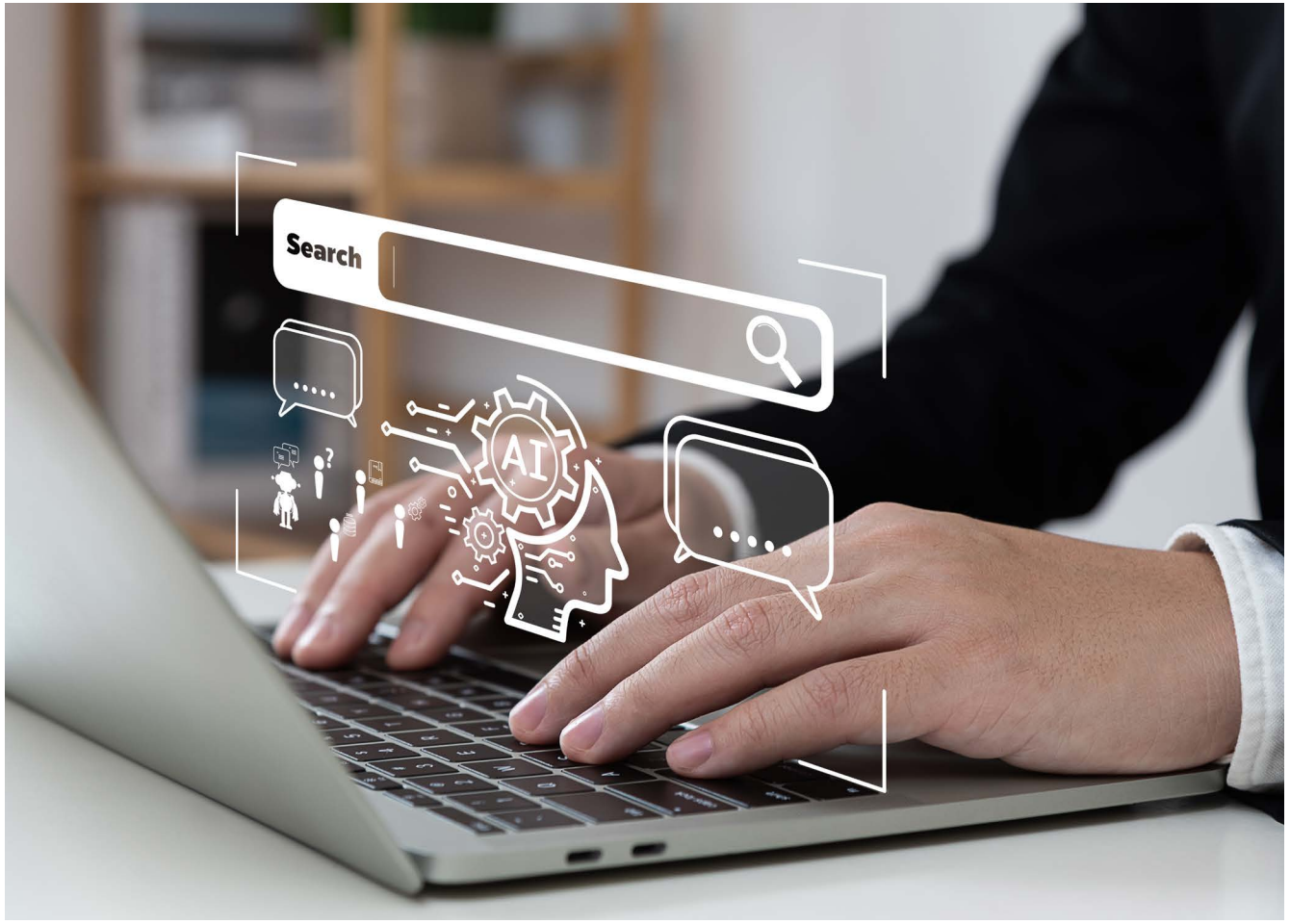
- Delayed resolution of shopfloor quality and maintenance issues due to information spread across siloed documents and systems
- Complex, sensitive data landscape requiring secure and scalable access
- Need for fast, adaptive responses to dynamic operational queries

Solution

- Developed a chatbot powered by LLMs to assist with manufacturing-related queries
- Enabled natural language querying of technical content
- Supported processing of multiple data types for richer context and accuracy

Value

- Accelerated issue resolution through intelligent query responses
- Centralized access to dispersed knowledge sources
- Reduced support and operational costs
- Empowered shopfloor workers with real-time decision support



NEW

Smart Manufacturing Insights with Knowledge Graphs

Trace, root cause, and scenario analysis – enabling rapid, ad-hoc insights across multi-source manufacturing data

Challenge

- Disparate data across systems makes it difficult to trace issues or uncover root causes
- Lack of a unified view hinders fast, informed decision-making
- Manual investigation is slow and not scalable for complex queries

Solution

- Created a unified semantic data layer to link data across manufacturing systems
- Enabled easy querying of relationships using natural language and BI tools, providing access through endpoints, copilots, and dashboards for broad usability

Value

- Accelerates root cause investigation and decision-making
- Supports predictive maintenance and reduces unplanned downtime
- Improves overall operational efficiency and cost control

NEW

Optimize Assembly Planning

Using NLP and machine learning to standardize work plans and benchmark assembly processes

Challenge

- High costs in product design and assembly planning phases
- Lack of efficient methods to accelerate and reduce cost of planning
- Fewer than 5% of assembly plans use a standardized process language, limiting reuse and automation

Solution

- Transformed unstructured assembly instructions into structured data using natural language processing (NLP)
- Trained a model in Altair® RapidMiner® to predict assembly plans for new truck engines and components
- Used the model to estimate assembly times

Value

- Identified optimal assembly process combinations for improved efficiency
- Enabled a faster, lower-cost manufacturing and assembly process by optimizing work plans and identifying efficiencies
- Accelerated time-to-market

NEW

Automated CAE Image Evaluation for Stamping Quality

ML-based image classification to replace subjective assessments and optimize manufacturing parameters

Challenge

- Manual evaluation of stamping CAE results is subjective and varies between individuals
- Review process is time-consuming and labor-intensive
- Inconsistent judgments can lead to quality risks and inefficiencies

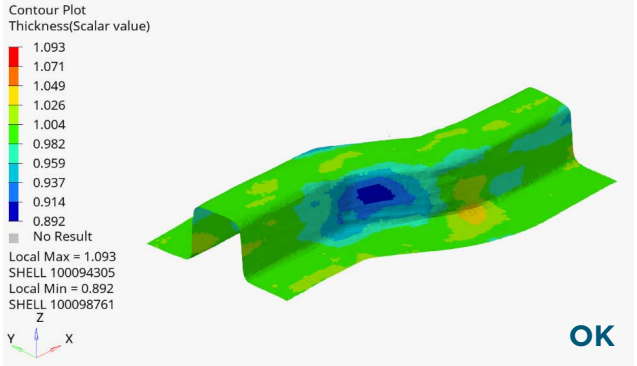
Solution

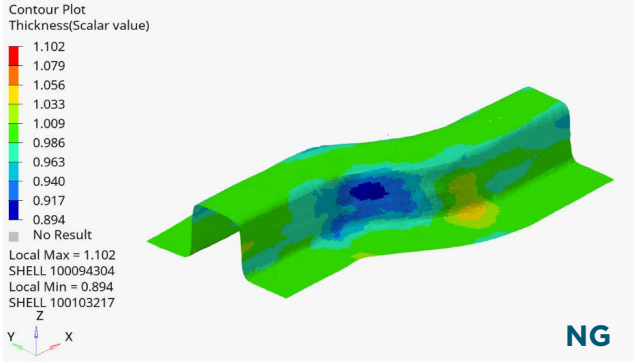
- Applied ML model trained on CAE contour images to classify results as OK or NG
- Replaced manual evaluation with automated, consistent decision-making
- Used Altair® AI Studio to build and deploy the classification pipeline

Value

- Achieved over 90% accuracy in OK/NG classification of CAE images
- Enabled automated optimization of stamping parameters to improve yield
- Reduced dependency on human reviewers, accelerating validation and improving consistency

Manufacturing CAE Results (Image Data)

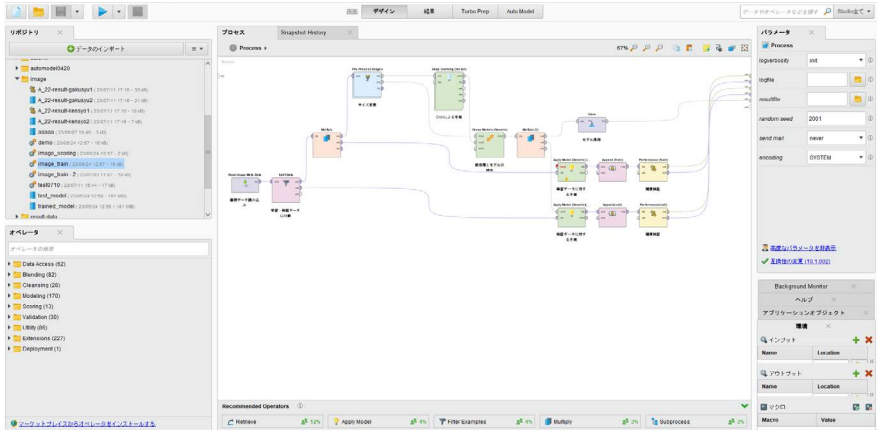




AI Studio process

Input:
CAE contour image data

Output:
OK or NG



NEW

Efficient Material Model Calibration for DEM Simulations

AI-powered reduced order modeling accelerates parameter tuning and aligns simulation results with experimental data

Challenge

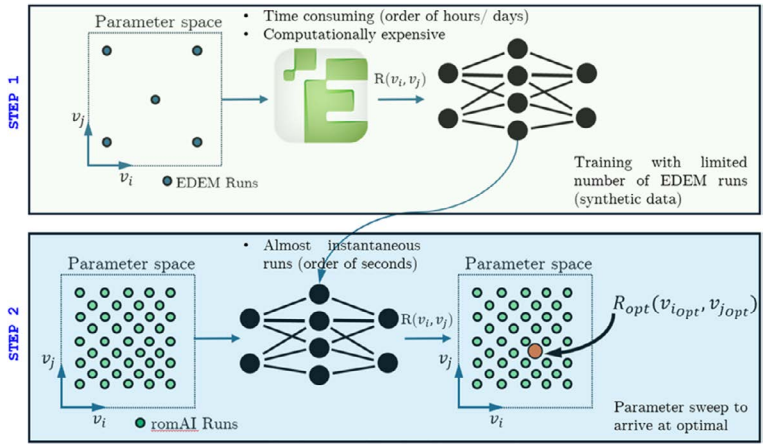
- Material model calibration involves first running a physical calibration test (experiment), then recreating those results in a DEM simulation
- This recreation requires iterative tuning of material interaction parameters, which is computationally expensive and time-consuming
- The goal is to identify parameters that closely reproduce the experimental response, but the process lacks efficiency and scalability

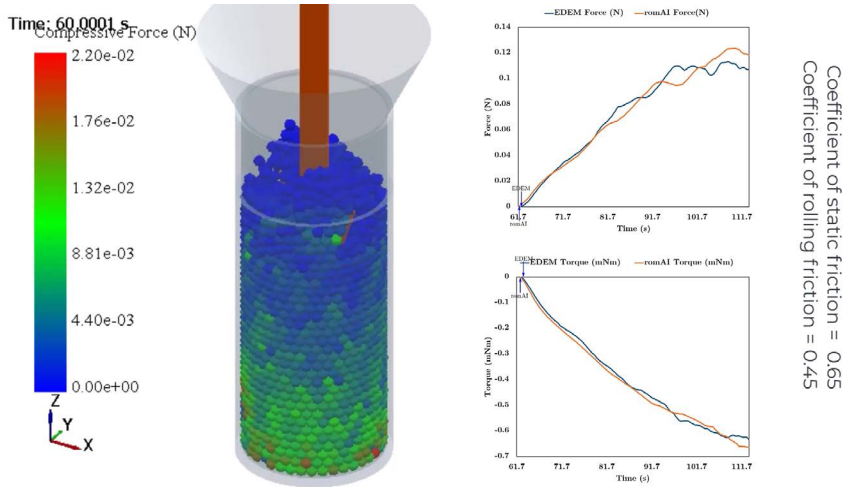
Solution

- Used Altair® EDEM™ to generate synthetic training data by running a limited set of DEM simulations
- Trained a reduced order model (ROM) in Altair® romAI™ to replicate DEM responses across varying material interaction parameters
- Leveraged the ROM model to rapidly sweep parameter combinations and identify those that best replicate experimental behavior

Value

- Achieved high-accuracy calibration of material properties with significantly reduced compute time
- Streamlined and accelerated high-fidelity physics-based simulations through an AI-enhanced workflow





Coefficient of static friction = 0.65
Coefficient of rolling friction = 0.45

ALTAIR

NEW

Rheology Optimization of Dense Particle Suspensions for Manufacturing Efficiency

Replace trial-and-error with data-driven virtual optimization combining DEM simulations and ML-driven parameter tuning

Challenge

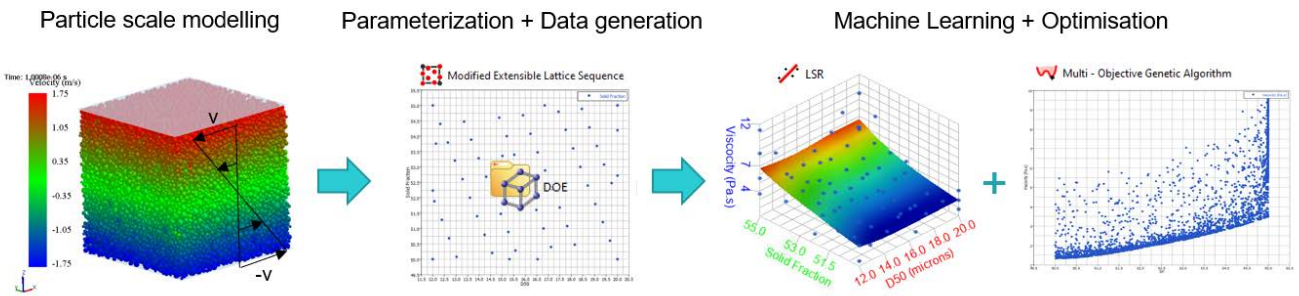
- Optimizing dense suspension rheology at the particle scale is critical for process reliability in pharma and battery industries
- Trial-and-error methods are slow, costly, and not scalable for modern R&D

Solution

- Simulate particle-scale behavior using Altair® EDEM™ to model dense suspension characteristics
- Defined inputs and generated synthetic data via Modified Extensible Lattice Sequence DOE in Altair® HyperStudy®
- Trained surrogate models (e.g., Linear Stepwise Regression) to approximate rheological from synthetic data
- Ran multi-objective optimization in HyperStudy to find parameters that maximize performance and reliability

Value

- Achieve faster convergence to optimal rheological parameters through data-driven virtual optimization
- Reduce reliance on costly and time-intensive physical trial-and-error testing
- Lower R&D costs while improving process reliability and consistency across formulations
- Accelerate time-to-market by enabling early, accurate prediction of material behavior using surrogate models



NEW

Predicting Processing Conditions for Alloys

Predicting carbon percentage and tempering temperature using ML-driven regression models

Challenge

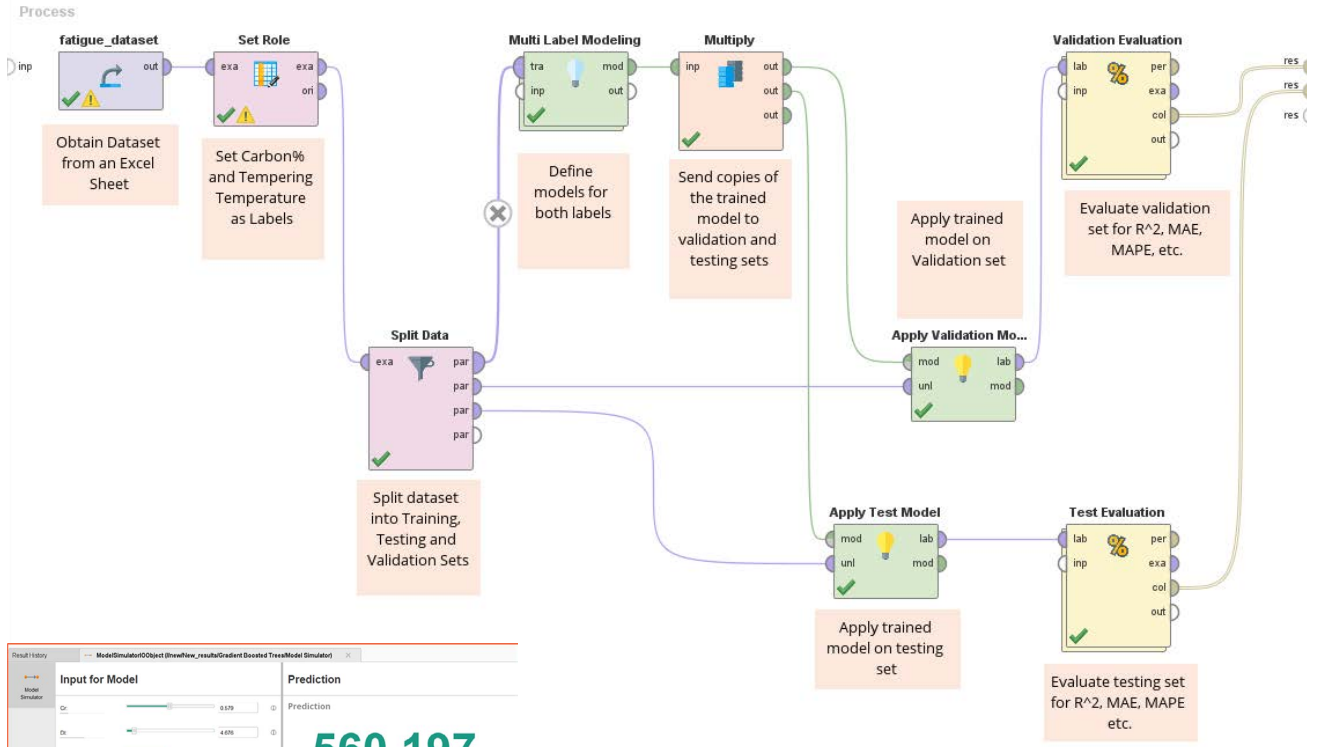
- Determining optimal chemical composition and heat treatment conditions to meet target mechanical and fatigue properties
- Traditional alloy development requires extensive physical testing and iteration

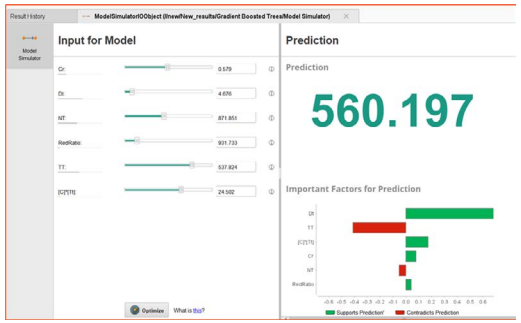
Solution

- Processed historical material testing data using Altair® RapidMiner® and trained machine learning regression models
- Applied 70%-30% train-validation data split to evaluate and select the best-performing models
- Modeled relationships between inputs (e.g. carbon %, tempering temp) and performance metrics to enable predictive insights

Value

- Save testing costs and engineering resources by reducing reliance on repeated physical trials; minimize material waste through data-driven predictions
- Shorten development cycles using predictive models to reduce lead time in new material and product design
- Empower materials engineers, metallurgists, and OEMs to determine the right alloy composition and heat treatment temperature before manufacturing, improving process efficiency and product quality





NEW

Energy Optimization for Automotive Paint Shops

Reducing carbon footprint and cost by decreasing gas consumption using AI-driven oven modeling and scenario planning

Challenge

- Improve operational efficiency while reducing energy use in the paint shop (~40% of plant energy)
- Leverage diverse sensor data and process variables across multiple oven zones
- Navigate limited flexibility for optimization due to strict production constraints

Solution

- Built a paint shop oven digital twin using production sensor data with predictive modeling
- Simulated multi-zone oven performance to find energy and process improvements opportunities
- Integrated AI-powered scenario planning to explore “what-if” conditions and compare oven configurations

Value

- Reduced gas consumption by 8–10% through data-driven oven parameter adjustments
- Provided insights to optimize ovens on/off timing, overnight idle states, and temperature setpoints across zones
- Enabled energy-efficient decisions without disrupting production

NEW

Accelerated Cost Estimation from Visual Input

Using AI to generate early cost predictions from component images and historical data

Challenge

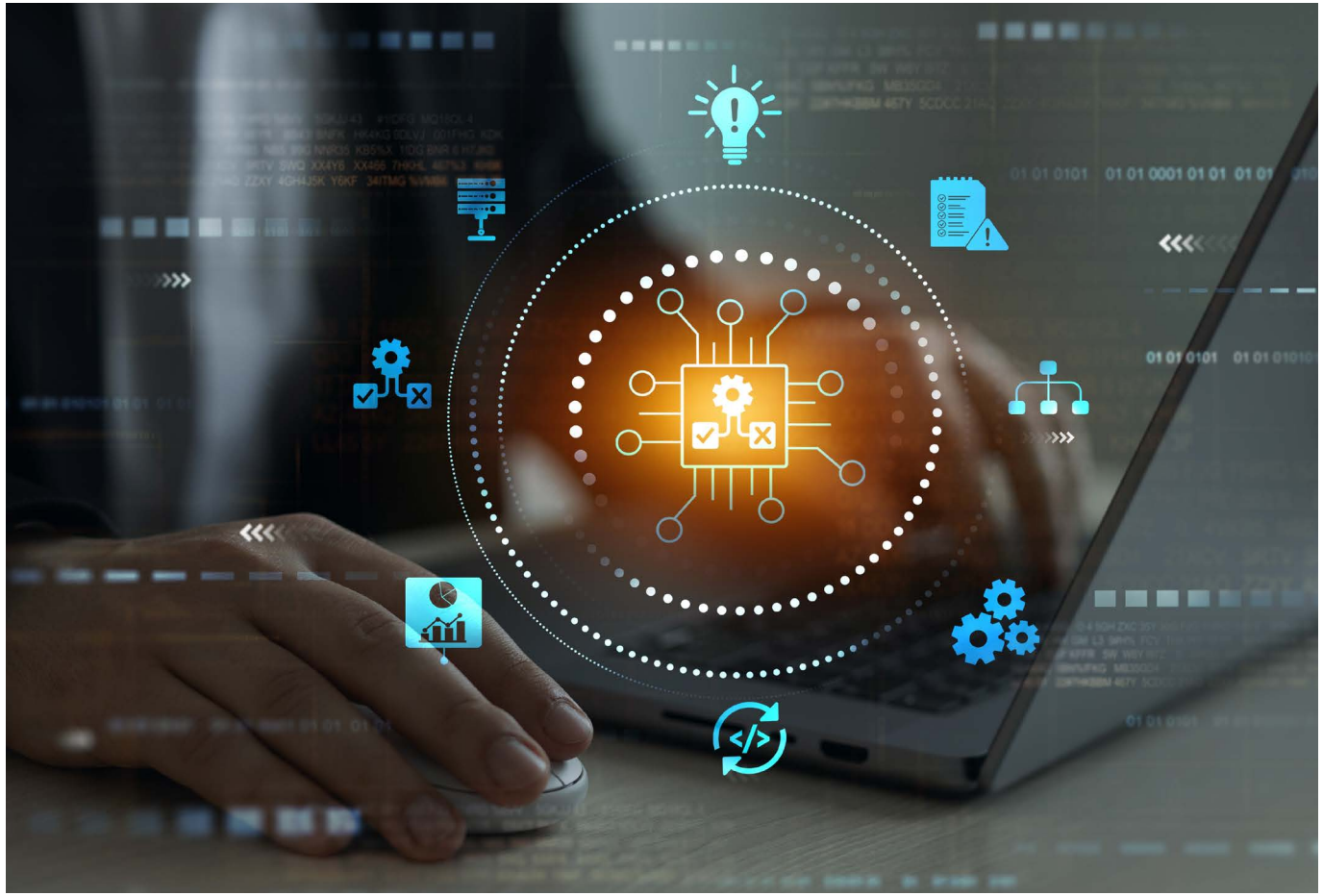
- Estimating component cost from early data (e.g., images) is slow, manual, and inconsistent
- Relies on expert judgment, limiting scalability or automation
- Need a solution to speed up early estimates without r eplacing experts

Solution

- Paired historical cost data with labeled component images for consistent inputs
- Trained ML model to classify parts and predict cost-drivers from image-derived characteristic
- Enabled preliminary cost estimates by linking new images to historical cost classes and adjusting for market factors

Value

- Accelerates design-to-quote workflows with earlier, more reliable cost visibility
- Enables better budgeting and sourcing decisions across part families
- Frees engineering and procurement teams to focus on strategic initiatives
- Supports pricing and product planning through consistent, data-driven cost insights



Health and Life Science Use Cases

NEW

Leading Global Pharmaceutical Company Scales Blending Without Trial-and-Error

A digital twin and ROM-based approach enabled virtual validation, eliminated costly physical trials, and delivered multi-million dollar savings

Challenge

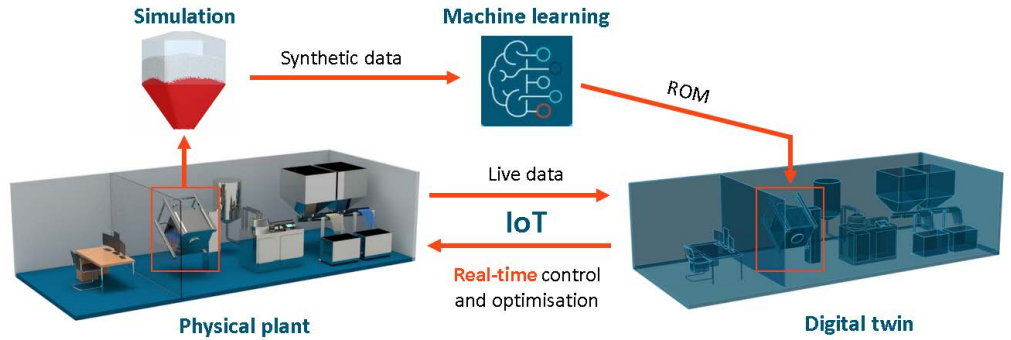
- 75% of pharma products are Oral Solid Dosage (OSD), tightly regulated and hard to scale
- No universal rules exist for scaling unit operations across varying processes and equipment
- Significant variation in equipment, process design, and production scale limits repeatability
- Trial-and-error approaches carry high cost, risk of failure, and inconsistent outcomes

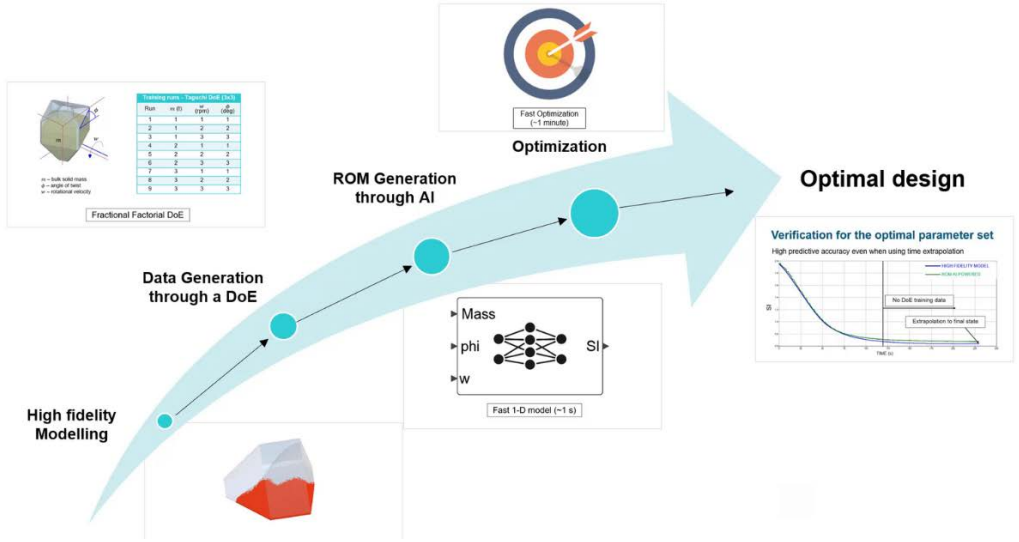
Solution

- Applied a digital twin and ROM-based simulation to the blending unit that previously failed at high fill occupancy
- Ran virtual experiments across fill levels to validate performance and identify optimal conditions
- Replaced physical trials with predictive modeling to assess blend uniformity at production scale

Value

- Saved millions by avoiding costly physical trial-and-error methods
- Recovered a product line worth tens of millions annually
- Enabled scalable adoption across product lines with multi-billion dollar potential





NEW

End-to-End Digital Twin for Oral Solid Dose Manufacturing

Combining simulation, AI/ML, HPC, and IoT to deliver an end-to-end digital twin solution for pharmaceutical production

Challenge

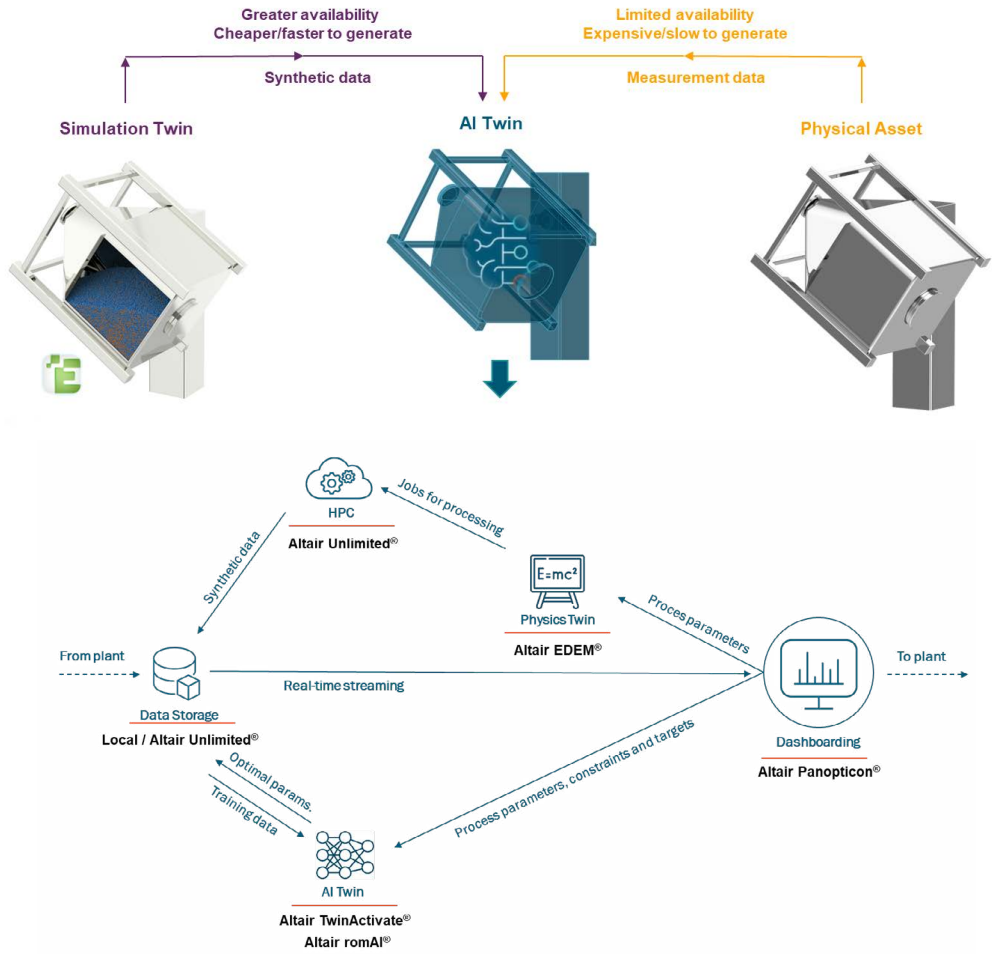
- Digital twins are essential for optimizing pharmaceutical manufacturing, particularly for Oral Solid Dose (OSD) processes
-
- Developing and deploying digital twins requires integrating physics-based simulation, machine learning, HPC, read-time dashboards, and IoT

Solution

- Simulated particle behavior using Altair® EDEM™ to generate high-fidelity physics-based data, forming the foundation of the digital twin for the manufacturing process
- Trained and deployed an AI twin with Altair® romAI™ and Altair® Twin Activate®, learning from both simulated and real-world data to enable predictive insights and parameter optimization
- Integrated the twin into production using Altair® Unlimited™ for scalable compute, Altair® Panopticon™ for real-time visualization, and local storage in Altair One® for seamless data streaming and feedback

Value

- Significantly faster deployment and wider adoption of digital twins in pharma environments
- Reduced equipment downtime and maintenance costs through predictive insights
- Accelerated product optimization and time-to-market



NEW

Optimizing Coating Parameters in Tablet Manufacturing

Improve coating uniformity and reduce waste with DEM simulation, reduced-order modeling, and AI optimization

Challenge

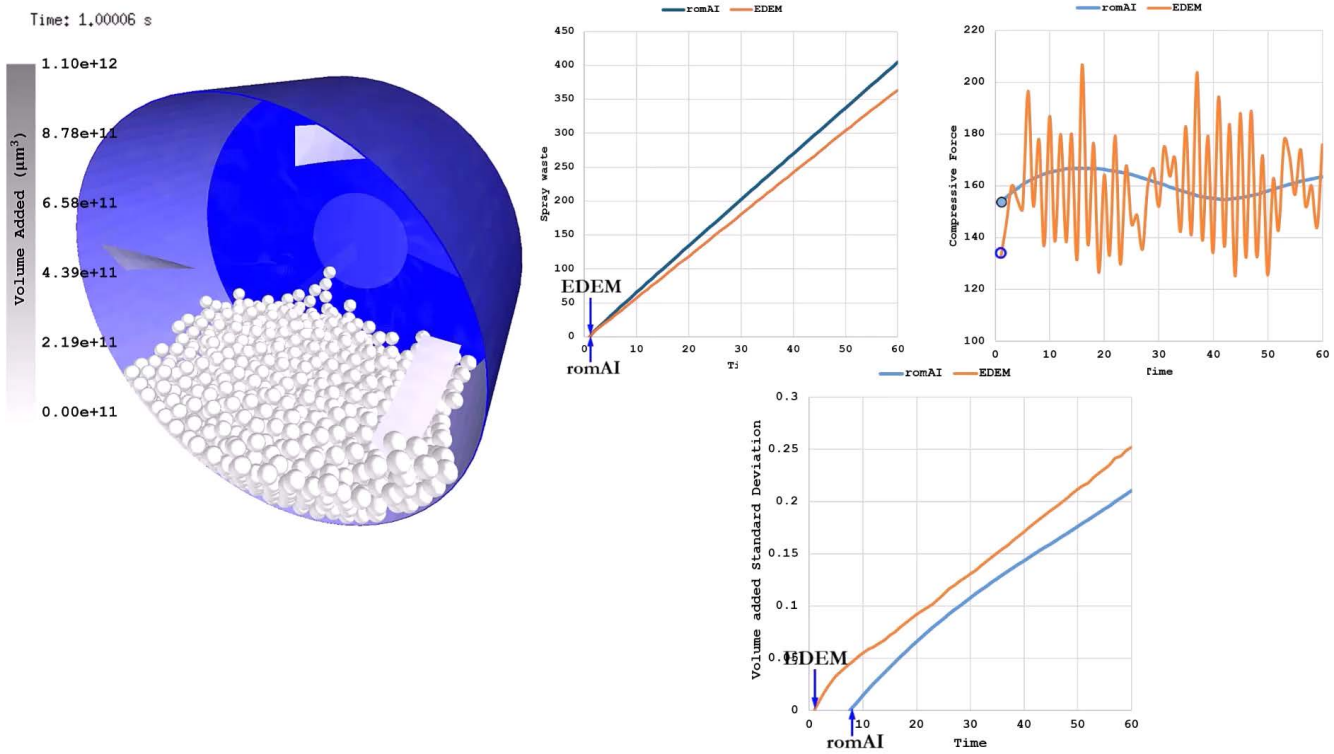
- Tablet coating is a critical step in oral solid dosage manufacturing, requiring high precision to ensure product quality
- Non-uniform coating can lead to batch rejection due to visual or performance inconsistencies
- Tablets are exposed to compressive forces during coating, which may cause breakage or cosmetic defects
- Suboptimal spray parameters can result in excessive material usage and production inefficiencies

Solution

- Conducted Discrete Element Method (DEM) simulation of the tablet coater to study tablet behavior under operational conditions
- Built a reduced order model (ROM) of the DEM simulation to enable faster iterations and analysis
- Used the ROM as a digital twin to run AI-powered optimization for spray parameters to improve coating uniformity, minimize waste, and reduce mechanical stress on tablets

Value

- Run hundreds of virtual simulations in minutes instead of spending weeks on traditional computational analysis
- Reduce waste and improve yield by minimizing broken tablets and ensuring consistent coating across batches



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