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100 AI-Powered Engineering Use Cases

Everything Solvable

Contents

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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.

Altair is driving the convergence of design and simulation with Altair® HyperWorks®, data analytics and AI with Altair® RapidMiner®, and high-performance computing (HPC) with Altair® HPCWorks™ under the umbrella of "AI for All." This vision aims to make powerful simulation technology accessible to all engineers. Here's how:

- Simulation Analysts and Engineers: Utilize Altair's solutions to predict simulation results and solve complex design challenges by using historical data and AI-powered analysis.
- Non-Simulation Engineers (Mechanical, Electronic, etc.): Leverage Altair's AI to seamlessly integrate with existing workflows, enhancing product design, automating solution development, and accelerating design iterations.
- AI for All Users: Gain access to valuable insights from Altair's AI solutions, which offer AI-driven design guidance that are agnostic to specific physics or industries, enabling real-time predictions for diverse applications.

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.

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Objective

The primary goal of this ebook is to illuminate the practical applications of AI in engineering.

This ebook showcases 50 AI use cases in AI-powered engineering—25 previously released and 25 newly added—with 50 more planned for future release, offering an expanding resource for AI and engineering.

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

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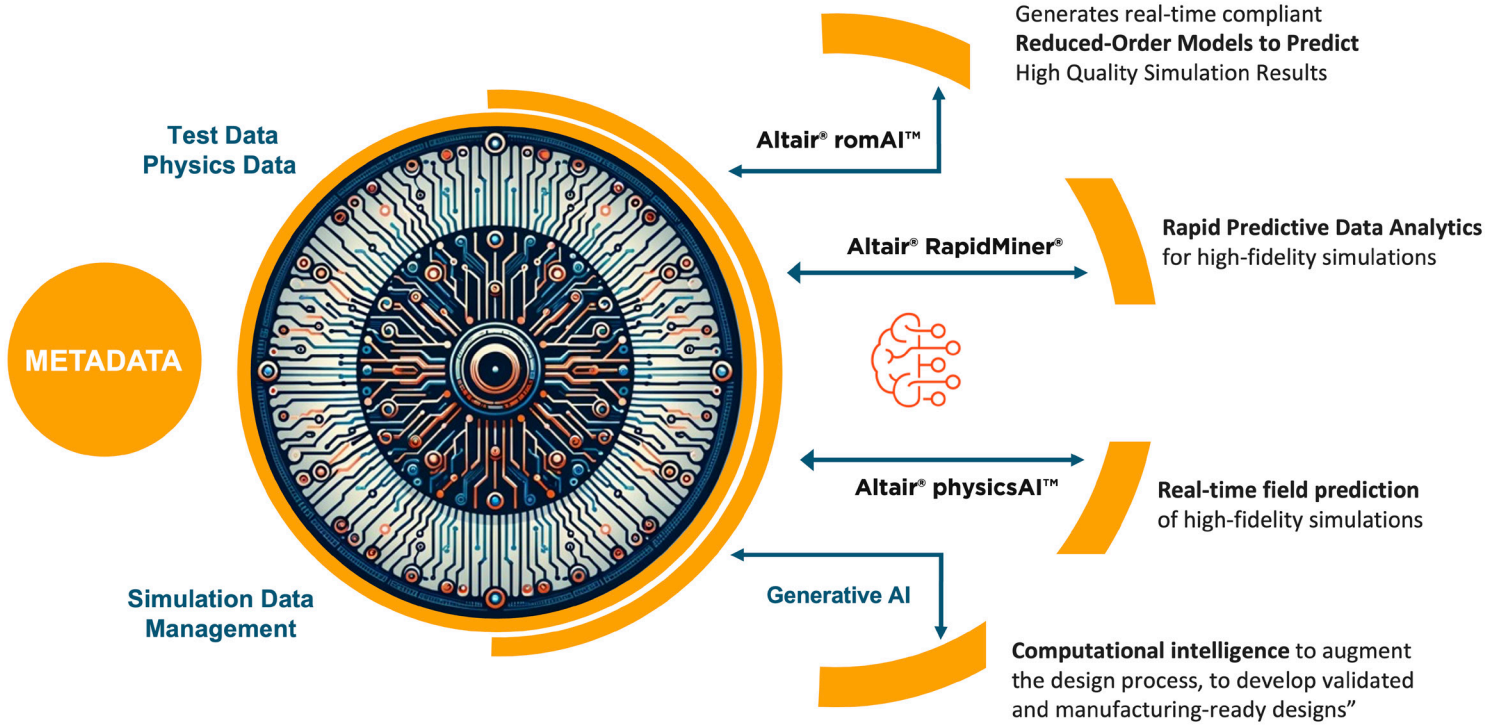
How to Use This Book

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.



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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 classification and 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
- Excessive time spent manually classifying data, slowing down overall efficiency

Solution

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

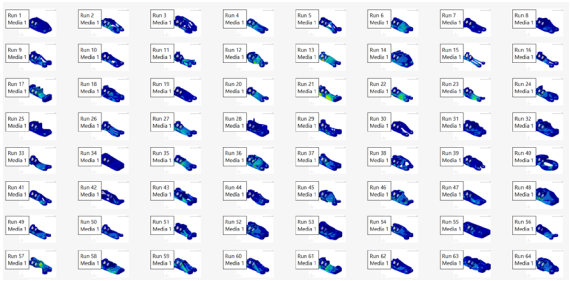
Value

- 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

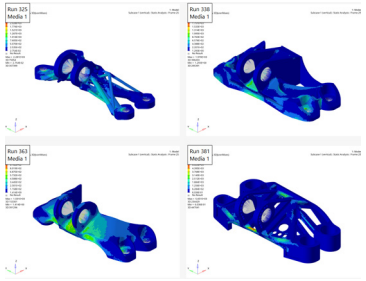
Dataset generated by: MIT DSL, http://digitalstructures.mit.edu/

Historical data

Training Data

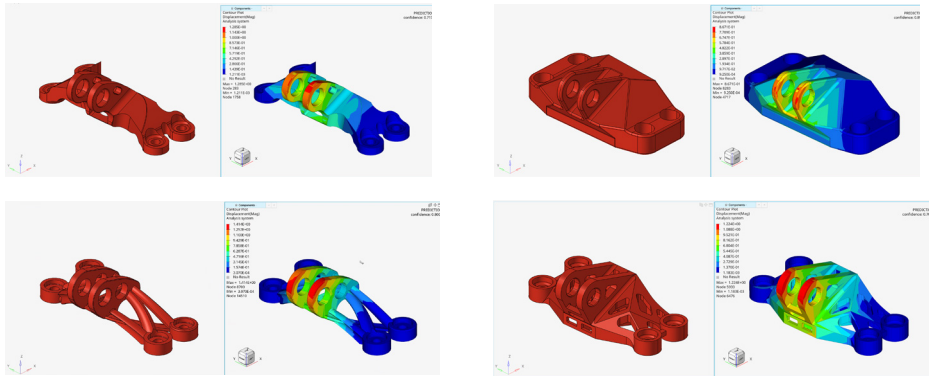


Test Data



Real-time exploration

CAD Data



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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

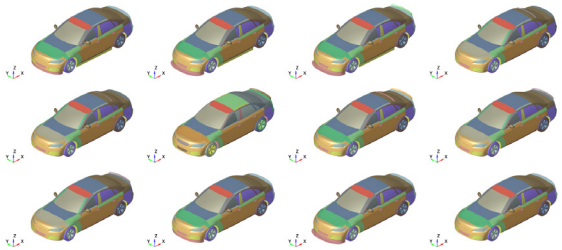
- Trained Altair® physicsAI™ on historical simulation data to develop predictive modeling for accurate insights on new, unseen CAD/CAE models

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



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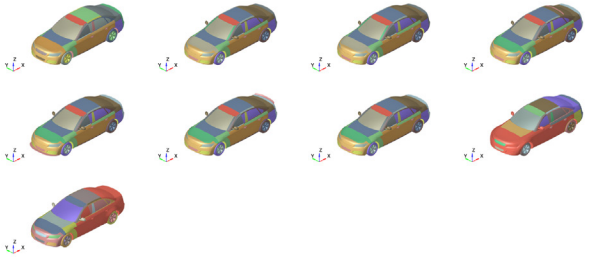
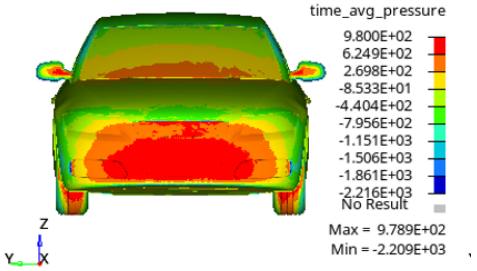
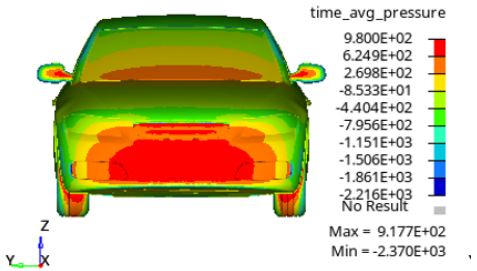


Real-time exploration

ML Runtime 3 min



CFD Runtime 750 min



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Hood Impact Analysis

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

Challenge

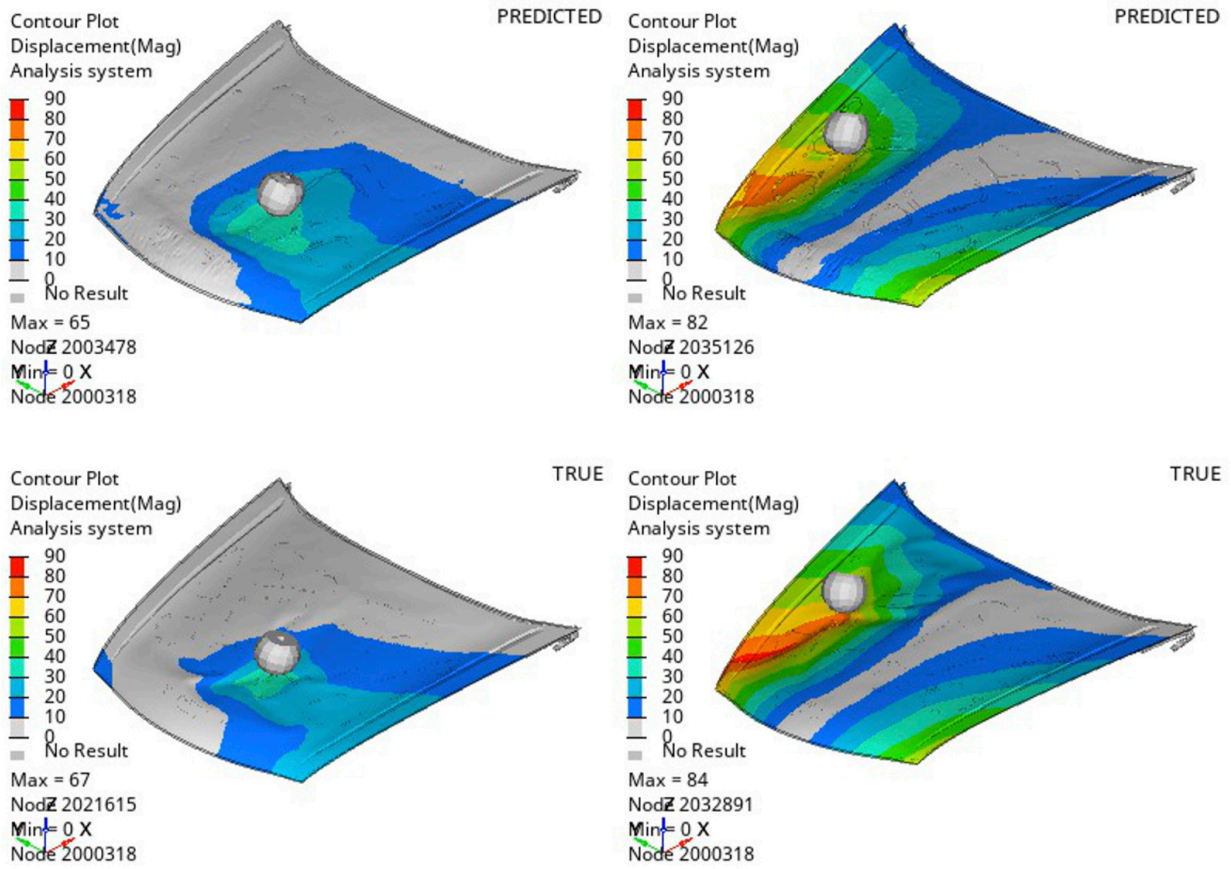
- There were multiple variable impact points that needed to be analyzed
- Large deformation simulations were required for transient behaviors, adding complexity

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



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Detect NVH Performance Issues Early

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

Challenge

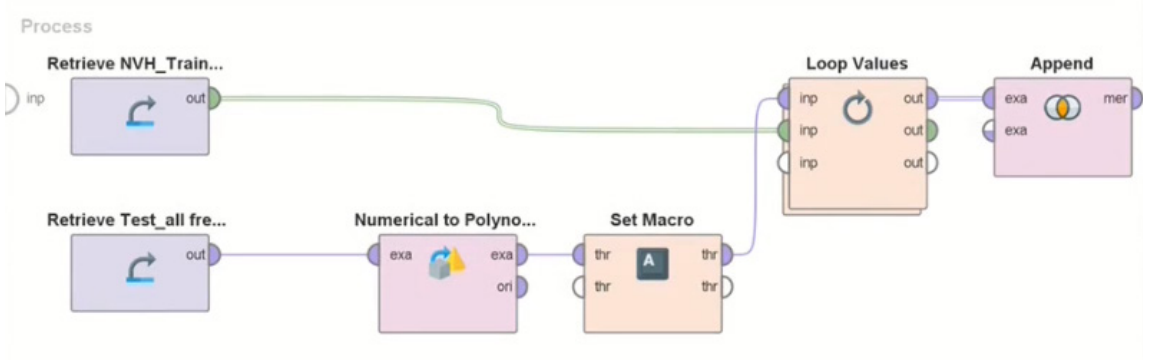
- Difficulty in detecting NVH issues early, which risks brand reputation, especially with the shift toward fleet electrification
- Need for faster NVH performance analysis to assess design variables and ensure structural reliability

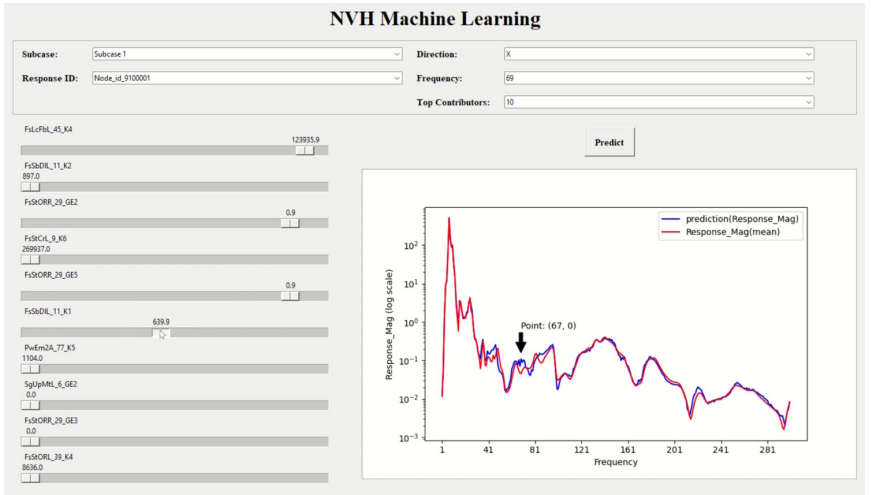
Solution

- 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





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Headlamp Leveling Test for AIS 008

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

Challenge

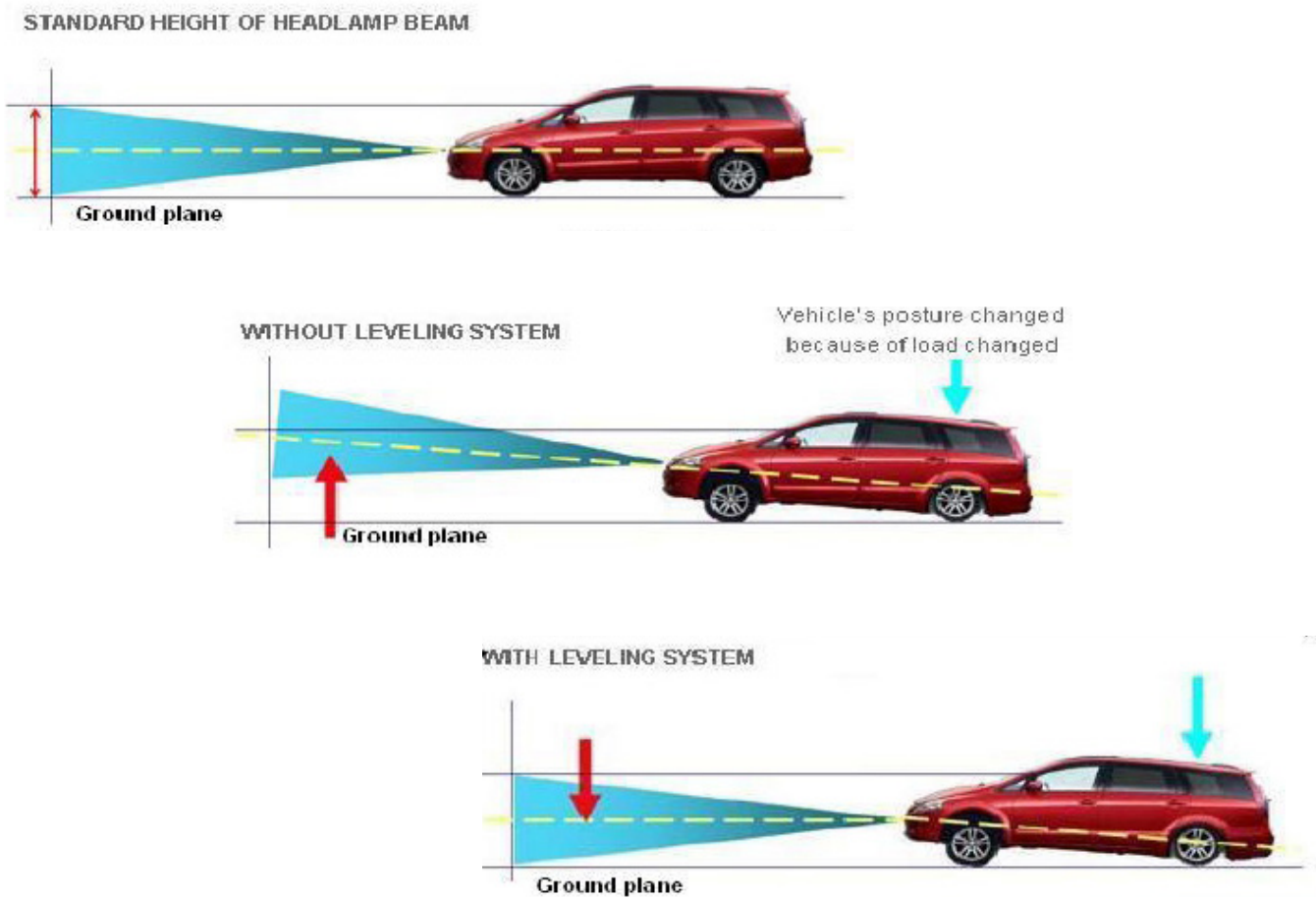
- Headlamp checks (AIS 008) at the testing stage involve time-consuming physical vehicle loading with dead weights

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



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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

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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

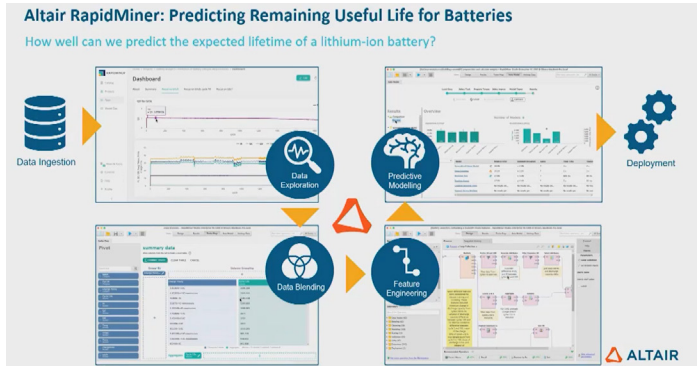
- Predict battery remaining useful life (RUL) and state of health (SoH) using field data
- Account for environmental and operational conditions that affect battery performance
- Accurately measure battery capacity in real-time, which is crucial for RUL assessment

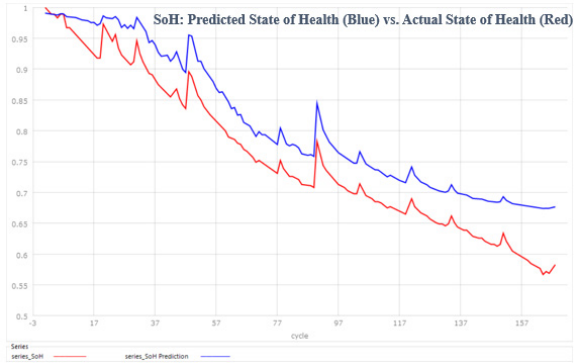
Solution

- 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





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Improve Passenger Thermal Comfort Simulations

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

Challenge

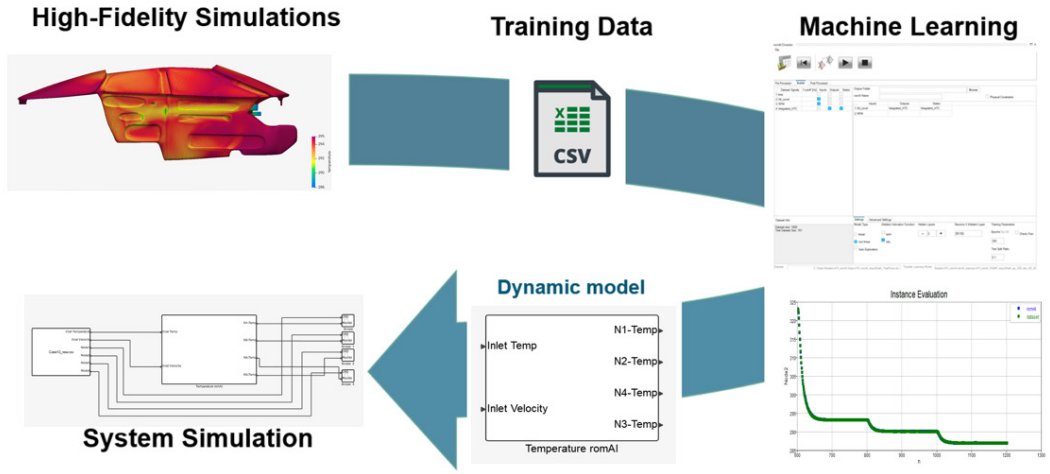
- Difficulty in achieving real-time coupling between CFD and system-level simulations
- System simulation models lack accuracy when relying on equations alone
- Long computational times are required for CFD simulations, slowing down romAI data collection

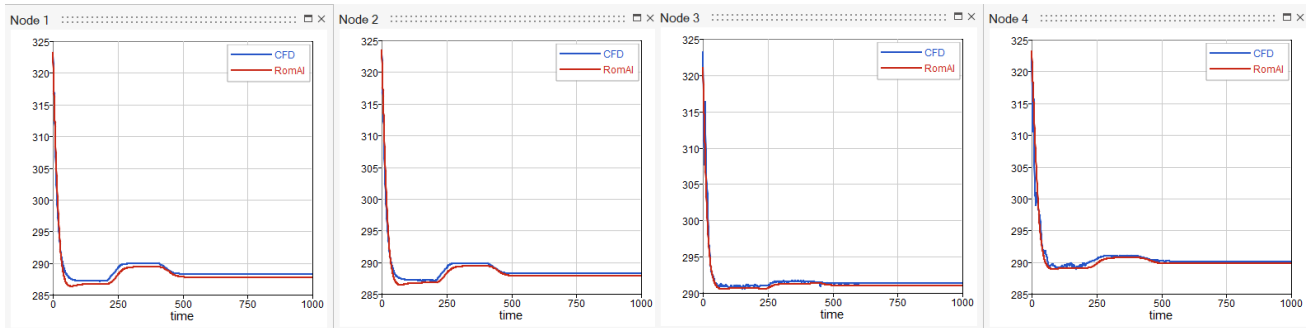
Solution

- 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





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Rattle Reduction in Automotive Design

AI-powered ROMs, derived from CFD simulations, address thermal dynamics and system-level simulation challenges, enhancing SnRD accuracy to minimize automotive rattle

Challenge

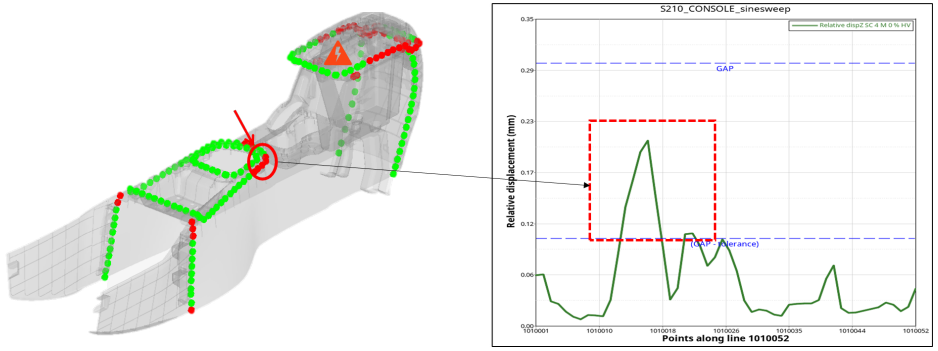
- Difficulty achieving real-time coupling between CFD and system-level simulations due to complex thermal dynamics
- Lack of accuracy in system simulation models when relying solely on equations
- Extended computational times required for CFD simulations to gather data for romAI models

Solution

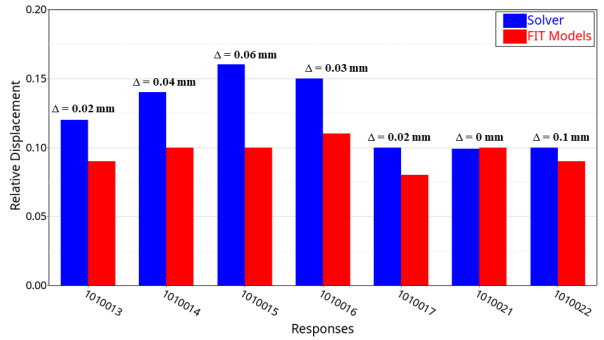
- Conducted comprehensive CFD simulations to gather detailed data for model development
- Developed advanced Altair® romAI™ models using dynamic and static ROMs to improve simulation fidelity
- Integrated romAI models into Altair® Twin Activate™ for seamless system-level simulations

Value

- Real-time insights enable faster decision-making and project advancement
- Increased accuracy in simulations improves confidence in design choices, reducing risk
- Reduced simulation times accelerate time to market, optimizing resource utilization



		Train Data Set 450 Runs	Cross Validation	Test Data Set 50 Runs
Label	Fit Type	R^2	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



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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

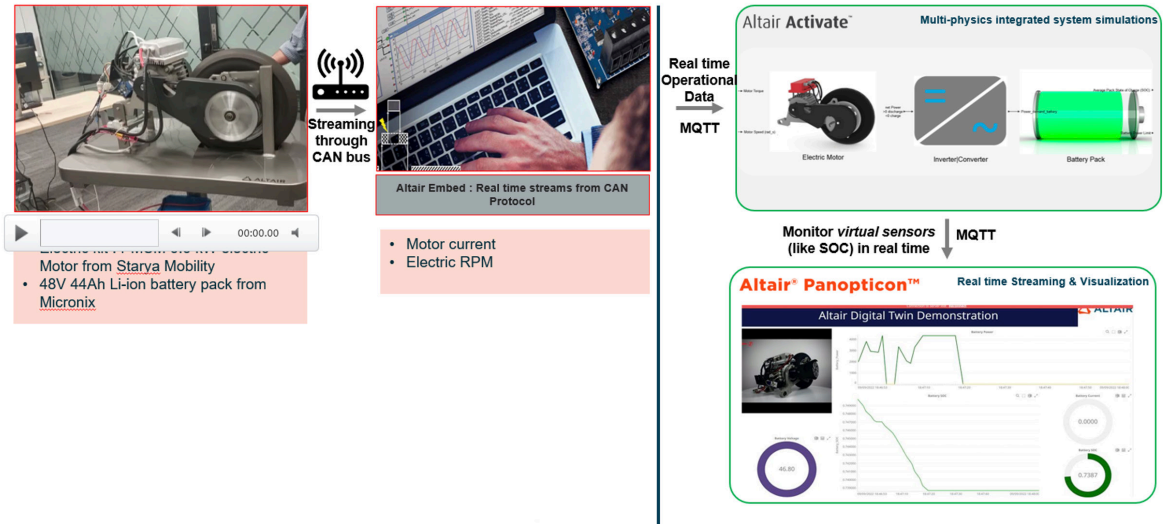
- Develop a digital twin capable of monitoring supplier-procured batteries in real time without the use of physical sensors

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

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Thermodynamic Analysis of Linear Actuator Time Constants

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

Challenge

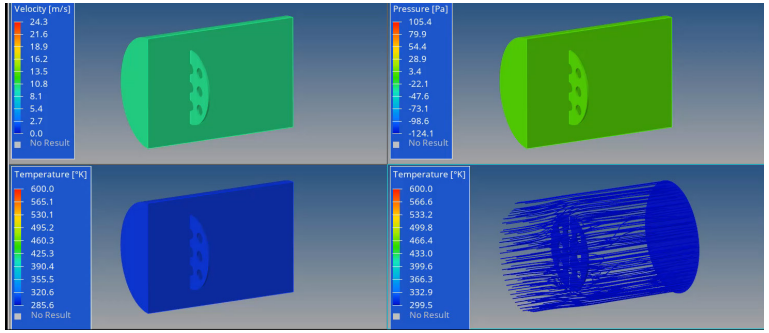
- Time-consuming analysis when studying the time constant of a linear actuator across different spring configurations
- Complexity in accurately modeling thermo-fluid dynamics for various spring configurations
- Difficulty integrating dynamic models into system-level simulations efficiently

Solution

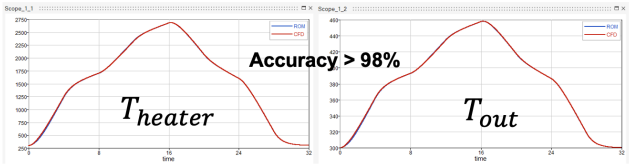
- Generated training and test data using Altair® AcuSolve®
- Built dynamic ROMs using Altair® romAI™ for improved simulation speed
- Integrated the ROMs with the controller in system-level simulations using Altair® Activate®

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

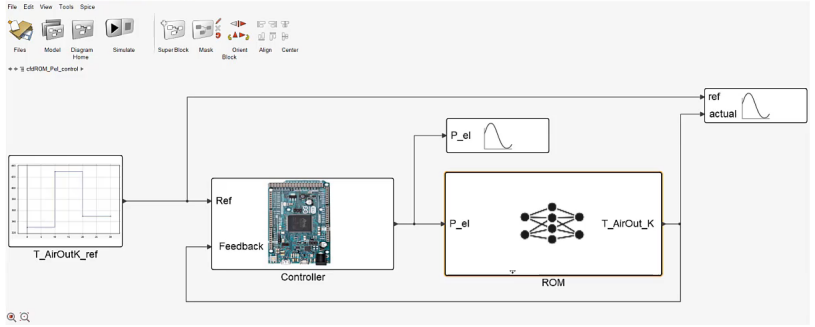


Test Results



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]



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NEW

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

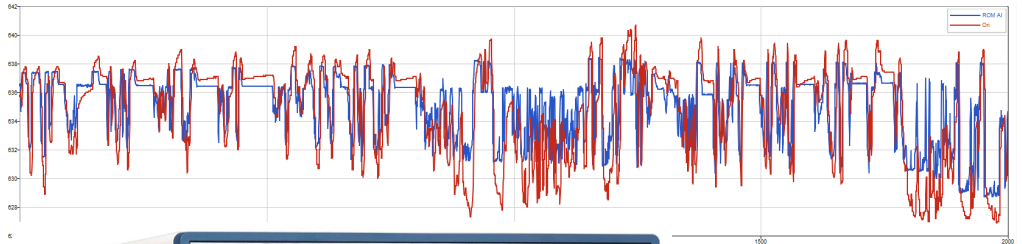
- Achieve real-time simulation with a 1ms time step
- Integrate vehicle, powertrain, and motor models
- Verify accuracy against real-world field test data

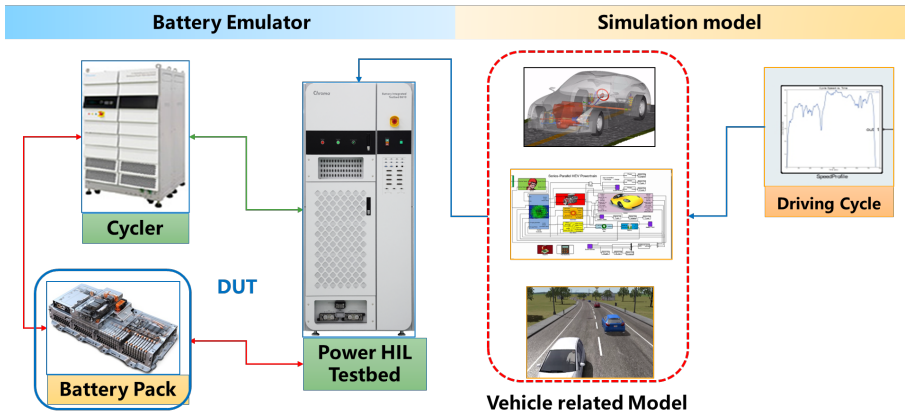
Solution

- 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





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NEW

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

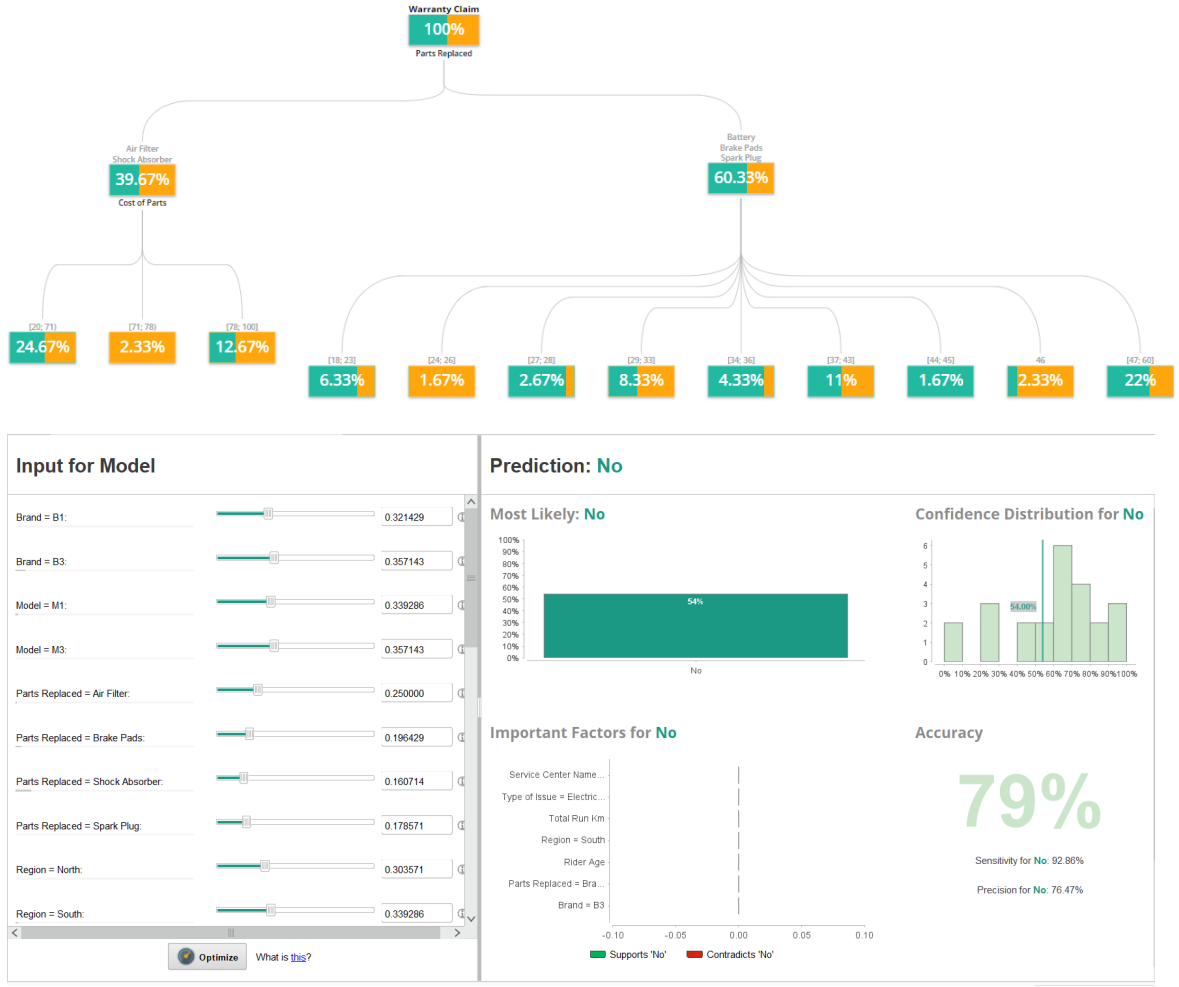
- Manual analysis of large, multi-year datasets is constrained by data complexity and volume, slowing processing and delaying critical insights
- Increasing volumes of warranty data strain manual processes, driving up operational costs and limiting scalability
- Manual analysis introduces risks, from 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



ALTAIR

NEW

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

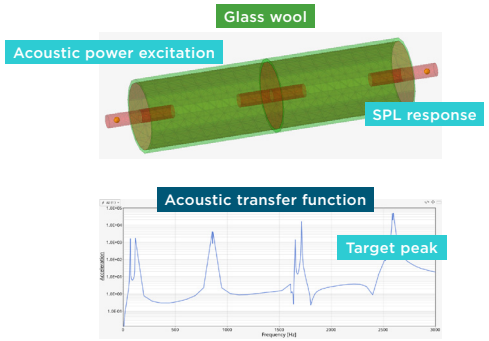
Solution

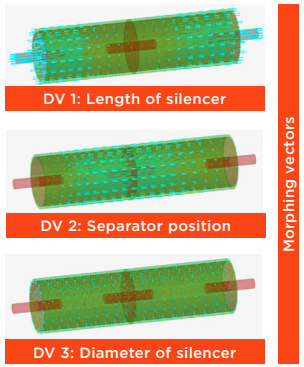
- Solved SPL calculations using Altair® OptiStruct®
- Applied morphing techniques to change the silencer shape
- Created a training dataset with Altair® HyperStudy®
- Developed an AI model with Altair® RapidMiner® and identified the optimal silencer size using the optimization feature

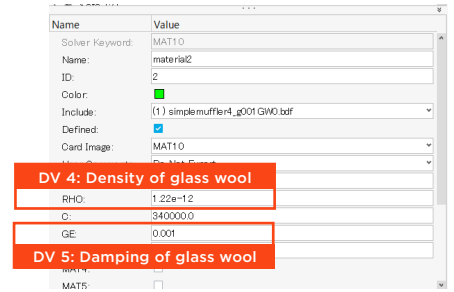
Value

- 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

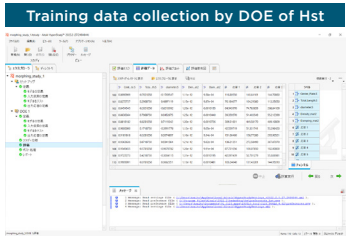
Analysis & Optimization Condition

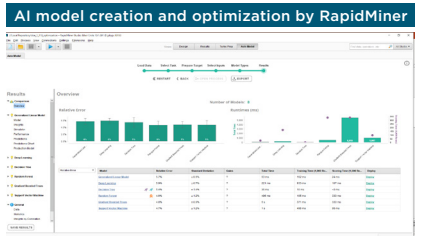


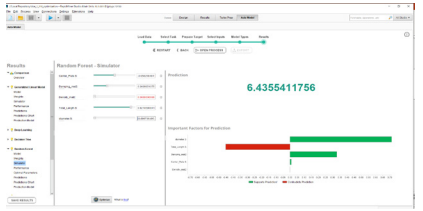




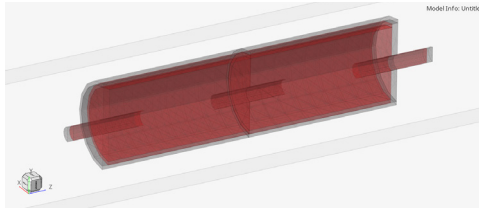
AI/ML Model Creation and Optimization by RapidMiner



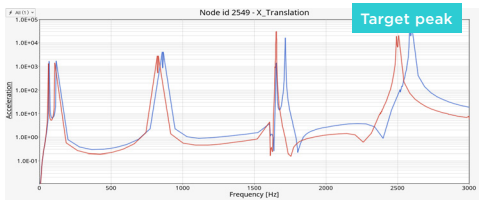




GRAY: Initial shape RED: Optimum shape



BLUE: Initial shape RED: Optimum shape



ALTAIR

NEW

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

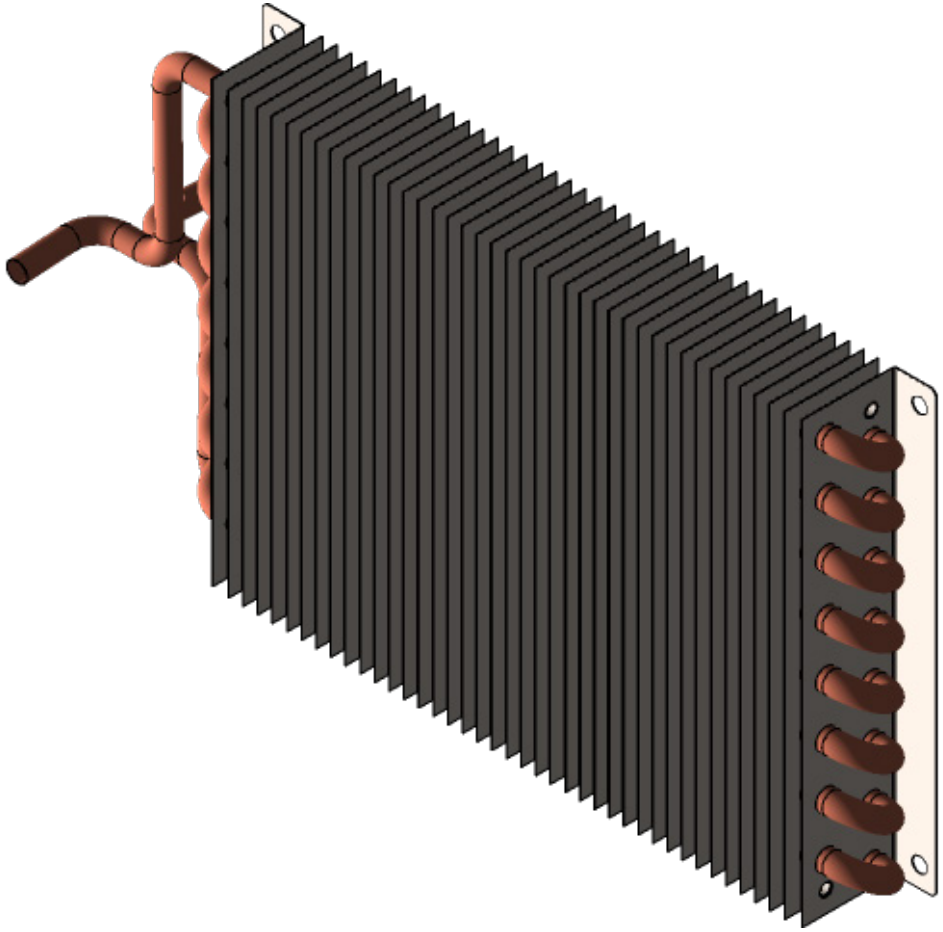
Solution

- 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

Reference: Kenta Kobayashi[1], "Speed-up 3D-CFD Simulation of Flow Distribution Inside HVAC by romAI", Altair Technology Conference Japan 2023, Day2 Hall B 16:30-16:55



ALTAIR

NEW

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

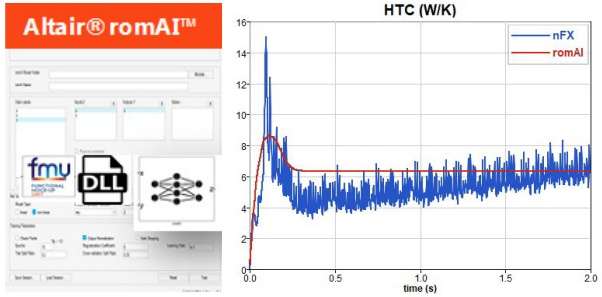
Value

- 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

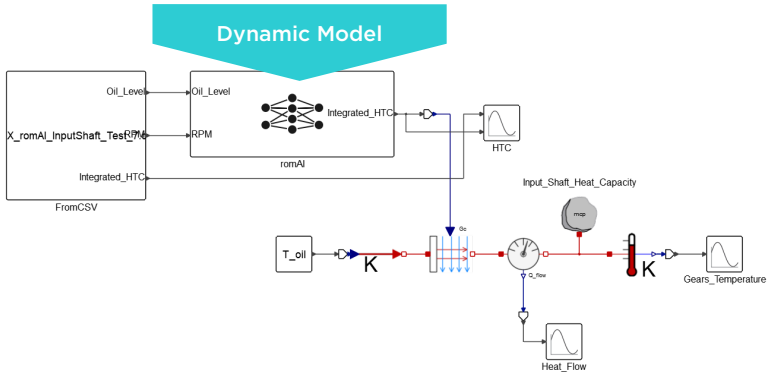
Training Data

romAI Machine Learning



Dynamic Model

1D System Simulation



ALTAIR

NEW

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

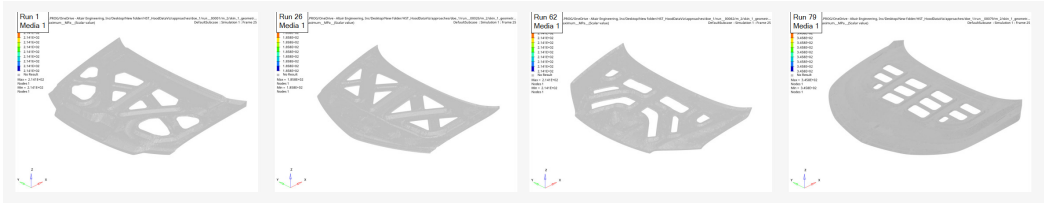
Solution

- 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

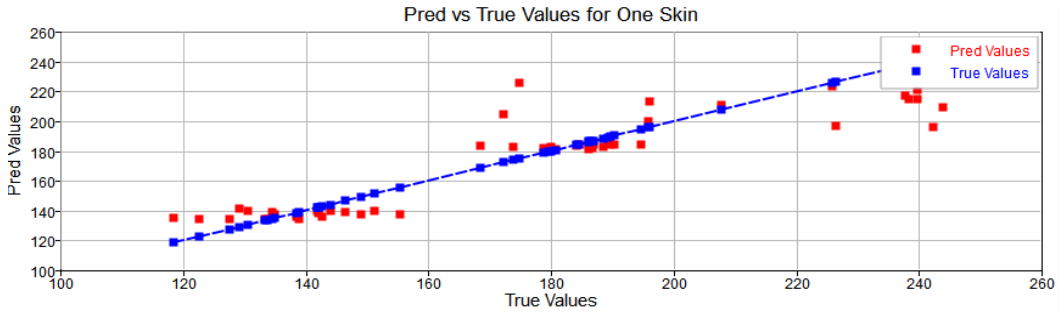
Value

- 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

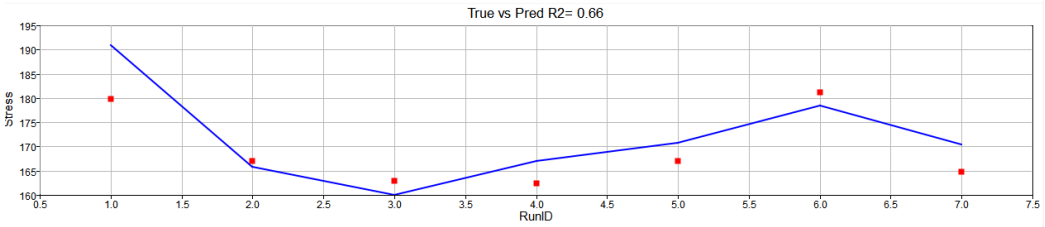
Sample Data



physicsAI vs Solver Results



Transfer Learning for New Program



ALTAIR

NEW

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

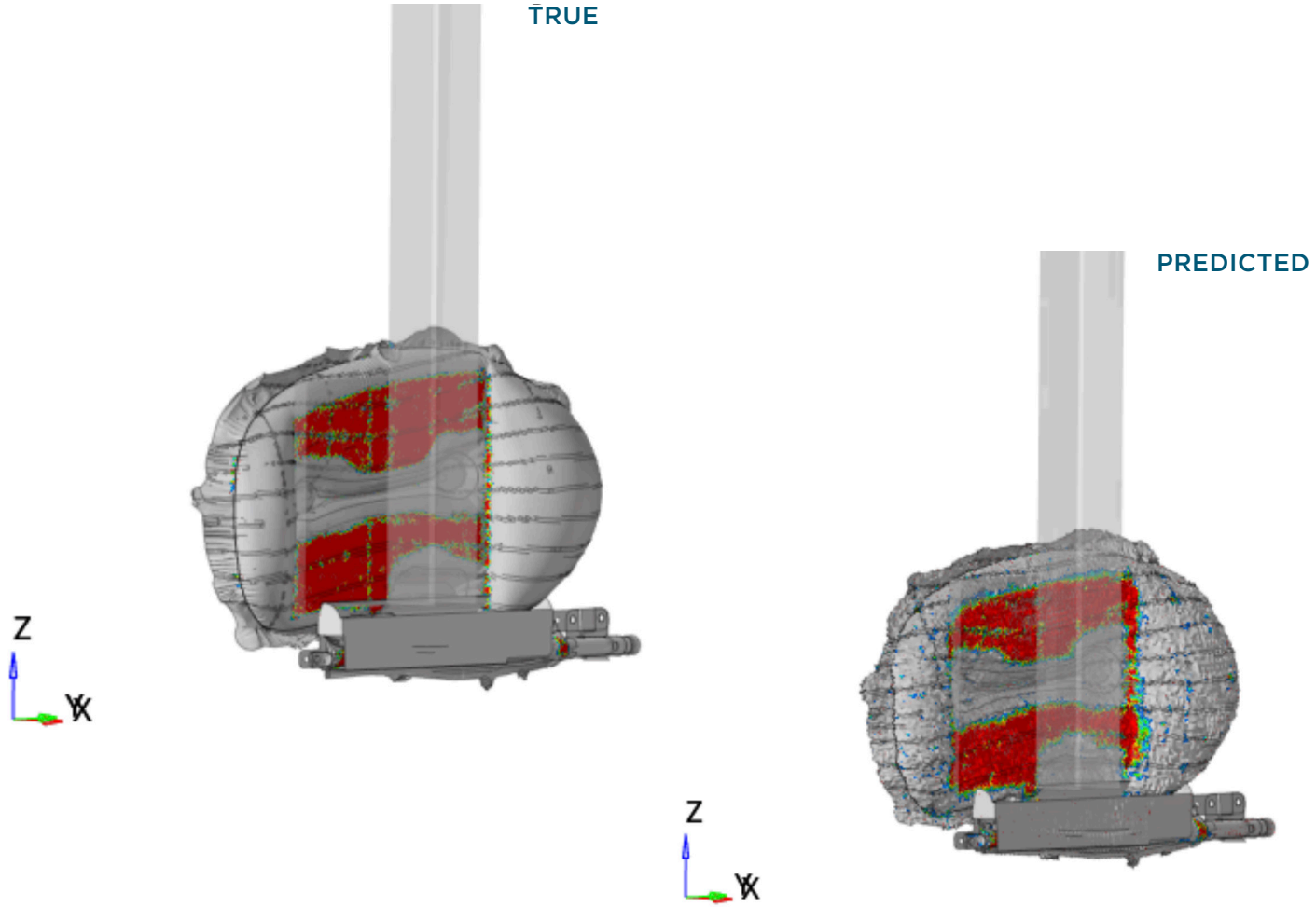
- Airbag validation is critical for ensuring proper airbag function during crash events
- Traditional methods for designing and validating HAB behavior are time-consuming and computationally expensive
- Analyzing vast data across scenarios delays design validation and product development

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



ALTAIR

NEW

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

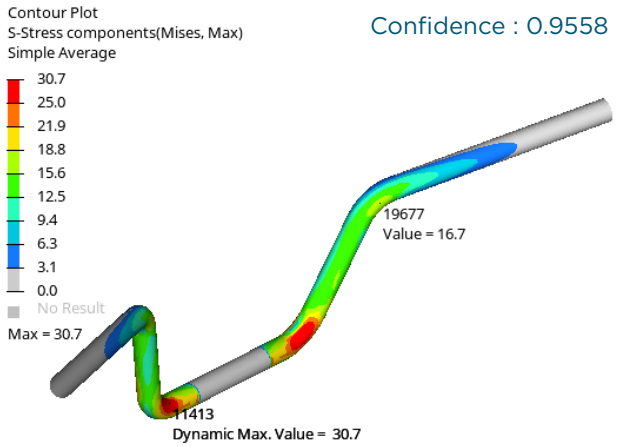
- The handlebar is critical to a motorcycle's ergonomics, affecting rider effort, cornering, and overall comfort
- Traditional methods for building and simulating handlebar designs are time-consuming, limiting opportunities for design exploration

Solution

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

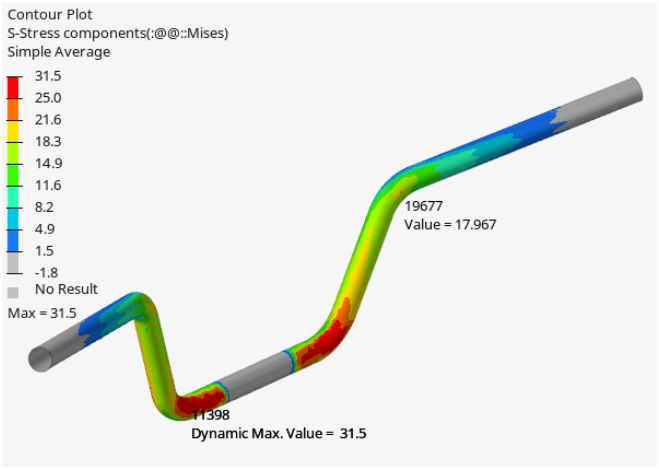
Value

- 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

ALTAIR

NEW

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

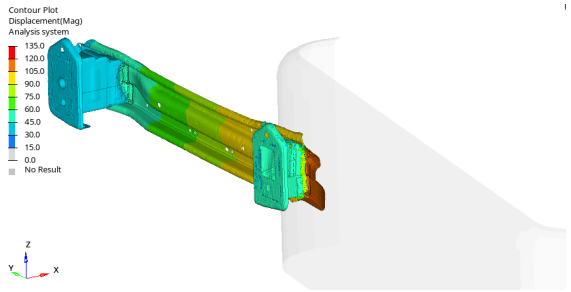
- Crash box simulations require up to 14 hours, making rapid design exploration and iteration impractical
- Extended simulation times limit opportunities for innovation and performance optimization

Solution

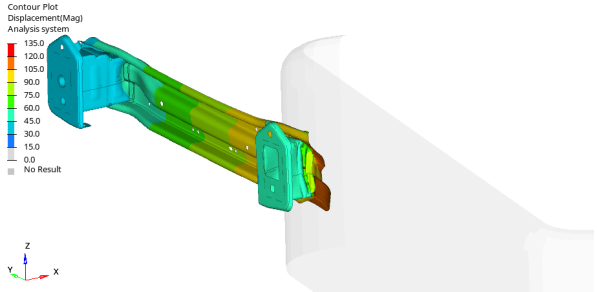
- Generated synthetic data using Altair® HyperStudy® to efficiently support design variations
- Trained an AI model using Altair® physicsAI™, leveraging simulation data to enable faster physics predictions and drastically reduce simulation time

Value

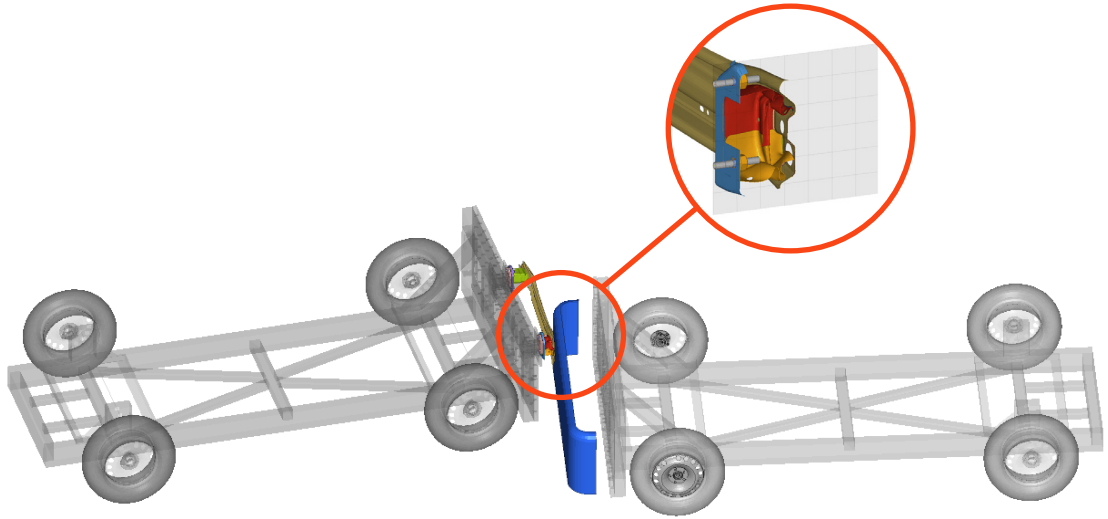
- Reduced simulation time from 14 hours to just 10 seconds, allowing faster evaluation of highly nonlinear transient behavior
- Simplified access, usage, and post-processing through the flexibility and interoperability of the Altair® HyperWorks® platform
- Enabled rapid design exploration, fostering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



physicsAI: 10 seconds



Solver: 14 hours



ALTAIR

Heavy Engineering Use Cases

NEW

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

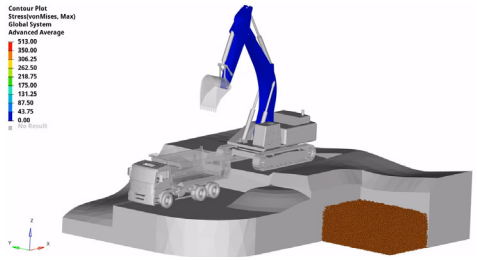
Solution

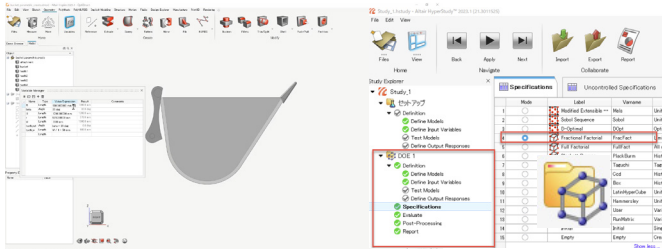
- Leveraged the co-simulation between Altair® MotionSolve® and Altair® EDEM™ to simulate the full multibody excavator, including flexible components, interacting with granular material/particles
- Created a parametric bucket shape using Altair® Inspire™ sketching and parametric features for flexible 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™

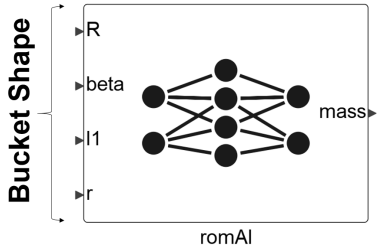
Value

- 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

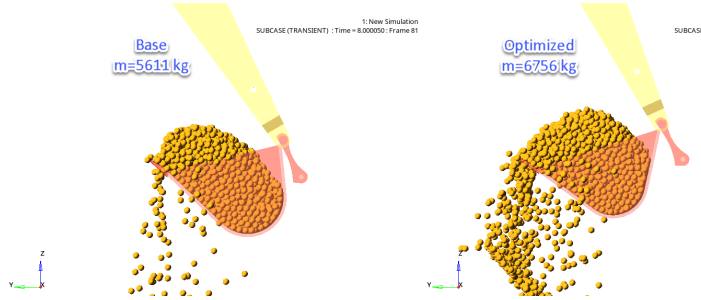
Full 3-D model (~1 hour)







Accurate ROM (~1 s)



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

ALTAIR

NEW

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

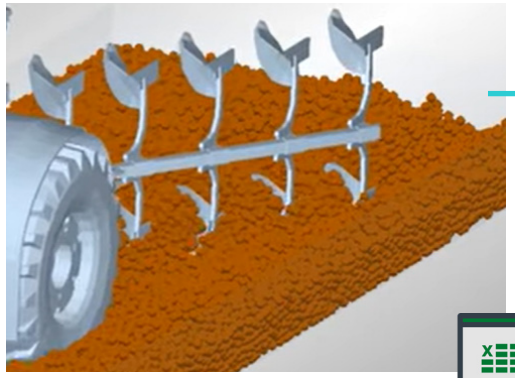
Solution

- 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

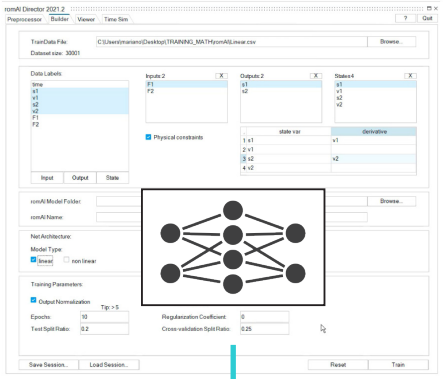
Value

- 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

ALTAIR

NEW

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

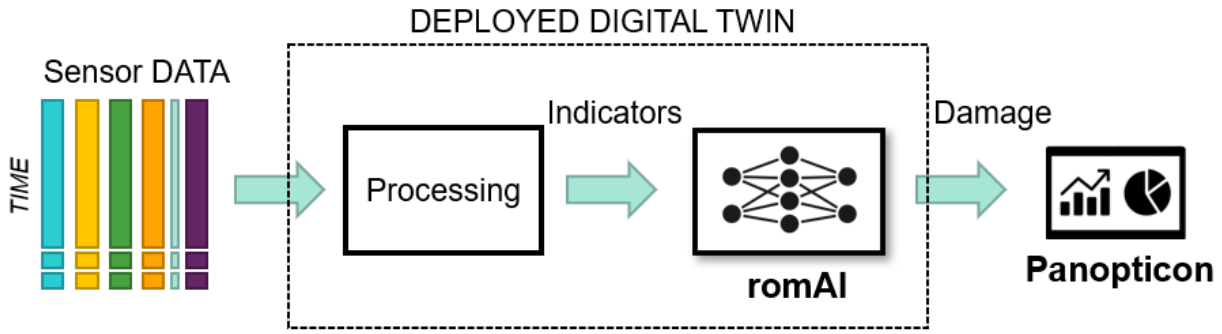
- Accurately estimating the state of health (SoH) of critical components in real-time using sensor data such as accelerations and pressures is essential to avoid failures and reduce downtime

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



ALTAIR

NEW

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

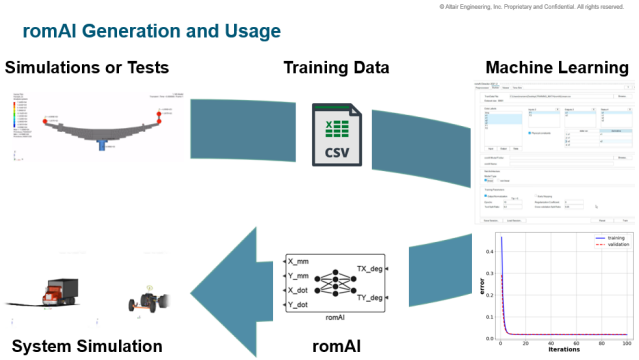
- Traditional system-level simulations for full vehicle dynamics are time-consuming, hindering the ability to quickly evaluate and optimize performance

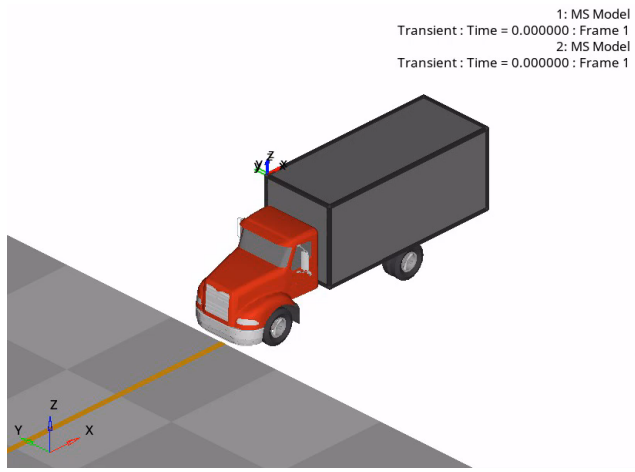
Solution

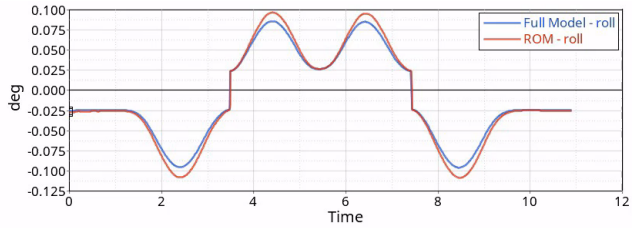
- Generated training and test data for the leaf spring suspension using the Leaf Spring Builder in Altair® MotionView®
- Created a ROM for the leaf spring suspension using Altair® romAI™
- Simulated the full vehicle dynamics, incorporating the ROM for faster analysis, using Altair® MotionSolve®

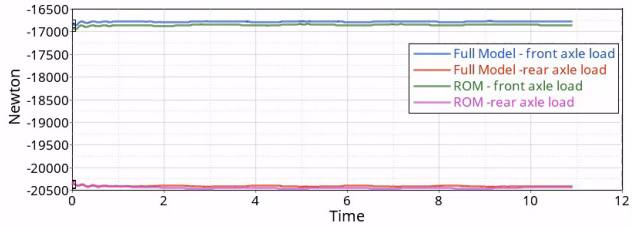
Value

- 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









ALTAIR

NEW

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

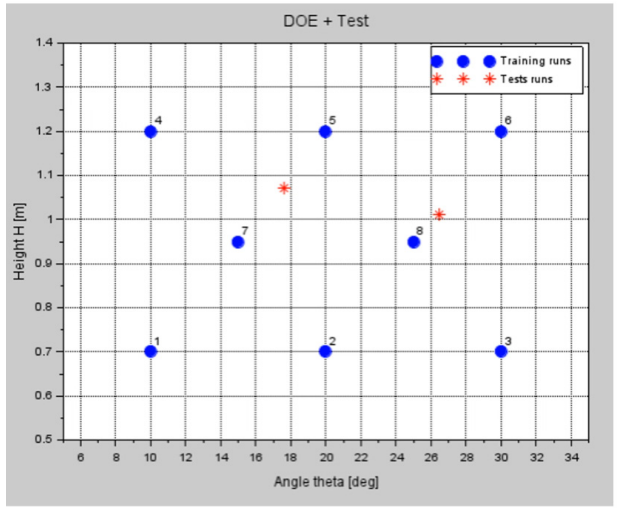
- Reduce the rotor power consumption of a mixer used for feeding systems

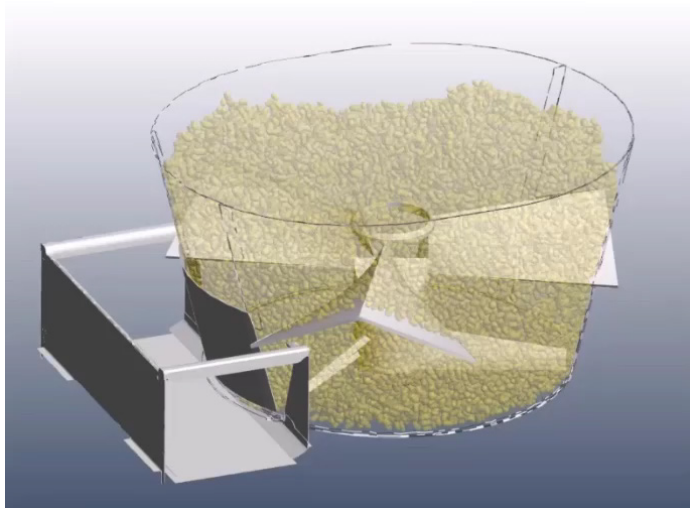
Solution

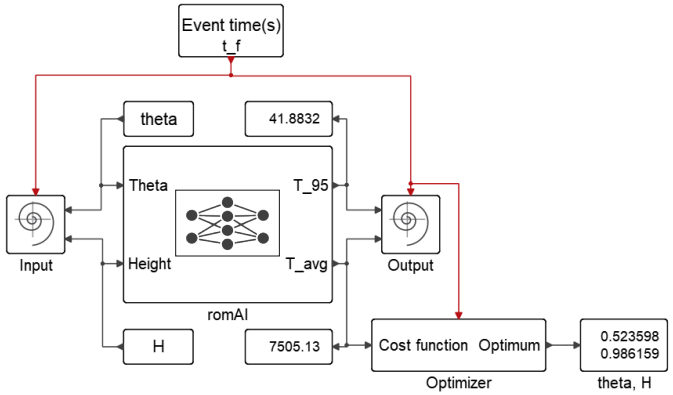
- Optimized a complex non-linear system using Altair® EDEM™ high-fidelity DEM solver, drastically reducing simulation time while maintaining accuracy through Altair® romAI™ technology

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%

ALTAIR

NEW

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

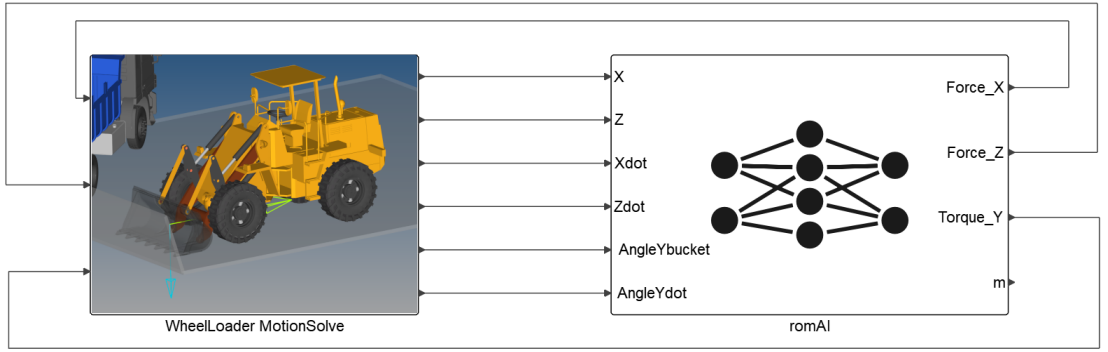
- Accelerate system-of-systems simulations for vehicle dynamics, control systems, and material interactions in a wheel loader to allow for further optimization analysis, addressing the computational cost of simulating granular material dynamics

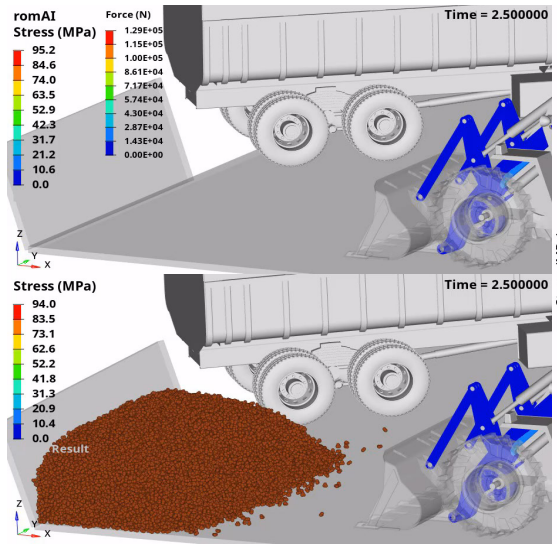
Solution

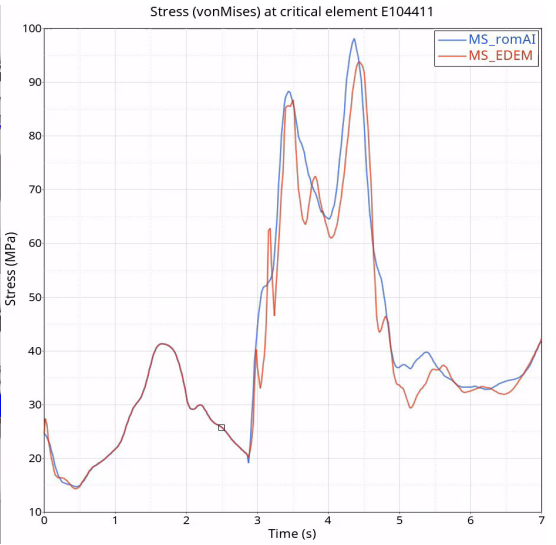
- Developed a high-fidelity, co-simulation model with Altair® MotionSolve® for vehicle dynamics, Altair® Twin Activate™ for control and actuation, and Altair® EDEM™ for handling the granular material dynamics of the particles and the interaction forces between the bucket of the wheel loader
- Created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







ALTAIR

Aerospace and Defense Use Cases

Optimize Aircraft Skin-Stringer Design

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

Challenge

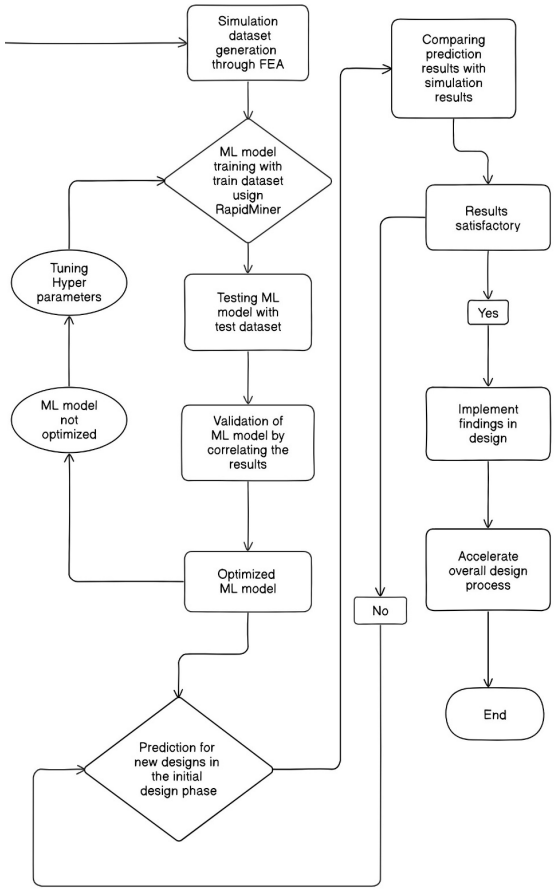
- Designing airplane skin requires advanced knowledge and complex calculations to ensure structural integrity
- Excessive bending poses a risk of buckling, which can lead to potential failure
- Frequent inspections are necessary to catch issues early and maintain safety standards

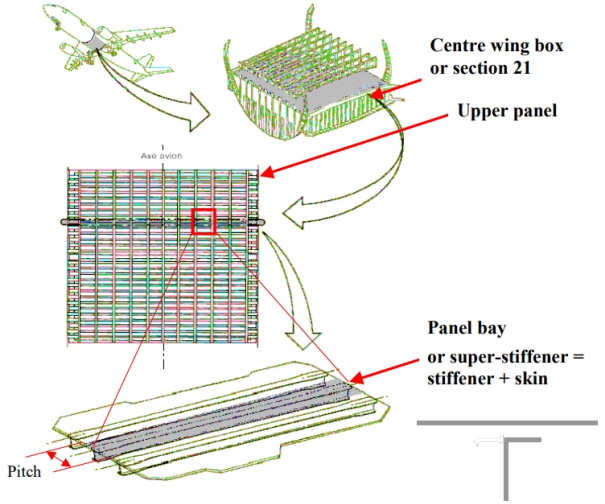
Solution

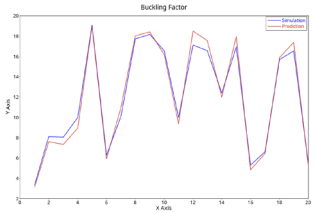
- Advanced CAE tools allow for comprehensive structural analysis, enabling faster and more accurate designs
- AI/ML optimization predicts and improves design efficiency, reducing both time and costs
- Predictive maintenance ensures safety by using data-driven insights from historical performance to schedule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

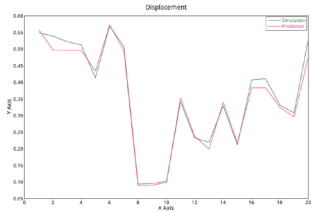
Value

- 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

ALTAIR

Strength Verification for Airworthiness Certification

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

Challenge

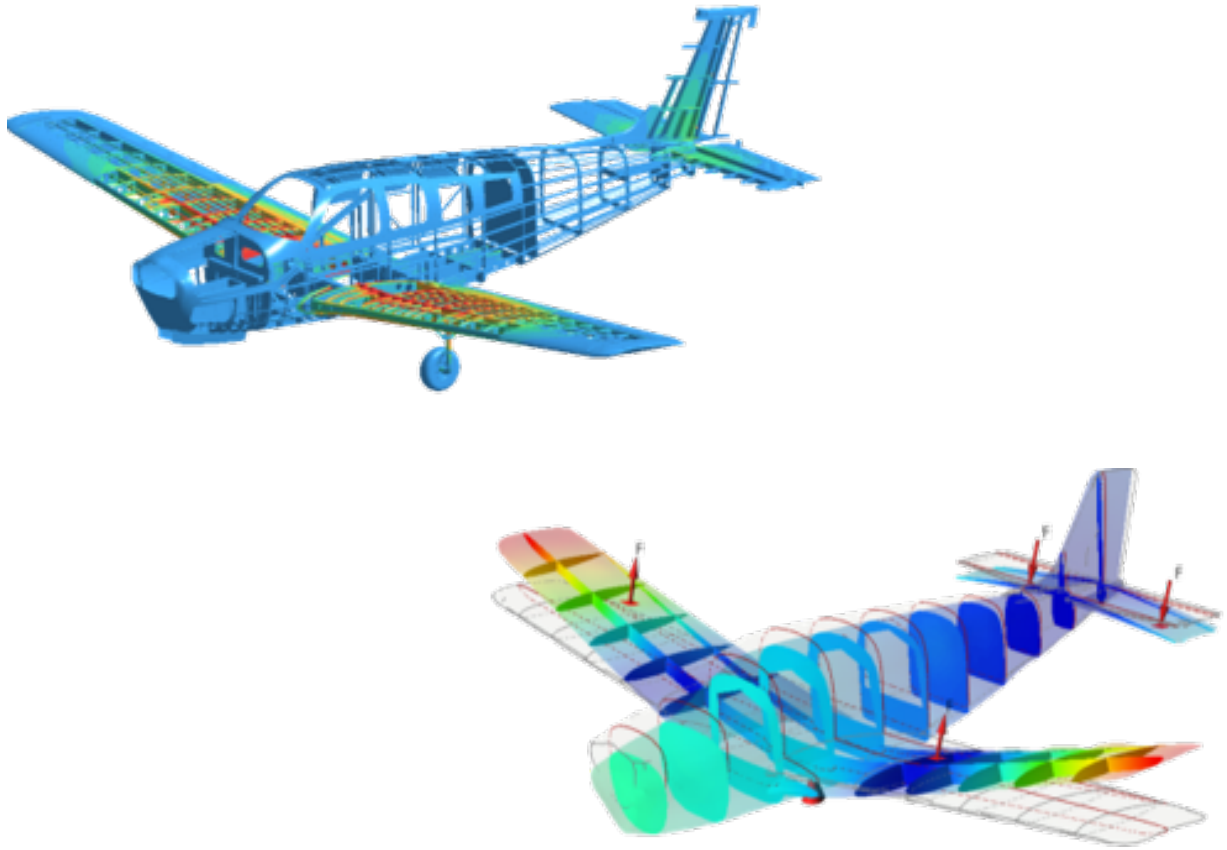
- Quickly verify airworthiness specifications across various gust profiles and altitude levels to meet stringent requirements

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



ALTAIR

Compare Aerodynamic Performance of Airfoil Designs

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

Challenge

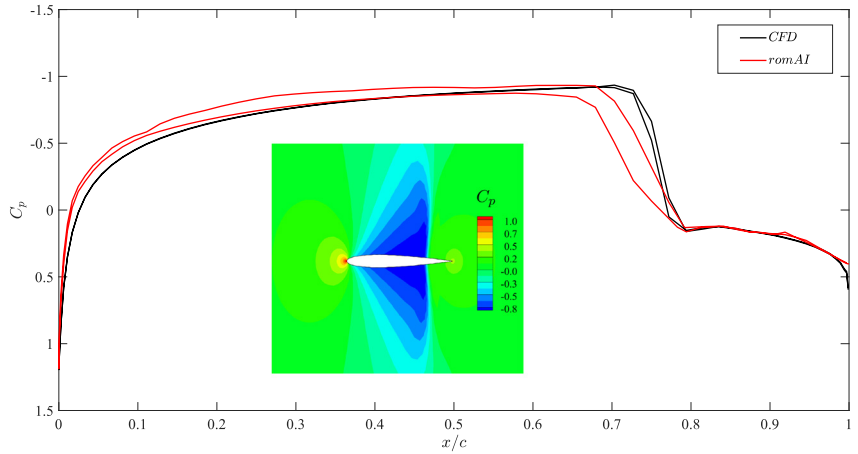
- Traditional CFD simulations for multiple airfoil designs are time-intensive and require significant computational resources
- Difficulty in assessing coefficient variation for different airfoil designs in transonic and inviscid flow
- Challenges in managing and comparing large datasets from various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

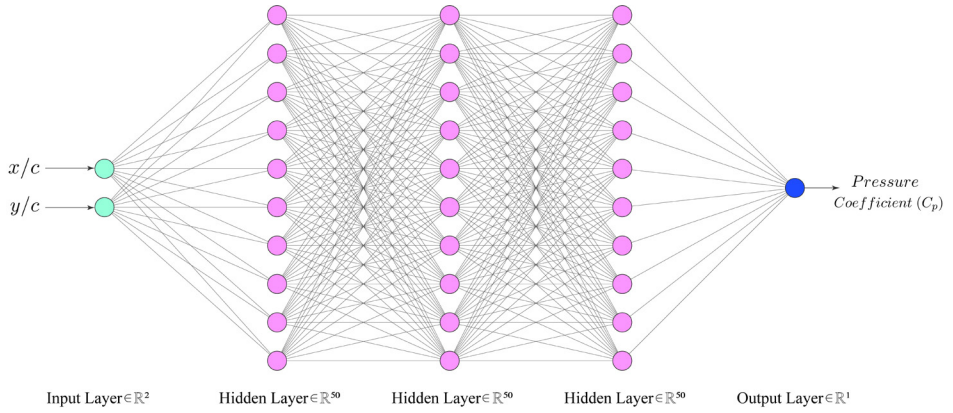
Solution

- 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





ALTAIR

NEW

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®

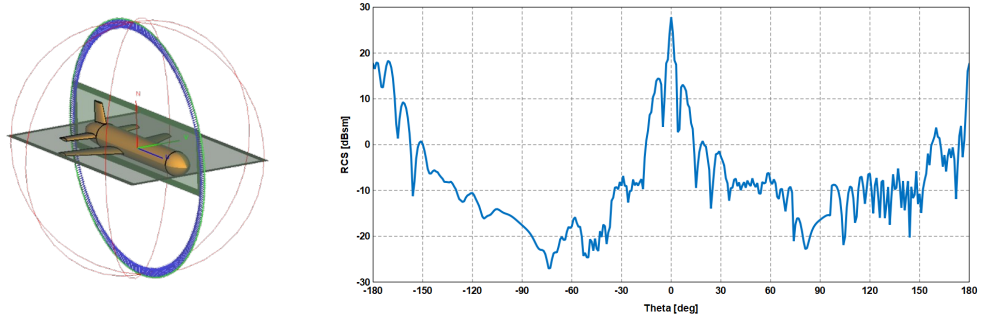
Solution

- 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

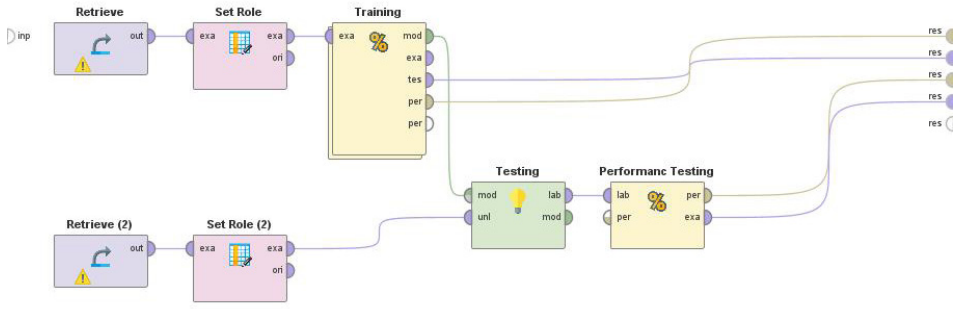
Value

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

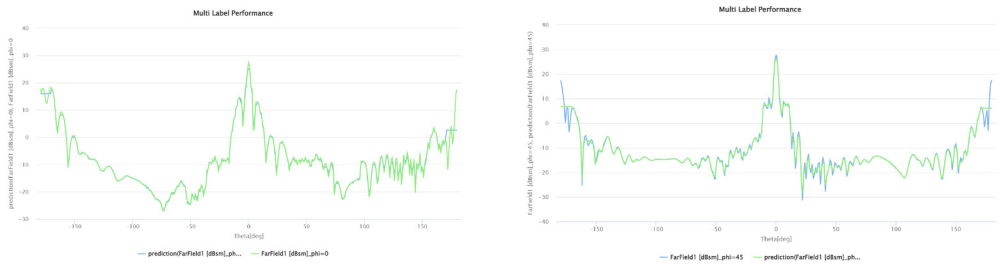
Cruise Missile Model and RCS Results - Feko



ML Workflow - Rapid Miner



Simulated Results with GBT ML Model - Rapid Miner



ALTAIR

NEW

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

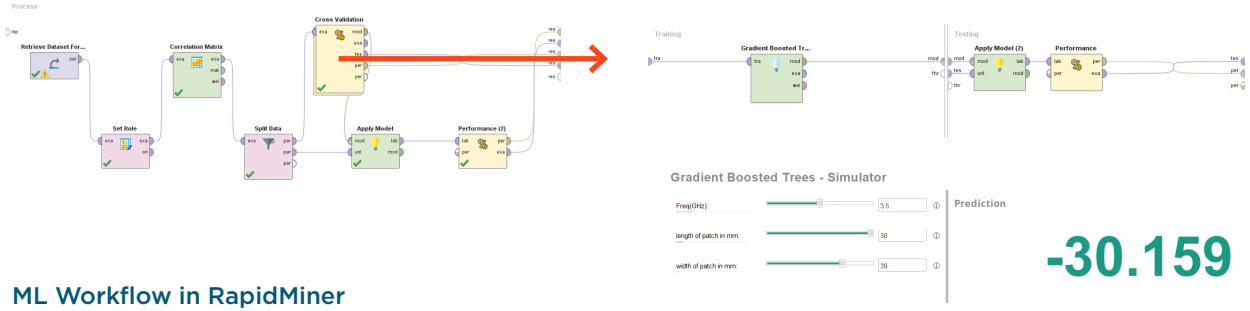
- 5G antennas operate across sub-6GHz and mm-wave frequency bands, where typical antenna design structures are simulated to optimize parameters such as S-parameters, gain, and bandwidth, while maintaining miniaturized dimensions
- Structuring the dataset for ML optimization is challenging due to the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

Solution

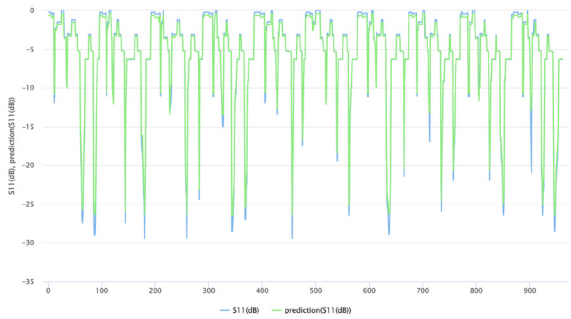
- Developed an ML model to optimize 5G antenna performance for specific frequency bands, focusing on S-parameters, gain, and bandwidth
- Built a robust dataset of 5G antennas and their performance characteristics, enabling the model to recommend the best antenna for optimal performance across the target 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

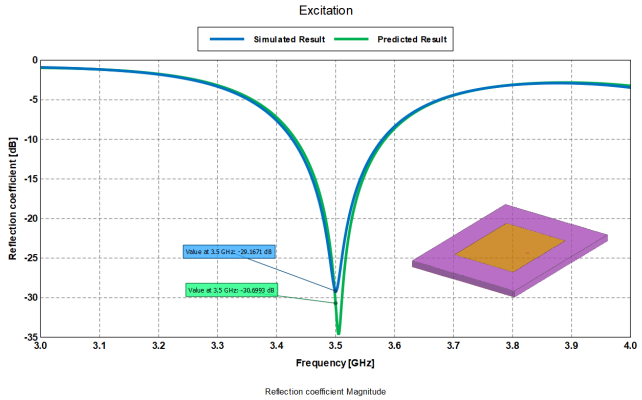
- Ensured accurate selection and performance optimization for 5G antennas
- Achieved peak 5G antenna performance within the target frequency band, reducing simulation time and costs for faster development cycles



ML Workflow in RapidMiner



Optimized results with GBT Algorithm in RapidMiner



Comparison of Simulated and Predicted Reflection Coefficient (dB)

ALTAIR

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

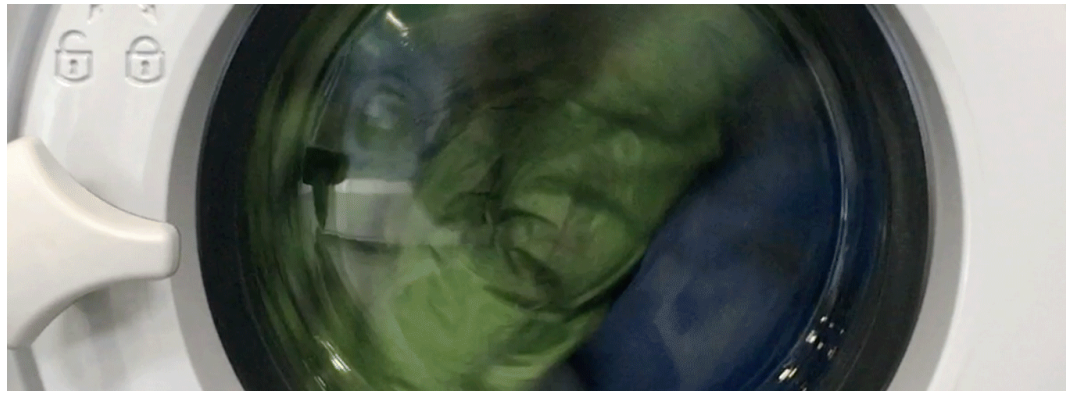
- Optimize drum RPM in spin cycles to enhance water and energy efficiency

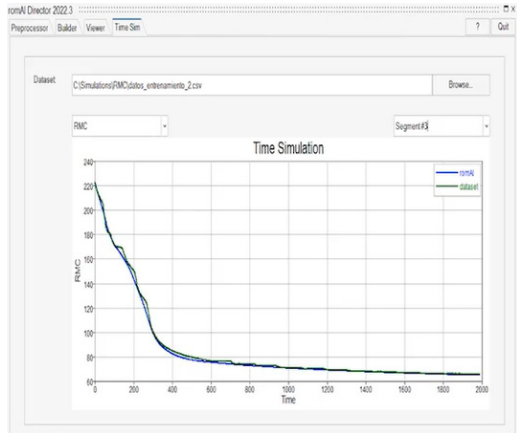
Solution

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

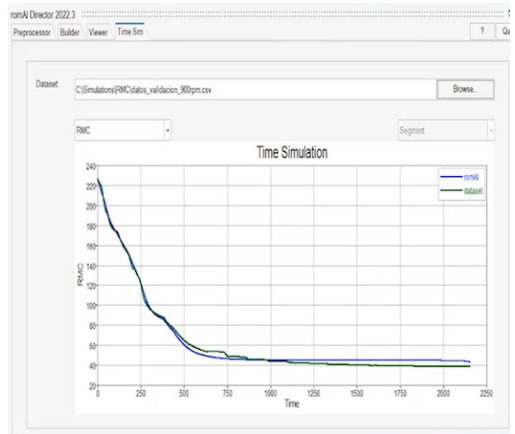
Value

- 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

ALTAIR

Estimate Linen Weight for Resource Efficiency in Washing Machines

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

Challenge

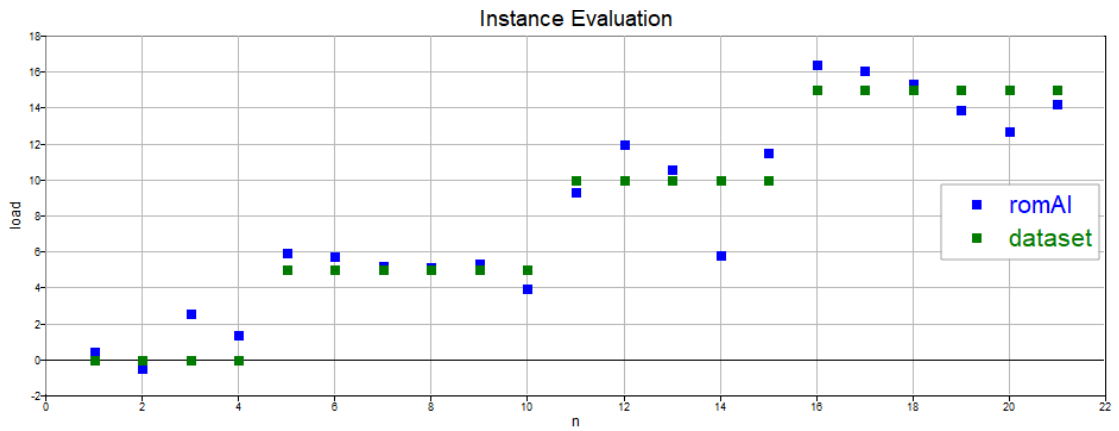
- Reduce water and energy consumption in washing machines

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



ALTAIR

Smart Grid Energy Management for Transformer Health

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

Challenge

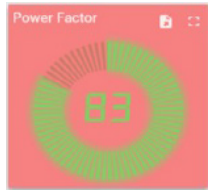
- The integration of distributed energy resources and storage systems complicates grid management, posing challenges at various grid stages
- A need for automation in identifying and categorizing transformer failures, including bushing, oil preservation, and core issues

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



ALTAIR

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

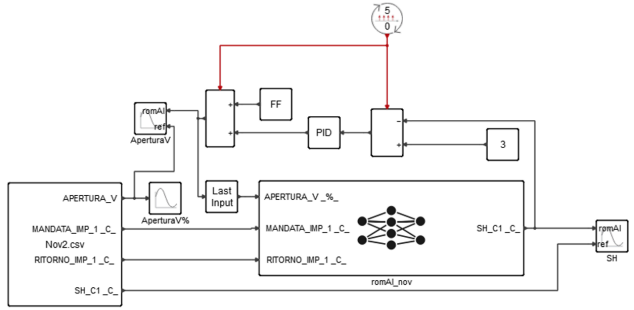
- Optimizing the controller of electro-valves used in heat pumps across various building types

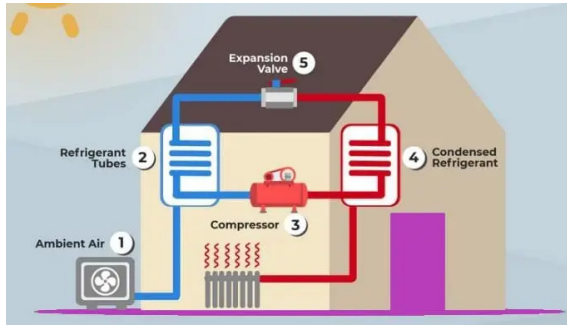
Solution

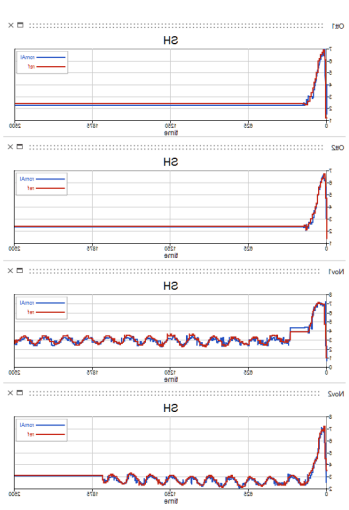
- An accurate model of the heat pumps was identified using Altair® romAI™, enabling virtual testing of different control strategies
- Field data was automatically processed and adjusted for training/testing, extracted from the IoT platform, using Altair® Monarch®.
- The identified ROM model was hosted,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

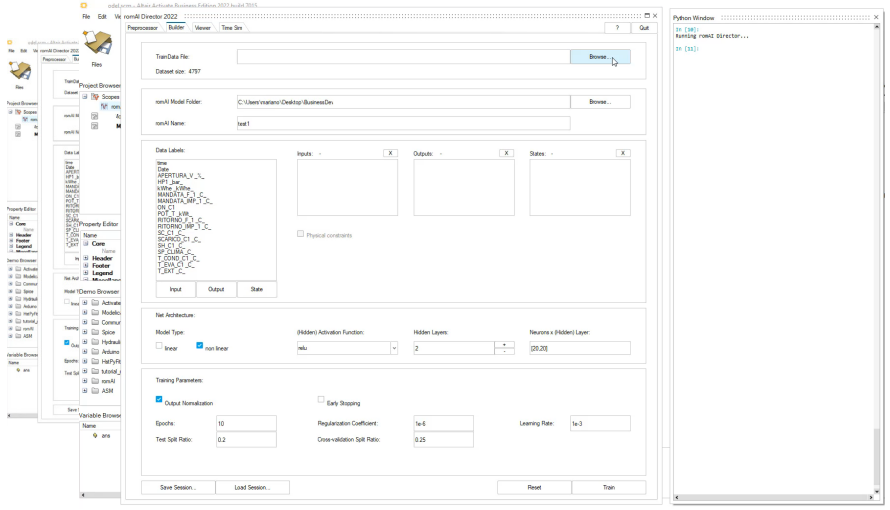
Value

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









ALTAIR

NEW

Temperature Evaluation of Electro-Flow

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

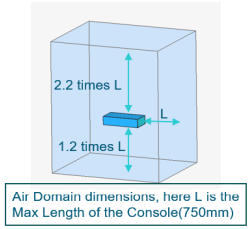
- Optimize thermal management by predicting and controlling temperature distribution for various fan openings and heat source positions in an electronic console

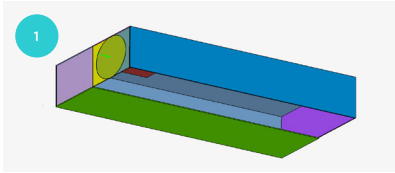
Solution

- 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

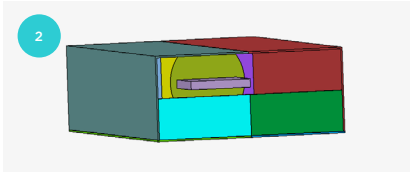
Value

- 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

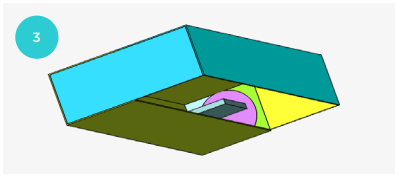




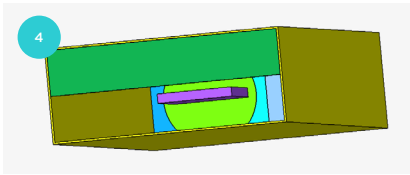
First Half Opening at Bottom face



First Half Opening at Front Face

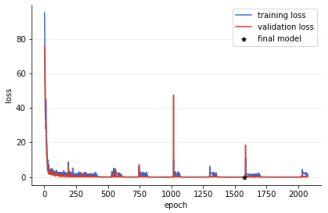


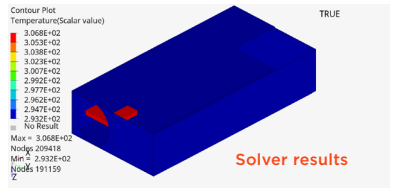
Second Half Opening at Bottom face

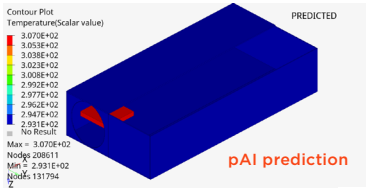


Second Half Opening at Front Face

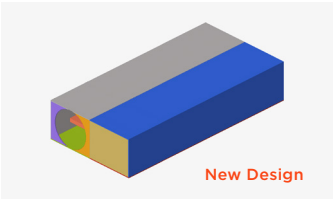
Testing

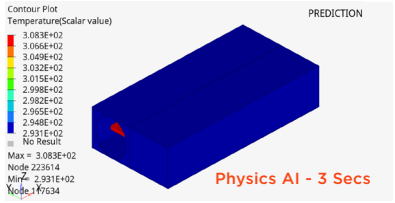


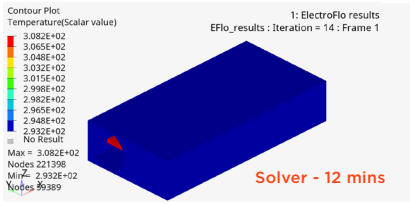




Prediction







ALTAIR

NEW

Load Forecasting for Smart Buildings

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

Challenge

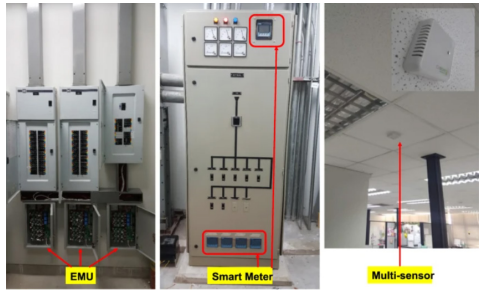
- Address energy demand fluctuations and manage complex consumption scenarios across different building zones and load types under various weather and operational conditions in a Smart Building
- Manage large datasets of electricity consumption and indoor environmental measurements of a commercial building

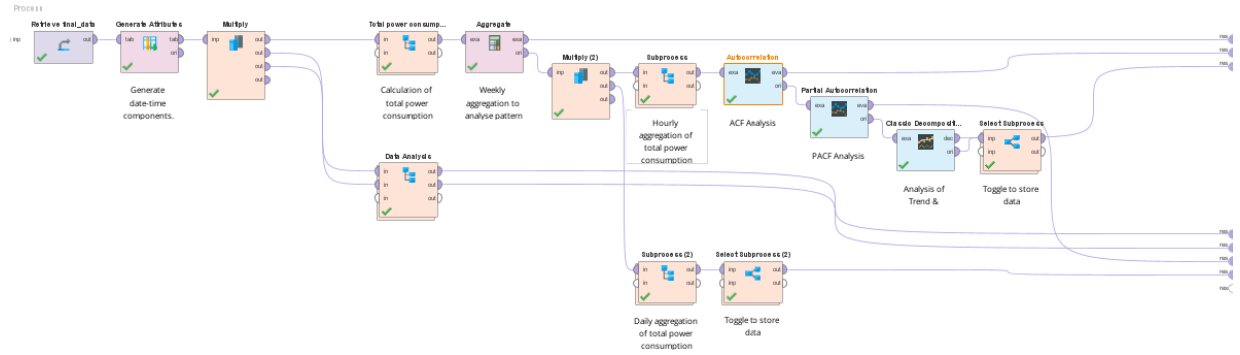
Solution

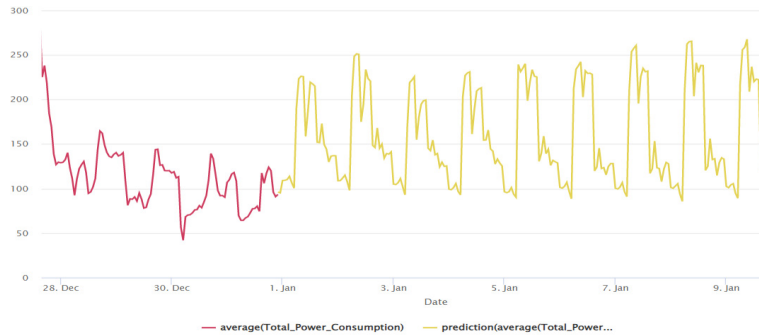
- Developed forecasting models for electricity consumption across multiple appliances under varying conditions, supporting applications such as zone, floor, and building-level load forecasting, indoor thermal modeling, simulation validation, demand response algorithm development, and anomaly detection

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







ALTAIR

NEW

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

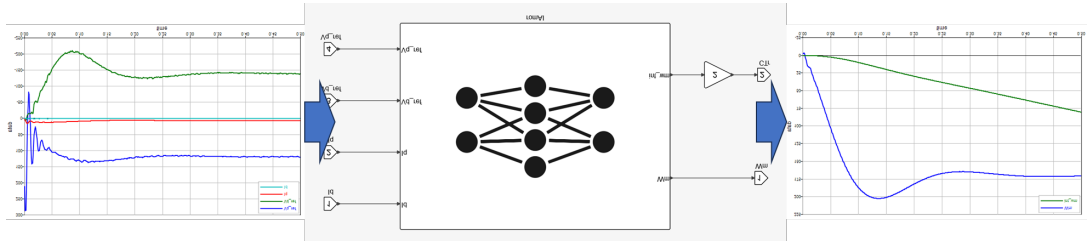
- Predict angular velocity and rotor angle based on DQ motor currents and DQ reference voltages for a Permanent Magnet Synchronous Motor (PMSM)

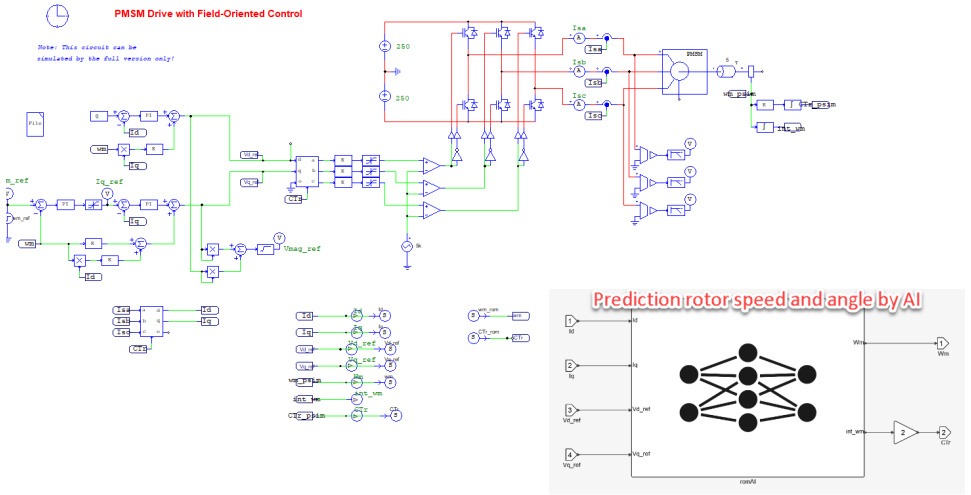
Solution

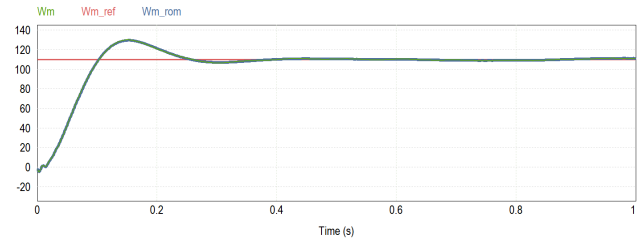
- Used Altair® PSIM™ for motor control and power electronics in PMSM
- Integrated and simulated the system between the power electronics and ROM using Altair® Twin Activate™
- Created reduced order motor models with Altair® romAI™
- Ran the DoE for the PSIM model using Altair® HyperStudy®.
- Pre-processed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







ALTAIR

Material and Manufacturing Use Cases

Detect Steel Sheet Defects

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

Challenge

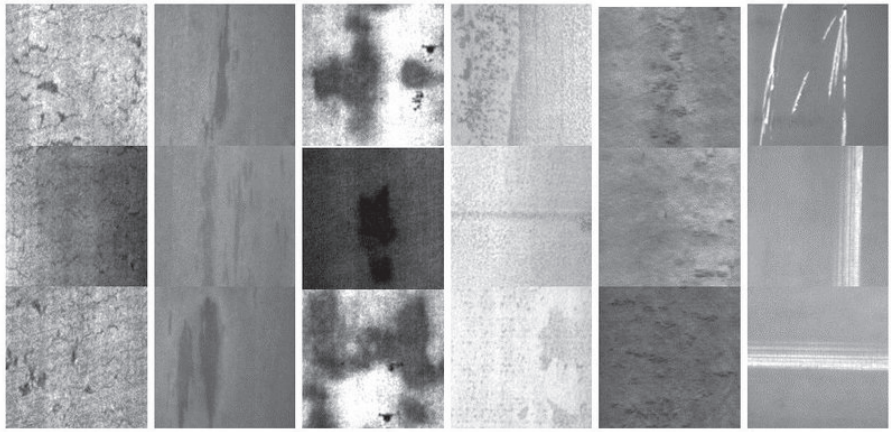
- Ensuring consistent steel quality is difficult and impacts both product costs and processing precision
- Poor steel quality negatively affects the accuracy of subsequent processing steps
- High part rejection rates result in significant financial losses

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



ALTAIR

Operational Digital Twin for Sheet Metal Forming

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

Challenge

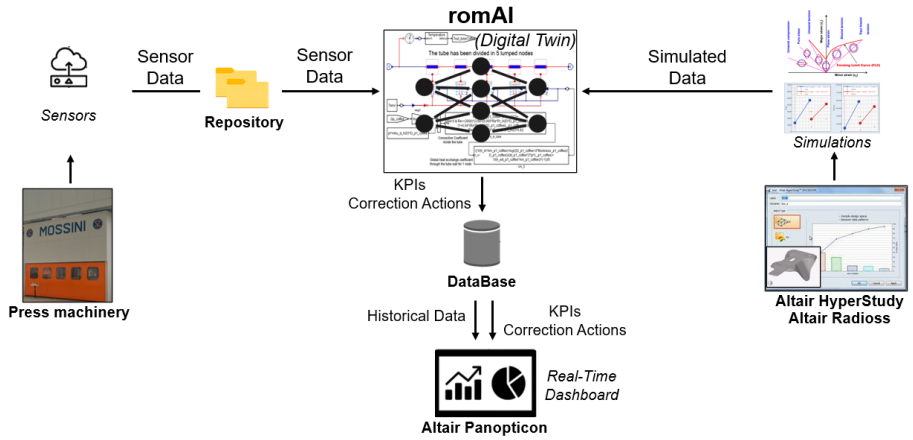
- Identify causes of divergence from nominal conditions in the sheet metal forming process

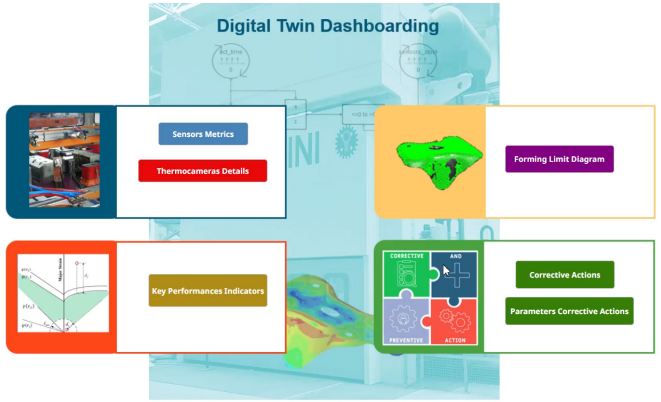
Solution

- 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





ALTAIR

Accelerate What-If Analysis for Sheet Metal Forming

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

Challenge

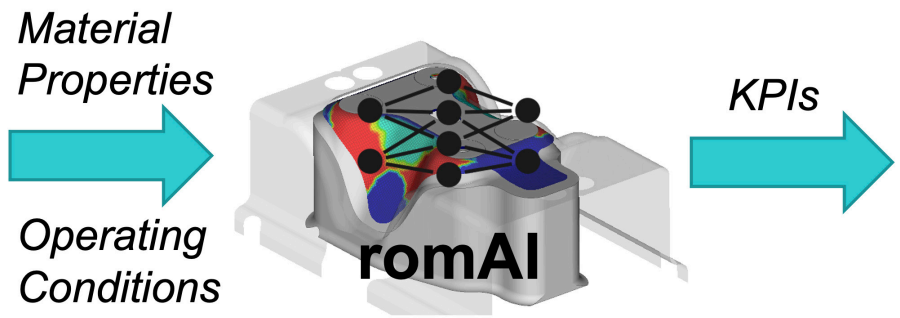
- Quickly understanding the variation of KPIs as a function of material properties and operating conditions, such as pad force and die friction

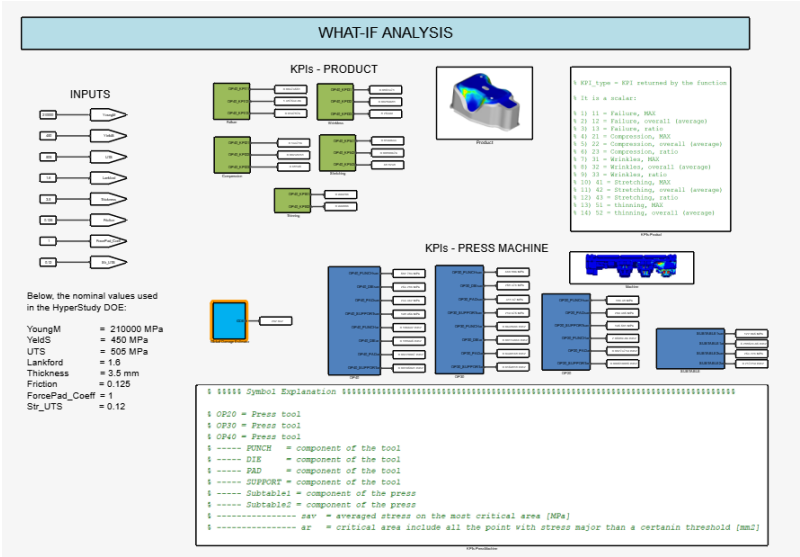
Solution

- 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

ALTAIR

Crash-Optimized Megacasting Design for Enhanced Performance

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

Challenge

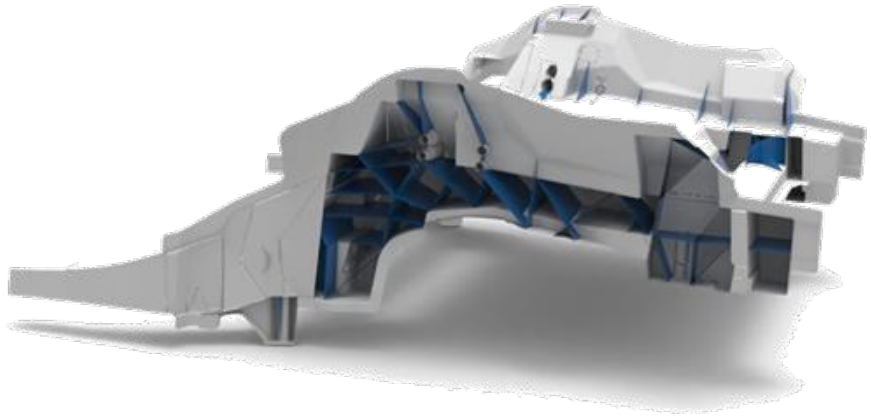
- Complex design challenges in megacasting manufacturing, requiring intricate analysis
- Processing large volumes of simulation data to identify optimal solutions
- Meeting sustainability goals by developing lighter products with superior performance across multiple disciplines (crash, NVH, etc.)

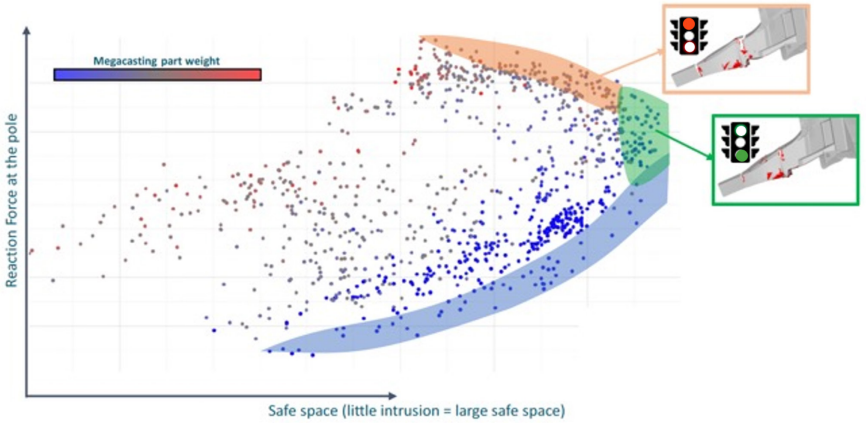
Solution

- 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





ALTAIR

NEW

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

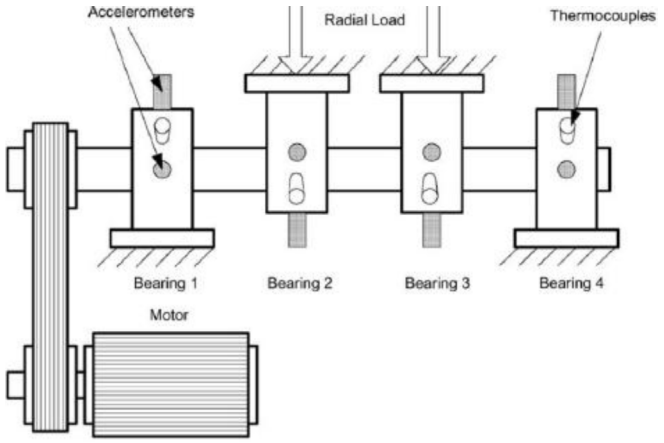
- Downtime and production losses due to various bearing failures, including inner race, outer race, roller issues, and complete breakage
- Real-time sensor data requires efficient processing to avoid delays

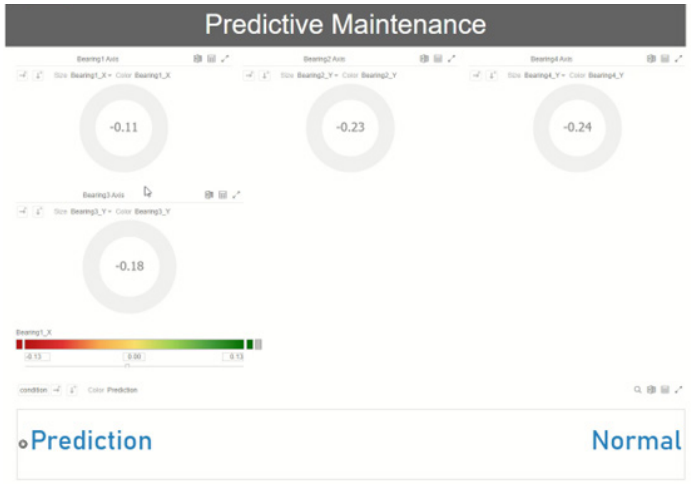
Solution

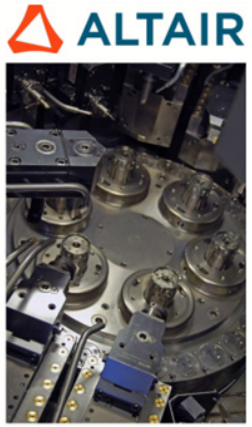
- Built a predictive model using historical accelerometer sensor data from bearings, enabling real-time condition monitoring and failure prediction
- Connected Altair® Panopticon™ to edge devices via the MQTT Protocol for real-time streaming and visualization of accelerometer data
- Extracted statistical, 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







NEW

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

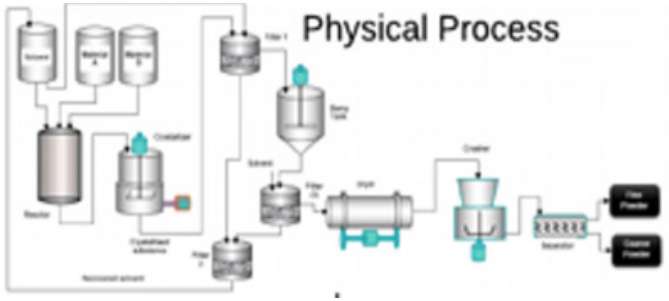
- Meet the 90% fine/coarse particle size requirement, reducing business waste bay minimizing the need to discard/reprocess coarse powder through additional crushing and separation

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

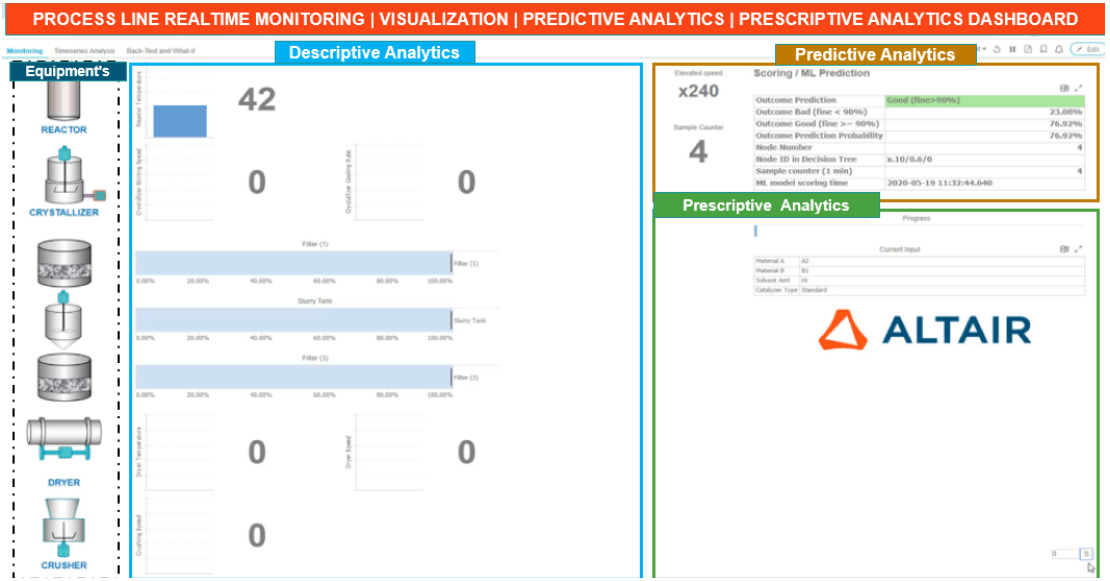
Value

- 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



ALTAIR

NEW

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

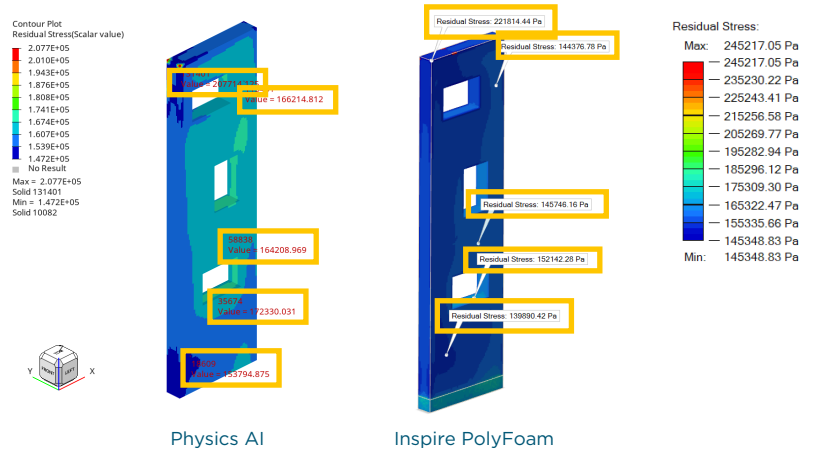
Value

- 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

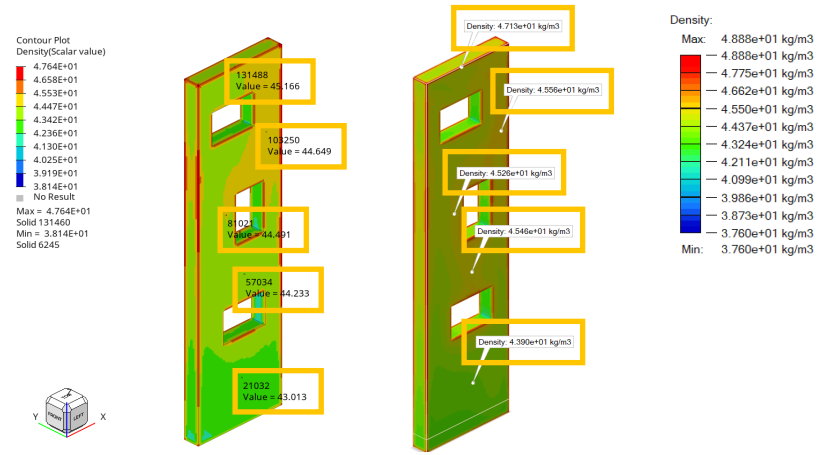


Physics AI Inspire PolyFoam

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

NEW

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

ALTAIR

NEW

Automated Scalable Material Outlier Detection

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

Challenge

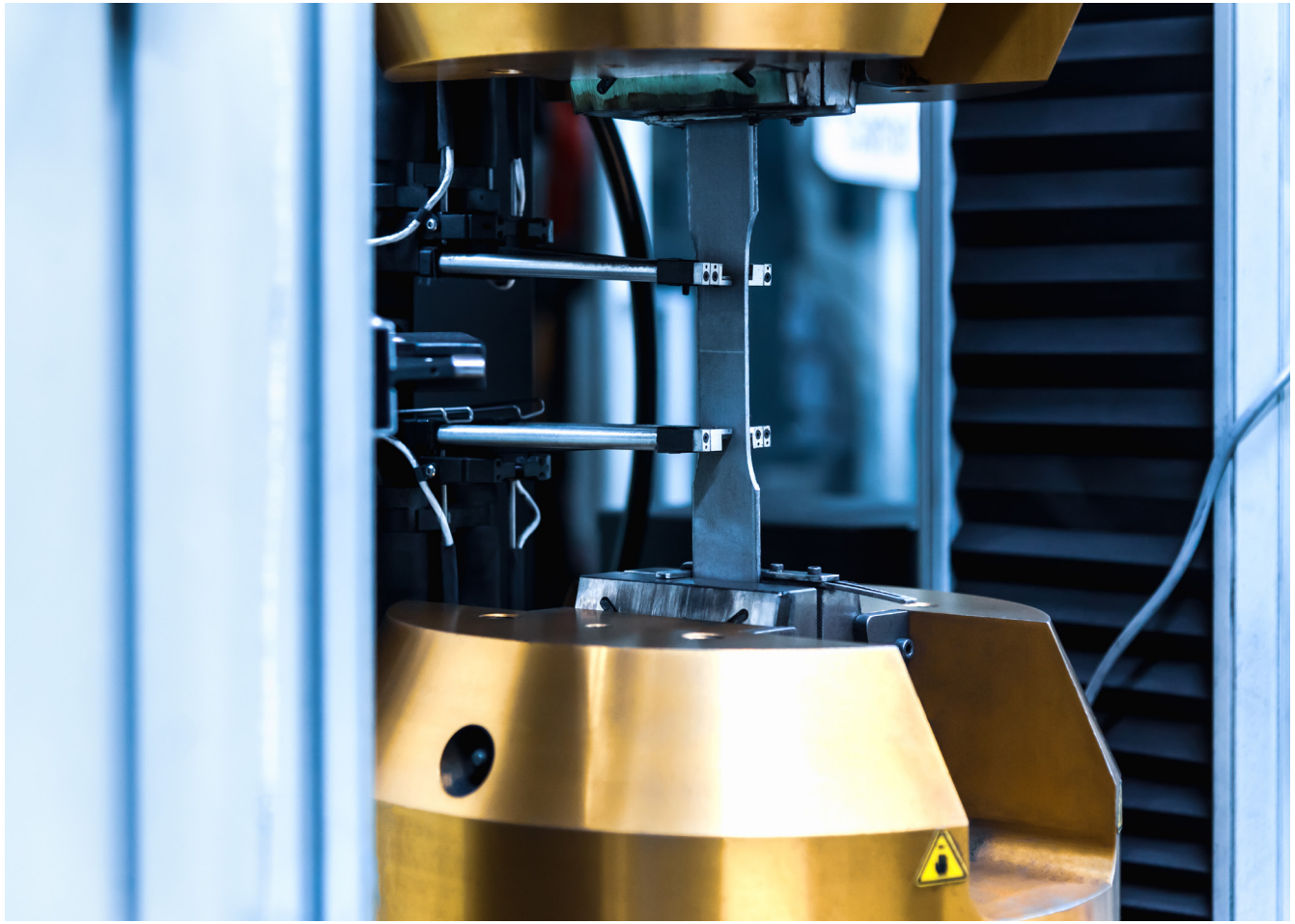
- Raw material data is often noisy and variable, making it difficult to detect true patterns. Effective preprocessing is essential to filter out noise and identify material outliers accurately

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



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