GUIDE TO ACCELERATING E-MOBILITY TO REALIZATION

INTRODUCTION

The electric mobility revolution is ready to go mainstream. OEMs, suppliers, and emerging vehicle manufacturers are investing billions to develop innovative electric vehicles and optimize development and production processes to deliver e-mobility to the masses. For companies to realize their goals of achieving mass adoption and profitability, we see simulation technology as the cornerstone of any e-mobility strategy.

Whether updating existing vehicle design processes to go electric or developing a new program from the ground up, it can be challenging to identify the technology required and ensure these tools work harmoniously to model the complexities of the vehicle's interconnected systems.

In this e-book, we set out to help electric vehicles manufacturers build a comprehensive technology stack, develop a sustainable design process, and deploy manufacturing operations that scale to meet growing demand.

The global stock of electric passenger cars passed 5 million in 2018, an increase of 63% from the previous year. Electric vehicle sales are estimated to reach 44 million in 2030.

IEA (2019), "Global EV Outlook 2019", IEA, Paris https://www.iea.org/reports/global-ev-outlook-2019

KEYS FOR ACHIEVING E-MOBILITY SUCCESS

Biggest Challenges Facing e-Mobility Manufacturers

The compelling demand for electric mobility solutions has led to a gold rush, with scores of traditional OEMs and suppliers as well as new and emerging startups flooding the marketplace. With opportunity, however, comes technical and operational challenges. Here are the three biggest hurdles that presently stand in the way of mass adoption of electric vehicles.

1

Performance Requirements. The market expects brands to deliver the power and range they enjoy in internal combustion vehicles, but to achieve this and get the most mileage out of each charge, manufacturers must reduce vehicle weight and improve the energy efficiency of batteries, electric motors and electric propulsion systems. Lighter cars require less battery power for accelerating and maintaining speed, allowing a single charge to take passengers further. Since less power is required for propulsion in lighter vehicles, carmakers can reduce the size and weight of the battery packs, which are one of the biggest contributors to an electric car's weight.

2

More Stringent Regulation. The Worldwide Harmonised Light Vehicle Test Procedure (WLTP) is a new regulatory process developed in the European Union and similar regulations are quickly being adopted globally. WLTP sets more rigorous rules for fuel consumption and emissions for internal combustion engine vehicles, but also includes regulations for energy consumption values of alternative powertrains and electric vehicle range. A key difference from previous testing procedures is that WLTP is based off real driving data, not theoretical results. It's now more important than ever to incorporate energy and range requirements into vehicle designs from an early stage to ensure that the end-product will meet regulatory standards and eliminate the need for costly and inefficient redesign cycles.

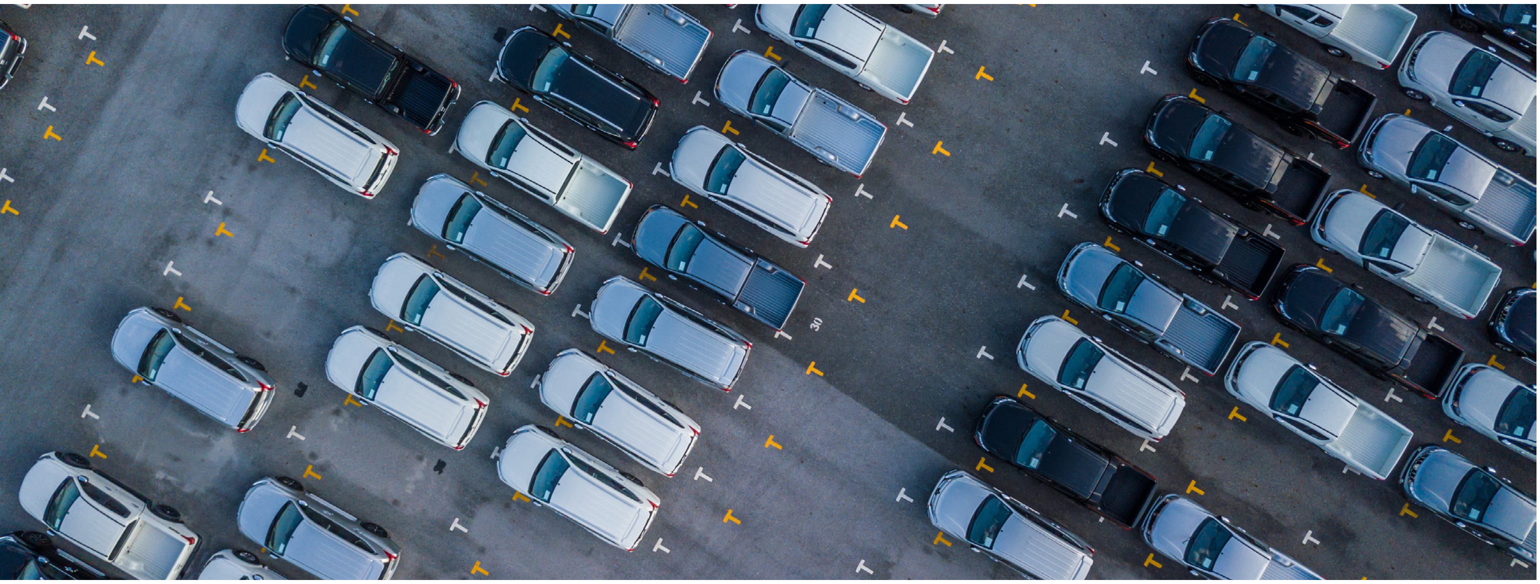
3

Achieving Balanced Vehicle Design. Designing at the sub-system or component-level in isolation is insufficient to achieve truly optimized system-level performance. Vehicle designers must consider cost, development time, size, weight, thermal and structural performance, and importantly, how each attribute effects the others and influences the performance of the system as a whole. Multiphysics simulation and multi-disciplinary optimization are gaining adoption for modeling complex systems, allowing for more informed design decisions about the balance of key structural and performance-based vehicle attributes.

Solutions for Today's Automakers

Simulation is where intrepid companies gain an edge and stand out from the crowd. Deploying an effective simulation strategy in these domains is key to a modernized and sustainable electric vehicle development strategy.

06 / Developing Sustainable Design Solutions to Meet Vehicle Demands
08 / Designing for e-Propulsion System Efficiency
12 / Battery Impact, Crashworthiness, and Occupant Safety
13 / Battery System Design and Performance
16 / Comfort and Perceived Quality
18 / Vehicle Architecture and Lightweighting
20 / Electromagnetic Reliability and Connectivity
22 / Plan for Scaling e-Mobility from Niche to Mass-market
23 / Building a Comprehensive Technology Stack
24 / Leveraging Data Analytics and Machine Learning



DEVELOPING A SUSTAINABLE VEHICLE DESIGN PROCESS

A streamlined, robust, and repeatable design process is a necessity for accelerating product development, enhancing energy efficiency, and optimizing integrated system performance. A successful workflow begins with a simulation-driven concept design phase, followed by a detailed physics simulation, and finally, the integration of vehicle systems ensuring optimized performance.

Concept Design

Detailed Design

System Integration

Concept Design

Rapid design exploration and feasibility ranking studies allow for informed e-motor selections to be made early in the concept phase to inform optimal downstream e-propulsion decisions. Performance comparisons can be made across duty cycles based on numerical simulation and optimization techniques and be deployed to select the best e-motor topologies considering constraints such as efficiency, temperature, weight, compactness, cost.

For concept design processes like the pre-design of e-motors, engineers need to be able to easily aggregate available data and utilize it to inform the selection of suitable topologies. Tools like Altair FluxMotor enable the designer to build a machine from standard or customized parts, add windings and materials to quickly run a selection of tests and easily compare the machine performance. In addition, they can predict the machine performance at one or more working points, as well as for complete duty cycles. By coupling FluxMotor to Altair HyperStudy for design exploration and optimization, motor concepts can be optimized and ranked by key performance attributes at an early design stage. Designers can then select and focus on the topologies that fulfill the key criteria before going further with detailed electromagnetic design and multiphysics analysis.

Detailed Design

After developing an optimized concept, detailed analysis is needed to accurately model the physics of the vehicle components and systems. Balancing performance, cost, and weight requirements with multiphysics, vehicle designers can utilize simulation to enhance every aspect of the e-mobility driving experience. Detailed electromagnetics and magneto-thermal simulations allow engineers to evaluate e-motor thermal performance and explore cooling strategies. Noise and vibration analysis offer insight into sound quality and passenger experience influenced by the e-propulsion system as well as external wind and road noise.

Repeatability and automation contribute to sustainable detailed design processes, especially when dealing with complex systems and multiple physics. Platforms like Altair SimLab enable intuitive model pre-processing and setup of automated workflows, which can then be used in multiple physics analyses such as electromagnetic, thermal, and vibration analysis, all within a common simulation environment.

System Integration

Electric vehicle subsystems have considerable influence on each other, providing opportunities to not only analyze but optimize the performance of the entire vehicle. System-level simulation helps designers to take dynamic interactions into account, enabling the use of feasibility studies to explore system architecture with multiple configurations, paving the way for accurate target setting that guides the development process and maximizes product performance.

Model-based development solutions leverage simulation models to accelerate design delivery while supporting different levels of mechatronic system complexity. Varying levels of model fidelity (from 0D to 3D) can be deployed in electric machine, power converter, and control strategy design to match the vehicle development phase. This allows you to improve control algorithms throughout the process. 1D and 3D simulation studies can be coupled, sequentially or simultaneously, to evaluate product performance through representative system models, all built to enhance the efficiency of your designs. Enedym Inc., developers of next generation permanent magnet, induction, and switched reluctance e-motors, use multi-disciplinary system simulation models to predict the effect of various parameters on the electromagnetic, thermal, and structural performance together to produce an optimized design.

Electric motors in general, are made of standard parts, such as the stator, rotor, coils and magnets. These parts might look simple and bulky from the outside, however, the highly interrelated relationship between the geometry of these parts, characteristics of materials, and the way the current is controlled, defines the cost, size, efficiency, performance, and durability of the motor. In electric motor design, multi-disciplinary aspects are highly interrelated.

View The Enedym Presentation

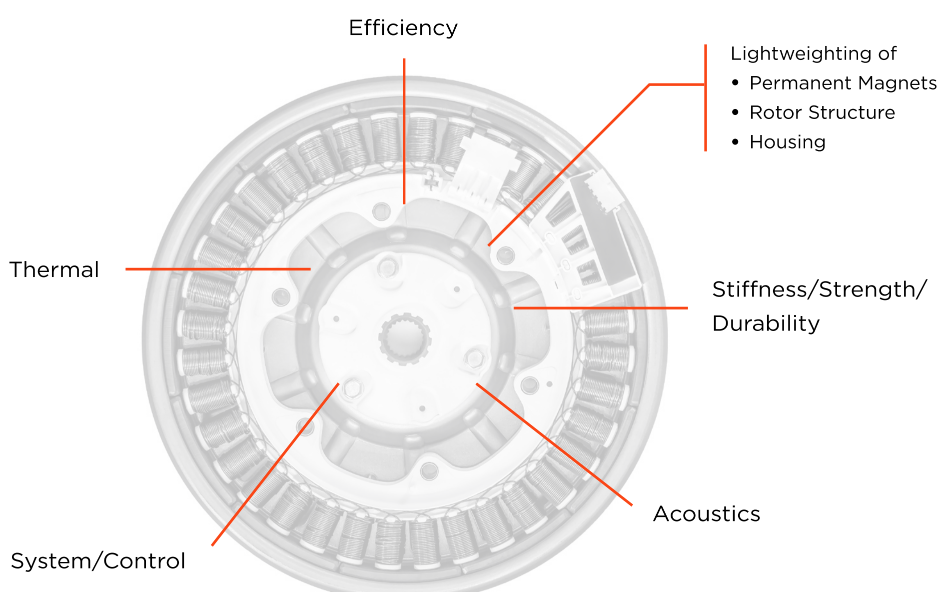
MAXIMIZING VEHICLE RANGE WITH HOLISTIC PROPULSION SYSTEM DESIGN

Today, an e-motor cannot be developed just by looking at the motor as an isolated unit. The powertrain of electric vehicles must be developed to consider and fulfill an increasing number of internal, customer and legal requirements as well as increasingly ambitions target fulfillment goals.

Classical development strategies often take place among several parallel disciplines where negotiations and unfavorable compromises concerning attribute performance are common to reach a final design. More integrated and holistic development strategies are necessary to better meet future requirements without significant sacrifices on target fulfillment. New optimization methodologies offer opportunities to support integrated development strategies by accounting for various requirements resulting from different physical phenomena simultaneously, a process called multiphysics optimization.

Porsche AG's Integrated E-Motor Design Process

Porsche AG is responding to the challenge of e-mobility by developing high performance electric powertrains which will meet every Porsche standard in terms of performance, fuel efficiency, driving dynamics, and everyday practicality.



Multiphysics Design Loop

The advanced drivetrain development team at Porsche AG, together with Altair, has approached the challenge of improving the total design balance in e-motor development by taking a multiphysics approach. The classical motor efficiency/power design problem is coupled with other physics to account for thermal effects, structural boundary conditions and vibrations. Additional effects of the inverter on the motor performance will also be evaluated by integration of both controls and physical modeling. The objective of the design optimization is to maximize torque and power under defined driving conditions.

Simultaneously, rotor stresses, motor vibrations and motor temperature must be kept within certain limits. The design process accounts for both individual motor design points (e.g. max torque) and evaluation in standardized driving cycles using reduced order models based on data provided by full-order models in the Altair suite of physics simulation and optimization tools.

Different physics simulation and optimization tools are combined and integrated to create a process for multiphysics e-motor optimization. The results of this effort are e-motor designs with maximized power outputs and minimized base torque ripple. You can find details on Porsche's simulation coupling strategies and the ways this process has the potential to improve Porsche's total e-motor design balance in the technical paper linked below.

Read the Porsche Technical Paper

Mercedes AMG's Automated Multiphysics E-Motor Strategy

Mercedes-AMG GmbH utilizes a unique, highly automated, multiphysics design strategy for e-motors development. In collaboration with Altair, their strategy considers essential development requirements, including electromagnetics, thermal, NVH, stress and durability. It accommodates for DOE, multi-objective optimization and design exploration methods to be used to explore and find feasible motor designs.

Multiphysics processes present many logistical challenges, particularly with setup time and repeatability. To create a more sustainable process, Mercedes AMG focused their efforts on applying consistent treatment of design changes throughout different physics, installing high levels of automation and support to simplify the setup process, and ensuring efficient handling of data to and from the various design process tasks. Mercedes AMG's strategy adds efficiency to their e-motor development process, which directly impacts the total costs of development. A video outlining the Mercedes AMG e-motor design process can be viewed at the link below.

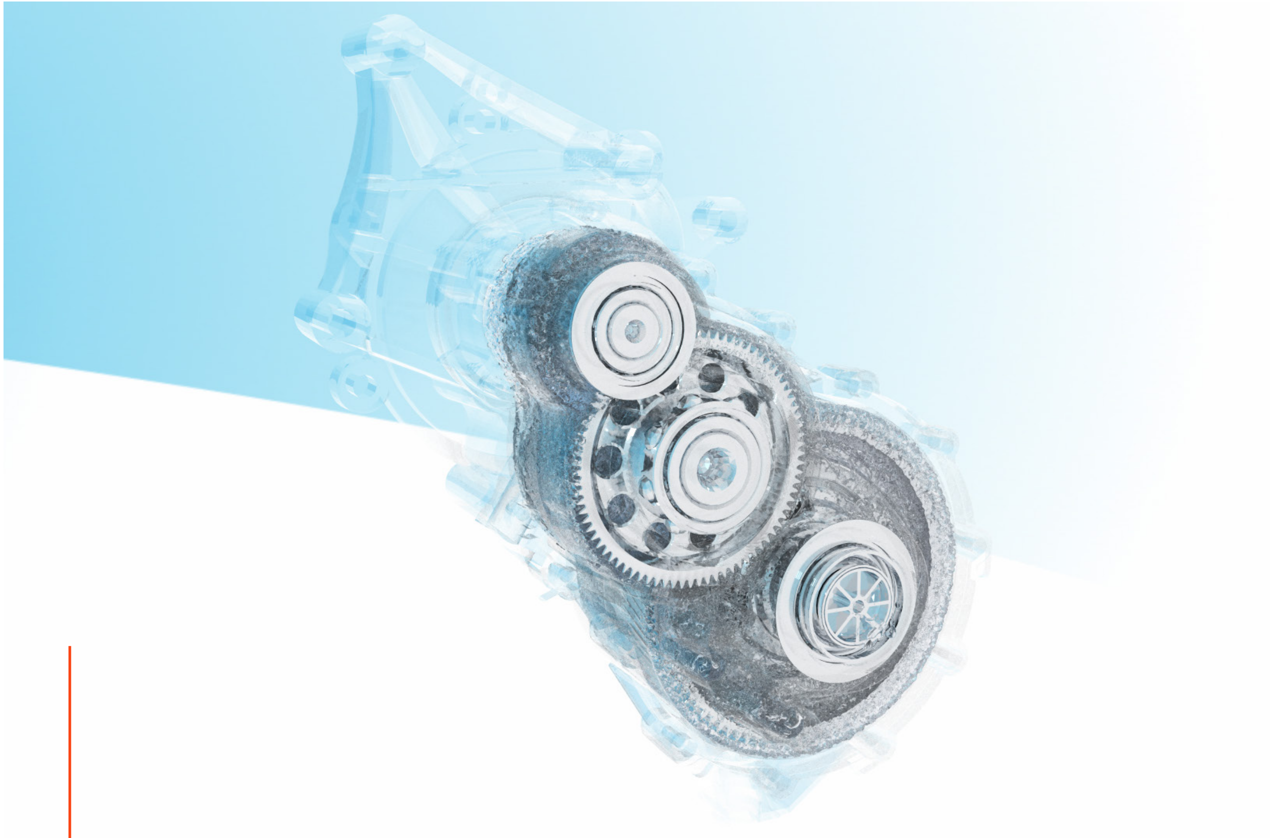
View the Mercedes AMG Presentation

CFD-driven Efficiency and Thermal Management

Computational fluid dynamics simulation such as EV gearbox oiling and spray lubrication of e-motors has traditionally proven to be complex and computationally expensive endeavors. Only recently has the rise of GPU-based CFD solvers enabled simulation to be completed efficiently enough to accommodate tight vehicle development cycles.

Multiphase smooth-particle hydrodynamics (SPH), backed by GPU hardware, can support cooling and lubrication system development for powertrain efficiency and thermal management improvements. Altair nanoFluidX is a GPU-based SPH solver that handles true multiphase flows, including oil aeration and windage effects. A CFD workflow can be set up and run using the Altair SimLab multiphysics platform, where meshing, boundary conditions, and solver settings are defined. The typical gearbox model can be created in less than one day in SimLab. From the SimLab platform, the user calls nanoFluidX to then run the job. The average solve time is about 50 hours, which marks a drastic improvement from typical CPU-based runs which can take a week or more to complete.

The speed at which GPU solvers deliver gearbox oiling and other CFD analysis results not only shortens development times, but actually enables companies to move these studies earlier in the engineering process.



Rather than relying on physical prototypes to reactively respond at the end of the design cycle, CFD simulation can serve as a predictive and prescriptive tool for optimizing powertrain and thermal management systems.

THE EVOLUTION OF EV SAFETY

Modeling Thermal Runaway for Battery Impact Safety

A major challenge for automotive OEMs and suppliers is to create Battery Electric Vehicles (BEVs) for mainstream customers and not just enthusiastic earlier adopters. This requires bringing BEV development cycles into alignment with traditional powertrain vehicle program timelines. New technologies and regulations mean new engineering team structures and toolsets are necessary.

The analysis of BEV crash, impact, and shock events that can cause structural failures and potentially battery fires are essential to the design process. Completing these full-vehicle safety simulations overnight, including an accurate model of the battery, is critical to achieve commercial viability, but modeling battery impact with traditional FEA processes simply does not support this timing. A micro model of a battery can comprise of between 30 – 50 million elements, so due to the model complexity, running an impact analysis on the battery pack can be even more computationally expensive than the impact simulation of the entire vehicle body.

Altair has initiated a three-year-long project named Altair Battery Designer, an investment in validated vehicle safety simulation modeling includes batteries and modules for crash events, road debris impacts, shocks, and penetrations. This initiative will develop a software tool derived from directed research and multiphysics optimization. Altair Battery Designer will consider the mechanical, electrical, electrochemical and thermal physics of the battery cell, module, and pack under exceptional mechanical loads to predict safety risks and prevent short circuits, thermal runaway, and combustion.

Altair will work with industry partners and one of the foremost authorities in battery simulation, Professor Jun Xu, the Director of the Vehicle Energy & Safety Laboratory at the University of North Carolina at Charlotte, to achieve the goals of the Altair Battery Designer project.

View the Battery Impact Safety Presentation

Addressing Crashworthiness Challenges of Electric Vehicles

Automotive crash testing, for both legislative requirements and consumer ratings, are vital requirements for any commercially viable vehicle. For electric vehicles, there are also specific requirements, like electrolyte spillage, electrical isolation, and prevention of shock from high-voltage systems, that must be anticipated in the design stages in order to ensure regulatory compliance and passenger safety.
Full multi-disciplinary optimizations are useful for ensuring compliance across all impact tests, front, side, and rear, while also considering global stiffness, equivalent static stiffness, and acoustics.

View the Vehicle Impact Presentation

POWERING PROGRESS WITH BATTERY INNOVATIONS

Improving Battery System Performance

Improving battery system performance is critical to facilitating the projected global electric vehicle market growth. An accurate battery model is the starting point for battery pack design, system control and optimization. Unfortunately, the simple equivalent circuit (EC) models that are typically used today lack predictive power and are insufficient to the task. Considering the high cost and time required for physical battery experiments and testing, taking a physics-based approach to simulating integrated systems can significantly improve the design of battery-based systems and optimize their long-term performance and safety while shortening overall development time and saving overall development costs.

Software like CellMod™ from Sendyne, a member of the Altair Partner Alliance, can help to accurately model and predict battery behavior. CellMod is the first lithium-ion virtual battery capable of predicting cell and pack behavior, including thermal behavior. Utilizing a sophisticated electrochemical model, CellMod is packaged as a functional mock-up unit (FMU), allowing it to be easily integrated into most major system simulation packages, such as Altair Activate™. The FMU accepts inputs including current, ambient temperature and time-step, and will output voltage, cell internal temperature, surface temperature, SOC and any other cell internal state variable. In addition, designers can simulate behavior of aged cells and can be scaled to represent parallel and serial combinations of cells.

Unlike EC models, more sophisticated simulation models accounts for the physical processes taking place inside the cells, including diffusion in solids, diffusion in electrolytic solutions, reaction kinetics, charge transport, heat transport, etc. allowing a greater degree of accuracy in predicting battery cell behavior.

View the Sendyne Presentation

Battery Cooling

Battery cooling (BC) systems are frequently composed of several parallel branches, each leading to and away from a series of cooling plates. Key requirements include correct flow distribution in each branch and overall pressure drop, so numerical computation is extremely important from the early stages of development, especially because the number of components and their dimensions have a relevant impact on the total cost. For Hutchinson, the 3D computation of battery cooling cases was time consuming and costly, both in terms of computational power and cost of software licenses, so it is important for them to minimize the number of simulation iterations. They now leverage system simulation in their early-stage development process to produce quicker results and allow for the necessary optimization cycles. Altair Activate is used by Hutchinson to develop a library of ROMs representing different circuit components through which they create 1D models for quickly and precisely responding to project requirements.

View the Hutchinson Presentation

Solving Infrastructure and Clean Mobility Challenges with Unique Charging Solutions

Much of the world's transportation infrastructure is built around internal combustion engine vehicles. Vast networks of gasoline fueling stations ensure drivers can confidently navigate well beyond the range of a single tank of gas. In order to empower BEV drivers to go further, companies, industry organizations, and governments need to collaborate on innovative ways to improve battery charging availability and facilitate the use of charging systems for fleets of manned and autonomous electric vehicles.

In the near future, cars will be capable of parking autonomously, which necessitates solutions to autonomously charge these vehicles for their next use. Even today, studies show that plug-in hybrid electric vehicle owners often neglect to charge them after the first few times since electric power is not a prerequisite to drive the car. Easier, more automated, and smarter charging options are being developed now to address these pressing challenges.

French startup Gulplug is a spin-off of Schneider Electric Group founded in 2014. Gulplug has set out to revolutionize the plug and charging technology used in today's electric and hybrid vehicles by creating an automatically self-plugging, magnetic based charging solution.

Gulplug's automatic magnetic based, self-plugging, conductive charging solution was developed to provide more power at a competitive price. By employing Altair Flux for the modeling of all magnetic issues, Gulplug engineers could make sure the plug was guided and inserted into the right spot to make it run.

Simulation helped them to define the sizes and placement of the coils used inside the device which are required to create the electromagnetic force to guide the plug.

[Watch the Gulplug Video]

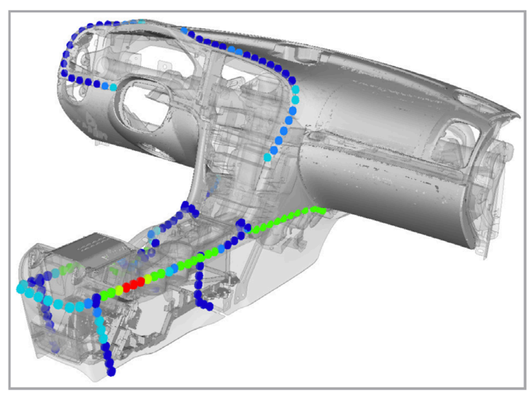
NOISE, VIBRATION, AND HARSHNESS

Creating a Quieter Cabin

A key challenge for sound engineers working on electric mobility projects is the interior cabin audio experience. The sounds of a traditional internal combustion engine actually mask many of the sounds made by the engine, gearbox, drivetrain and other vehicle components, so with that noise substituted by nearly silent electric motors, all the engine and gear whines, squeaks, rattles, and exterior wind and road noises seem heightened to the vehicle operator. Interior NVH has a great effect on overall cabin comfort and perceived quality, so companies take great efforts to dampen noise and integrate NVH optimization into the multiphysics simulation process.

National Electric Vehicle Sweden (NEVS) leverages Altair Squeak and Rattle Director to identify and minimize risks of interior noise. An electric vehicle contains many complex systems, like batteries, high and low voltage cables, cooling systems, and of course the vehicle structure itself. The Squeak and Rattle Director technology helps NEVS identify contact between and within these systems and subsystems that could contribute to noise and vibration and potentially lead to damage. They simulate these contacts against several different driving conditions in order to accurately predict problem areas make design adjustments to produce an optimized cabin experience. Access to this rapid risk identification data early in their design process helps NEV determine ideal material selection for vehicle parts, accelerate their development time and a reduced the need for physical prototypes.

Old generation Saab 9-3 cockpit module



SnRD visualization of S&R risk zones in new design cockpit

Read the NEVS Customer Story

Improving Driver Comfort Through Internal Noise Modeling

To make the driving experience more comfortable for passengers inside a vehicle compartment in an increasingly shorter development cycle, predictive methods for the acoustic response characterization are used by vehicle engineering teams. The main purpose is to estimate the sound field in the car cabin. The FCA NVH team identified an opportunity to develop a complete solution for acoustics simulation with the help of Altair simulation tools.

A new methodology was created to convert frequency domain analysis into actual sound waves. This method was used to study the NVH steady-state acoustic performances. Development is in progress to simulate an acoustic environment to reproduce all vehicle noises in operational condition. Using this methodology, it's possible to virtually understand the acoustic behavior of vehicles, helping to make decisions in early design stages which could save design cost, time, and improve the driving experience for passengers.

View the FCA Presentation

"AS AUTOMATION BECOMES MORE COMMON AND AUTONOMOUS VEHICLES BECOME A REALITY, WHAT WE DO AND HOW MUCH TIME WE SPEND IN THE VEHICLE WILL CHANGE. THIS WILL MAKE THE INTERIOR AND COCKPIT EXPERIENCE MORE IMPORTANT."

Joe Mannino, senior vice president of technical at Toyoda Gosei

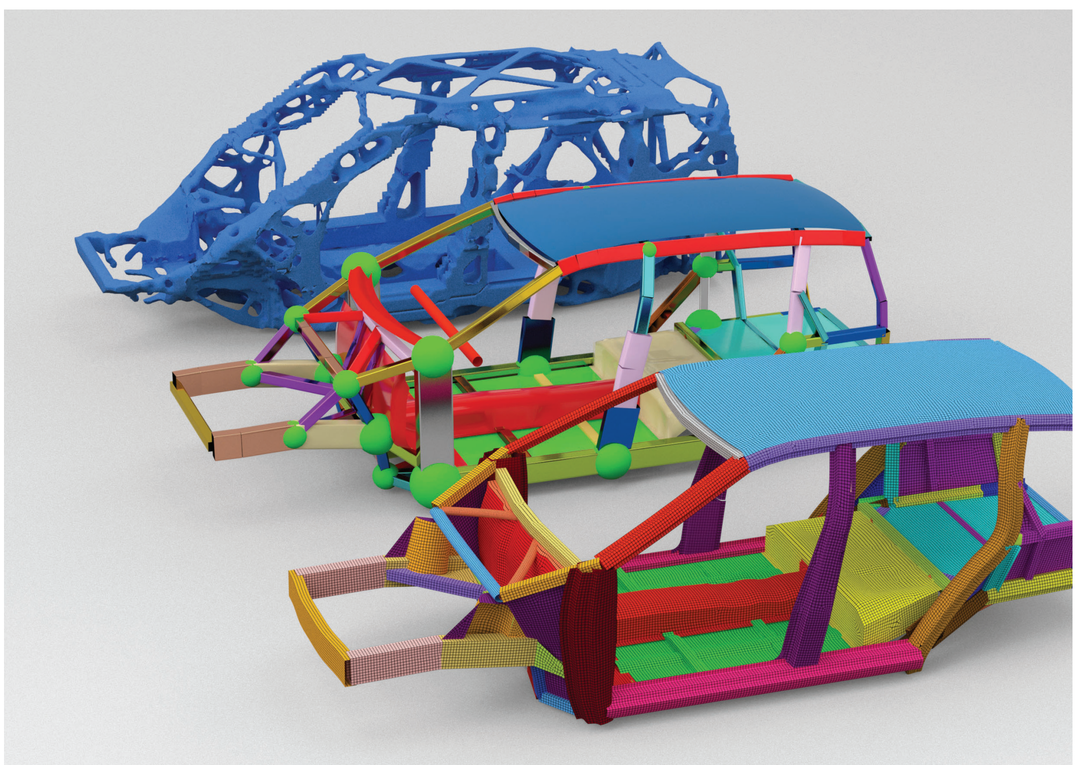
Sweeney, Chris. (2018) "Quiet, please: Reducing cabin noise brings opportunities for suppliers". Plastic News. 02 May 2018. https://www.plasticsnews.com/article/20180502/NEWS/180509970/quiet-please-reducing-cabin-noise-brings-opportunities-for-suppliers. Crain Communications, Inc. Accessed 25 February 2020.

VEHICLE ARCHITECTURE AND LIGHTWEIGHTING-DRIVEN PERFORMANCE

A Systematic Approach to Weight Reduction

In order to get the most mileage out of each charge, manufacturers are turning to generative design to create lightweight vehicle structures and components. Lighter cars require less battery power for accelerating and maintaining speed, allowing a single charge to take passengers further. Generative design techniques enable engineers to remove material from the structure and individual components, all while maintaining the strength and stiffness properties required for vehicle safety and ride comfort. Removing weight from the structure also has compounding benefits. Since less power is required for propulsion in lighter vehicles, carmakers can reduce the size and weight of the battery packs, which are one of the biggest contributors to an electric car's weight.

The Altair Concept 1-2-3 (C123) design process enables designers to confidently create innovative next generation architectures to address unique e-mobility challenges. C123 uses optimization to inform vehicle architecture, manufacturing processes, material selection and platform strategies. Robust to key loads and allowing a seamless hand-off from pre-program to program, C123 provides rapid insight to the weight and performance implications of structural changes to the vehicle before detailed design.



View the C123 Presentation

Addressing Packaging and Weight Distribution Challenges in EVs

The Ampera-e was developed by Adam Opel AG for daily usage with a range of up to 500km at a moderate price point. One of the biggest challenges during the vehicle development was the integration of the RESS (Rechargeable Energy Storage System) with 60kWh capacity into the car. The large battery pack and surrounding electrical components needed to be packaged into the vehicle, attached to the body structure, and protected during crash events in an efficient way. On top of these requirements, the design team was also tasked to bring down the overall vehicle mass as much as possible. Opel partnered with Altair to help determine optimum balance between performance, package, mass and cost objectives. They implemented the C123 process as well as design and gage optimization to integrate the battery into a minimized mass structure without sacrificing crash or NVH performance or interior space.

View the Opel Presentation

ELECTROMAGNETIC RELIABILITY AND CONNECTIVITY

Reliability of Electronic Components and Systems

The electric drive system consisting of a high-voltage power source, a frequency converter, an electric motor and shielded or unshielded high-power cables, system which can introduce potential interference and compatibility issues with the many electronic and electrical systems within today's vehicles.

Electromagnetic compatibility (EMC) describes the ability of electronic and electrical systems and components to work when they are close together. Car manufacturers and suppliers not only need to ensure that electromagnetic problems, including electromagnetic interferences (EMI) and electromagnetic susceptibility or immunity (EMS), will not occur when integrating components and systems into a car, but also that governmental and industry EMC regulations are met.

Altair Feko helps electric vehicle designers perform electromagnetic simulations of EMC for analysis, design, and validation for both electromagnetic emissions and immunity. EMC tests can be performed at component and vehicle levels considering the powertrain of an EV. Feko offers simulation of both radiated emission and immunity problems. These also include the ability to model complex cable harnesses, antenna coupling in the vehicle and shielding effectiveness. A comprehensive EMC simulation approach ensures the harmonious co-existence of systems in the vehicle while complying with the relevant EMC standards.

Read the Hyundai Mobis Customer Story

Intelligent e-Mobility with Assisted and Autonomous Driving Systems

The sophistication of future cars will extend beyond the performance of the individual vehicle itself. With the rapid improvement and proliferation of vehicle-to-vehicle and V2X communication, advanced driver-assistance systems, and autonomous driving, e-mobility solutions must be developed to connect and interact with their surroundings without interfering with in-vehicle electrical systems. High frequency electromagnetics and wave propagation tools help vehicle designers to perform virtual drive testing and consider a full array of environmental obstacles.

Cars have started being developed to save lives by talking to each other and to the infrastructure around them using communication antennas in a connected car concept. The automotive evolution towards the autonomous driving includes also ADAS radar sensors to be aware of surrounding obstacles. Both radar sensors and installed car antennas can be efficiently evaluated using virtual-drive tests in Altair WinProp. WinProp considers the full environment including buildings, cars, street objects in order to get accurate representations of the radio waves impinging on the installed car antennas and the multipath radar channels including reflections, diffractions, and scattered contributions. Car objects can be efficiently analyzed considering Dedicated Short-Range Communications (DSRC) or 5G wireless signals and replaced by their corresponding radar cross sections. This allows the realistic and fully reproducible evaluations of different options for the antennas and sensors including their integration and configuration.

ENHANCING YOUR MANUFACTURING OPERATIONS

Advancing BEV development to match traditional vehicle program timelines
Bringing battery electric vehicle development cycles into alignment with traditional powertrain vehicle program cycles requires changes to engineering team structures and toolsets. To address unique challenges like crash events including detailed battery models or vehicle-wide weight reduction initiatives, simulation-driven design processes enable optimized concepts to advance through the design stages with fewer redesign iterations and physical prototypes.

In the video below, Kent Bovellan, Vice President, Architecture for China Euro Vehicle Technology (CEVT AB) discusses their process for minimizing mass and maximizing performance using multi-disciplinary optimization.

Watch the CEVT Video

Design for Manufacturing
No matter how well a virtual model performed, it's useless if it cannot be manufactured in an efficient and cost-effective way. From traditional processes like metal or polymer extrusion, casting, or forming, to advanced manufacturing processes like selective laser melting (SLM) additive manufacturing, simulation can guide engineers to the materials and architectures that maximize the benefits of the given manufacturing process. Global automotive parts manufacturer, U-SHIN, uses casting simulation to optimize the injection speed of their die casting processes to remove turbulence due to air entrapment. They can also accurately predict critical porosity location zones to identify whether design modification is needed.

BMW was awarded the 2018 Altair Enlighten Award for their work with a metal 3D printed convertible roof bracket, which captured 44% component weight savings on the 2018 BMW i8 Roadster. This part was said to be the first 3D printed metal component used in a mass production series vehicle. Leveraging simulation, BMW was able to use topology optimization to reduce component mass, then run manufacturing simulation to determine the print behavior and orientation that would allow them to print entirely without the use of supports.

Upon receiving this award, Maximilian Meixlsperger, Head of Additive Manufacturing Metal at BMW Group, stated the clear lightweighting opportunities additive manufacturing provides. Mass production of additive manufactured parts would have been unheard of until very recently, but now BMW and other automakers are beginning to integrate this process into their standard design and manufacturing approach.

BUILDING A COMPREHENSIVE DESIGN AND DEVELOPMENT TECHNOLOGY STACK

To build a sophisticated, performance-driven electric vehicle development program, you need tools the right tools for the job. Below are suggested software categories you should consider to help design, optimize, and bring your project to market.

System modeling and controls
- Integration of electric motor, battery, power electronics

Mechanical
- Noise, Vibration, and Harshness
- Computational Fluid Dynamics (CFD)
  - Thermal
  - External aerodynamics
- Structural analysis
  - Static and dynamic loads
  - Linear and nonlinear
  - Generative design / topology optimization (lightweighting, packaging, vehicle architecture)
- Multi-body simulation
  - Weight distribution
- Crash
  - Occupant safety
  - Battery pack safety and impact analysis

Electrical
- Electronics & embedded software
  - Controls
  - Thermal / cooling
- Motor analysis and low-frequency electromagnetics
  - Motor pre-design
  - Detailed motor design
- High-frequency electromagnetics
  - EMC/EMI
  - Antenna design
  - V2X

Enabling technology
- Cloud computing, virtual appliance
- On-site physical appliance
- Multiphysics/multi-disciplinary optimization

THE ROLE OF OPTIMIZATION AND MACHINE LEARNING IN E-MOBILITY DEVELOPMENT

Multi-disciplinary optimization is a powerful way to account for the performance outputs and requirements of many complex and disparate systems within an electric vehicle and find an ideally balanced final design. Design of experiments and response surface optimization are two such processes that help engineers leverage multiphysics environments to arrive at optimized designs.

Always looking for ways to improve the accuracy and robustness of these outputs, vehicle designers are turning to machine learning to help build predictive models that leverage the simulation data and performance optimization results of these multi-disciplinary optimization processes.

For a project such as the maximization of the power output of an electric motor while minimizing base torque ripple, optimization software like Altair HyperStudy can be automated to collect simulation data and perform design of experiment sampling studies from multiphysics analysis results, which connects to machine learning software like Altair Knowledge Studio to build a predictive model. Data profiling and prep is performed within the machine learning software, then is deployed to create predictive models such as linear and logistic regression models, PLS regression, constrained regression, regularization, or deep learning neural networks. These advanced predictive models then feed back into the optimization to produce designs that better reflect real-world behavior while meeting performance goals across all vehicle systems.

The market valuation of automotive artificial intelligence is expected to reach $12 billion by 2026.

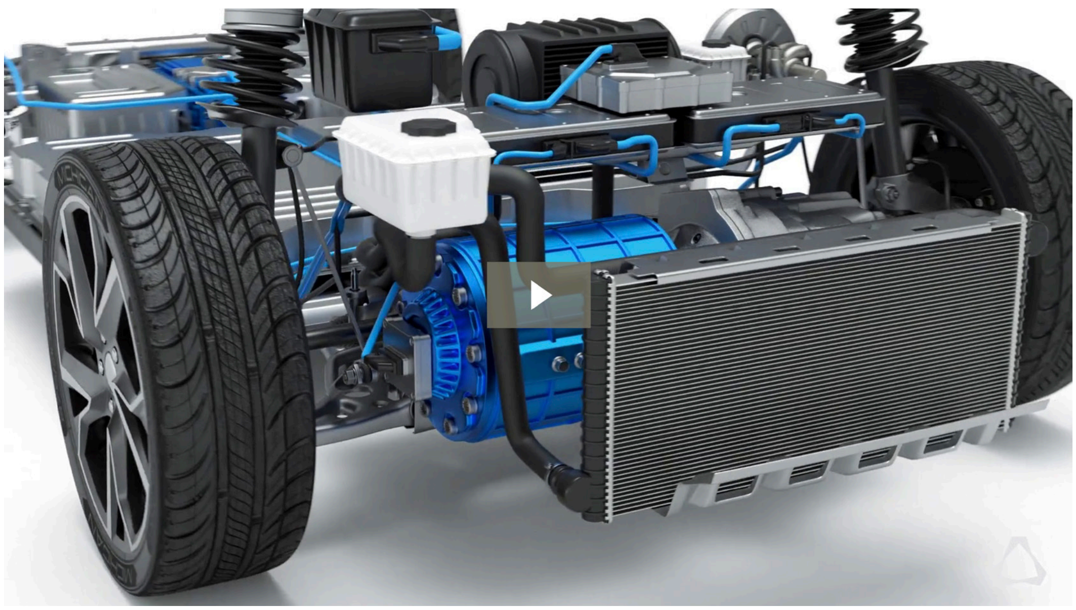
Wadhwani, Preeti and Kasnale, Sachin. (2019) "Automotive AI Market Size worth over $12bn by 2026". Global Market Insights. 18 December 2019. https://www.gminsights.com/pressrelease/automotive-ai-market GlobeNewswire, Inc. Accessed 24 February 2020.

WORKING WITH ALTAIR

"[Altair] is making a difference in this whole world of simulation and helping us design totally new systems."

Dr Gero Kempf, Chief Engineer, Jaguar Land Rover

Altair provides leading edge simulation technology and consulting services to the world's top electric vehicle OEMs and suppliers. With the industry's most comprehensive suite of physics solvers and integrated multiphysics workflows, pervasive optimization, and data intelligence solutions, Altair is a powerful innovation partner for your next e-mobility program.



Watch the Video

Altair is a global technology company that provides software and cloud solutions in the areas of simulation, high-performance computing (HPC), and artificial intelligence (AI). Altair enables organizations across broad industry segments to compete more effectively in a connected world while creating a more sustainable future.

To learn more, please visit www.altair.com