Ansys ADVANTAGE

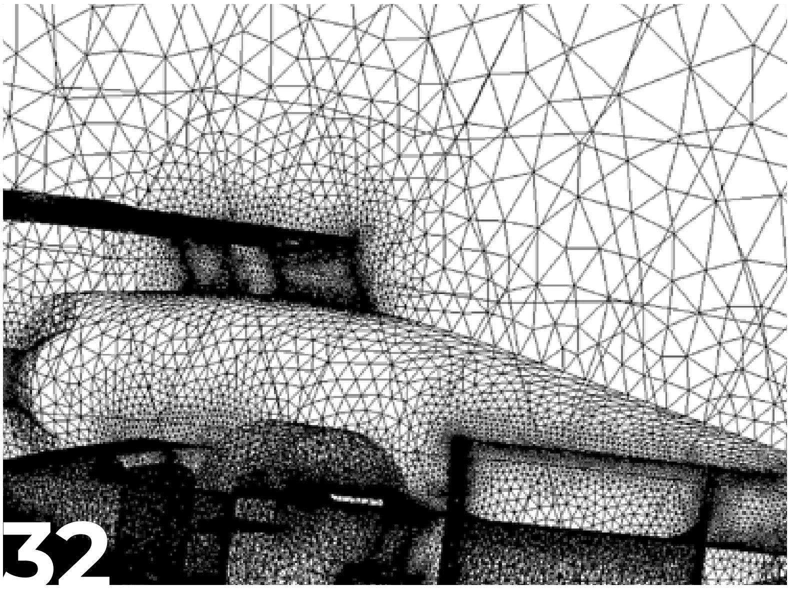
POWERING INNOVATION THAT DRIVES HUMAN ADVANCEMENT

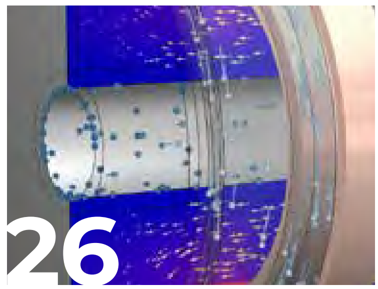
ISSUE 3 / 2023

DRIVEN BY SIMULATION

Ansys

Table of Contents





Focus on Automotive

DIGITAL DOWNLOAD

Ansys.com/advantage-magazine

ADVANTAGE

Welcome to Ansys Advantage! We hope you enjoy this issue containing articles by Ansys customers, staff and partners.

The Editorial Staff
ansys-advantage@ansys.com

Editorial Adviser
Kim Woodham

Executive Editor
Jamie J. Gooch

Managing Editor
Tim Palucka

Contributors
Laura Carter, Judy Curran, David Dang, Tim Palucka, Jennifer Procario, Aaron Talwar, Scott Wilkins, and Kim Woodham

Editorial Contributor
Ansys Customer Excellence

Art Director
Ron Santillo

Designer
Dan Hart Design

ANSYS, Inc.,
Southpointe, 2600 Ansys Drive, Canonsburg, PA 15317

Visit Ansys.com/advantage-magazine

Powering Innovation That Drives Human Advancement

When visionary companies need to know how their world-changing ideas will perform, they close the gap between design and reality with Ansys simulation. For more than 50 years, Ansys software has enabled innovators across industries to push boundaries by using the predictive power of simulation. From sustainable transportation to advanced semiconductors, from satellite systems to life-saving medical devices, the next great leaps in human advancement will be powered by Ansys.

Ansys is the global leader in engineering simulation. We help the world’s most innovative companies deliver radically better products to their customers. By offering the best and broadest portfolio of engineering simulation software, we help them solve the most complex design challenges and engineer products limited only by imagination.

Automakers Are Tackling Their Biggest Challenges Using Simulation

By **Judy Curran**, Senior Chief Technology Officer, Automotive and Transportation, Ansys

The automotive industry is one of the largest and most influential markets on the planet. It is currently experiencing more change than in the hundred years prior. The ever-changing landscape in the industry stems from rapid technological innovations, regulations associated with environmental and safety challenges, and customer and market expectations. Automotive original equipment manufacturers (OEMs) and suppliers are simultaneously grappling with the need to increase the electric vehicle (EV) adoption rate, add more capable assisted driving features, and innovate more personalized experiences for connected consumers. At the same time, they must continue to stay abreast of market challenges such as keeping vehicles affordable, understanding the quickly changing use cases of artificial intelligence and machine learning (AI/ML), and protecting against data breaches and cybersecurity.

For decades, automakers have used simulation to cut costs and time and improve quality in applications such as aerodynamics, durability, crashworthiness, and combustion. Today, the need to use simulation has grown exponentially to address all facets of vehicle design as the automobile becomes more complex. Let's look at some of the use cases in the areas of electrified powertrains, assisted driving, and software-defined vehicles.

DESIGNING ELECTRIFIED POWERTRAINS

The urgency to transition vehicles to fully electric powertrains is top of mind in the industry. In some sense, electric powertrains are much easier to design because they have fewer components; gone are the hundreds of expensive, intricate parts such as radiators, pistons, fuel tanks, and spark plugs. But the industry still grapples with the biggest, most significant, and expensive component of the EV: the battery.

Simulation workflows are essential in developing the optimal size, package, and range of a battery. Effective simulations must detect and mitigate battery thermal run-aways during crashes, charging, and under extreme operating conditions. Physics-based reduced-order models (ROMs) of batteries are essential in the development of battery management software. Simulation is also critical in optimizing components with multiphysics design criteria — such as the structural, thermal, and electromagnetic requirements of the motor and power electronic modules. Optimizing these criteria simultaneously can only be done using simulation, which can explore thousands of design iterations at the same time it would have taken to design, build, and test a few iterations using the traditional method of physical prototyping.

A simulated lidar sensor image produced by Ansys AVXcelerate

ADVANCING DRIVER ASSISTANCE SYSTEMS AND AUTONOMY

Some predicted we would be fully autonomous by now, but many developers have pulled back or delayed previously optimistic goals due to challenges limiting the acceptance and growth of self-driving vehicles. The public concerns underscore what has always been a primary concern of the automotive industry: ensuring the safety of drivers and passengers.

With the growth of compute power, AI/ML, and sensor technology, the industry can now offer a host of active safety features in addition to the traditional passive/crash protection. The gradual introduction and adoption of advanced driver assistance system (ADAS) features such as adaptive cruise control, automatic braking, and automated parking has driven demand for more driving assistance as customers appreciate their benefits and automakers realize the endless innovations possible to protect their customers.

In the most complex systems it is no longer efficient, and sometimes impossible, to use the traditional design, prototype, and test development process. Simulation gives engineers the tools to navigate the complexities safely and efficiently. Rather than validating test cases over millions of physical miles, safe automated driving technologies can be virtually developed, tested, and validated in just a matter of days. Incredibly complex scenarios can only be identified by bringing safety analysis and simulation together to replicate real-world conditions and predict results much earlier in the development process.

SUPPORTING SOFTWARE-DEFINED VEHICLES

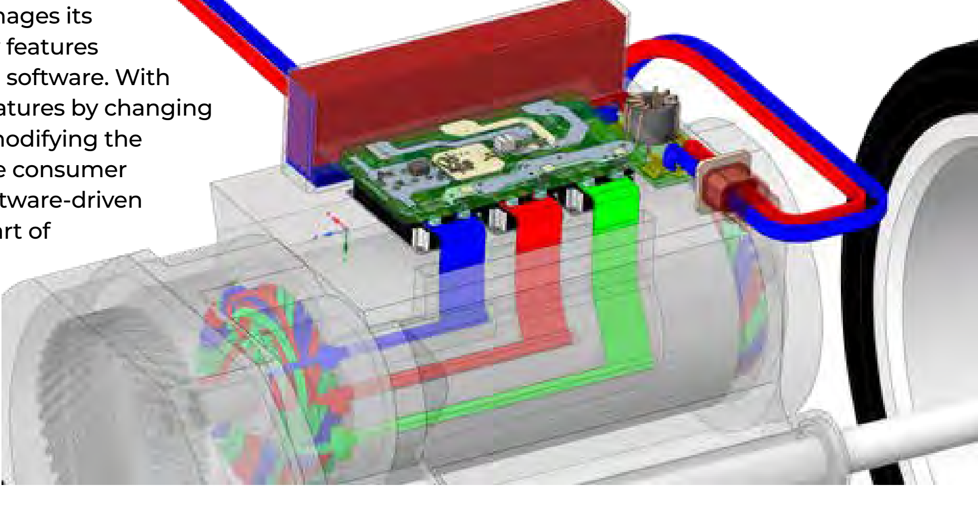
As the amount of software in a vehicle grows to over 100 million lines of code, the industry has realized the necessity of transitioning to a software-defined vehicle (SDV) architecture. SDV is commonly used in the industry to refer to a vehicle that manages its operations and enables new features primarily or entirely through software. With SDVs, OEMs can add new features by changing only the software, without modifying the hardware, like the cell phone consumer product and experience. Software-driven features are developed as part of the original vehicle design but are also updated after the vehicle is sold through over-the-air (OTA) transmissions.

Methodologies such as model-based systems engineering (MBSE) are critical to managing the requirements for these features over the vehicle's life; not only for the requirements of the changing software, but also the original hardware requirements. Functional safety and cybersecurity analysis and assessment is also critical as part of the original design but also as the software continues to be improved. Likewise, simulation should be used to design the original vehicle hardware, but then also used to validate the new software over the life of the vehicle using digital twin hardware models. Virtual validation is critical to assure safety and reliability before new software is dropped OTA to the customers' vehicles.

Although EV powertrains, ADAS features, and SDVs are the latest trends in mobility, innovation continues throughout all aspects of motor vehicles, including lighter, more sustainable materials; "smarter" electromechanical components; and new lighting/optical technologies, among others. Simulation is critical to help ensure that each component is optimized to achieve the highest quality, lightest weight, lowest cost, and smartest technology.

In this issue of *Ansys Advantage*, we tell the success stories of some of our customers who are using simulation and model-based methodologies to help address the increasing complexity of vehicle development. Only the most innovative and efficient will survive this transformation.

"For decades, automakers have used simulation to cut costs and time and improve quality in applications such as aerodynamics, durability, crashworthiness, and combustion. Today, the need to use simulation has grown exponentially to address all facets of vehicle design as the automobile becomes more complex."



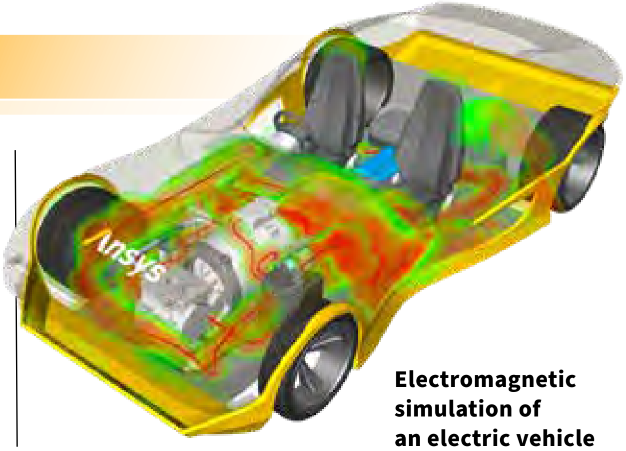
A simulation of an electric motor

Advancing Automotive Trends: Electrification, Autonomy, and AI Connectivity

By **Kim Woodham**, Senior Industry Marketing Manager, Ansys, and **Laura Carter**, Senior Marketing Communications Writer, Ansys

We've arrived at a major inflection point in the automotive industry. Everything we know about the journey from point A to point B is rapidly changing, punctuated by bursts of innovation. The road ahead is paved with exciting, yet unfamiliar, experiences. The trends that will define our future mobility experiences — namely, electrification, autonomous vehicles, and the connectivity and artificial intelligence that supports their operation — are enabled by simulation. Whenever there are uncertainties with next-generation technologies, simulation can help manufacturers and suppliers realize the promise of innovations faster.

The debate over whether automotive is going electric or not is over. All major original equipment manufacturers (OEMS) have announced plans to go fully electric within the next decade or two. Of all the factors that play a role in this transition, the biggest one is cost. How do you reduce the cost of engineering, materials, and EV production? At the same time, how do you make the product more reliable?



Electromagnetic simulation of an electric vehicle

> ***"Digital engineering through simulation helps companies innovate faster, better, and cheaper — from initial design to simulation-driven product development. And almost everyone is focused on using more simulation to help drive EV designs of the future."***
>
> — **DR. ZED TANG**, *Technical Account Manager, Ansys*

It's safe to say virtually everyone in the automotive space believes that digital engineering and digital innovation are the way to go. From specifications to systems validation, Ansys helps mobility innovators evolve their electrification strategies.

"Digital engineering through simulation helps companies innovate faster, better, and cheaper — from initial design to simulation-driven product development," says Dr. Zed Tang, Technical Account Manager at Ansys. "And almost everyone is focused on using more simulation to help drive EV designs of the future."

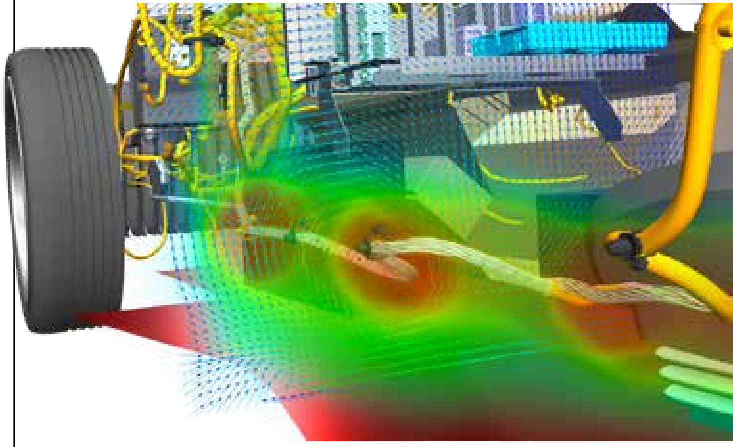
PUSHING THE BOUNDARIES OF EFFICIENCY

Within this new environment, OEMs and top-tier automotive suppliers face new challenges in pushing the boundaries of engineering design. Using an internal combustion engine as an example, improving overall efficiency by just a tenth of a percent is significant to extending vehicle range. But at the end of the day, you could also just increase fuel tank capacity by one more gallon to achieve a similar result.

This is not the case for EVs, as adding one or more battery modules to a vehicle adds significantly more weight — which impacts more than just the battery pack design. It would also require the size of the electric motor to be adjusted and additional cooling for the electronics. Suddenly, the EV is heavier, and more of the battery's energy is consumed. Now, companies must push the boundaries of EV design to reach maximum efficiency, because every bit of energy wasted can lead to a big disadvantage in the current market.

For this reason, engineers are doing whatever they can to push the boundaries of their design. If peak efficiency is 98%, everybody is trying to develop something that is 98.1%.

"So, what does it mean to engineers working in the field?" asks Tang. "You can't prototype enough or test enough to determine what that extra one-tenth of a percent is anymore. You have to dig deep, and how do you do that? You use simulation, because with simulation you can find out all of this. With some tweaks here and there with added automation and optimization, you can see results virtually and visually in a way that can help you understand much better how to extract that additional 0.1%."



Electromagnetic simulation of an EV cable bundle

AUTONOMOUS VEHICLES

We're still many years away from riding around town in an autonomous vehicle — and most of us aren't in a hurry to relinquish the steering wheel. In a recent survey conducted by the American Automobile Association, a majority of drivers favored improvements to driver assist systems already in place over the development of fully autonomous experiences. In fact, when asked, 85% said they were fearful or unsure of self-driving technology.[1]

However, automotive engineers continue to advance autonomous vehicle (AV) technologies to improve advanced

driver assistance systems (ADAS) and to approach full autonomy further down the road. Unaffected by driver input, AVs offer transformative safety opportunities for all vehicle occupants (and the pedestrians they encounter during their travels). They also have the potential to make transportation more accessible and equitable for everyone, improve air quality, and, through thoughtful urban planning, reduce traffic congestion and create greener spaces.

ELIMINATING HUMAN ERROR

"Essentially all the human factors you can think of that negatively influence driving would be reduced by the adoption of autonomous driving," says Gilles Gallee, Business Developer at Ansys. "So, to put these risk factors behind us, we must be able to confidently state that autonomous driving is safer than a human driver before we can fully embrace self-driving vehicles. As we advance through various levels of autonomy, the key question for OEMs is how to make the technology safer, and how to demonstrate that an AV is, in fact, safer than the human driver to the appropriate authorities."

In the case of autonomous technology, OEMs cannot replicate safety performance through testing alone. This means OEMs must use safety of the intended functionality (SOTIF) scenarios that apply a certain methodology of testing to show the safety of their systems. SOTIF (ISO PAS/21448) was specifically developed to address autonomous and semi-autonomous vehicle safety challenges faced by vehicle software developers.

To help meet the huge effort required for safety validation, Ansys safety analysis software, in conjunction with the autonomy simulation toolchain, combines simulation at scale with statistics and scenario-based analysis. It also enables virtual sensor simulation for perception testing and sensor behavior validation in real-world scenarios for efficient reliability analysis.

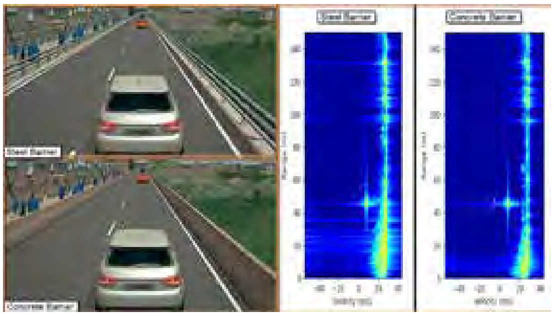
To demonstrate these capabilities, Gallee's team proposed that Mercedes should use Ansys design optimization tools in their demonstration of safety to German authorities. Their success using this method helped to make the Mercedes Benz 2022 S-Class the first L3 autonomous vehicle on the market worldwide.

VEHICLE CONNECTIVITY AND ARTIFICIAL INTELLIGENCE

The future of autonomy could very well be driven by insights gained from the sharing of vehicle information connected via high-speed wireless networks. Several factors must be considered to reach high levels of autonomy, including advanced sensor technology, precise determination of vehicle location, up-to-date mapping information, local perception of other vehicles and pedestrians, and planning and decision making.

To give you a feel for the magnitude of these interactions, in 2019 there were 31 million vehicles operating with some level of automation. By 2025, almost 60% of global new vehicle sales will function at level two (L2) autonomy[2]. Still, that represents limited inroads to full autonomy.

A huge computational task remains that will involve numerous in-vehicle applications requiring near real-time response. All this activity will be coordinated by artificial intelligence (AI) and a high level of connectivity supported by simulation at every turn — from safety validation to real-world sensor and antenna performance verification.



Radar simulation of range and velocity of an AV and surrounding vehicles

VEHICLE CONNECTIVITY: THE BRIDGE BETWEEN AI AND AV

Of course, many conversations need to happen between an AV and other elements within a self-driving ecosystem that rely on consistent, low-latency connectivity to expand perception beyond what is directly in front of the vehicle.

"Fully autonomous environments of the future will all be dictated by a larger communication grid coordinating vehicle movement," says Christophe Bianchi, a Chief Technologist at Ansys. "The vehicle in the city talks to the city, talks to the other vehicles, and all of that involves a mission going from one place to another safely. So, how do you simulate all the events, everything that's happening in the environment, plus all the communication required, including the quality of signals between all these different parameters? That's a mission for digital mission engineering software."

We're beginning to see some of these smart interactions play out now. For example, Autotalks, a fabless semiconductor company devoted to vehicle-to-everything (V2X) communications, has created a small apparatus that connects to the handlebar of your bicycle to avoid the risk of collision. This system connects to vehicles and related vehicle infrastructure as part of a broader mobility ecosystem, so that all vehicles, including bikes, will be connected and talking to the infrastructure and each other, monitoring traffic and sharing critical information in real time.

Reliable service and coverage are the most important success metrics that Autotalks, and other connected tech, will be measured by. Simulation enables 5G designers to achieve these objectives and increase product reliability while optimizing power, performance, and cost.

ARTIFICIAL INTELLIGENCE: THE BRAINS OF THE APPLICATIONS

AI relies on data, which is good for the automotive industry because data-driven insights, coupled with machine learning (ML), have accelerated self-driving technology. One big challenge related to ADAS and autonomous applications is that AI/ML requires a massive dataset that covers all fringe corner cases and works in cohesion with rule-based systems to achieve better performance.

Ultimately, it's through AI/ML-driven decision-making systems working closely with rule-based systems for AVs that the complexity of operating safely within a real driving environment is prioritized for safety. AI/ML systems can calculate the risk scores for any driver maneuver, giving them the necessary control to make a decision.

"In automotive AI/ML, one of the critical challenges is that the discovery of those rules becomes a hard problem when the data is not covering the entire space correctly," says Jay Pathak, Senior Director of Research and Development at Ansys. "On the road, multiple factors are in play, and the dataset coming out of any on-road interactions is a reflection of all these environmental factors happening together; whereas, to discover all of them independent of each other, we simply don't have the data. This presents a big challenge in the automotive machine learning community."

Obtaining the necessary data will involve a shift away from big data to useful data, as well as unsupervised AI learning methods augmented by simulations, to create challenging dynamics in datasets which otherwise will be difficult to find in real situations. AI applications in autonomous driving will absorb data from innumerable driving simulations to better inform autonomous control software of how to react in any driving situation.

Accelerating electrified and autonomous driving to meet current industry trends demands extraordinary solutions. Behind nearly every on-road communication and every cloud-based data exchange is a corresponding Ansys solution. Mobility leaders are benefiting from a vast portfolio of Ansys simulation and software-related tools to drive the next wave of vehicle technology.

References

1. *AAA Survey Reaffirms Public Skepticism Over Self-Driving Tech, IoT World Today, May 20, 2022.*
2. *Autonomous Vehicles World Wide - Statistics & Facts, statista.com, September 23, 2022.*

LEARN MORE

Ansys Technology Trends:
Ansys.com/technology-trends

Keep Pushing:

Oracle Red Bull Racing Overtakes Design Challenges with Simulation

By **Laura Carter**, Senior Marketing Communications Writer, Ansys

See how a racing team's winning aerodynamic strategy takes shape in a virtual testing environment in Ansys' latest docuseries Driven by Simulation.

It's a truly exciting time for racing fans, as Max Verstappen and the rest of the Oracle Red Bull Racing team speed through another successful season. However, Verstappen's driving skill is only part of Oracle Red Bull Racing's success, as he has to rely on the car itself. In fact, Oracle Red Bull Racing Tech Chief Pierre Wache recently identified the efficiency of their 2023 Oracle Red Bull Racing RB19 Formula One car design as the single biggest force behind Verstappen's unprecedented season this year.

So, what does efficiency mean in the context of Formula One? For Wache, it's directly linked to aerodynamics, or the science of airflow, which considers the properties of the air as it moves and its interaction with solid objects moving through it. To illustrate this idea, imagine sticking your hand out the window, palm to the wind, and feeling the force of the wind pushing back as you drive. On the track, this force is significant, as Formula One cars experience airflow around a car traveling at speeds in excess of 223 mph (358 kph).

THE DOWNSIDE OF DOWNFORCE

Racing aerodynamics are primarily a function of the front end of the vehicle, including the overall shape, side mirrors, ducts, suspension, and vehicle floor. The objective of Formula One design is to streamline a car's shape to generate a lot of downforce, or aerodynamic force that pushes the car down on the track. As the air goes up, over, around, and underneath the car, downforce increases its grip, stability, and cornering at high speeds.

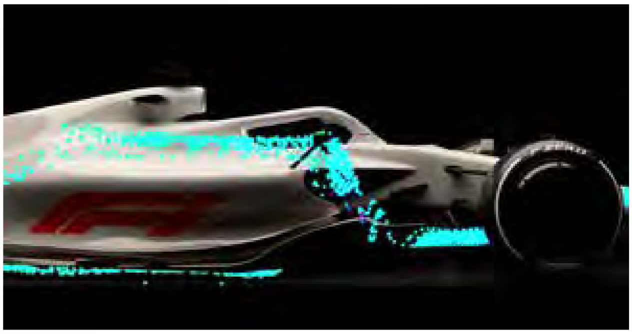
However, the downside of downforce is that it creates drag that can slow the car down. The faster the car goes, the more resistance, or drag force, it faces as it accelerates forward. The imperative for Oracle Red Bull Racing is to strike the perfect balance between both downforce and drag in a winning vehicle design, which traditionally requires a lot of wind tunnel time the team doesn't have.

The challenge was exacerbated during the 2022 season. Several new front wing and nose design requirements introduced by Formula One and the FIA (the governing body of motorsport) in 2022 were announced that would radically influence other parts of the car.

And while aero is a significant factor in designing the front end of the car, the floor design was also critical. Within the rules for 2022, the cars now rely on ground effect, effectively channeling the air flow underneath the car rather than over the top to reduce the effect of dirty air — or turbulent air currents caused by fast-moving cars — on following cars, with the aim of making overtaking easier during a race.

For Oracle Red Bull Racing engineers, this turn of events was a huge shift from a focus on the wings and other aero surfaces to the exploitation of the underside of the car.

In the end, what could have been considered a major setback has instead inspired the Oracle Red Bull Racing team to double down on a more efficient strategy with help from Ansys, an Oracle Red Bull Racing Innovation Partner since 2008. Ansys simulation is helping the world's greatest motorsport teams heighten their competitive edge.



Ansys Fluent simulation showing air flow under and over the Formula One race car chassis

HITTING THE APEX OF AUTOMOTIVE ENGINEERING WITH SIMULATION

When you're a driver sitting on the grid and the whole world is watching, there's no time to assess the enormous complexity of the race ahead, despite the risks. Self-doubt is replaced by determination and complete focus, as any miscalculation on the track can be costly — or even fatal.

Like Formula One drivers, Oracle Red Bull Racing's engineers have no room for error. They are tasked to push the boundaries of automotive engineering and design to evaluate, test, and optimize aero-critical components and assemblies, including braking, cooling, and exhaust

assemblies before the season begins. All this activity is shaped by varying track topographies and conditions faced by both car and driver on the circuit.

To tackle their aerodynamic challenges, Oracle Red Bull Racing engineers pivoted to simulation to test a computer-aided design (CAD) model of the car's exterior in a virtual wind tunnel. Iteratively testing different versions of their designs in a virtual environment enables faster, more economical analyses. The Oracle Red Bull Racing team gathered simulation data they could then validate against a physical prototype of their final concept in an actual wind tunnel.

Specifically, Oracle Red Bull Racing employs Ansys' simulation solutions to analyze aerodynamics and engine cooling intakes with Ansys Fluent fluid simulation software. The Oracle Red Bull Racing team also conducts materials data management and optimization with Ansys Granta MI material data management software and performs virtual impact testing with Ansys LS-DYNA explicit simulation software.

"Simulation is now a really key part of our development process for all sorts of parts for the car — but critically, aerodynamics," says Zoe Chilton, Head of Strategic Partnerships, Oracle Red Bull Racing in the first episode of Driven by Simulation, the latest Ansys docuseries. "When we think about computational fluid dynamics simulation, the biggest job that it serves, probably on the chassis side, is how the exterior of the car is going to be shaped. And that's not just individual components, but the whole concept. How do we create downforce, how do we make the car heavier as it goes faster, and how do we get the balance right between downforce and straight-line speed? Because different circuits require different things from the car."

A major component of Oracle Red Bull Racing's competitive edge comes from their ability to engineer, test, tweak, and adapt its winning vehicle design continuously, right up until race day. For more insight, tune into episode one of Driven by Simulation to hear Oracle Red Bull Racing talk simulation and aerodynamic strategy.

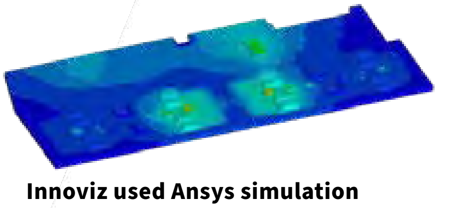
See how simulation is a key part of the development process in episode 1, "Pursuing Perfection," of Driven by Simulation at DrivenBySim.com.

Simulation Is Changing the Perception of Self-driving Tech

By **Laura Carter**, Senior Marketing Communications Writer, Ansys

While opinions on the adoption of autonomous vehicles (AV) vary, one thing's for certain: Self-driving technology is one of the biggest emerging markets in the automotive space. By 2035, autonomous driving is projected to create $300 billion to $400 billion in revenue in the passenger car market.[1]

Still, for any autonomous vehicle to safely perform without human intervention, it must be able to sense, analyze, and act upon the immediate environment more consistently, even better than a human driver possibly could. Mastering autonomous tech sufficient to achieve this level of performance is no small feat. Be it advanced AVs or partially autonomous vehicles with advanced driver assistance system (ADAS) features, both rely on a complex network of lidars, radars, cameras, and GPS hardware, along with the navigational software needed to collect and process data critical to vehicle surroundings. To get from point A to point B safely, AVs need 360-degree views of the environment, which is precisely what their sensor architecture is striving to provide.



Innoviz used Ansys simulation software to help develop its InnovizOne solid-state lidar.

The second episode of our online docuseries, Driven by Simulation, explores the work of two startups: EasyMile and Innoviz Technologies. Both are using Ansys simulation to improve perception around the driverless technologies of the future in more ways than one.

EASYMILE SHUTTLE DEMONSTRATES ELECTRIC, AUTONOMOUS VEHICLE SAFETY

Which electric vehicle (EV) can move up to 12 people comfortably, see up to 320 feet (97 meters) ahead, and 130 feet (40 meters) on either side while moving at 25 mph (40 kph) for up to

“We do a lot of analysis with Ansys solutions like medini analyze in order to model the complex systems against all the potential scenarios, and then we switch to the integration and simulation tools in order to see if all of the additional safety and cyber systems we recommend for safety and cybersecurity work well.”

— **ROMAIN DUPONT**, *Safety and Cybersecurity Manager, EasyMile*

16 hours on one battery charge without a driver?

It’s the EZ10, EasyMile’s driverless all-electric shuttle that operates at Level 4 (L4) autonomy. At this level, there is no human supervisor onboard the EZ10 during operation. Instead, its movements are monitored remotely while performing within specified operating domains.

After almost seven years of operation, these vehicles continue to wind their way through college and corporate campuses, hospital grounds, stadium surroundings, and city centers in places like Denver, Colorado; Toulouse, France; Berlin, Germany; Adelaide, Australia; and Singapore, Southeast Asia, to name a few.

Based on the shuttle’s success, EasyMile has also extended the same level of autonomy to TractEasy, an autonomous tractor designed for material handling and industrial environments.

Of course, the EZ10 isn’t traveling at the speeds a traditional passenger vehicle might. However, whether you’re traversing city streets or your local university, safety is the top consideration. The shuttle needs to see past any roadblocks that could compromise its operation, including pedestrians, vehicles, or other objects that cross its path.

An in-house EasyMile software package a nd embedded system act as the “brains” central to vehicle operation and help automate both the EZ10 and TractEasy transportation platforms. The software coordinates with numerous vehicle sensors to collect data on the surroundings, which is shared with EasyMile to provide localization, perception, and path planning. The harmonious interaction of these technologies results in more automated, less infrastructure-centric environments.

Romain Dupont, Safety and Cybersecurity Manager at EasyMile, and Driven by Simulation host Miss Emma Walsh step out of the EasyMile EZ10 autonomous shuttle.

Ansys medini analyze, with support from Ansys and Ansys Elite Channel Partner CADFEM, helps sort through the complexity of all of this data to define and demonstrate the safety of EasyMile’s autonomous products. Specifically, medini analyze acts as a turnkey solution that includes all of the tools needed to conduct the level of safety analysis required by EasyMile’s customers, and to provide necessary safety documentation needed for regulators. Also top of mind for EasyMile is cybersecurity. The threat of hacking by foreign actors can significantly impact operational safety, an activity that can be mitigated preemptively by EasyMile with the help of Ansys solutions.

“We do a lot of analysis with Ansys solutions like medini analyze in order to model the complex systems against all the potential

EasyMile’s Romain Dupont (left) and Julien Martin inspect a safety calculator.

scenarios, and then we switch to the integration and simulation tools in order to see if all of the additional safety and cyber systems we recommend for Safety and Cybersecurity work well," says Romain Dupont, Safety and Cybersecurity Manager at EasyMile. "We do cyberattacks in the end to prove that it works well for our customer to present to regulation authorities, but also to a safety assessor in order to get a stamp at the end saying we're approved, and all the attacks are known and well-managed."

INNOVIZ TECHNOLOGIES BUILDS A BETTER LIDAR

When you consider that human error accounts for a huge number of vehicle accidents, then removing the driver from the equation is a logical next step to safer automobile travel. In a new, driverless reality, vehicle perception is everything. Sensing tech holds the key to overcoming perception challenges in both driver-assisted and driverless environments.

The second half of Driven by Simulation episode 2 drills down on Innoviz Technologies' lidar that enables a car to interpret the variable distance between itself and another object in its path.

Lidar is coveted by original equipment manufacturers and automotive suppliers for its ability to capture high-resolution, long-range 3D images. By sending light beams in all directions via pulsed laser, an object's distance from a vehicle can be calculated based on beam bounce-back to a laser scanner. Recording each laser beam's reflection point, an onboard computer generates a point cloud, which is a 3D representation of the objects around it.

This explanation of Innoviz lidar sounds simple enough. But for OEMs, lidar must meet performance, reliability, and cost requirements in a more compact design — a rarity in the marketplace. Producing a new design using a traditional build-test-iterate approach can take years. Additionally, the solution must be designed to the highest level of accuracy before production, which often results in a long development arc defined by a costly number of iterations.

To address these challenges, Innoviz turned to Ansys simulation to drive real, substantive change in lidar solutions. Using various Ansys products helped Innoviz streamline development and achieve its first-time validation target for its flagship product, InnovizOne solid state lidar. InnovizOne is a high-performing, low-cost lidar in a smaller package than traditional solutions.

Oren Buskila, Chief R&D Officer and Cofounder at Innoviz Technologies

"Developing the lidar was, and is, super challenging because we need to take so many different conditions and requirements into consideration," says Oren Buskila, Chief R&D Officer and Cofounder at Innoviz Technologies. "We get several thousands of requirements from our customers that our product needs to comply with. And this is where simulation comes in very handy, or actually critical."

All aspects of development were done in-house at Innoviz, enabled by many Ansys tools and solvers, including:

- Ansys Mechanical for structural analysis that leads to more robust mechanical and optical system parts.
- Ansys Fluent for thermal analysis to understand airflow around the component.
- Ansys Maxwell to understand the electromagnetic elements of individual system parts.
- Ansys Zemax OpticStudio to run both sequential and non-sequential optical simulations to achieve the desired light path integral to accurate object detection.

TUNE IN TO DRIVEN BY SIMULATION TO SEE SELF-DRIVING IN A NEW LIGHT

From self-driving shuttles to the sensing technology that helps them "see" what's ahead, EasyMile and Innoviz are challenging (and changing) perceptions around how we'll move. Be sure to catch "How We'll Move," Episode 2 of Driven by Simulation at DrivenBySim.com to learn how Ansys is helping to bring advanced driver assisted systems and self-driving technologies to market.

REFERENCES

1. Autonomous Driving's Future: Convenient and Connected, McKinsey & Company, January 6, 2023.

How Ferrari **Aerodynamic Excellence** Makes the World Dream

By **Laura Carter**, Senior Marketing Communications Writer, Ansys

At the Ferrari Challenge Trofeo Pirelli, simulation sets the pace for outstanding on-track performance.

October 2023 marked yet another historic moment in Ferrari history with the debut of the 296 Challenge, the ninth model to appear in the Ferrari Challenge Trofeo Pirelli. The event brings together Ferrari customers on four continents to compete in a series of sprint races organized by ability — from gentlemen racer to professional driver.

For this particular event, Ferrari is focused on designing a track-ready car that delivers an exciting, yet safe, race-day experience for everyone who takes the wheel, regardless of skill level. To do this, the Italian automotive manufacturer must find a compromise between peak performance and more predictable vehicle behavior that relies heavily on aerodynamics.

Every three years, Ferrari spends 12 months transforming a single production car model, limited by street laws and long-term reliability, into a track-ready, high-performance race car. Part of the Prancing Horse single-make series, the 296 Challenge car has undergone substantial modifications with the help of Ansys simulation software to maximize performance in a unique aero design.

FERRARI MAINTAINS ITS GRIP ON PERFORMANCE WITH ANSYS FLUENT

On raceways around the world, aerodynamics can mean the difference between first place champagne moments or passing the checkered flag with the middle of the pack. Success in this context requires a careful consideration of downforce, an element of aerodynamics that can increase the speed of a race car during braking, cornering, and

The 296 Challenge's optimized aero package delivers 870 kgs of downforce at 250 km/h, which is unprecedented in its class. Its strategically angled spoiler, extreme braking system, and a custom tire design help the car maintain a strong grip on handling and

Computational fluid dynamics simulation of the airflow around the 296 Challenge car

> ***"The addition of this solver to our computational fluid dynamics (CFD) workflow will have a tremendous impact on our aerodynamics designs in the future. This 8X productivity increase will empower us to achieve improved accuracy with more complex turbulence modeling and realize many more design variants than previously possible."***
>
> — **MASSIMO BENDAZZOLI**, *Ferrari Challenge Product Technical Manager*

accelerating. As the air moves over various vehicle surfaces, downforce adds weight that pushes down on the vehicle and makes it more stable on the track.

Downforce is really helpful because it increases tire grip as well as handling while cornering to help maintain a higher speed. On a straightaway, not so much, as downforce creates drag that can slow a vehicle down. Consequently, translating these interactions into a winning vehicle design optimized for aerodynamics can be complicated.

To manage these on-track interactions and meet event-specific design requirements, Ferrari engineers used Ansys Fluent fluid dynamics simulation software to fine-tune the 296 Challenge's big rear wing spoiler and many other auxiliary aerodynamic devices. The race car also needed a different radiator design layout to increase heat rejection efficiency (the ability of the radiator to reject heat) and an upsized power unit (engine) design validated by simulation.

performance in a streamlined design fine-tuned for aerodynamics, thanks to simulation.

BREAKOUT SIMULATIONS THAT RUN EIGHT TIMES THE SPEED OF ONE

Up to this point, Ferrari has been running steady-state, low-fidelity simulations to investigate a large enough design space needed for optimization of a vehicle geometry that satisfies performance requirements. A team led by Matteo Aroni, Senior Application Engineering Manager at Ansys, saw an opportunity to speed this process, and decided to put Ansys Fluent's native multi-GPU solver to the test to see by just how much.

Running his own tests against the new 296 Challenge vehicle design, Aroni discovered that with a multicore graphics processing unit (GPU) and impressive memory bandwidth, the solver makes shorter lead times possible.

Natively developed for GPU architectures, the multi-GPU Fluent solver unleashes unprecedented throughput, which enabled

Aroni to run eight simulations of the 296 Challenge in the time it normally takes to run one.

Drilling down on this discovery a little further, a simulation taking more than 5 hours on 256 CPU cores can be run in 40 minutes on eight NVIDIA A100 GPUs. For less time-bound tasks that do not need a throughput increase, the same throughput can be achieved, reducing hardware costs by 5X and energy consumption by 7X.

"Ferrari Challenge cars represent the pinnacle of racing performance for generations of commercial cars, and we are proud to help them engineer new aerodynamic designs that will lead to more victories on the track," says Aroni. "Motorsport teams like Ferrari's are always looking for performance advantages, and the Fluent native multi-GPU solver accelerates the solving process to give them that competitive edge. By answering design questions sooner, it can maximize production efficiency to support tight developmental timelines common to motorsport."

PARTNERSHIPS DRIVE CHAMPIONSHIPS

Clearly, the magic happening behind the scenes that led Ferrari to extend its partnership with Ansys was fueled by more than software. While the multi-GPU Fluent solver was not used to develop the 296 Challenge, results from Aroni's analyses of its design were enough to impress Ferrari — so much so that they have committed to using it to optimize future Ferrari Challenge vehicle designs.

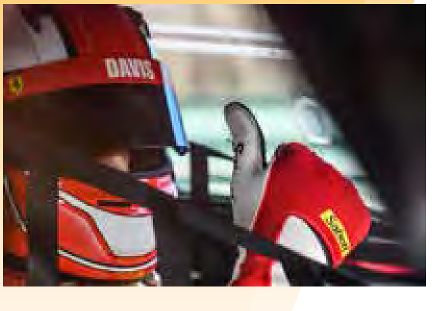
"The addition of this solver to our computational fluid dynamics (CFD) workflow will have a tremendous impact on our aerodynamics designs in the future," says Massimo Bendazzoli, Ferrari Challenge Product Technical Manager. "This 8X productivity increase will empower us to achieve improved accuracy with more complex turbulence modeling and realize many more design variants than previously possible."

Tune into episode three of Driven by Simulation (DrivenBySim.com) to see how Ansys helps Ferrari chase perfection — from accelerating development of new car concepts to providing the real-time insights needed to guide on-track decision making.

DID YOU KNOW?

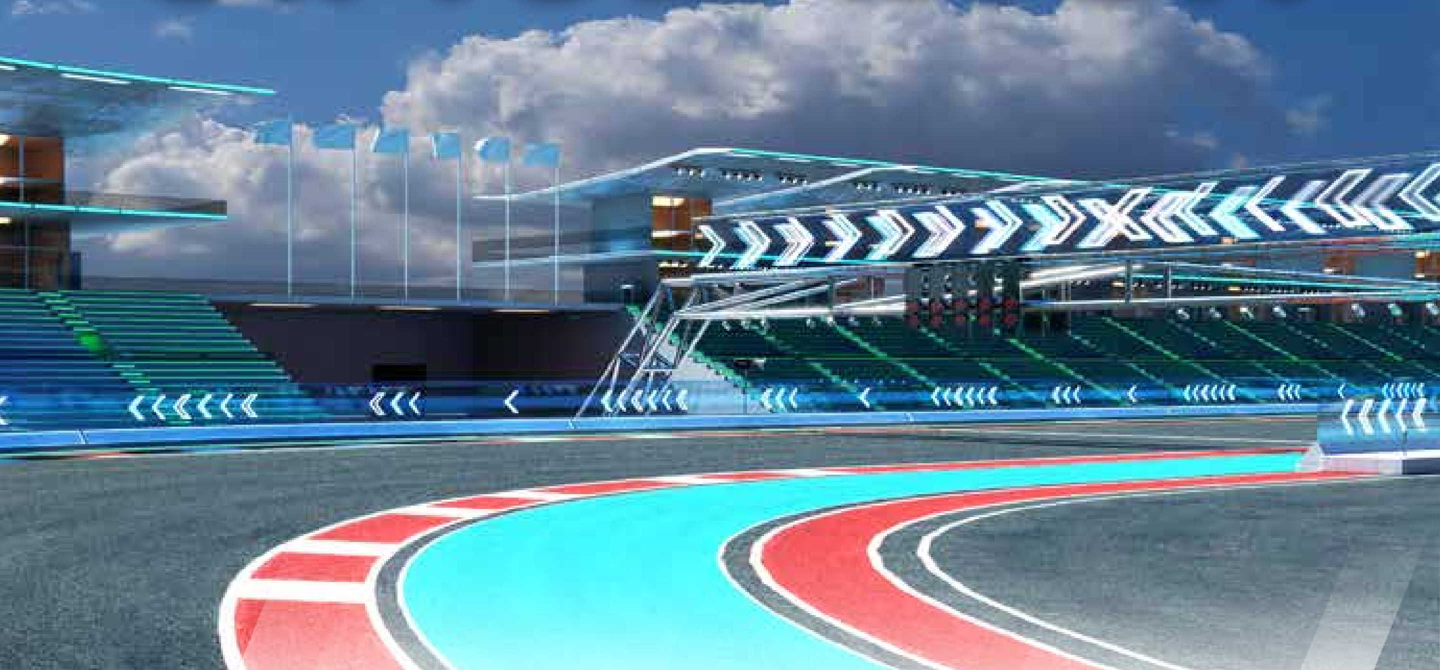
The Ferrari Challenge Trofeo Pirelli is a once-in-a-lifetime opportunity. Established in 1993, the event has been described as both a hardcore racing competition, and a lavish celebration for gentleman drivers and their guests.

Participants are treated to a high-end professional racing experience — including factory-built race cars, meticulously groomed tracks, veteran driver coaches, International Motor Sports Association (IMSA) racing officials, and televised coverage of the entire event. After, racers are treated to a lavish meal prepared by Italian chefs, parties, and new-model introductions.



This event reflects Ferrari's commitment to meeting the expectations of owners and drivers while upholding its iconic brand identity. And it all began with founder and race car driver Enzo Ferrari's passion for perfection in vehicle design.

TAG Heuer Porsche Formula E Team Races Toward Efficiency with SIMULATION



By **Laura Carter**, Senior Marketing Communications Writer, Ansys

As we amp up to an all-electric automotive future, original equipment manufacturers like Porsche are testing out the agility of some of the fastest, lightest vehicles ever made. There's really only one competition on the planet in which you can see electric cars speeding down city streets for 45 minutes at up to 200 miles per hour, and that's the ABB FIA Formula E World Championship.

Formula E racing isn't just about power; it's about how efficiently you use it to win a race. Here, being the fastest coincides with being the most efficient, and losses are measured not only in kilowatts, but in milliseconds. To meet this all-electric challenge, every aspect of a Formula One racer has been rethought, redesigned, and rebuilt for high-performance, efficient, sustainable racing.

> ***"By comparing our pre-event simulation data with the data we gained on the track during practice sessions, we can evaluate if our estimations on track conditions, such as grip or temperatures, match reality. Using data to analyze these differences and root out causes enables us to improve our simulation models and adapt our overall strategy before the race."***
>
> — **LEONARD MENGONI**, Development Engineer - High Voltage Power Units in the Motorsport Department, Porsche Motorsport

To realize a winning level of efficiency, Gen3 electric powertrains must be optimized over a wide range of operating points. These performance requirements extend to different tracks on multiple continents over varying terrains, where a combination of efficiency and speed rules the day.

ONGOING OPTIMIZATION LEADS TO SMARTER ENERGY CONSUMPTION

Leonard Mengoni at Porsche Motorsport understands the challenges of ABB FIA Formula E racing and the impact efficiency will have on electric race car development in the future. He is one of several design engineers involved in the ongoing optimization of the Porsche 99X Electric Gen3 Formula E racer's electric powertrain. He uses simulation as a guidepost involving any number of variables to benchmark and to help maintain the highest level of efficiency during a race.

"During a race there can be different scenarios, like a safety car or full course yellow, that result in additional laps that must be completed," says Mengoni. "As soon as such an event occurs, the target for energy consumption of the driver is adapted. We also monitor our competitors to estimate which strategy they are using and adapt our strategy to that."

Mengoni's team routinely looks to detailed models of powertrain components to identify opportunities for optimization and lightweighting of the Porsche 99X Electric's electric machine and its inverter. From there, the team makes incremental changes to achieve the highest level of efficiency over an entire race. Having an efficient powertrain helps the TAG Heuer Porsche Formula E Team during the race, as they can use the amount of energy saved through optimization to overtake their competitors.

"By comparing our pre-event simulation data with the data we gained on the track during practice sessions, we can evaluate if our estimations on track conditions, such as grip or temperatures, match reality," says Mengoni. "Using data to analyze these differences and root out causes enables us to improve our simulation models and adapt our overall strategy before the race."

ANSYS PUTS PORSCHE'S POWERTRAIN CONCEPTS TO THE TEST

The latest iteration of the Porsche 99X Electric Gen3 car is a significant departure from its

The Porsche 99X Electric taking a lap at the 2023 Cape Town E-Prix. TAG Heuer Porsche Formula E Team driver António Félix da Costa went on to win the race.

The TAG Heuer Porsche Formula E pit crew zooms in on the technical details to support Porsche 99X Electric at the 2023 Cape Town E-Prix.

predecessor. It has a higher power drive and energy recuperation, but less battery capacity, which required the team to find the right balance between high power density and high efficiency.

Before any testing and validation activities begin, possible hardware and software powertrain modifications are simulated to judge their potential. It's in the predevelopment stage that simulation plays a particularly critical role, as there are many technologies and powertrain topologies to choose from. Determining the most promising approach before testing ensures the team uses testing time as efficiently as possible.

Ahead of season nine, the TAG Heuer Porsche Formula E Team looked to the increased power level of the car as motivation to investigate a broad range of powertrain concepts. Having initially analyzed different powertrain variants, the team could not decide on a path to follow. So, revisiting their analysis with simulation, considerable time was given to drill down further on the details around how loss is generated in the components and how that loss could be modeled in the most efficient manner.

The TAG Heuer Porsche Formula E Team did a lot of iterative work using simulation to develop a powertrain that is efficient under virtually every condition. Specifically, the team used Ansys Maxwell 2D and 3D for electric machine simulation, as it offers many degrees of freedom and number of parameters in the model that are estimated from the data. Support from Ansys experts enabled the TAG Heuer Porsche Formula E Team to incorporate additional loss models and take the switched output voltages of the inverter into account.

Ansys Motor-CAD software was also used to evaluate the thermal performance of the electric machine, as the team found it delivers quick but precise results. For the inverter, the team relied on a mixture of analytic calculations and an inverter model in Ansys Twin Builder software for more detailed calculation and validation of its designs.

HOW SIMULATION MEASURES UP DURING VALIDATION

In a racing environment, every simulation must be validated by measurement. Whenever simulation is used during predevelopment, the team tries to validate it as quickly as possible to make sure they include all relevant physical effects. Overall, more accurate validation with simulation means fewer measurement activities are required in the long run, as long as the technology and materials under investigation are within a certain variance.

"We have to use simulation to get a precise evaluation of which concept or technology is beneficial for the new powertrain before the season begins," says Mengoni. "By comparing our simulation results with measurement data from the test bench and track, we can further improve our models. It's important for us to get a good grasp on what modification is needed upfront, as during the season, we can only improve the car via software updates."

Look for more on Porsche Motorsports' use of simulation in an upcoming episode of Driven By Simulation at DrivenBySim.com.

WOMEN IN TECHNOLOGY

MAKING THE WORLD A SAFER, MORE EQUITABLE PLACE

By **Laura Carter**, Senior Marketing Communications Writer, Ansys

Today, it's understood that women in technology perform just as well as their male counterparts. Regardless, we're still experiencing a science, technology, engineering, and mathematics (STEM) gender gap, as women represent just 34% of the total workforce in STEM, of which 16.5% are engineers and architects.[1] One reason is that from a young age, women are often steered away from math and science in favor of other career paths.

Despite the challenges, Lisa Savage pursued her dreams and assumed a prominent role in automotive engineering, as safety technical lead for safety of the intended functionality (SOTIF) and artificial intelligence/machine learning (AI/ML) at Aptiv. After completing a video shoot for an upcoming episode of the Ansys online docuseries Driven by Simulation, we had a chance to talk to her about her career, how Ansys software informs her work, and how she's supporting and encouraging young women to follow her path.

Question: Could you share a bit about your background, and how it prepared you for a career in automotive?

LISA SAVAGE: I got my start in engineering back in high school on the robotics team. Through robotics, I realized how fun creating products was. I realized that I could design things to make people's lives better. So, I ended up going to college for mechanical and aerospace engineering.

After graduation I spent some time in defense, space, medical, and consumer goods as both a mechanical and a robotics engineer before landing in the automotive space. I love automotive engineering because there are so many different opportunities to work on new technology. I've been involved with the design of advanced driver assistance systems, or ADAS, and also automated driving products in both systems engineering and safety engineering roles.

Now I'm putting this experience to work as a safety technical lead at Aptiv in our global product organization, specifically on SOTIF and safety of AI-related to automotive applications.

"I want to be able to decrease the number of crashes so that more people can return home to their loved ones. That was the critical piece that drew me to the automotive space, especially with so much technological advancement happening."

— LISA SAVAGE, Safety Technical Lead, Aptiv

Lisa Savage presenting on automotive safety

Q: What inspires you to come to work every day?

SAVAGE: Crash statistics are still really, really bad, much due to human error and environmental factors. I want to be able to decrease the number of crashes so that more people can return home to their loved ones. That was the critical piece that drew me to the automotive space, especially with so much technological advancement happening.

I really like Aptiv because we are working on products that will make people's lives better, safer, greener, and more connected. That's a big piece for me. I never feel like I'm stagnating in my role because there are always new challenges to solve or problems to fix.

Q: How did you find out about Ansys software? What products are you using currently?

SAVAGE: I actually first used it in college. I used a little bit of Ansys LS-DYNA and Ansys Fluent in both my coursework and project work. After graduation, I started out in my career dabbling a little bit in Ansys Zemax OpticStudio with optics and laser systems.

In my current safety role, I work with Ansys medini analyze. We use medini to do analysis, be it a hazard analysis, risk assessment, fault tree analysis, or failure mode and effects analysis. It enables us to really dive down into what exactly we need to implement to make sure that our product is safe within certain circumstances.

Q: What impact is medini having on safety analysis at Aptiv?

SAVAGE: I'm part of a team responsible for creating the core solutions for safety. We prepare the products that can then be used with and tailored for customers further down the line.

Medini is central to establishing the requirements that are needed, or to fully define the operational design domain in which our products are operating. It ensures that I'm decently covering the space that we're working in. Most recently I've been working through some fault tree analyses to understand, from a statistical standpoint, how likely unwanted system behavior is to happen, and whether or not it is acceptable.

Q: So, we're going to shift gears here a bit and talk about what it's like to be a woman in tech. What have you experienced during your engineering career?

SAVAGE: I think that we have, as a society, made a lot of progress recruiting women to

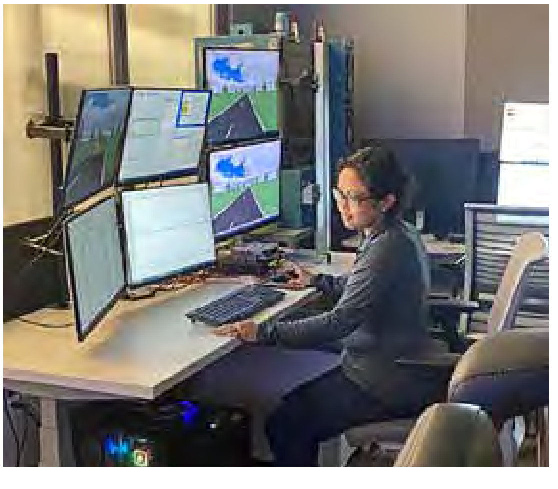
STEM, and to engineering in particular. I've been pretty fortunate to not have experienced too much outright sexism in the field. That said, I do think that there are still a lot of unconscious biases out there, even at the youngest levels, causing girls to drop interest in STEM before they even make it to the industry. It's super important to me, personally, that I do what I can to grow and foster an interest in STEM in our youth.

Personally, I have been in situations where I've been second-guessed more than my male counterparts, or where my work was attributed to someone else — even though I might have had just as much if not more experience than others in the room. During moments like these, I had to find my voice and stand up for myself. Of course, I'm aware that might be happening to other women as well, and I try to support them where I can so that I can make sure that their voices are heard, too.

Q: How are you supporting women in your field?

SAVAGE: I'm part of Aptiv's Women's Network and Aptiv's Technical Women's Network, both at the local and global levels. We bring each other up and support each other professionally through mentoring, training, and upskilling. Currently I have a mentee, and I also lead Aptiv FIRST, which works to provide STEM mentorship to students from grade school all the way up through high school.

Something else I've had the opportunity to kick off since I started here at Aptiv is an apprenticeship program, targeted towards giving young adults the opportunity to break into the technology space. There are a ton of young women who just might not have had



Part of Lisa Savage's position involves developing scenarios for testing Aptiv's features in the simulation space.

Lisa Savage with her team at an Aptiv Robot Showcase event.

the opportunity to get a technical degree, and the partnership program is their way to get that training and get involved with the automotive industry.

I am proud to have mentored kids in STEM, individually or as part of a student team. Seeing them find their passion and forge their career path has been really rewarding. Some of them go on to get advanced degrees in engineering; many take what they've learned to change the world. It's very rewarding to see.

Q: What would you say to young women who are looking for career in automotive engineering?

SAVAGE: Never stop exploring. Always try to understand more about the world around you. The reason that I am where I am now is because I kept exploring, always looking at different industries and different products and trying to understand how exactly they worked. Even though I graduated with my degree in mechanical and aerospace, I stayed really hungry and tried to learn more about the electrical and the coding spaces, for example.

References

1. *"The STEM GAP: Women and Girls in Science, Technology, Engineering, and Mathematics," AAUW (American Association of University Women), http://www.aauw.org/resources/research/the-stem-gap/*

Lisa Savage Lends Her Star Power to Driven by Simulation

We wanted to thank Lisa for sitting down with us to do a great interview after a long day of filming for Driven by Simulation, our online docuseries.

You can see her and some of her team members in an upcoming episode. And while you're waiting, you can catch up on all of the latest episodes of Driven by Simulation at DrivenBySim.com.

ZF's electric motor is uniquely compact due to its innovative rotor design.

Charging Through Electric Motor Development with SIMULATION

By **Laura Carter**, Senior Marketing Communications Writer, Ansys

"Simulation is among the core elements of digital transformation needed to revolutionize our product development. Ansys' solutions pay off in shorter development cycles and less prototyping — key points in digitizing our R&D processes that help us take our mobility solutions in new directions."

—**DR. HELMUT SCHMID**, *Manager in the Advanced Development Department, ZF Friedrichshafen AG*

In the shift toward vehicle electrification, consumers are clearly aware of the challenges that come with this relatively new and emerging technology, including driving range and the charging infrastructure needed to support long-distance travel. Batteries are a key element in the rapid adoption of electric mobility, as they directly impact how far electric vehicles (EVs) can go on a single charge. However, EVs — and hybrid EVs, for that matter — are really driven by not one but three important enabling automotive technologies: e-drives, batteries, and vehicle control systems.

Electric motors play an important role, as they use electromagnetic forces to convert electricity from the battery into mechanical power that sets a vehicle in motion. However, not all of the energy collected during charging is captured and used during this conversion. Some of it is lost due to heat or friction. So, for original equipment manufacturers (OEMs), the goal in any electric motor design is to achieve maximum energy efficiency to ensure most of the power from the battery is used by the electric motor to extend vehicle range. To do this requires an understanding of the physics behind a given design, enabled by simulation-driven engineering.

Dr. Helmut Schmid knows a lot about electric motors. He works in the Advanced Development Department of ZF Friedrichshafen AG, a global technology company and systems supplier of electric drives for passenger and commercial vehicles. Dr. Schmid's focus is on simulation, specifically on how to improve Ansys-enabled simulation frameworks and workflows to deliver sustainable solutions to individuals involved in the core development of ZF's electric motor technology.

"ZF is automating development for all characteristics of electric motors related to electromagnetic, thermal, and mechanical domains," says Dr. Schmid. "Our goal is to continuously deliver software solutions and provide novel methods and tools that can be used by our stakeholders all along the development process."

TAKING CHARGE OF THE MOBILITY NARRATIVE WITH NOVEL SOLUTIONS

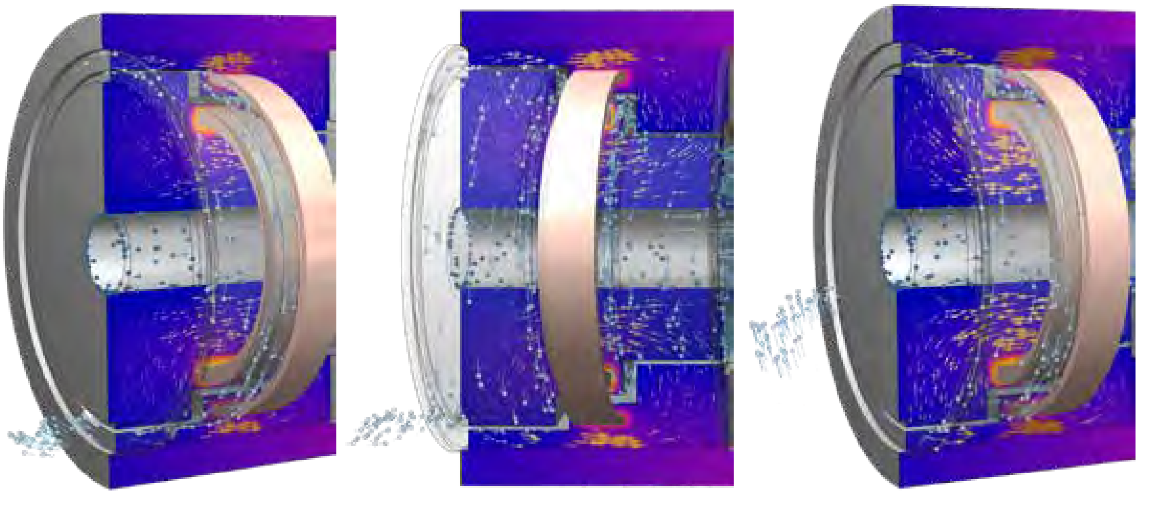
At the moment, ZF is enabling the next generation of mobility by developing systems and components they say can "see, think, and act" through hardware, software, and sensor technology. It offers a comprehensive solution that extends to vehicle motion control, integrated safety, autonomous driving, and electric mobility to help advance more sustainable transportation.

To this end, Ansys simulation helps ZF to develop electric motors and related products for high volume at an affordable cost, all while delivering the simplest functionality required to best address OEM requirements. Using simulation, Dr. Schmid's team can standardize development on the product side as well as the simulation side to find greater efficiencies.

"We developed a modular kit for our electric motors, with a specific focus on commonality of parts, which can be shared among different electric motors," says Dr. Schmid. "With simulation, we could address requirements to achieve standardization throughout our product offerings. We have also standardized our simulation processes to successfully reduce efforts across development departments."

BENCHMARKING INNOVATION WITH SIMULATION

Benchmarking competitive components is a big part of ZF's design workflow — activity efficiently accomplished by Ansys simulation. Not only does this activity apply to electric motors, but extends to other aspects of an electric powertrain, including inverters. Inverters are electronic devices critical to the conversion of electricity from DC to AC output required to power the motor. In one instance, ZF's inverter team looked to Ansys Q3D Extractor software for parasitic extraction (PEX), or the calculation of the parasitic effects or frequency-dependent characteristics of their

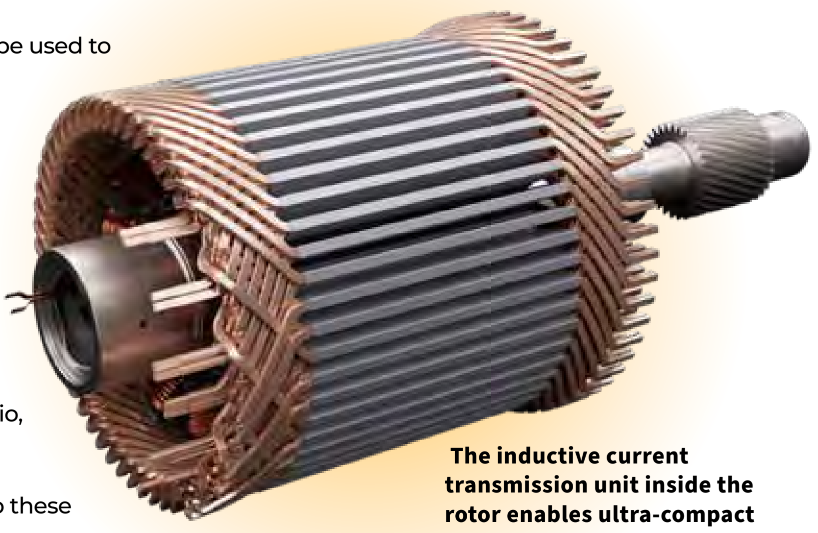


Fluid, thermal, and electromagnetic simulation of an inductive exciter unit for ZF's Separately Excited Synchronous Motor (SESM)

designs. Parasitic extraction is an important part of electronic design automation, as it helps the team create an accurate model of the circuit to enable detailed simulations of circuit response.

The model is then passed through Ansys Maxwell to precisely characterize the motion of the electromagnetic components and their effects on overall design. From there, a fully parametric (statistical) model can be realized, then worked on in Ansys Twin Builder via Ansys Electronics Desktop connected to an electromagnetic simulation workflow. This activity is followed by a transient simulation to extract the results needed to further parameterize the Twin Builder setup as part of a larger model, which can be optimized to meet necessary component requirements.

Ultimately, this workflow will be used to calculate thousands of different designs to find a very specific concept, which can then be benchmarked against a similar competitive product in the market for factors including performance, efficiency, compactness, and cost. It also enables ZF to deliver competitive, yet simple, electric motor designs that are standardized across their portfolio, giving the company a decided advantage in the ability to bring convenient mechanical power to these applications.



The inductive current transmission unit inside the rotor enables ultra-compact e-motor design.

WORKING WITHIN THE ANSYS ECOSYSTEM YIELDS FASTER RESULTS

ZF electric motor simulations are run either on local high-performance workstations or on worldwide available ZF clusters. Simulations are distributed to the cluster via an application programming interface (API), which enables fast high-performance computation (HPC).

Achieving shorter development times, plus a higher degree of maturity on the product side as quickly as possible, are big reasons for ZF's big push for the use of multiphysics simulation in all of their programs. But that's not all — simulation also facilitates ZF's "blank canvas" approach to development, enabling the R&D team to freely play in the white space to figure out an entirely new principle reflected in a new product around a serious application for their customers.

> ***"We used the Ansys simulation ecosystem to simulate multiple physics and domains. These simulations were used to quickly evaluate thousands of design variants. This helped us to ultimately build up a hardware prototype that outperforms today's benchmark in terms of power density, and still achieves an efficiency of more than 95% at system level."***
>
> — **ROBIN MICHELBERGER**,
> *Simulation Engineer, ZF Friedrichshafen AG*

"To transmit electrical power to a rotor of a brushless electrical excited synchronous machine, we developed a rotating inductive transformer unit," says Robin Michelberger, a Simulation Engineer in the Advanced Development Department at ZF responsible for electrical design. "We used the Ansys simulation ecosystem to simulate multiple physics and domains. These simulations were used to quickly evaluate thousands of design variants. This helped us to ultimately build up a hardware prototype that outperforms today's benchmark in terms of power density, and still achieves an efficiency of more than 95% at system level."

Learn more about ZF's use of Ansys simulation in an upcoming episode of Driven by Simulation at DrivenBySim.com.

Kuraray Is Making Electric Vehicles Go Farther with New Materials

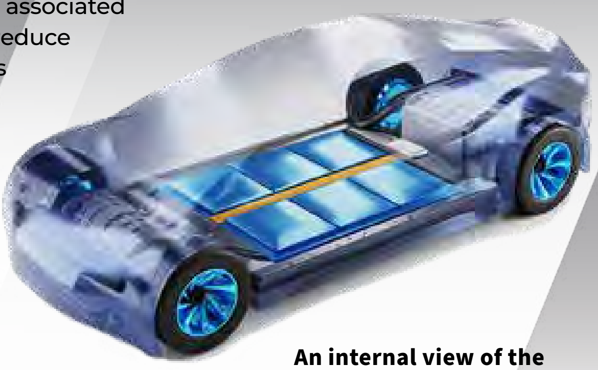
By **Scott Wilkins**, Lead Product Marketing Manager, Ansys

It's no secret that vehicle original equipment manufacturers (OEMs) are aggressively pursuing electric vehicle (EV) development. Among the headwinds they face in selling their technology to consumers are price and vehicle range. Not surprisingly, there is a direct correlation between the two — in 2021, for any EV under $40,000, the average vehicle range was 187 miles, while the lowest vehicle range for any internal combustion engine (ICE) vehicle was 240 miles

Subject to ideal charging and discharging, EV batteries also degrade two to three percent per year, impacting range further over the life of the vehicle.[2] To overcome these obstacles, manufacturers are looking to integrate new materials into their designs to help EVs go farther. Kuraray, a global leader in specialty chemicals and functional materials, is partnering with Ansys to support these objectives.

A key focus area is lightweighting — making a vehicle lighter through material and design choices. EV batteries and their associated systems are heavy, so manufacturers are trying to reduce the weight of vehicles in any way they can. Vehicles with ICEs are heavy too, but unlike EVs, the range of an ICE-powered vehicle is less sensitive to a reduction in its mass.

"What sells vehicles at the moment is range," says Andrew Miller, Director of R&D at Ansys. "If you can get 50 miles or more range out of your EV than your competitors then you've got a winner. Of course, you could make the battery better, or the motor more efficient. But the easiest way to increase range is to just make the whole vehicle lighter."



An internal view of the power train of an electric vehicle

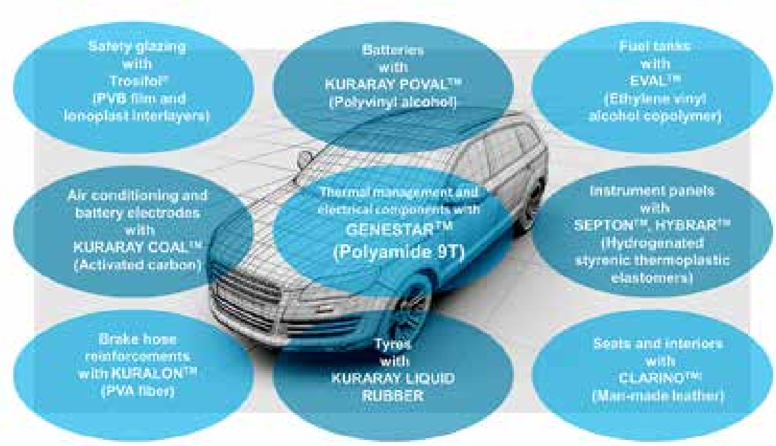
"What sells vehicles at the moment is range. If you can get 50 miles or more range out of your EV than your competitors then you've got a winner. Of course, you could make the battery better, or the motor more efficient. But the easiest way to increase range is to just make the whole vehicle lighter."

—**ANDREW MILLER**, Director of R&D, Ansys

BRINGING AUTOMOTIVE POLYMER PROPERTIES INTO DESIGN

GENESTAR™ is a brand name of heat resistant polyamides developed by Kuraray. These PA9T series materials are well-balanced, long-chain polyphthalamides (PPAs) that combine low water absorption and high mechanical properties over a broad temperature range, resulting in dimensional stability and blister resistance during surface mounting processes. The materials enable lightweight designs and parts miniaturization for EV batteries for better efficiency while ensuring safety in high-voltage applications. Their low-permeation properties significantly extend the life and durability of EV battery coolant tubes and battery parts subject to a wide range of temperature and humidity changes.

These all sound like appealing properties for an engineer to be considering in their next simulation of a vehicle component they may be developing, but with thousands of polymers out there, how do you find the information you need?



Kuraray's automotive products

Kuraray and Ansys teamed up to provide detailed materials information on GENESTAR™ PA9T series materials to use directly in Ansys solvers. The data includes nonlinear mechanical properties such as stress-strain and creep curves, along with thermal and electrical properties at a range of temperatures. Ansys applied its expertise of material models to ensure all data is "simulation-ready" and available in its Global Polymers materials library for Ansys Granta MI and Ansys Granta Selector users. From there, it can be exported into a wide range of Ansys simulation tools, including Ansys Mechanical and Ansys Workbench.

In this way, Ansys is building partnerships with companies like Kuraray, where Ansys acquires data on their material products and publishes it in the Ansys ecosystem. The idea is to add value to that data by preparing it for simulation, hence the term "simulation-ready." Basically, Ansys gives customers data on materials that they can directly use in their simulations via Ansys tools, such as Mechanical and Ansys Discovery. What Kuraray and other material producers gain is added exposure in the marketplace, as a relationship with Ansys helps their materials gain access to some of the top engineering companies while reinforcing high product quality.

CHOOSING THE RIGHT AUTOMOTIVE MATERIALS FOR THE JOB

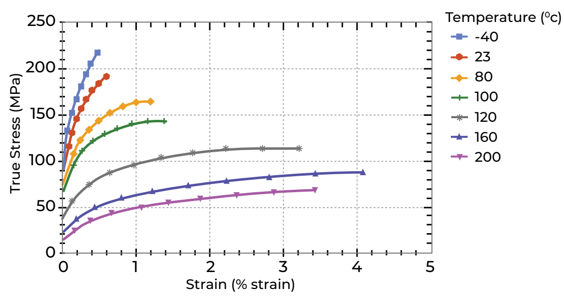
To customers interested in a specific material, Ansys materials databases provide all the data they need. But it's still up to each customer

GENESTAR™ PA9T in automotive applications

to decide whether they have found the right material choice for their EV application. Ansys offers a huge database of different polymers from numerous companies; however, within Granta MI, searching simulation-ready materials cuts the list down to 2000 polymers based on significant properties. It's an exclusive subset of materials data available to Ansys simulation users, including OEMs looking for materials solutions to their lightweighting challenges.

Temperature-dependent data is one important element of this subset directly related to EV design. Often, OEMs use very high-performance polymers to address elevated temperatures near the battery pack and HV wiring, or on the vehicle interior or exterior where exposure to direct sunlight can easily drive temperatures upwards of 50°C (120°F). Having data with the right thermal properties enables accurate simulation of a range of temperatures that leads to better thermal management.

Polymers exhibit highly nonlinear behavior and to accurately simulate that behavior you need to use nonlinear material models. These nonlinear models generally require stress-strain data, so if you don't have that data you cannot use these models, and the accuracy of your simulation will suffer. Tapping into temperature-dependent and nonlinear materials data provided by Granta MI, OEMs can run multiple



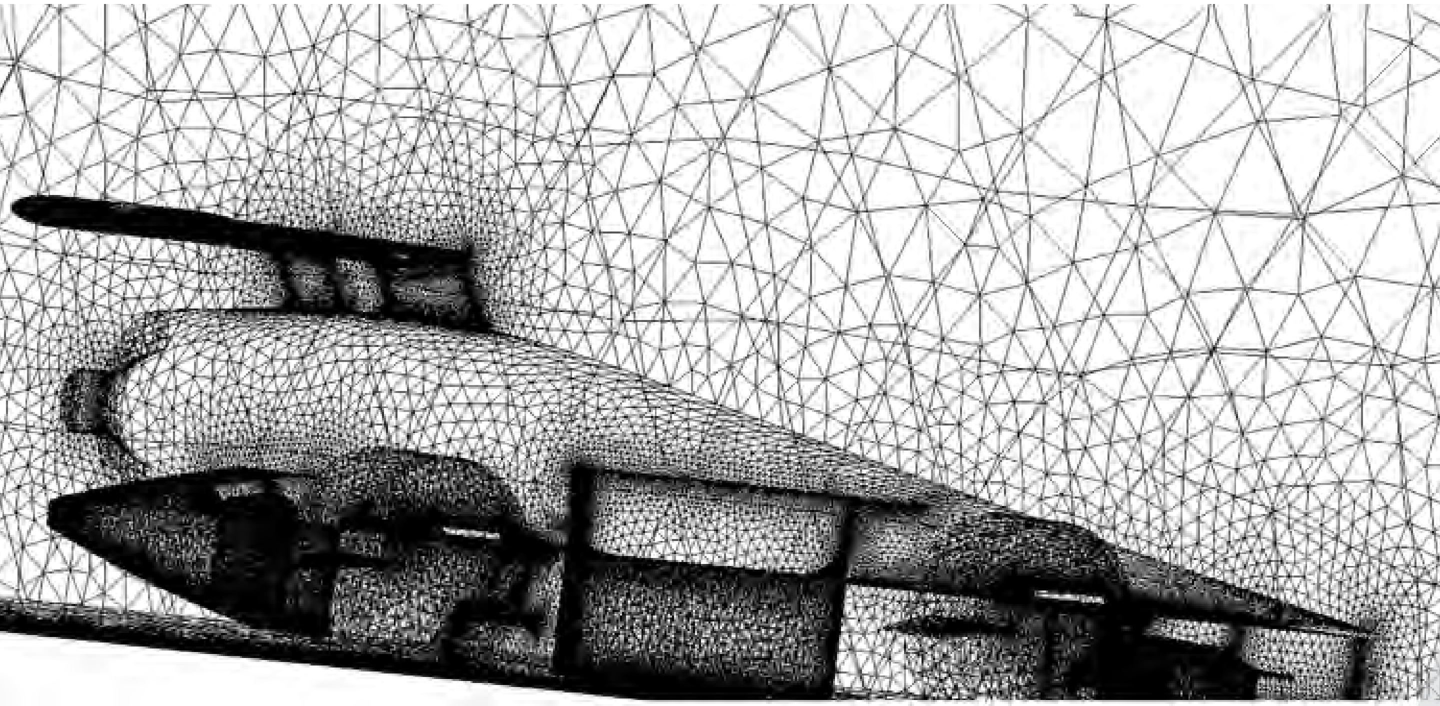
Example non-linear polymer performance data (at various temperatures) in Ansys Granta MI

simulations using the full extent of Ansys technology and expect good results.

"Without tools like Granta MI, a lot of time is wasted searching for data needed for simulation," says Miller. "Customers will Google it, they will go through old papers to find it or recreate it to support their simulations, ultimately leaving them open to errors. We're giving that data to them, ready to import directly into their simulations, validated by Ansys, which amounts to a huge time savings. And because we're giving them temperature-dependent, nonlinear data, users can expect accurate simulation results."

REFERENCES

1., 2. Engine Builder Magazine, Internal Combustion Engines vs. Electric Vehicles (EV), October 14, 2021 https://www.enginebuildermag.com/2021/10/ice-vs-ev



High Schooler Realizes Computational Engineering Passion During F1 in Schools Competition

By **Jennifer Procario**, Corporate Communications Writer, Ansys

Most students head to college unsure of which classes to take, which major to pursue, or which career path to follow. Typically, college is one of the first places where students can dive deeper into subject matter, gaining the hands-on experience needed to understand their likes, dislikes, strengths, or weaknesses. But what if students developed this insight in high school? They would likely enter college with a competitive edge, richer background, and clearer academic plan. At least that's the case for recent high school graduate Aryaman Bansal.

Bansal participated in F1 in Schools competitions in India throughout high school. F1 in Schools is the only global multidisciplinary challenge in which teams of students integrate computer-aided design (CAD) and computer-aided manufacturing (CAM) software to design, manufacture, and race miniature, compressed-air-powered cars made from an F1 model block. After three years of competing in the Indian Nationals, Bansal participated in the 2022 F1 in Schools World Finals as a senior and applied Ansys simulation to the F1 challenge for the first time.

Aside from the thrill of international competition, Bansal was most impressed by the computational fluid dynamics (CFD) experience he obtained as the team's sole engineer. As part of the Ansys Academic Program, Ansys provides access to free simulation commercial software for student teams in competition. As a result, Bansal gained firsthand experience with computational methods, developed a passion for computational engineering, and plans to pursue the field at university this winter.

GETTING INTO THE FLOW WITH CFD

Aryaman Bansal

To compete in the 2022 F1 in Schools World Finals, Bansal and a group of five other engineering enthusiasts from different schools formed the Helios Racing team, its name inspired by the Greek sun god. They spent approximately nine months completing their car, Aethon — named for one of the four horses of Helios — from design conceptualization to manufacturing. As the team's sole engineer, Bansal worked exclusively on Aethon's development using Ansys simulation. At the time, Bansal attended the Shri Ram School in Moulsari, India.

"Before being sponsored by Ansys, I had used other CFD solvers that provided inconsistent and therefore unreliable data," he says. "This inconsistency led to misguided engineering decisions based on that data and upon rerunning those simulations with Ansys, I realized that many of the decisions had actually worsened the car's performance. Ansys CFD solvers completely eliminated this problem."

For the global competition, Bansal completed all CFD simulations using Ansys Discovery, a 3D design software tool that combines interactive modeling and simulation, enabling him to address critical design challenges earlier in the design process. Virtual modeling is a key component of the competition, which challenges students to integrate CAD/CAE software into building miniature, air-compressed cars that will race on the official 20-meter F1 in Schools competition track at the famed Silverstone Circuit in England.

DID YOU KNOW?

Computer Engineering vs. Computational Engineering

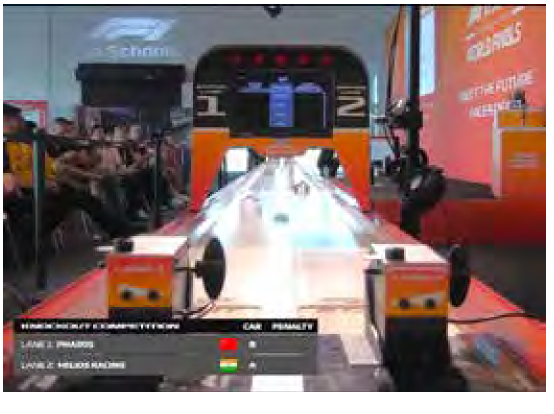
Computer engineering focuses on the design of hardware and software components for computers.

Computational engineering uses computers and computational methods to solve engineering design challenges across a wide range of industries and fields.

ENGINEERING TINY YET MIGHTY MODELS

Miniature is a fair description. Aethon's specs were roughly 210 millimeters in length, 85 millimeters in width, and 65 millimeters in height — approximately 8 inches, 3 inches, and 2.5 inches, respectively. But don't let its size fool you. Aethon consisted of several components, including a chassis, front wing, rear wing, and two-wheel support structures (one for the front wheels and another for the rear wheels).

Students can choose their own materials for the front wing, rear wing, and wheel support structures, so Bansal and his team selected materials such as Nylon 12, ceramic, and stainless steel



Helios Racing defeats team Pharos during the 2022 F1 in Schools World Finals Knockout Competition.

Helios Racing's miniature, compressed-air powered car, Aethon

Renderings of Aethon show the car disassembled (left) and fully assembled (right)

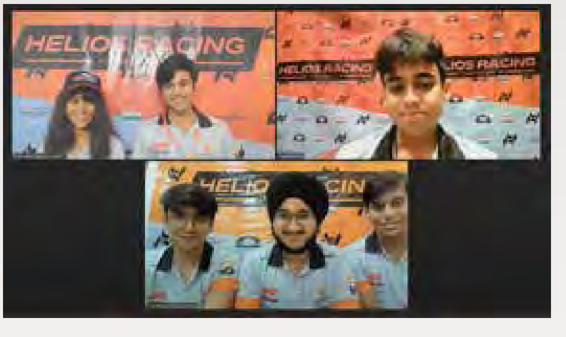
for these parts. However, teams are required to create the car chassis using a polyurethane model block supplied by competition organizers. The model block is manufactured in a computer numerical control (CNC) machine to achieve the desired chassis shape and then the teams attach the remaining car components to the model block using different assembly methods such as super glue or friction fits.

Of course, aside from the structural savvy it takes to build a car this size teams must also develop its aerodynamic components, which pose more challenges than a standard internal combustion engine-based car. Compressed-air cars are powered by pressure vessels filled with compressed air and rely on a thermodynamic process.

"Ansys proved to be extremely valuable in the engineering process for several reasons," says Bansal, noting some of the additional challenges, including power generation.

For starters, every car in the competition is powered by the same air canisters supplied by F1. This means most of the car's performance depends on its aerodynamic and mechanical efficiency to utilize the gas canister's energy. Hence, engineers are limited in what they can do to enhance power generation. In addition, all teams must adhere to stringent technical regulations regarding car design.

"Consequently, F1 in Schools cars featured complex components such as the front and rear wings, which needed to be meticulously crafted to ensure a smooth airflow over the entire car body," he says. "This was in contrast to standard road cars, which have a single-component structure with one surface blending across the entire car body. Furthermore, given the small size of an F1 in Schools car, Ansys CFD simulations played a crucial role in visualizing the airflow using CFD simulation tools. This would have been impractical in real life as qualitative data from wind tunnels at such a small scale would have been highly unreliable."



The Helios Racing Team: Top (l-r): Mysha Tabrez, Samridh Sharma, Aryaman Bansal; bottom (l-r): Ashmit Gupta, Samik J. Singh, Saksham Sagar

Discovery's CFD capabilities, which are powered by the Ansys Fluent solver, allowed Bansal to understand, model, and analyze Aethon's aerodynamic behavior. In addition, Discovery's structural analysis capabilities enabled the team to construct mesh, test design ideas, and receive immediate insight on structural performance.

GEARING UP FOR THE FUTURE

The 2022 F1 in Schools World Finals four-day competition took place in July but all project elements, including the cars and technical documentation, were submitted months in advance for detailed examination. On the day of the competition, Helios Racing came in sixth place, winning one of the

> ***"Having experience with Ansys simulations greatly influenced my decision to pursue a career in computational engineering. While using this software for various methods and gaining a deeper understanding of its workings, I came to appreciate the immense potential of computational tools like Ansys and how they can revolutionize problem-solving approaches across various industries."***
>
> — **ARYAMAN BANSAL,** *High School Graduate*

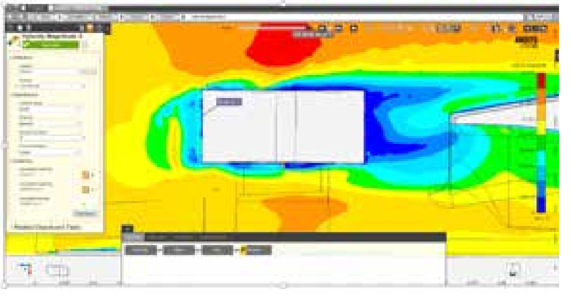
deciding "Knockout Championship" rounds. Additionally, the team was nominated for the "Best Engineered Car" and "Best Scrutineering" awards. Still, for Bansal the real victory came upon discovering his passion for computational methods and engineering.

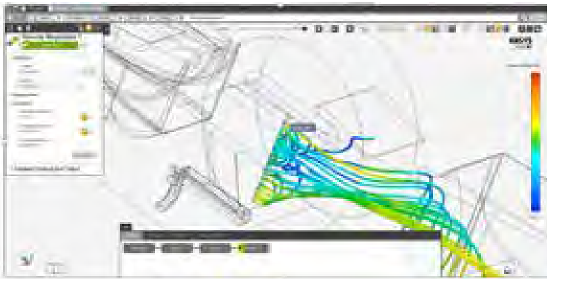
"Having experience with Ansys simulations greatly influenced my decision to pursue a career in computational engineering," he says. "While using this software for various methods and gaining a deeper understanding of its workings, I came to appreciate the immense potential of computational tools like Ansys and how they can revolutionize problem-solving approaches across various industries."

Likewise, his budding interests led him to the International Baccalaureate Diploma Program (IBDP), an internationally recognized educational program offered to students aged 16-19 at participating schools. As part of the program, students are required to write a mini research paper known as an extended essay. Participating in the May 2023 submission series, Bansal focused his essay on the aerodynamic effects of aircraft flying in formation and used 3D models of airplane wings to conduct CFD simulations in Ansys Discovery.

Bansal's research indicated that formation flight could enhance fuel efficiency, supported by higher lift-to-drag ratios in formation versus individual wings. His paper achieved the highest attainable grade in the IBDP examination.

"The Ansys Academic Program played a pivotal role in both my F1 in Schools project and my research paper," he says. "Similarly, in the case of my research paper, without access to Ansys CFD solutions, I would have had to abandon my research topic altogether. The entire methodology of my research relied on CFD simulations, and other solvers would not have produced reliable data to draw replicable conclusions."





Team Helios verifies Aethon's aerodynamic behavior in Ansys Discovery.

Bansal plans to pursue computational engineering at university in January 2024 and is confident his skills will benefit him in any field.

"Before I started using Ansys simulations, I had no idea how much technology was shaping research and development in the engineering field worldwide," he says. "I was particularly fascinated by the ingenious solutions these tools offered, such as creating complex geometries into meshes, and I felt a strong desire to contribute to this emerging technology and be part of the change in the engineering world.

"Currently, I am not limiting myself to any specific industry because I believe that computational methods hold potential in virtually every major industry," he continues. "I believe my skills can be applied to contribute to the development of such tools in any of these fields."

BUILD SMART CITIES

in a Digital Sandbox on the Road to Full Autonomy

By **Kim Woodham**, Senior Product Marketing Manager, Ansys, and **Laura Carter**, Senior Marketing Communications Writer, Ansys

It's no longer hard to imagine an automotive world driven entirely by electricity, connectivity, and artificial intelligence/machine learning (AI/ML). Autonomous vehicle (AV) tech could one day dramatically transform our view of the road ahead by simultaneously disincentivizing vehicle ownership, democratizing transportation, and freeing up more urban green space.

The future of self-driving vehicles is a particularly hot one among automotive original equipment manufacturers (OEMs), suppliers, and thought leaders. According to *Forbes*, total global investments in AV tech for 2022 exceeded $200 billion and are expected to continue their upward trajectory in what is becoming an increasingly competitive market.[1]

> ***"Everything being modeled for an autonomous driving environment involves a system or collection of systems designed from day one to carry out a mission of purpose."***
>
> — **NATE MCBEE,** *Senior Manager, Product Management, Ansys*

Consequently, within a few decades many of us could be ordering AVs owned by transportation-as-a-service (TaaS) companies to get around. Already, the idea is generating a lot of discussion behind the scenes among thought leaders trying to carry out what promises to be an incredibly complex mission: integrating technologies into automobiles and urban infrastructure that can support self-driving environments.

Just last year, at an automotive event organized by the *Financial Times* in London, Ansys Chief Technologist Christophe Bianchi met one of the developers involved in the futuristic city of Ali Mendjeli in Constantine, Algeria. Ali Mendjeli is one of several new cities being created as urban centers that adequately plan for and address the availability of housing for the local population.[2]

Central to their conversation was the much-anticipated move to higher levels of vehicle autonomy, and the role of AVs in redefining urban infrastructure in ways that better accommodate people living within it. They discussed the need to extend autonomous technology to driving environments, and the ability of digital mission engineering to help deliver on that goal.

Digital mission engineering is defined as the use of digital modeling, physics-based simulation, and analysis to incorporate the operational environment and evaluate mission outcomes and effectiveness at every phase of the life cycle. Using digital engineering to create a model of the environment in which your system must perform, you can simulate a model of your actual system operating within this environment or digital mission model and see how it fares — from development, through operation, maintenance, and sustainment.

MAPPING THE SELF-DRIVING DIGITAL MISSION

To understand the role digital mission engineering might play in the implementation of autonomous tech on a broad scale, some context is needed. Some smart city visionaries expect AVs to be an important aspect of urban planning. They have even proposed limiting travel within smart cities to TaaS AV fleets exclusively. These shared fleets wouldn't need large throroughfares or as many parking lots, which will free up space for parks, open air markets, and other people-focused amenities.

Despite recent advances in AV tech, implementing it on a broader scale is an incredibly complex task. Proper deployment will depend on multiple entities coming together to execute a much larger digital mission.

It will also require a high level of synchronous, automated vehicle functionality through the seamless connection of disparate yet interconnected data systems, processes, and applications. For instance, downloading a vehicle software update as you're driving could enable the detection of an unseen vehicle coming around a corner while simultaneously rerouting based on construction.

Still, many other system interactions originate apart from an AV. Ultimately, implementing the level of coordination needed to support activities like these depends on many complex interactions, traceable over a single digital thread.

SIFTING THROUGH MISSION COMPLEXITY

Ansys' digital mission engineering capabilities, which have been applied to aerospace and defense (A&D) applications for years, are well-positioned to address the challenges of autonomous driving and smart cities.

"Everything being modeled for an autonomous driving environment involves a system or collection of systems designed

Ansys STK can incorporate radio frequency impacts while exploring vehicle link quality within urban environments.

from day one to carry out a mission of purpose," says Nate McBee, Senior Manager, Product Management in the Digital Mission Engineering business unit at Ansys. "The mission comprises all the steps involved and all the pieces needed to validate and verify all the systems that make this level of autonomy possible."

Whether you're talking about traditional A&D applications or autonomous systems, the approach to digital mission engineering using tools like Ansys Systems Tool Kit (STK) is largely the same. It is, in the simplest of terms, a digital modeling approach in which you simulate the model of your system or systems in a model of the conditions it must operate under, to evaluate how well it will perform.

A commercial unmanned aerial system operation being modeled within an urban environment. Data like the expected signal quality shown at mission altitude from available cellular network stations would be useful for autonomous vehicles in smart cities.

Achieving success in a fully autonomous driving environment will require support from key players like network infrastructure providers to build the high-speed networks that can accommodate real-time communication in dense urban centers. It will also require the geographic information system solution providers for mapping well-timed digital routes according to established traffic patterns. As a matter of safety and compliance, close cooperation among national, state, and local regulatory bodies is also a must.

CONNECTING THE DOTS

In thinking about all of this activity, what resonates for McBee is the value of Ansys digital mission engineering software to connect the modeling and simulation activities in one multidomain operational environment model. This is true whether you're considering autonomous systems in general, or the pieces of infrastructure supporting those systems.

"Using a tool that's specific to digital mission engineering and systems analysis, like STK, gives you a digital sandbox for bringing all of these models together," says McBee. "Within that sandbox, you can analyze them all in the context of their interactions to find answers to questions that you previously weren't able to ask. You can explore how a system or collection of systems supporting vehicle autonomy is going to perform under different conditions, situations, and scenarios within that operational environment."

STK's modeling environment is designed to be flexible so that you can ingest position or orientation data in an agnostic way. This enables you to derive benefits from other expert tools while leveraging all of the other aspects of the STK environment's modeling and system of systems analysis approach.

One aspect of this modeling activity might involve bringing the resulting routes and positions and orientations supporting a fully autonomous vehicle fleet into STK, thus providing a place for the model to live if you want to simulate objects moving through space and time. This would also require accurate 3D models and all of the rest of the sensor systems and other components you want to represent on board that vehicle.

Within the context of this virtual model, certain questions might then be answered about vehicle performance. For example, what an actual AV would be able to see or detect around them in different driving conditions, or how well they would be able to communicate with other actors and objects within different scenes. There's also the question of how well the environment itself was modeled to reflect certain conditions and resolve various questions the user might have.

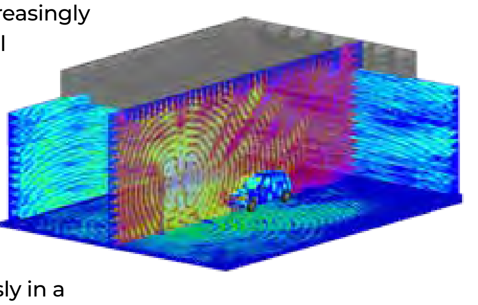
This type of activity informs a typical digital mission engineering approach. If you're working within the framework of a mission model, it's easy to swap out models or adjust operational conditions and rerun the mission again and again. This makes it possible to understand how one aspect of a system performs while holding all the other variables constant.

REFERENCES

1. Autonomous Vehicles And Their Impact On The Economy, Forbes.com, February 14, 2022.
2. New town created according to the ascending procedure: Case of Ali Mendjeli, elibrary.net.

PARTNER SPOTLIGHT

How EMA Helps Automotive and Aerospace Customers Simulate Electromagnetic Compatibility



As automotive, rail, and aircraft technology becomes increasingly complex, the electromagnetic environment both internal and surrounding these systems is more critical. With electric and autonomous vehicles rapidly advancing, regulatory compliance and functional safety are the highest priorities.

EMA has over forty years' experience performing simulations across diverse platforms from cars to aircraft to spacecraft. These simulations help complex systems meet design requirements and perform flawlessly in a wide range of electromagnetic environments. Ansys EMC Plus (formerly EMA3D® Cable) simulates performance from a single module up to the full vehicle level.

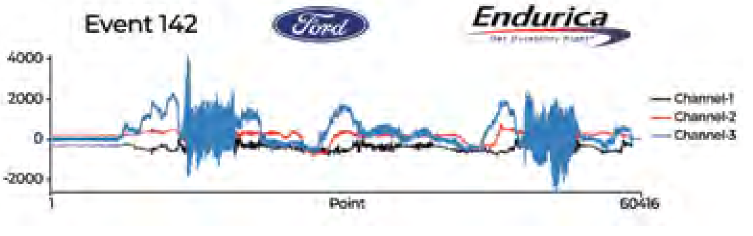
Testing expertise and laboratory facilities allow us to validate model results to ensure accuracy for EMC design. Our staff are active members of international standards committees and have a deep knowledge of regulatory and technical challenges facing the transportation industry. Whether you require design assessment early in product development or need to troubleshoot a failed EMC test, EMA has the skills to assist your team.

Learn more: https://www.ema3d.com/ansys-partner-spotlight/

PARTNER SPOTLIGHT

15 Million Time Steps:

Accurate, Complete and Scalable with Endurica



See the entire durability qualification procedure used by Ford for an elastomeric motor mount simulated in Ansys Workbench and post-processed with Endurica. The loading schedule includes 144 different events recorded at the test track, each having as many as 6 input channels (3 forces and 3 moments). The analysis begins by computing a nonlinear map of global load inputs to local FEA stress-strain fields. This map is then used in Endurica EIE to rapidly generate full transient stress-strain history (15.6 million time steps!) for each finite element. Over 3 terabytes of stress-strain history is produced, which is then passed to Endurica CL to solve for fatigue life. The analysis takes into account the elastomer's nonlinear material properties, and correctly predicts failure location and fatigue life. Endurica EIE can be used independently and is ready to tackle your next oversized computing challenge.

https://endurica.com/ansys-ford/

Ansys-onsemi Collaboration Leads to Greater Vehicle Perception Down the Road

Simulation enables accurate forecasting and validation of sensor functionality across driving environments.

By **Aaron Talwar**,
Senior Product Marketing Manager,
Ansys

It may be difficult to envision a world in which we give up control and let our vehicles do the driving. But, in fact, we are getting a glimpse of what that might look like now. Many vehicles on the road today already benefit from advanced driver assistance systems (ADAS) that use sensors such as camera, radar, and lidar technologies to avoid collisions with obstacles, help us stay in our driving lane, parallel park, and more.

All of these systems are guided by artificial intelligence (AI) sensing — such as computer vision, which is a core function of the perception stack in an autonomous vehicle (AV). An AV stack is made up of layers of components responsible for the sensing, connectivity, processing, analysis, and decision-making necessary for self-driving. Much like the human driver, a vehicle's perception stack "looks around," collects data from vehicle sensors, and processes it to understand and respond to its immediate driving environment.

As two key players in the AV industry, Ansys and onsemi are advancing this mission by collaborating to deliver a unique solution that not only complements each other's technology, but also enables an ecosystem for original equipment manufacturers (OEMs) and Tier 1 suppliers to use in advancing their development and perception validation goals.

As a leader in power and sensing technologies, onsemi's objective is to foster innovation and develop intelligent technologies that solve complex customer challenges, including those around vehicle perception in support of AV development. Collaborating with Ansys enables onsemi to create system-level simulations to analyze the effect of its development decisions and advance its technology. The onsemi team created a sensor model and a virtual twin, then used Ansys AVxcelerate simulation to integrate various driving scenarios, thus converting the sensor model to a broader system level simulation.

"The value of onsemi's sensor model is enhanced when we are able to forecast and authenticate the sensor's functionality across different situations," says Shaheen Amanullah, Director of Imaging Systems in onsemi's Intelligent Sensing Group. "Ansys' simulation tool plays a crucial role in achieving this, thanks to its physics-based approach in generating scenes that offers the accuracy we require. Using simulation, we establish a foundation that enables us to showcase, assess, and develop next-gen sensors that meet the evolving demands of our customers. Moreover, this platform will aid us in gauging the influence on both human and machine vision applications."

"The value of onsemi's sensor model is enhanced when we are able to forecast and authenticate the sensor's functionality across different situations. Ansys' simulation tool plays a crucial role in achieving this."

— **SHAHEEN AMANULLAH**, *Director of Imaging Systems, onsemi*

SIMULATION ESTABLISHES A REAL-WORLD CORRELATION TO SENSOR PERFORMANCE

The value proposition presented in this scenario is the ability to establish a real-world correlation using a model that is very close to the performance of the actual sensor. This output can be used by OEMs and Tier 1 suppliers to assess their own system designs with confidence. AVxcelerate Sensors provides a physics-based, multispectral light propagation in a dynamic scenario for onsemi's sensor model to quickly and accurately test and validate its performance — without the need for physical prototypes.

AVxcelerate Sensors enables onsemi to perform comprehensive validation across various scenarios during the definition and design phases of products. An OEM can pick up the onsemi model validated in AVxcelerate Sensors, do their perception algorithm testing, and immediately identify areas of improvement that lead to further sensor optimization through iterative changes — thus improving sensor development in the pipeline. This activity also enables the discovery of performance boundaries of the perception algorithms and provides a head start in training them.

JOINT IMAGER DEMO SUPPORTS AUTOMOTIVE CAMERA TESTING

From May 9-11, 2023, onsemi and Ansys showcased an imager demo at onsemi's booth at AutoSens Detroit 2023. In this demo, using AVxcelerate Sensors, onsemi and Ansys created a fundamental yet pivotal testing scenario for validating automotive camera performance in an ADAS/AV context. The onsemi imager model, fed by information coming out of AVxcelerate Sensors, is simulated using this fundamental scenario to better understand the impact of the sensor design on an ADAS/AV system. All the simulation output is then cross-checked against video recorded by the physical sensor.

To provide reliable solutions to its customers, the goal of the onsemi team is to achieve a high degree of correlation between actual and simulated sensors on image quality and behavior of the sensor. Key performance indicators (KPIs) are implemented to quantify the accuracy of the resulting simulation data. In this scenario, scene generation is a critical aspect of the experiment, as it plays a vital role in achieving an accurate correlation with an actual sensor.

Sensor image of a tunnel using onsemi technology (top) and a photo of the actual tunnel for ground truth verification

Ansys and onsemi worked toward reproducing, as accurately as possible, the benchmark scenes — a concerted effort that enabled both to improve their tools and better align on critical requirements. This use of virtual simulation will also help OEMs and Tier 1 companies to engage with sensor manufacturers at an earlier stage, facilitating the definition of next-generation sensors based on simulation-backed data that can better meet their requirements. Additionally, they can apply their perception stack on the simulation output and train their network much earlier in the process when compared to current practices.

"Presently, such activities take place after the sensor has been sampled, leaving a small time-to-market window that limits achievable outcomes," says Amanullah. "By gaining a head start, OEMs and Tier 1 companies will have more time to optimize their algorithms and train their networks, resulting in a shorter and smoother validation phase following the sampling process. Our intention is to enhance the current simulation methods and integrate additional features in the future, using AVxcelerate Sensors to provide a more accurate representation of a physical sensor in diverse scenes for our customers."

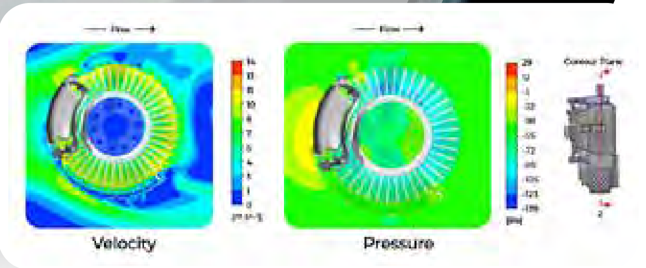
Breaking the Cycle of Brake Dust Emissions

By Tim Palucka, Managing Editor, Ansys Advantage

When you think of automobile emissions, most likely an image of exhaust fumes exiting the tailpipe comes to mind. But automobiles emit other potentially polluting particles that you probably haven't considered, coming from brake wear, tire wear, and road abrasion. In fact, only 15% of emissions come from the exhaust, with the remaining 85% coming from these other sources. Of these, small metal particles emitted from the brake disc have the best chance of capture by filtration. The European Union is considering legislation to control all emissions from vehicles, including brake disc particles.

Engineers at MANN+HUMMEL, located in Ludwigsburg, Germany, with additional engineering support from their India offices, are using Ansys Fluent to simulate the flow of metal particles as they leave the brakes. The goal is to design a passive filter (no moving parts) that fits onto the brake calipers to capture these particles before they exit into the surroundings.

The decision to use Ansys software was an easy one for the engineering team. "We had the great advantage of a lot of engineers who had experience with Ansys Fluent," says Christoph Schulz, Manager of Simulation Filter Elements at MANN+HUMMEL. "So Ansys was the first choice for us when we started on this project."



Velocity and pressure contour simulation results for flow in the brake system containing a brake dust particle filter (BDPF)

THE CHALLENGE OF MODELING BRAKE PARTICLE EMISSIONS

Though the brake disc/pad system appears to be relatively simple, it's more difficult to model than you might think.

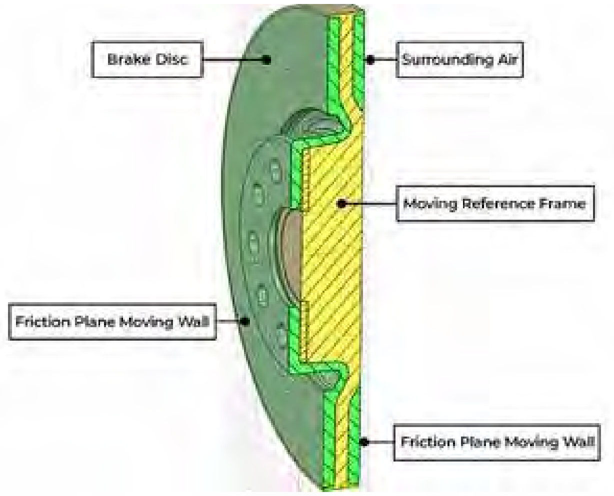
"The physics of brake disc particle creation and flow is not fully understood," Schulz says. "You could research and write several Ph.D. dissertations about this topic before you could really completely understand it."

Any simulation of this system with the addition of a brake dust particle filter (BDPF) must consider (among other variables):

- The entire flow field inside the BDPF, which is generated by the rotation of the inner-ventilated brake disc
- The material of the brake pad, brake disc, and metallic filter
- The separation efficiency of the filter for metal particle sizes ranging from 0.1 µm–10 µm
- The probability of a metal particle impacting the filter medium so it can be captured
- Quasi-static flow rates ranging from 10 km/h–130 km/h
- Thermal effects as the BDPF heats up during braking

Expanding on some of these points, Schulz explains that the materials of the brake disc (mainly cast iron) and the brake pad (metals, including iron, copper, steel, and graphite all bonded together) differ depending on the manufacturer of these components, so the amount of friction that develops between them during braking varies. This friction causes metal particles from the disc to form in different sizes and quantities. So, the size and number of particles are dependent on brake manufacturers, on temperature, and on the force that is applied by the hydraulic braking system.

Temperature also determines whether the metal particles are released into the air that travels through the brake or if they stick to the disc at first and release later. When they release, they enter the inner ventilation system of the disc, which consists of holes in the disc through which cooling air flows. This airflow can vary significantly depending on the driving speed and wind conditions.



Brake disc showing the moving reference frame simulation concept

In designing a BDPF, the engineers also have to be careful that the filtration system does not add to the airflow problem, because the metal mesh that serves as the filtration medium also slows down airflow, especially when the filter has been in use for a while and the mesh becomes clogged with entrapped particles. Reduced airflow can lead to undesired overheating.

"All these variables add to the complexity of designing a brake disc particle filtration device," Schulz says. "And complexity can lead to uncertainty in design."

REDUCING UNCERTAINTY THROUGH SIMULATION

In lieu of funding several Ph.D. candidates to research and write dissertations to solve these challenges, Dr. Florian Keller, Director of Engineering Air Filter Elements and Simulation at MANN+HUMMEL, led a research effort to better understand and track the flow of particles through a brake system equipped with a BDPF. As he wrote in the resulting journal paper "Development of a Modeling Approach to Numerically Predict Filtration Efficiencies" published by SAE International:

"While computational fluid dynamics (CFD) simulations for inner-ventilated brakes have become state-of-the-art, a holistic model from particle generation and emission to particle dynamics in the vicinity of the brake is not yet available."

"We had the great advantage of a lot of engineers who had experience with Ansys Fluent. So Ansys was the first choice for us when we started on this project."

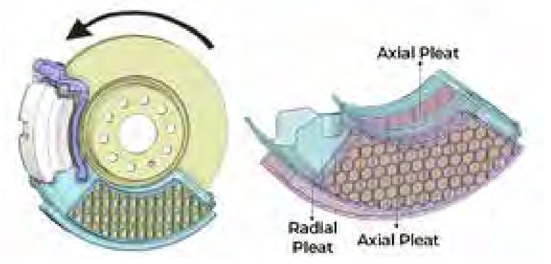
— **CHRISTOPH SCHULZ**, *Manager of Simulation Filter Elements, MANN+HUMMEL*

The paper describes his team's efforts to develop such a holistic model using Fluent to simulate filtration for 10 different filter designs and four floating caliper brake systems.

The BDPFs used in the simulations consist of a housing filled with a pleated metal fiber filter grid placed on both axial surfaces and on the radial surface of the housing. The pleats increase the surface area of the filtration medium. The housing attaches to the brake caliper. When the brake disc rotates, it causes air to flow through the inner ventilation and into the BDPF. This air contains metal particles from the brakes, which may become entrapped in the filter mesh. The goal of the simulations was to determine the fraction of metal particles leaving the brake that were captured by the filter.

Keller and his team set up the simulations using a moving reference frame (MRF) approach, in which the Navier-Stokes fluid flow equations in Fluent are transformed from the stationary frame to a moving frame. This is accomplished by taking into account the relative velocity of particles in the moving reference frame, the velocity in the inertial frame, the angular velocity, and the position vector from the origin of the moving frame. Using this approach, the acceleration of the air includes the Coriolis and centrifugal forces, which drive the air flow in the inner ventilation region.

The team used discrete phase modeling (DPM) to inject, track, and analyze particle

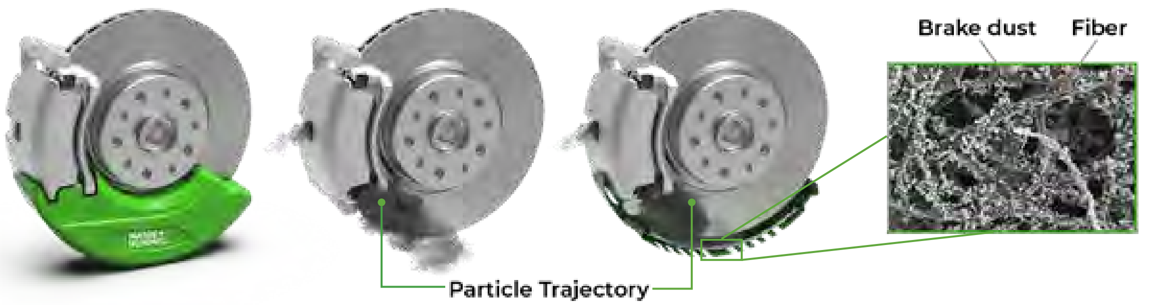


Pleated filter structure of the brake dust particle filter

behavior and ultimately compute the filtration efficiency of the BDPF. Discrete particles of sizes 0.1 μm, 0.5 μm, 1 μm, 2 μm, 3 μm, 5 μm, 7 μm and 10 μm having a density of 2650 kg/m^3 were injected into the simulation domain at four injection points in the vicinity of the brake pad.

The number of integration steps for particle trajectory tracking was set to 70,000 to reduce incomplete tracks. The simulated particle tracks revealed by Fluent show that the particles first move radially toward the filter medium and then flow alongside the filter element circumferentially. When metal particles reached the surface of the filter medium, they were considered to be trapped, while particles leaving the outlet of the domain were considered to have escaped.

From these simulations, Keller's team was able to track the flow of metal dust particles that came from the brake pad and the disc, predict the probability of impact with the filter medium, determine the particle size distribution, and



Filter concept for MANN+HUMMEL brake dust particle filter (BDPF), showing the filter unit in green, attached to the brake pads. Emitted brake dust is entrapped in a filter grid made of metal fiber.

calculate the overall filtration efficiency of the 10 BDPF designs. The probability that a dust particle would impact the filtration medium was as high as 80% for one of the designs.

VERIFICATION OF SIMULATION RESULTS

MANN+HUMMEL engineers developed a physical braking testing bench to compare simulation results with experimental ones. Keller and his team concluded that, using Fluent simulation, filtration results can be predicted with up to 10% accuracy compared to physical tests for the WLTC Class 3 cycle of automobiles, which includes vehicles with the highest power-to-mass ratio, representative of vehicles driven in Europe and Japan.

Even with such a close agreement between simulated and experimental results, simulations provided much more detail.

"What you don't get easily from a test bench is an impression of the flow field and of the particle movement itself," says Schulz. "So, this is something where you really have a big advantage using simulation. If you look at this brake system, there are a lot of small gaps where particles could escape and avoid the filter element. It's much easier to see these gaps in a simulation than in a real test bench. Fluent is a big benefit in revealing the details of flow and particle movement."

Particle tracks and impingement locations from one simulation run

CREATING SUBWAY AND OUTDOOR AIR FILTRATION PRODUCTS

Besides reducing emissions from cars, MANN+HUMMEL have also been participating in the Horizon Europe project, which is the EU's key funding program for research into climate change and sustainability. The company has been developing free-standing air filtration units to clean pollutants such as oxides of nitrogen (NOx) and particles from outdoor air and from subway stations.

"Our first pilot project with these outdoor installations was at Neckartor in Stuttgart — a traffic intersection infamously known as Germany's 'dirtiest intersection,'" says Christoph Schulz, Manager of Simulation Filter Elements at MANN+HUMMEL. They were working with the federal government and the city of Stuttgart. Along with standard air quality testing results, "they also requested that we provide some proof that our filtration units would work based on simulation," he says. "And we did the layout of particle filtration units in a nearby park with Fluent. We had a very good match there between the official air particle measurements and the simulations, so that was really cool."

MANN+HUMMEL also succeeded in cleaning the air in an amusement park in South Korea, followed by some installations in the streets of Brazil.

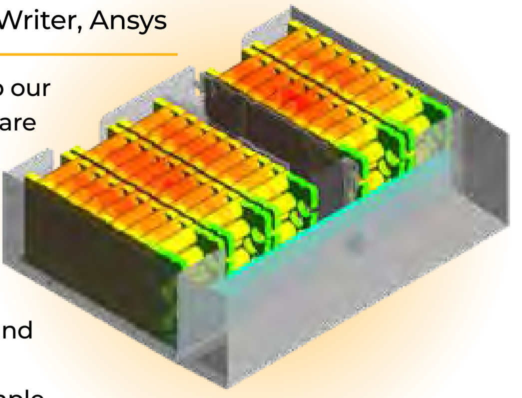
During the COVID-19 pandemic, they started to focus on cleaning up the particulate-laden air of subways. Schulz explains that subways have very high pollution levels coming from braking and from iron wheels running on iron tracks, causing a lot of abrasion. All this dust rises into the air when the train comes through the station.

"We have filter installations at three subway locations in France, always based on a combination of system layout done using simulation and then measurement onsite," Schulz says. "So far, we've had a very good match between what we simulated and what was measured. For this Horizon Europe funding project, our focus will be on simulation of subway stations, getting it to a higher complexity level, capturing the details better there, because we do see an upcoming market for air filtration in subways."

All Charged Up and Somewhere to Go

Ample looks to the Ansys Startup Program to design its innovative modular EV battery swapping platform

By **Laura Carter**, Senior Marketing Communications Writer, Ansys



Ansys Fluent thermal simulations of Ample battery modules using a multiscale, multidomain (MSMD) equivalent circuit model (ECM)

Climate change is accelerating, and the imperative to swap our gas-guzzling rides for all-electric plug-ins is real. Yet, many are hesitant to make the change. Range anxiety, or the fear of running out of battery power, is one big factor fueling this hesitancy. Without the proper infrastructure in place, drivers may find themselves stranded on the way to their destination.

There's also the issue of charging capacity. Plugging in and powering up can take anywhere from 4-10 hours using a 240 V charger, making long distance travel a real chore. Ample is proposing a solution to charging challenges that is quickly gaining traction in the automotive community — modular battery swapping.

"Our mission is to bring electric cars to everyone," says Steven Cho, director of computer-aided engineering (CAE) at Ample. "We believe that for the widespread adoption of electrification in personal and commercial mobility, facilitating the transition from gas to electric power has to be as fast, as cheap, and as convenient as gas."

SIMULATION INSPIRES AN ENTIRELY NEW WAY TO ENERGIZE AN EV

Someday, charging up your electric vehicle (EV) could be as simple as pulling up and swapping out your battery. Ample shortens the journey to fully charged to just under five minutes for any EV on its platform, regardless of battery density. Drivers can check into a swapping station, where their EV's "empty" modular battery is quickly replaced with a "full" one before hitting the road again.

By breaking an EV battery pack into smaller modular components, Ample aims to create a modular battery system that can adapt to multiple vehicle sizes and shapes with varying battery capacities to accommodate everyone. To do this, the automotive startup is using simulation, accessed through the Ansys Startup Program. The program enables early to mid-stage startups with limited funding access to a full suite of multiphysics simulation software, plus high-performance computing (HPC), at an affordable price.

Typically, time and cost are the most common challenges in the automotive industry — challenges Ample faced and overcame with simulation. Simulation can significantly shorten design cycles and save money and time that Ample can spend elsewhere. Even when a physical test is required, simulation can efficiently narrow down the key variables involved to reduce the total number of physical prototypes.

Ample also turned to simulation to address packaging and thermal management challenges, as well as other unexpected battery cell defects that could compromise vehicle safety. Various thermal and flow simulations in Ansys Fluent helped the team understand the basic physics and thermal flow behavior in the battery module structure, accelerating the time it took to achieve a final design.

Ample single port battery swapping station

"As a CAE engineer, I have been using Fluent from my college days and throughout my career in various applications such as automotive, solar, heat exchanger, and semiconductor," says Cho. "At the beginning stages of our work, the Ansys Startup Program offering was perfectly satisfying our demands."

Ansys solutions were also instrumental in developing swapping stations featuring simple, cost-effective robotics systems that are redundant, easy to deploy, and need minimal space to operate. Ultimately, simulation helped Ample arrive at a flexible design that can be deployed in days and support a wide range of vehicle applications — from small cars to large class three trucks in the same station, using the same modular batteries.

Ample swapping station with multiple carports

AMPLE DEMOCRATIZES CLEANER TRAVEL FOR ALL

Perhaps the most interesting outcome of this effort may be in the modularity of the batteries themselves. The tech is great, yet the price of entry is still prohibitive for most consumers. Cho's team, in working with original equipment manufacturers (OEMs), has another breakthrough solution in mind that will significantly reduce barriers to ownership.

"Instead of selling battery packs inside the car, we are trying to sell the vehicle without it," says Cho. "Your new vehicle would come equipped with a swappable battery module. The battery module is not yours. You're just paying for the electricity needed to fully charge it. This will be a real game-changer in terms of price."

As you might expect, OEMs are lining up to hear about Ample's solutions.

"Our modular battery swapping has the unique advantage of making it possible to make almost any electric vehicle swappable without requiring any modification to the vehicle," says Cho. "We are engaged with a few of the largest automakers in the world to prepare their EVs to be sold with Ample's technology. This enables them to solve a significant barrier to EV adoption, which is the availability of electric infrastructure and speed of energy delivery, especially to fleet partners for whom cost and speed make a significant difference."

There's a lot of concern for the future of our planet. Behind the scenes, startups like Ample are running with some big ideas (and help from Ansys) that could change it. If you need simulation to help bring your dreams to life, the Ansys Startup Program can help.

A vehicle undergoing the Ample battery swapping process

DID YOU KNOW?

Perhaps the biggest benefit of the Ansys Startup Program is access to solvers that set up new companies for success. The Ansys Startup product bundles were instrumental for Ample in facilitating a deeper understanding of the engineering and physics of EV batteries, including:

- **Ansys Fluent** for battery simulation, from cell to pack level. The software delivers good prediction of battery performance under various driving conditions, which helps the team understand the efficiency of the thermal management system, as well as driving range.
- **Ansys Twin Builder** for virtual testing of an entire battery module. Using a reduced-order model (ROM) unit trained by a full 3D Fluent model provides the team with simulation results based on various operating conditions in a short period of time, saving hours of product development and validation, and reduces costs.
- **Ansys Mechanical** for virtual validation of the battery module and swapping station, covering structure analysis from simple static load conditions to fatigue durability under more complex load conditions. Using the topology optimization function to optimize the battery module and pack structure helped maximize system performance.
- **Ansys LS-DYNA** for validating battery module mechanical integrity and safety through drop, impact, crush, and crash testing.
- **Ansys Electronics** to assess electromagnetic magnetic interference (EMI) / electromagnetic compatibility (EMC) of Ample's high-voltage system design early in the design process. Ample can also use the software to conduct root cause analysis for existing EMI challenges.
- **Ansys medini** analyze for functional safety analysis of the battery. The software is especially helpful in battery management system design and validation critical to conditions monitoring and the redistribution of energy resources.

If you're a startup in need of Ansys simulation and support to take your business to the next level, be sure to check out the Ansys Startup Program at Ansys.com/startups.

4 Ways to Design More Reliable Automotive Electronics

By **David Dang**,
Technical Account Manager,
Ansys

From engine management systems (fuel injection rate, emissions control, cooling systems) and autonomous controls (lane, speed, park assist, adaptive cruise control) to infotainment systems and comfort systems (climate control, electronic seat adjustment, automatic wipers, etc.), modern-day gas-powered and electric vehicles have more electronic devices than ever. Indeed, the microprocessors and chips that power modern vehicles are now so prevalent that they're practically a commodity in the same vein as steel and aluminum.

According to a Deloitte study,[1] electronics are responsible for 40% of a new car's total cost, with an expectation to grow to 45% within the next few years. Assuring automotive electronics reliability must be top of mind for designers and manufacturers as they deploy new models to the market. Ansys simulation software can help original equipment manufacturers (OEMs) and suppliers design for reliability (DfR) from the start of a project — from integrated circuits (ICs) all the way to printed circuit boards (PCBs) and enclosures.

THE FOUR CATEGORIES OF AUTOMOTIVE ELECTRONICS

Automotive electronics can typically be classified into four different categories:

1. Functional electronics (critical to vehicle operation): antilock braking systems (ABS), automatic transmission control, starters, fuel injection, headlights, and electromechanical parking brakes.
2. Regulatory compliance electronics (mandated by government agencies): airbags, emission controls, back-up camera, and collision detection radar.
3. Differentiating electronics (unique, customer-oriented technologies): infotainment, adaptive cruise control, Wi-Fi connectivity, and advanced driver assistance systems (ADAS).
4. Growth opportunities (for vehicles in general): collision detection, in-dash displays, head-up displays (HUD), enhanced infotainment systems, vehicle-to-vehicle communication (V2V), and improved Wi-Fi.

There are a large number and variety of electronics within an automobile — including potentially much longer duty cycles for autonomous vehicles. Automobiles also have longer lifetime requirements driven by consumer demands. For these reasons, automotive electronics designers and manufacturers must consider virtual validation along with physical testing to keep costs reasonable and meet shrinking development timelines.

TESTING FOR FAILURE

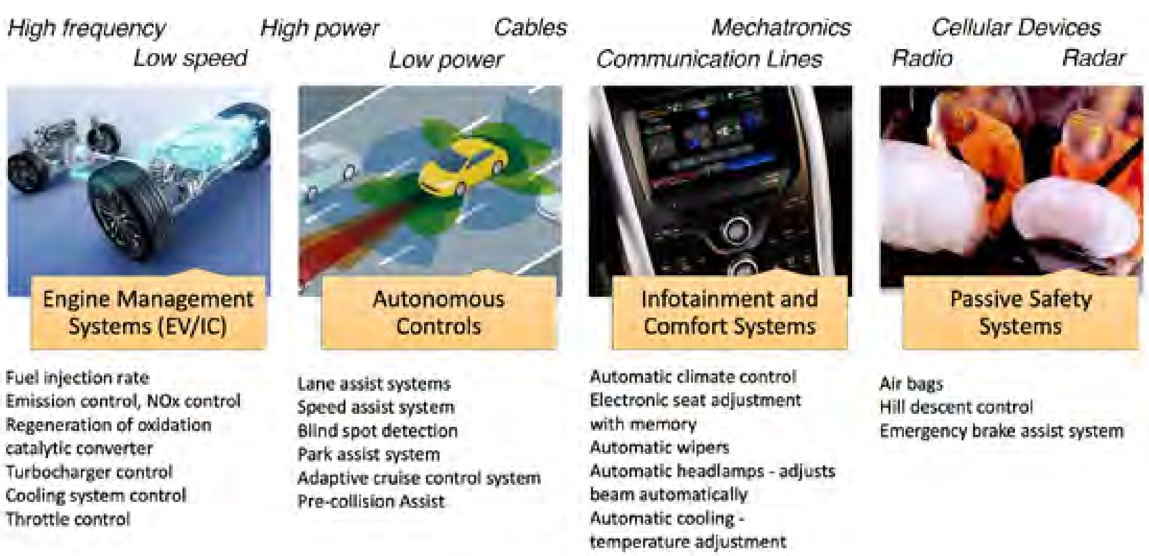
Electronics usage is not new, and other industries such as consumer electronics and high tech have to meet a number of requirements, including:

- Immobility/limited vibration
- Little to no mechanical shock
- Low humidity/controlled temperatures of office environments
- Predictable duty cycles

While those dynamics are ideal for, say, household electronics, the stressors that automotive electronics are exposed to are much more extreme, including:

- Harsh mobile environments
- Large temperature swings
- Sustained periods of vibration — and, in the case of accidents, sudden shock
- Longer lifetimes; a car is expected to last 10 years, unlike a cell phone or laptop

Couple this with ever-shrinking feature sizes, including environment and movement sensors, onboard computer systems and networks,



The Ansys ecosystem for supporting engineers and designers in data management, project tracking, data-driven decision making, and more

and vehicle control actuators. Suddenly, best performance predictability is on a sliding scale over one, five, or even 10 years of driving, and degradation takes its toll.

DESIGNING MORE RELIABLE AUTOMOTIVE ELECTRONICS

To design more reliable automotive electronics, there are a number of best practices to consider.

1. Eliminate Failures During Testing

A large amount of product development costs are caught up in a "fix-fail-fix-repeat" cycle. When electronic products are undergoing physical testing, they can go through rounds of design cycles to fix uncovered failure modes. However, this can be costly and time-consuming. Virtual prototyping, or simulation, is one of the best ways to test for failures before a product is physically manufactured.

Simulations must, however, include accurate material inputs and the proper loading conditions to ensure simulation results match up as close to physical reality as possible. This reduces design cycles by catching failures early in the design phase, allowing engineers to make design changes before a physical prototype is produced. Simulation does not completely replace physical testing, but it can greatly reduce the number of tests performed.

2. Reusing Engineering Ideas and Assets

Much of the automotive electronics manufactured can take advantage of model reuse. Once a reliable model is created, it can continue to be reused and optimized for future versions. This is a concept that can also be used in simulation, in which simulation models can be reused and updated based on new reliability and safety requirements.

The benefit of using simulation to help aid design is the variety of configuration and data management, visualization, transparency, and collaboration that is provided. All simulation models and results are documented for future use, and automation and optimization workflows can be used to facilitate design decisions.

In addition, having proper data management that is transparent allows different departments (such as electrical and mechanical engineering departments) to work together on a common design and ensure that all cross-departmental reliability goals are being met and data is being passed back and forth efficiently.

3. Auditing Suppliers

If you are an original equipment manufacturer (OEM), it's also exceedingly important to audit your automotive electronic suppliers. Since the start of the pandemic, supply chains have been affected, particularly within the automotive industry. Supply chains have slowed, opening the way for the proliferation of counterfeit or alternative parts. Unfortunately, it is often difficult to tell when a part is counterfeit. It is important to either audit your supplier or perform a robust design review of parts received to ensure they are valid.

4. Ensuring Manufacturing Is to Specification

There are a number of specs and requirements that automotive electronics must meet before they are included in an overall automotive manufacturing process. Some of those specs include requirements like the recently updated GMW 3172, VW 8000, and the ISO 26262 safety standard. Most of these standards require electronics to function at a reliable level at certain temperatures, vibration levels, moisture levels, and more. There are physical tests that can be performed to ensure electronic parts are meeting these reliability specs, but there are also simulation workflows that can be used to see if an electronic design will meet these requirements before a physical prototype is built. Most of these simulation workflows include multiphysics and involve a number of different software tools. This allows a user to perform the most robust and accurate analysis possible while considering the effects of electro-thermo-mechanical stress on the electronic parts within a vehicle.

References

1. *Car and Driver. "Electronics Account for 40 Percent of the Cost of a New Car," May 2, 2020.*

LEARN MORE

Ansys Reliability Engineering Services: Ansys.com/services/reliability-engineering-services