Ansys

ADVANTAGE

POWERING INNOVATION THAT DRIVES HUMAN ADVANCEMENT

ISSUE 3 / 2024

SIMULATING AUTOMOTIVE SAFETY

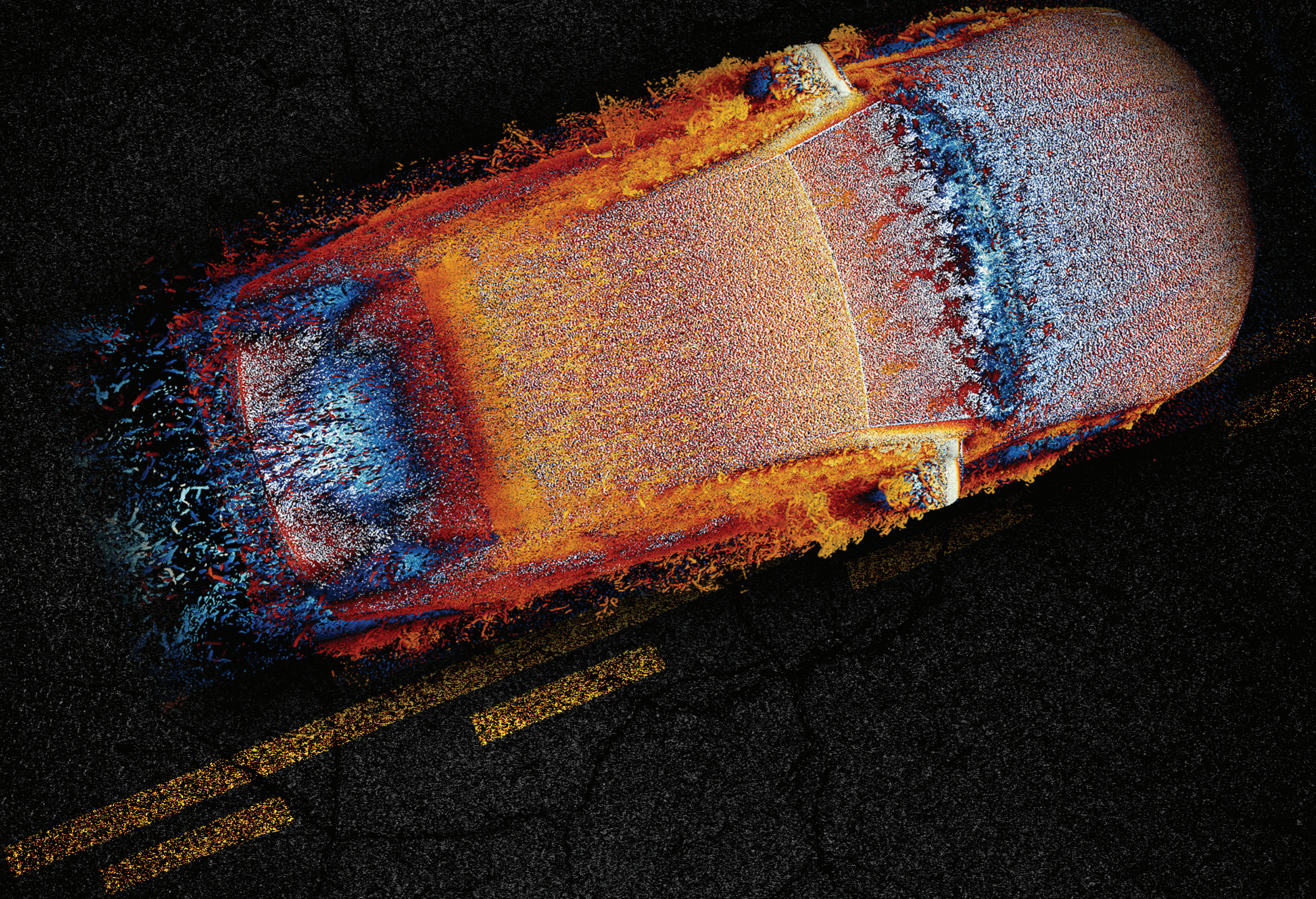
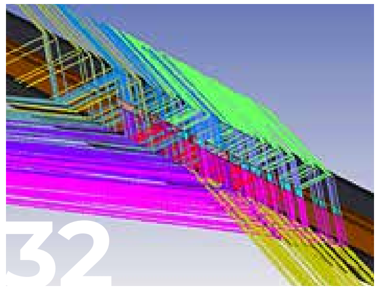
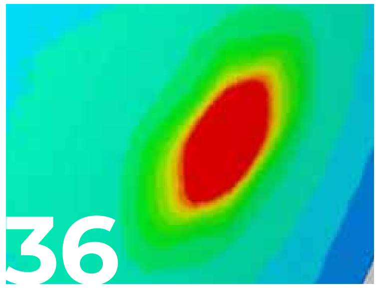
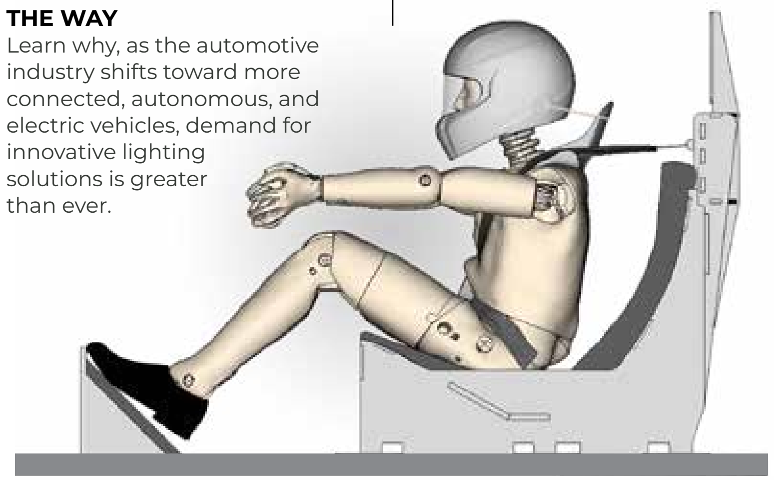


Table of Contents





Focus on Automotive Safety



DOWNLOAD THE DIGITAL ISSUE

To access the current and back issues online, visit 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 Hurt

Executive Editor
Jamie J. Gooch

Managing Editor
Greg Bartlett

Contributors
Laura Carter, Susan Coleman, Judy Curran, Kim Hurt, Lothar Pfeifer, Steve Defibaugh, Caty Fairclough, Mike Grove, Kerry Herbert, Steven LaCava, Aliyah Mallak, Gwenael Moysan, Krishna Samavedam

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

Engineering a Safer Road Ahead With Simulation

By **JUDY CURRAN**, Senior Chief Technology Officer, Automotive and Transportation, Ansys

The transportation industry faces cost and time-to-market pressures even as it drives to develop complex innovations in areas such as software-defined vehicles, electric powertrains, and advanced driver-assistance systems (ADAS). That means automotive engineering resources are stretched thin, as interdependent system complexity balloons and everyone asks engineers to go faster. Achieving those competing goals while improving safety would be impossible without simulation-enabled digital engineering. Let me explain why.

IMPROVE SPEED AND SAFETY

Not too long ago, we were comfortable taking four years to develop a large vehicle program. That is no longer competitive. Original equipment manufacturers are now aiming to develop vehicles in two years or less.

However, the latest data shows that vehicle programs are actually being delayed. Over half of the vehicle programs in the U.S. were delayed last year. This is a significant trend we've been tracking over the past seven years. Some programs are delayed due to market-based decision changes, but many delays are caused by poor launch execution. Could it be that initiatives to increase automotive technology everywhere from the drive train to lighting are becoming too complicated? Something needs to change, as delayed launches have a large impact on profit.

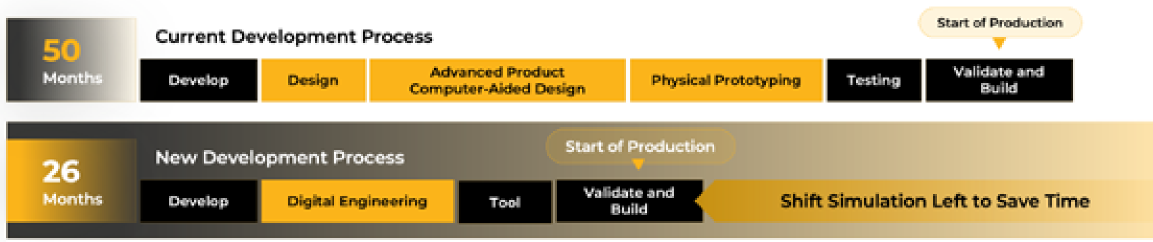
Simulation is a critical element of that change. It has kept pace with the ever-growing needs of the automotive industry over the years. For example, crash analysis in the 1990s analyzed details of a crash with a 12,000-cell mesh. With our latest innovations, we are analyzing over 20 million elements. And, we're doing it faster than ever with software that takes advantage of the latest innovations in cloud computing and graphic processing units (see page 28).

Another example can be found in human body modeling. Crash testing includes more load cases and crash scenarios than ever, adding to the complexity. For years, we primarily counted on crash test dummies that, too, have become much more sophisticated and expensive over time. We can now realize the benefits of having sophisticated virtual human body models (see pages 10 and 14).

We continually add simulation models to our crash library. For example, we are adding detailed models for connections. Are you considering a MIG weld, spot weld, or adhesives? Are you using composites or recycled materials? These have been traditionally difficult to simulate because of their random nature. We now have established correlated models for these materials.

From materials, to crash safety, to smart lighting, simulation enables engineers to rise to industry challenges by designing and validating new features without expensive hardware testing. You can even compress design cycles by combining simulation with artificial intelligence to meet evolving requirements and introduce new products.

PRODUCT DEVELOPMENT SPEED IS CRITICAL TO REMAIN COMPETITIVE



“New technologies are not able to be developed alone within a single team; these technologies are interdependent, so teams that haven't collaborated in the past will need to do so now.”

ENABLE DIGITAL ENGINEERING

Going faster requires a development process that is in a digital environment. At Ansys, we have a framework that will make it possible to integrate our technology and tools with your people, existing processes, and data to accelerate the product development process (see page 24).

SIMULATION RETURN ON INVESTMENT EXAMPLES

New technologies are not able to be developed alone within a single team; these technologies are interdependent, so teams that haven't collaborated in the past will need to do so now.

ADAS functions are a great example (see page 20) of interdependencies. How an ADAS controls steering, brakes, and lighting can help prevent or reduce the severity of an upcoming crash. The same goes for the battery team working with the body structure team. That's why it's critical to make it easier to co-simulate among teams.

Collaborating in the same digital environment can help teams optimize design options for improved safety. Ansys champions open workflows so that our products can be integrated into a more complete digital thread.

As the transportation industry evolves and innovates to deliver upon the goals of clean and safe mobility, efficient engineering processes are critical. Simulation is a key enabler in shortening engineering processes and making them more efficient. Visionary automotive companies know how their world-changing ideas will perform well before prototypes and production through the use of simulation and model-based systems engineering. No longer relegated to CAE departments, simulation has changed tremendously over the past few years, empowering every engineer to innovate faster than ever before.

LOWER COSTS AND RISKS

Digital engineering requires an investment but one that has obvious returns. Simulation is one of the most significant enablers of time and cost savings, yet to realize those savings requires an agreement to cut some of the traditional engineering process expenses: engineering material cost, prototype cost, test headcount, test facilities, prototype tooling, production tooling modifications, etc.

You can increase safety and mitigate risks by quickly assessing many scenarios in a virtual environment, but simulation also saves opportunity costs. Traditional prototype and testing regimes may allow an engineer to perform half a dozen tests, but with simulation that same engineer can perform thousands of tests in the same amount of time. That means edge cases, wild ideas, and re-testing unexpected outcomes are all benefits of simulation. When it comes to simulation, companies that defer expenditures to next year will find themselves another year behind.

SIMULATION

Helps NASCAR Assess the Impact of SAFER Barriers During a Race

By **Laura Carter,** Corporate Communications Manager, Ansys

Ask the Engineer: Get a glimpse into how Ansys simulation software helps NASCAR improve safety along the wall.

In the world of stock car racing, one driver's tactics can unexpectedly take others out of a race. That's exactly what happened in October at Talladega Super Speedway, when an aggressive push from Alex Bowman led to Ryan Blaney's late-stage crash.

It was that push that sent Blaney's car spinning into a SAFER (steel and foam energy reduction) barrier, jeopardizing his chances at the 2024 title. On average, NASCAR race cars have the potential to reach 190 to 200 miles per hour, yet Blaney managed to walk away from a chaotic scene unharmed due to these life-saving inner and outer barriers circling the track.

Was it luck, engineering, or a bit of both? In this instance and many others, SAFER barriers, also known as soft walls, have played a definitive role.

SAFER barriers are created by the vertical stacking and welding together of 8-inch square structural steel tubes to form 20-plus-foot-long, 40-inch-high modules. Internal steel splices join them together to build a continuous wall that is then typically placed in front of a concrete barrier. Retention straps serve as an anchor between the SAFER barrier and the concrete wall behind it. Trapezoid-shaped foam blocks are then placed between the concrete barrier and the steel wall for energy management.

We recently had the chance to talk to John Patalak, vice president of safety at NASCAR. His team uses LS-DYNA nonlinear dynamics structural simulation software for placement optimization of SAFER barrier modules to reduce vehicle accelerations for track-specific configurations. This includes the reconstruction of specific on-track crashes to identify the potential for driver injuries, then applying this knowledge to realize risk reductions on the racetrack.

Q: ***How likely are impacts in NASCAR compared with everyday driving?***

JOHN PATALAK: We have minor contact between race cars on the racetrack all the time. Typically, those cars either come down pit road and get new tires and continue on or bypass pit road altogether. We're not usually interested in those contact events, as they're not particularly injurious. We try to discriminate those out of our dataset by requiring trigger thresholds in our data recorders.

A few years ago, we did a statistical study based on black box data coming out of the car. We pulled about 10 years of data to understand the number of contact events that qualify as crashes occurring in our different series. To be fair, we chose to look at crashes per mile raced, because you might race in an event that's 250 miles or 600 miles long. Then there's the format and the configurations of the track, among other things to consider.

Based on the data, when we looked at the full-time NASCAR drivers during this time period, they experienced 134 times more crashes per mile traveled than the motoring public. Yet, these same drivers experienced over nine times less injuries per crash. So they crashed way more often, but their injury per crash was substantially lower.

Q: ***How do SAFER barriers support NASCAR's overall safety strategy?***

PATALAK: They're an integral part of a multipart safety strategy in NASCAR that also includes black boxes for crash data, driver restraints — including full-face helmets, head and neck support (HANS) devices, improved seatbelts and seats — and crashworthy vehicle designs. The SAFER barriers have had a huge impact in lessening vehicle impacts along the wall.

The SAFER barrier system was actually developed by the University of Nebraska, Lincoln (UNL) at the Midwest Roadside Safety facility (MwRSF) with support and funding from IndyCar and NASCAR. LS-DYNA software was used to optimize or tune the barrier for the vehicle's mass and the speeds at which it could impact a portion of the wall. As time went on, we're still using LS-DYNA software, trying to find more improvements in the overall design.

Q: ***What happens when a race car hits a SAFER barrier?***

PATALAK: Consider a race car approaching the wall at, let's say, 150 miles per hour. Whether the wall is concrete or SAFER barrier, that velocity is the same. When the car hits the wall, it begins to slow down. When the car leaves the wall, the car has changed

Photo credits: Getty Images

its velocity — let's say it's now going 100 miles per hour. During both a concrete wall and SAFER barrier crash, the vehicle had to change its velocity the same amount, in this case 50 miles per hour.

What makes the SAFER barrier so effective is that it displaces during the crash, much like the car does as it crushes. In both cases, we are adding time over which the velocity change is occurring, so the car is making that 50 miles per hour change over more time than it would if it impacted a concrete wall, which doesn't displace. The vehicle acceleration during the crash directly influences the forces on the driver's body. By adding more time during the velocity change of the crash, the SAFER barrier is very effective at reducing the peak accelerations experienced by the car and the driver. The lower the acceleration, the lower the forces on the driver's body.

Q: *How does LS-DYNA software lead to improvements in barrier design?*

PATALAK: We've used LS-DYNA software to study the SAFER barrier and how to implement it at racetracks. We occasionally have race weekends where we share the racetrack with other series. Other series vehicles may be much lighter than NASCAR vehicles, or they may go faster, so their impact conditions to the SAFER barrier are much different than NASCAR vehicles.

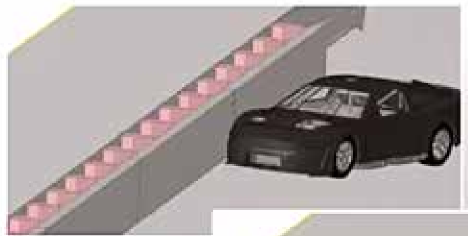
Last year, we used LS-DYNA software to study various impact angles at different speeds to soften the wall and get as much displacement out of it as possible. Working with Elemance LLC and UNL MwRSF, we did this analysis for the first time at the Los Angeles Memorial Coliseum for one of our opening events of the season, the NASCAR Busch Light Clash at the Coliseum.

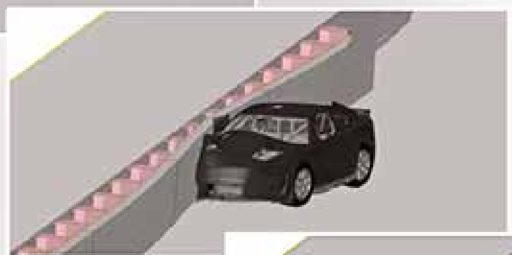
It's a shorter track, and the speeds are lower. Analyzing the impact angles there enabled us to remove every other foam block within the SAFER barrier to optimize the SAFER barrier without expensive physical testing.

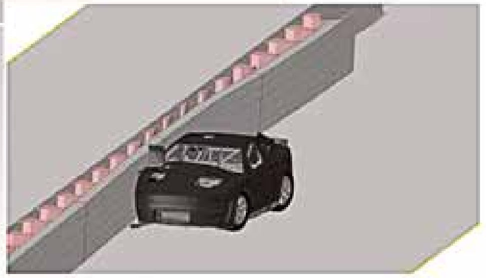
Q: Can you share some benefits of using LS-DYNA software in your work?

PATALAK: Based on the simulation data we're getting, our confidence level using the software is high. We can start to study other problems that previously were cost-prohibitive in terms of testing, like the alternate spacing of foam blocks. Without LS-DYNA software, it's the sort of testing that you're really not sure can be justified otherwise in terms of cost, because you don't know what you're going to find or if the project is even worth it. In a simulation environment, however, you can run that assessment for much less.

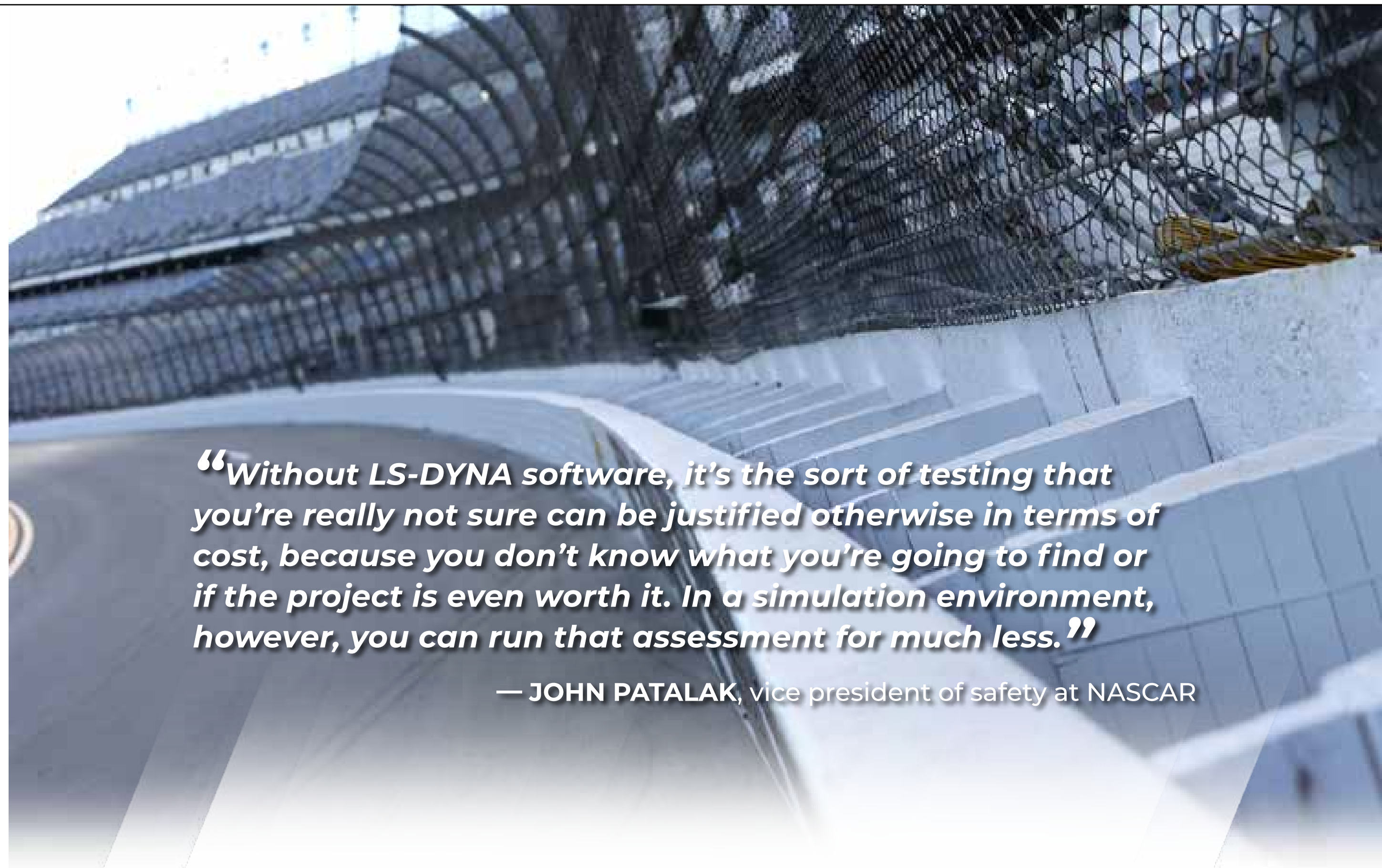
LS-DYNA software enables us to explore and see what the important factors are and what really makes a difference in barrier design. And in some cases, we will go run physical crash tests to verify and validate our results. For some projects, our confidence level is high enough to proceed without physical tests. For example, we were able to implement changes of the foam block spacing at the Los Angeles Memorial Coliseum last year without any empirical testing.







LS-DYNA nonlinear dynamics structural simulation software shows a 130 mph simulated crash into a SAFER (steel and foam energy reduction) barrier.



"Without LS-DYNA software, it's the sort of testing that you're really not sure can be justified otherwise in terms of cost, because you don't know what you're going to find or if the project is even worth it. In a simulation environment, however, you can run that assessment for much less."

— **JOHN PATALAK**, vice president of safety at NASCAR

Q: *How do you reconstruct on-track crashes leveraging virtual human body models in LS-DYNA software to prevent head injuries?*

PATALAK: Typically, we'll start with human body models because we have human drivers in our race cars. In many cases, the drivers wear mouthpiece sensors that are recording the acceleration and rotational velocities of their heads. Working together with the Center for Injury Biomechanics at Wake Forest University and the Wake Forest School of Medicine Biomedical Engineering groups, NASCAR introduced these mouthpiece sensors to capture on-track driver head kinematics. We will look at those outputs, then run our human body models to make sure that from a baseline standpoint we are predicting what the empirical data showed.

Once we are closely aligned with that data, we can start to tune things like helmet fit, helmet materials, seat stiffnesses, and head and neck restraint tether lengths. Using our engineering intuition and education, as well as the laws of physics, we can begin to answer some basic design questions. For instance, if we modify the stiffness of the head foam, can we reduce the head acceleration that the driver experienced?

We'll run through a bunch of different iterations and study it that way. All this work is done in a virtual modeling environment. If we find a change or iteration in design that might be a benefit, we will go and validate it empirically before we incorporate any meaningful changes to the restraint system.

Q: *Considering your work at NASCAR over the years, how significant is the SAFER barrier?*

PATALAK: It's been roughly 20 years or so since the SAFER barrier was first implemented on the track. Today, I would include this technology in my top five greatest hits of motorsport safety improvements. In fact, Dr. Dean Sicking, who at the time was leading the group at the University of Nebraska responsible for the SAFER barrier, is being inducted into the NASCAR Hall of Fame this February.

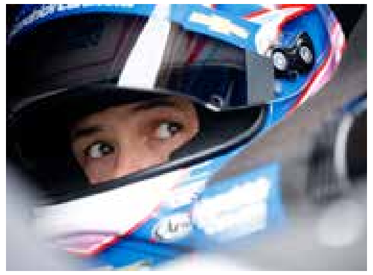
It's a landmark achievement. If you compare this technology to concrete, you're looking at anywhere from a 30% to 80% reduction in peak acceleration values experienced by the vehicle. It's a massive improvement now. Today, we're still using LS-DYNA software to squeeze out maybe another 5%, as the tool is much finer and more precise now.

NASCAR Reduces Injury Risk With Human Body Models and Simulation

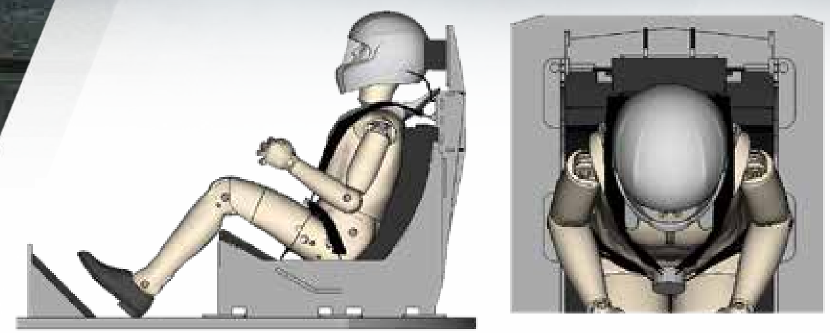
By **LAURA CARTER**, Corporate Communications Manager, Ansys

Racing is inherently dangerous. Thanks to virtual modeling in a simulation environment, the risk of serious driver injuries remains low.

NASCAR drivers are some of the best in the world. But when you're driving on the edge of traction at 200 miles per hour, crashes are bound to happen. John Patalak, vice president of safety at NASCAR, is keenly aware of the potential risks. To help maintain safety during racing season, his team leans on massive amounts of data acquired on the track, as well as data acquired in a simulation environment.



"From a speed standpoint, one of the things we're trying to always improve on is being able to respond faster to safety issues," he says. "Our drivers expect and demand that from us. We have to be fully confident that we have data to stand on if we're going to tell the driver to take some action to be safer. We can't do that solely based on opinion, but because we've got data that we're confident in and is robust enough to make that decision on, so we can sleep at night."



Helmet foam simulation, rear impact, THUMS 50th percentile male

While NASCAR drivers experience more crashes per mile than those in passenger cars do, fortunately the rate of injury per crash on the track is far less, according to Patalak. One particular driver injury NASCAR is studying is compression fractures between the thoracic and lumbar vertebral bodies of the spine.

To understand these types of injuries, NASCAR relies on a combination of test data using an anthropomorphic test device (ATD) or crash test dummy, and numerous virtual simulations in Ansys LS-DYNA, which is multiphysics structural dynamic simulation software.

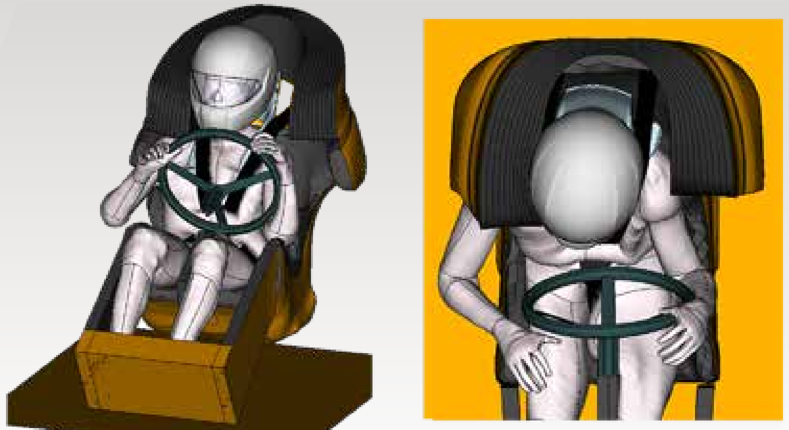
These virtual simulations also involve the use of the THUMS (Total Human Model for Safety) from Toyota, a digital representation of a human body which helps the team do more thorough spinal injury risk assessments during frontal impacts than with a mechanical dummy alone.

"We've done a lot of research into these types of injuries," says Patalak. "You can have a mechanical model. You can test it. You can validate it. Without simulation, you're really limited with empirical testing and physical crash test dummies for this specific injury mechanism. The crash test dummies do have lumbar load cells, but their spines are not very biofidelic, so we quickly get to the limits of those tools. Using human modeling in a simulation environment transcends these limitations."

STILL, YOU CAN LEARN A LOT FROM A DUMMY

Aside from any limitations, NASCAR's baseline for testing is the ATD. The dummy model helps the team validate its restraint system models. To do this, the team must reference material models of seat belt systems, seat foams, the helmet, and the HANS device (a head and neck support device or yolk-like collar tethered to the helmet and positioned under the driver's shoulder belts).

Before any digital modeling is done, the team empirically tests the mechanical



Helmet foam simulation, right-side impact, THUMS 50th percentile male

dummy with all the relevant pieces of safety equipment. This entire setup is digitally recreated in LS-DYNA software to look at all the sensor outputs on the dummy, as well as other physical parts.

Validation against the empirical dummy gives the team a higher level of confidence in the virtual representation of seat belts, helmets, head and neck restraints, and seat foams that are touching the dummy. Once the team has those pieces, it can remove the ATD from the virtual environment and start to look at much more detailed and nuanced issues from injury mechanisms with the human body model.

Based on this activity, NASCAR engineers can tweak the restraint system, such as the stiffness of the foam the human body model is on or the angles of the seatbelt to realize incremental improvements. As of late, the team is examining the posture of the human body model pre-impact. This includes turning on some of the musculature in the model to activate a bracing posture (with the help of a high-speed video of real drivers during a crash) to get an idea of how a driver is positioning his or her body pre-crash.

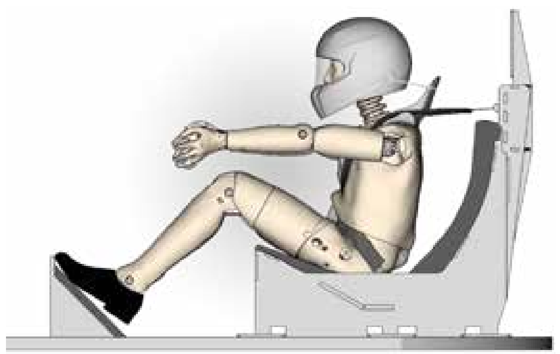
"If you have a thoracolumbar spinal fracture, the dummy has a somewhat limited output set to help us understand that specific injury mechanism," Patalak says. "So the reason we went to the human body model is because we can look at localized strains on each vertebral body and start to compare those strains to failure strains of an area of the spine. We can also look at cross-sectional forces through each vertebral body and the bending moments so we can extract all of that information to optimize the system overall."

ANSYS SOFTWARE GIVES ENGINEERS A HEADS-UP ON HELMET PERFORMANCE

Five key safety improvements in NASCAR have been identified as lifesavers on the track:

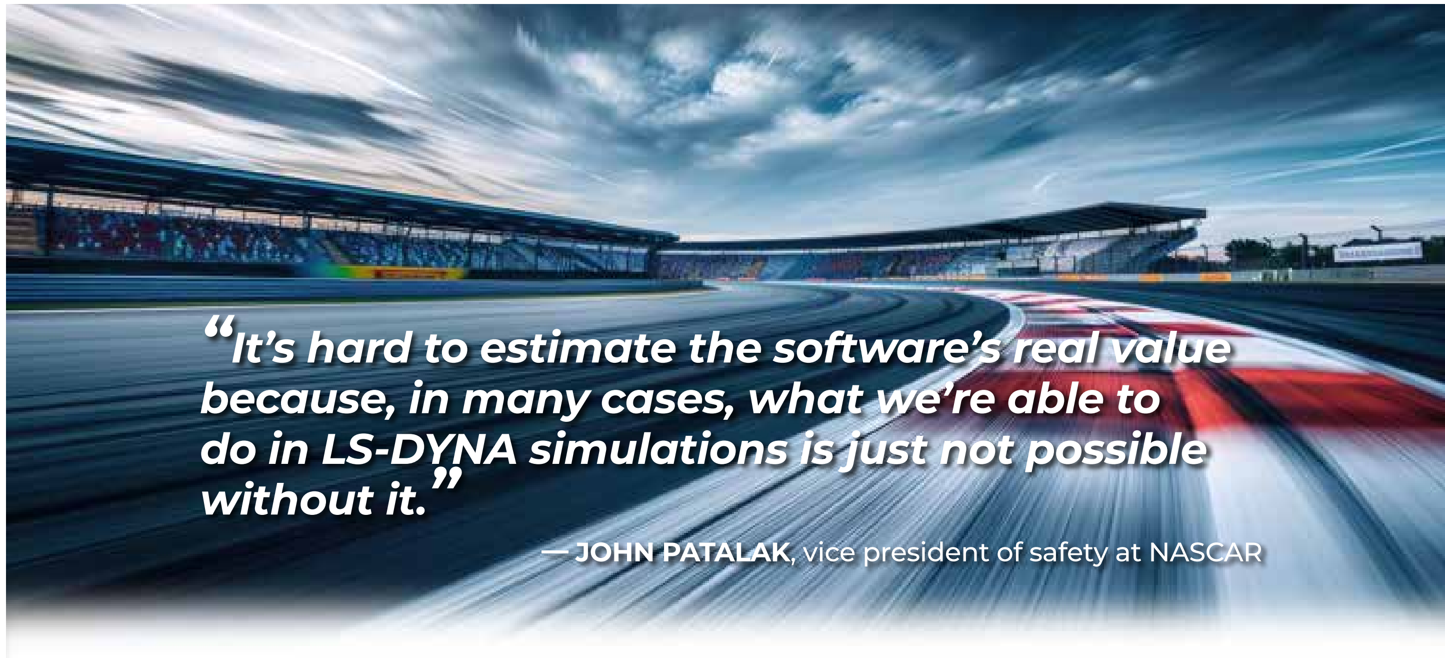
1. Black boxes for crash data
2. Full-face helmets
3. HANS devices
4. Steel and foam energy reduction barriers
5. Improved seat belts and seats

Among them, full-face helmets get the most attention for their colorful appearance and ability to protect a driver's head during a race. By design, they are engineered to distribute the force of a crash across the entire head and protect drivers from facial injury during high-speed impacts.



Crash dummy sled testing

Just how well do helmets do their job during a NASCAR race? According to Patalak, it's rare that a driver experiences a severe impact to the helmet shell itself. That's because NASCAR drivers are pretty well contained within full-head surrounds and a roll cage over them. Still, there's always room for improvement.



One area the team has been looking to squeeze out a bit more performance from the helmet is in the area of low-severity impacts. The objective is to balance safety with driver expectations in an environment that can be noisy, harsh, and even claustrophobic. Drivers want to be very well-coupled — engineering speak for attached to the car (which is very beneficial from a safety standpoint) — through the driver's seat and energy-absorbing foam.

In the cockpit, a driver's helmet is surrounded by crash foam, which, while minimizing crash injury risks for the head and neck, can be problematic for regular driving. As drivers go over bumps and curbs, they may get jostled from left to right, causing impacts between their heads and the crash foam. One area of focus for the team is to explore and understand these low-severity impacts between the helmet and the head surround foam that can become uncomfortable during a race.

"To replicate this phenomenon, we have characteristic pulses that we run against head foam models through the system to see how the human body model head responds," says Patalak. "Then we look at modifying material properties within the helmet or the head foam within the context of our simulation environment to lessen the effects of these impacts."

SAFER SEASONS AHEAD WITH SIMULATION

Testing efforts in helmet development are part of a long-term study at NASCAR. Currently, the team is modeling in LS-DYNA simulation software to try to develop empirical tests. The intention is to develop tests that helmet manufacturers or standard-bearers, including the Snell Memorial Foundation and the FIA, or Fédération Internationale de l'Automobile, can use to evaluate helmet efficacy at lower severity levels.

Both Snell and the FIA work in evaluating, testing, and regulating motorsport helmets. In sharing its work with both organizations, NASCAR is on track to make a difference in motorsport safety, as not everyone is fortunate to have access to full LS-DYNA models of their helmet systems.

Patalak's team is also examining what adjustments to the HANS tethers that the helmet is attached to can be made to better protect the driver. Research includes the effect of tether length, height, and angles on upper and lower neck loads. The idea is to find the sweet spot within a modeling environment that will significantly reduce head acceleration without increasing neck forces upon impact. In the end, it's work that would otherwise be severely limited, if not impossible, without simulation.

"I think the value of the LS-DYNA simulations is that we can set aside the inherent small variabilities of physical testing and really assess the effects of minute changes to a system with a high level of confidence much, much faster and cheaper," Patalak says. "It's hard to estimate the software's real value because, in many cases, what we're able to do in LS-DYNA simulations is just not possible without it."

LEARN MORE

Watch "Driven by Simulation: NASCAR Simulates Safety With Next Gen Car."

ansys.com/campaigns/driven-by-simulation/NASCAR-simulates-safety

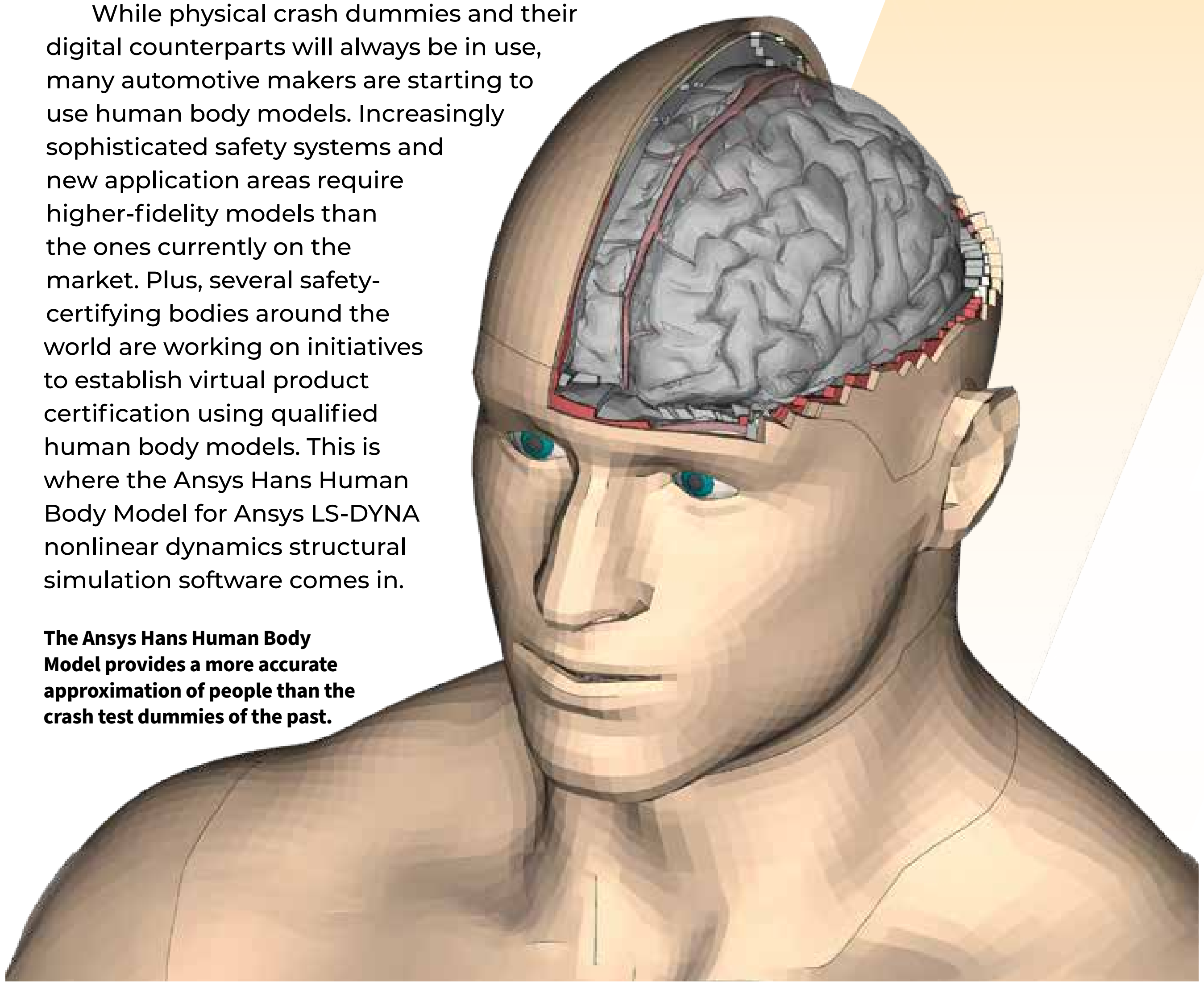
Meet Hans,

The Human Body Model Helping Make Cars Safer

By **Aliyah Mallak**, Corporate Communications Manager, Ansys

For decades, car companies have boasted about their safety, with commercials depicting a car crashing into a wall and a test dummy coming out more or less unscathed. But with electrification and autonomy hot on the minds of automotive engineers and consumers, passenger and pedestrian safety is of utmost importance.

While physical crash dummies and their digital counterparts will always be in use, many automotive makers are starting to use human body models. Increasingly sophisticated safety systems and new application areas require higher-fidelity models than the ones currently on the market. Plus, several safety-certifying bodies around the world are working on initiatives to establish virtual product certification using qualified human body models. This is where the Ansys Hans Human Body Model for Ansys LS-DYNA nonlinear dynamics structural simulation software comes in.



The Ansys Hans Human Body Model provides a more accurate approximation of people than the crash test dummies of the past.

"With virtual crash simulation, we now have our Hans Human Body Model that we can put in cars and look at what's going on inside the body in terms of bones, muscles, and tissue."

— **ALEXANDER GROMER**, senior manager application engineer, Ansys

DUMMIES BUT NOT DUMB

Crash test dummies have been making transportation safer since the late 1940s, when they were first used by the U.S. Air Force to test pilot restraint and ejection systems. The Air Force previously used real people until safety tests became too rigorous for humans to safely participate in. After seeing the success that the Air Force had, auto manufacturers started creating their own versions.

Different iterations of test dummies were created to suit each maker's needs, but GM's Hybrid III dummy became the industry standard for frontal impact and airbag safety compliance testing in 1997. All versions of test dummies were designed to mimic the human body as closely as possible — with similar weight, size, and proportions to that of an average adult male — but the Hybrid III did it best. Equipped with accelerometers, potentiometers, and load cells, automakers could measure the acceleration, deflection, and forces that people experience during car crashes.

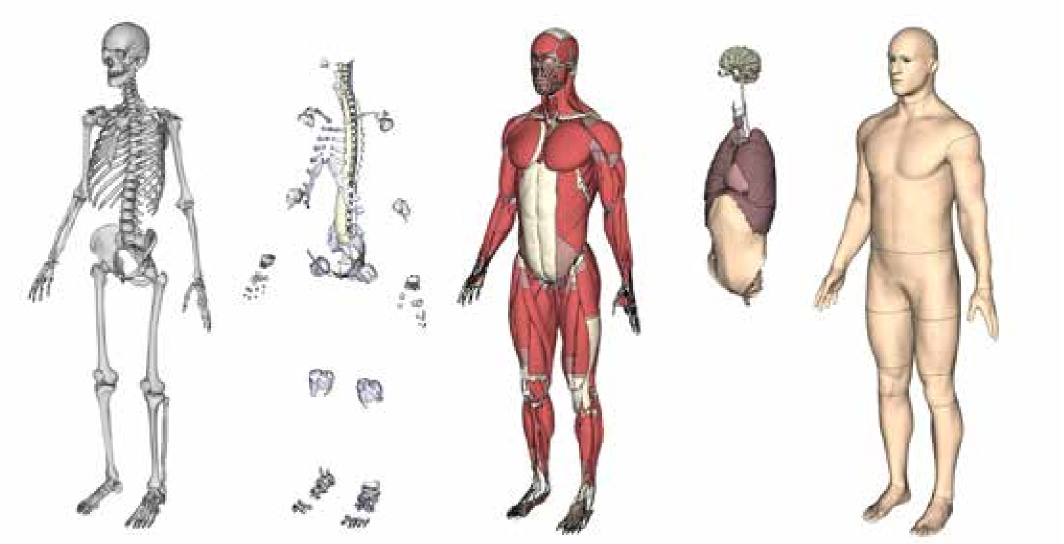
But as technology advanced, researchers acquired more data and a greater understanding of the human body, and automotive safety requirements increased to reflect this new knowledge. Thus, new and improved crash test dummies like WorldSID and THOR have surfaced. The latest evolution of crash testing involves virtual human body models.

The Ansys Hans Human Body Model is a passive model targeted for any kind of explicit impact simulation, from car crashes to sports injuries.

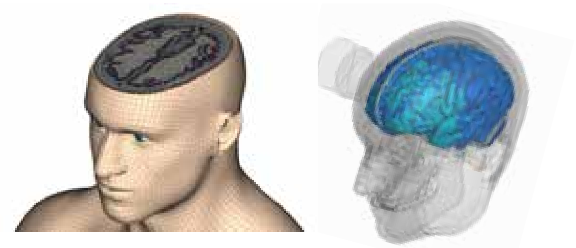
HI, I'M HANS

Hans is a high-fidelity human body model that provides more accurate approximation of people than traditional test dummies. He is a passive model targeted for any kind of explicit impact simulation, from car crashes to sports injuries. The first release of the Hans model focuses on the musculoskeletal system, with future releases fine-tuning inner organs, adipose tissue, and joint and muscle movements. Hans is based on a 30- to 40-year-old man who weighs about 77 kg (170 lbs.) and is 176 cm (5 ft., 9 in.) tall. The model organization consists of five layers:

1. Skeleton: includes cortical and trabecular bone
2. Connective tissue: includes ligaments, joint capsules, and cartilage
3. Muscles and tendons: all modeled as individual parts
4. Inner organs and brain: all individually discretized
5. Adipose tissue and skin: includes adipose tissue, dermis, and epidermis



The different model layers in the Ansys Hans Human Body Model (from left to right): skeleton, connective tissue, muscles and tendons, inner organs and brain, and adipose tissue and skin



Hans brain model (left) and brain impact simulation in Ansys LS-DYNA nonlinear dynamics structural simulation software (right)

Physical crash testing is very expensive, and manufacturers can see what happens only on the outside of the dummy, with limited knowledge of the internal reactions. "But with virtual crash simulation, we now have our Hans Human Body Model that we can put in cars and look at what's going on inside the body in terms of bones, muscles, and tissue," says Alexander Gromer, senior manager application engineer at Ansys.

THE BRAINS OF THE SYSTEM

While it's important to account for injuries to the entire body, the brain is of particular importance for any high-impact situation. Broken bones can heal, but the long-term consequences of brain trauma — especially repeated injuries in settings such as sports — can have detrimental effects. Modeling the brain and how it moves in a skull during impact enables car manufacturers to see if a fender bender could result in a simple headache or something much more nefarious.

"If you think of our head like an egg, our skull is the eggshell, our brain is the yolk, and cerebrospinal fluid is the egg white," says Skylar Sible, an application engineer on the Hans team. "I'm tracking 12 points in the brain to see how the brain shifts relative to the skull in an effort to model the cerebrospinal fluid better."

SAFETY FIRST

"The goal of Hans is to provide everything you would need for any kind of safety application," says Gromer, "whether that be someone sitting in a car crash event or pedestrian safety analysis."

Using digital models reduces the number of physical car crash tests that automakers need to perform, which saves time and money. Engineers can see what happens virtually during a crash, make tweaks, and run the test again without having to physically prototype every single car part. And with all that data, car makers can make better, safer, more efficient cars in the years to come. "I don't think it will be possible to get a five-star safety rating without doing these kinds of simulations by the end of this decade," says Gromer.

And automotive is just the beginning. The Hans team plans to improve the model's capabilities to cover load cases for defense, sports, and healthcare next.

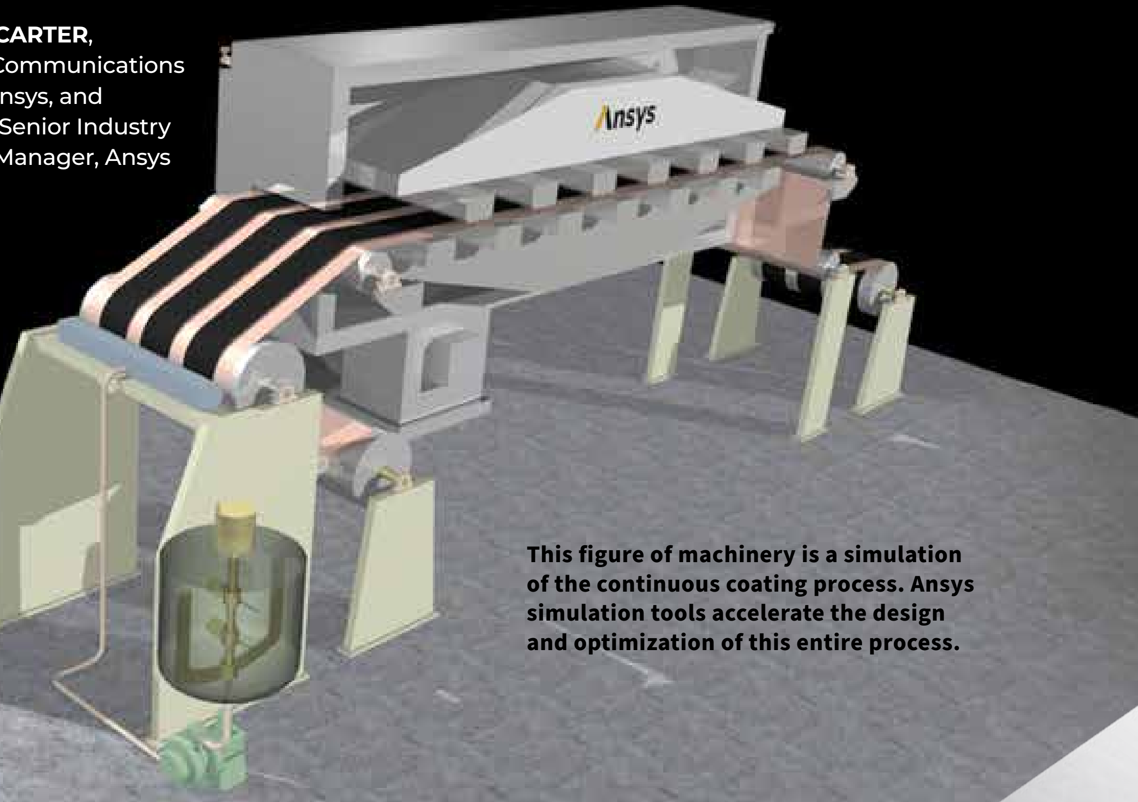
LEARN MORE

Learn more about how the Hans model for LS-DYNA software can help with your simulation needs.

ansys.com/products/ansys-hans

How Simulation Boosts Efficiency in EV Battery Manufacturing

By **LAURA CARTER**, Corporate Communications Manager, Ansys, and **KIM HURT**, Senior Industry Marketing Manager, Ansys



This figure of machinery is a simulation of the continuous coating process. Ansys simulation tools accelerate the design and optimization of this entire process.

Streamlining electric vehicle battery production using multiphysics simulation can drive down costs and increase consumer sales.

According to a report from the International Energy Agency (IEA), electric vehicle (EV) fleets are projected to grow by a factor of eight globally by 2030. Yet, in the United States, EV inventories on dealer lots increased by 506% compared to a year ago. That means, on average, an EV will sit on the market 18 days longer than a gas-powered vehicle.

There are several reasons for this. Apart from range considerations, the biggest factor contributing to the rate of adoption is price. So why are EVs cost-prohibitive for most consumers?

"If you look at the price of an electric vehicle today, currently 30% to 40% of the total cost of that vehicle can be attributed to the battery," says Padmesh Mandloi, Asia-Pacific regional vice president, Ansys Customer Excellence. "Additionally, if the battery doesn't work or needs replacing after so many miles, the burden of cost is passed along to the consumer. This has had a chilling effect on the marketplace, particularly in the United States, where EV production seems to have hit a speed bump."

OPTIMIZING BATTERY PRODUCTION PROCESSES WITH SIMULATION

Now for some good news. Leading global financial institution Goldman Sachs sees a bear market on the horizon for raw materials commonly used in EV batteries, such as nickel and lithium, as supply is catching up and cooling overall demand. Next year, we'll most likely see EV prices begin to drop.

There is another reason for the 40% decline in battery prices predicted to happen between now and next year. To further reduce costs, manufacturers are reducing complexity through simpler packaging. They're also making better material choices — like silicon, for example — that simultaneously reduce charging time and increase energy density to deliver even more energy for the same amount of weight.

But sticking with more traditional manufacturing approaches to execute on these ideas puts limits on efficiency and sustainability. Without any significant deviations, they will most likely continue to struggle to optimize production processes, identify cost-saving opportunities, and address sustainability concerns effectively.

Lacking a clear methodology for improving processes, manufacturers find themselves caught in a drawn-out build-experiment-waste-repeat cycle. Simulation delivers the insights needed to address various stages of the manufacturing process and production line development that can reduce these costly trial-and-error experiments and improve uptime. Without data insights coming out of simulation, this level of complexity is nearly impossible to address.

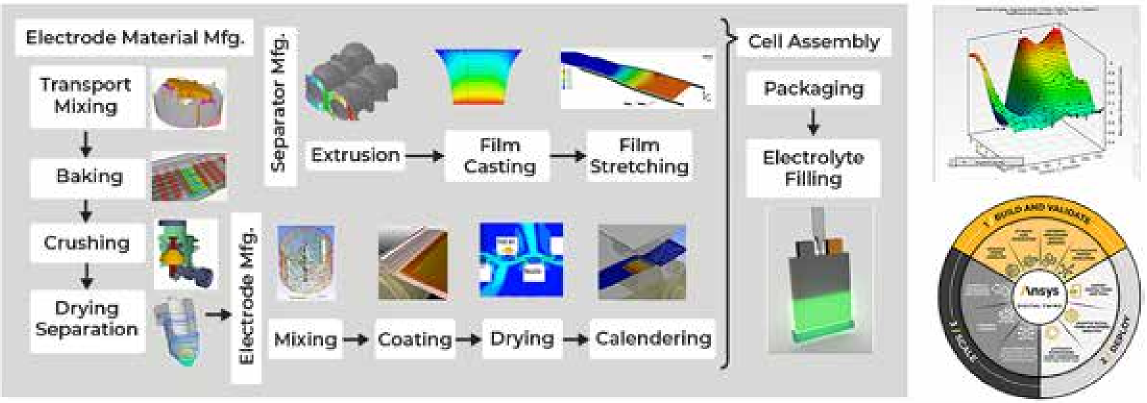
Across the EV battery market, battery cell manufacturers are tackling numerous technical engineering challenges in a virtual environment. They're leaning in on simulation to meet customer specifications, reduce costs, maintain quality, ensure safety and compliance, address labor shortages, and improve end-of-life battery disposal and recycling with positive results.

"More battery manufacturers are leveraging physics-based simulation and safety analysis to gain valuable insights during production," says Mandloi. "Ansys' simulation tools and solvers enable them to optimize battery designs, as well as identify suitable equipment and workflows on the factory floor that can increase scalability, quality, and sustainability in the process."

Ansys' breadth of physics and depth of capabilities cover many aspects of the battery production process. For instance, during the coating process accurate, multiphase simulation with Ansys Fluent fluid simulation software can test many conditions and geometries of the coater virtually before the physical prototype is prepared.

After this coating is applied, it needs to go through a compaction process called calendering, which has significant impact on the pore structure and performance of li-ion battery cells. With Ansys Rocky particle dynamics simulation software, it's possible to look at the microstructure level during the calendering process and, together with Ansys Mechanical finite element analysis (FEA) software for structural engineering and Ansys LS-DYNA multiphysics software, identify the residual strains resulting from compression during this process, especially if there are imperfections.

"Battery manufacturing is very dynamic," says Akira Fujii, principal application engineer at Ansys. "At the same time, engineering goals on the customer side highlight the need for both process and equipment optimization to maintain consistent quality or improve on it while satisfying specific criteria. A film coating process that lacks uniformity in thickness, for example, or a change in material thickness impacting geometry are just a few of many scenarios that can be quickly evaluated and addressed in a simulation environment."



Ansys simulations support design optimization for all processes related to battery creation with the process integration and design optimization (PIDO) platform and digital twin technologies.

Kneading (Electrode)	Die Internal Flow	Coating	Drying	Calendering	Slitter	Filling
• Homogenous mixing • No breakup of particle	• Uniform flow at exit • Maximize throughput	• Uniform coating • Maximize throughput	• Maintain at humidity • Reduction of residual stress	• Maintain wear endurance	• Maintain smooth edges • Extend blade life	• Rapid and uniform filling of cells

This diagram captures various steps in lithium-ion battery manufacturing. Simulation presents significant optimization opportunities throughout the entire process.

MANUFACTURERS LOOK TO DIGITAL TWINS FOR OPERATIONAL SUCCESS

One transformational battery manufacturing trend on the horizon involves further digitization of production enabled by digital twins. Manufacturers can develop digital twins using sensor data and simulation data. These models, or virtual representations of real-world production processes, can be used to understand and improve the entire manufacturing process. They can also be applied to specific corner cases to understand where a process can potentially fail — followed by predictive analytics or predictive maintenance to identify the conditions leading up to this failure.

Ansys provides digital twin-driven analytics solutions to battery manufacturers to sensitize the entire manufacturing process. This includes the delivery of virtual sensor data to provide insights to customers about the process, the quality of the product, and where failures could happen at any point along the way. In this case, reduced-order models (ROMs) capturing critical aspects of the digital twin would be used to generate data that can be fed into an analytics engine to do predictive maintenance.

"We're currently exploring various ways we can connect simulation-based digital twins and do the whole sensitized analytics process because training the analytics engine takes a lot of time and requires a lot of data," says Mandloi. "If you simply wait for that data to come through the natural process, it can take you a year or maybe two years before your engines are really able to make predictions. So how can you fast-track that process? One way of accelerating it is to enrich that engine with a lot of data coming from simulations where you've tried multiple design of experiments (DOE) variations and you've fed all of that data back to that engine."

ANSYS ADDRESSES A PRESSING NEED FOR SOLID-STATE SOLUTIONS

An ongoing challenge for battery manufacturers involves the search for a safer, more efficient alternative to li-ion batteries. The introduction of solid-state batteries promises improved safety and can deliver higher energy density over a much wider operating range in a smaller, more flexible form factor. And since the manufacturing process of solid-state batteries does not include a drying process, suppliers can shave off development time to make inventory faster and cheaper.

Simulation is integral to moving this battery technology forward. Ansys' efficient, seamless workflow for a solid-state battery solution, including many multiphysics tools, enables identification of optimal particle size distribution, material mixing ratio, and compaction pressure.

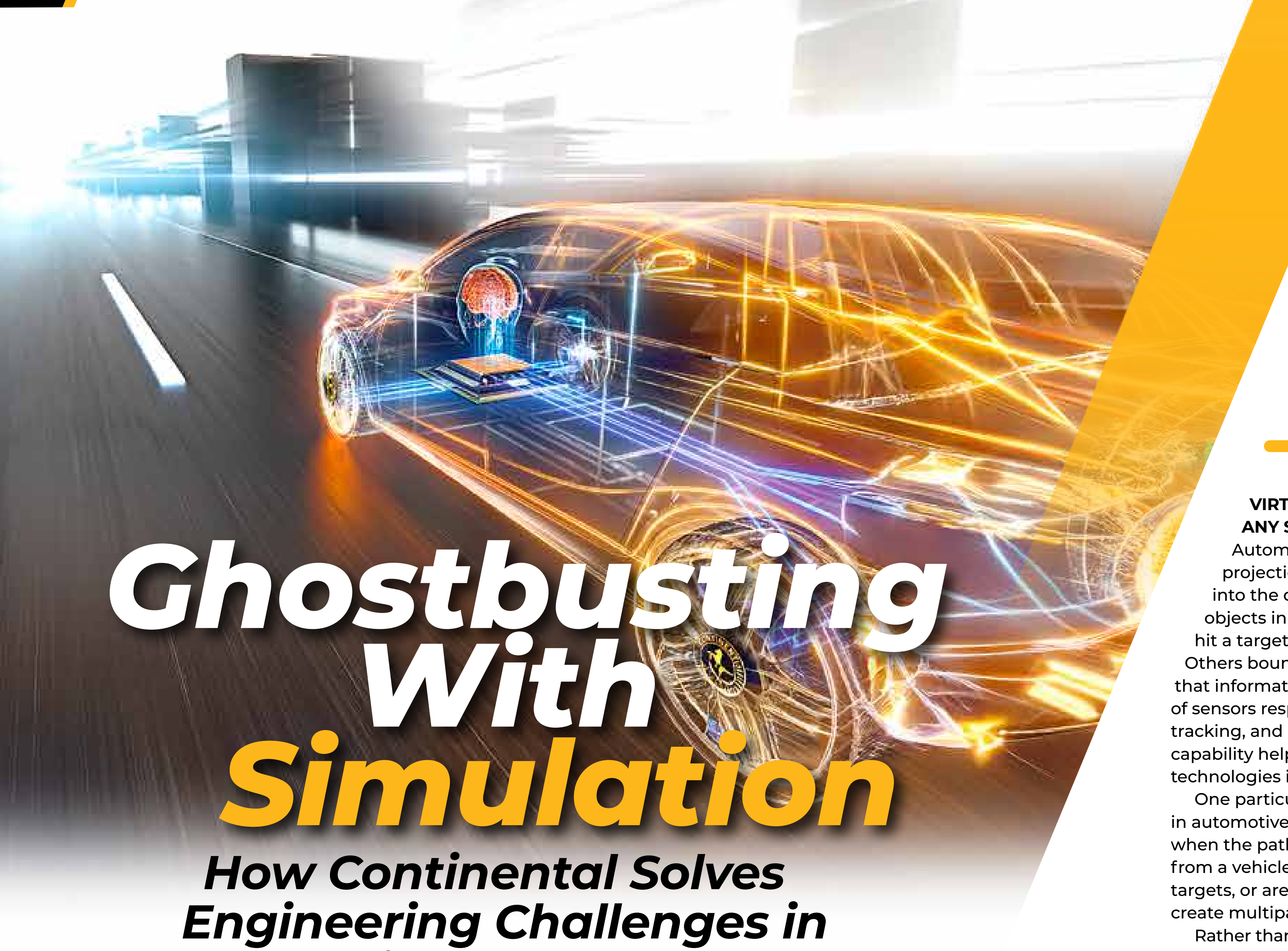
FINDING GREATER EFFICIENCIES WITH ANSYS

We've touched on the benefits of a comprehensive, simulation-driven digital engineering strategy for EV battery manufacturing. Every day, engineers are using a combination of Ansys simulation solutions to gain valuable insights — to optimize battery designs and identify suitable equipment and workflows for scalability, quality, and sustainability.

LEARN MORE

Watch the EV battery development webinar series.

ansys.com/events/electric-vehicle-battery-webinar-series



Ghostbusting With Simulation

How Continental Solves Engineering Challenges in Automotive Radar Development

By **LAURA CARTER**, Corporate Communications Manager, Ansys

Probably the biggest trick to the adoption of full autonomy in the automotive space is learning how to safely achieve a level of perception that matches that of a human driver. Carmakers are rising to the challenge with a combination of advanced camera, radar, and lidar sensing technologies, machine learning, and artificial intelligence that makes self-driving possible. This includes the advanced driver-assistance system (ADAS) platforms already in play on our roadways, which are designed to assist drivers with safe vehicle operation.

However, the performance of these self-driving solutions is limited by unforeseen developments that lead to mechanical failure, including those impacting automotive radars. In this case, Ansys helps Continental AG cut through complexity during development to pinpoint the source of any negative effects like ghosting that impact radar function — and then implement solutions to quickly resolve them for customers.

> ***"We leverage simulation to address various nuances after the radar is integrated inside the vehicle that contribute to ghost targets. Our vision is all about integrating simulation-driven design into our workflow so that it can accelerate our development process from design study to prototype, thus shortening our time to market and reducing our costs."***
>
> — **YADHU KRISHNAN M K**, global co-lead of electromagnetic simulation at Continental

VIRTUAL TESTING CLEARS UP ANY SYSTEM MISPERCEPTIONS

Automotive radar relies on the projection of electromagnetic waves into the driving environment to detect objects in a vehicle's path. When waves hit a target, some are absorbed as energy. Others bounce back to the vehicle, where that information is interpreted by a system of sensors responsible for detection, ranging, tracking, and sensing of nearby objects. This capability helps an ADAS and self-driving technologies interpret a given driving scene.

One particularly challenging phenomenon in automotive radar is ghosting. This happens when the path of the electromagnetic waves from a vehicle to an object is affected by ghost targets, or areas inside the vehicle chassis that create multipath reflections along the way.

Rather than leave the vehicle, some of these waves are reflected off these objects as input to the vehicle's radar receiver. They are then incorrectly interpreted without ever reaching their intended target. The corrupted waveform then becomes the foundation for all subsequent signal processing, including machine learning and signal tracking, which compromises autonomous function.

While a correction might seem fairly straightforward, the origins of these multiple, indirect reflections between the target and the radar that lead to misperceptions are not easily pinpointed. For Continental, it takes Ansys HFSS high-frequency electromagnetic simulation software to accurately identify the exact location or root cause of these reflections, then determine the appropriate amount of absorber material needed to eliminate any unwanted signals.

"We leverage simulation to address various nuances after the radar is integrated inside the vehicle that contribute to ghost targets," says Yadhu Krishnan M K, global co-lead of electromagnetic simulation at Continental. "Our vision is all about integrating simulation-driven design into our workflow so that it can accelerate our development process from design study to prototype, thus shortening our time to market and reducing our costs."

ANSYS HELPS CONTINENTAL TAKE ON RADAR COMPLEXITY, LAYER BY LAYER

The basic component in radar design is the antenna array, or radiating system composed of multiple connected antennas working together to send and receive radio waves. Continental engineers leverage HFSS software to optimize all the elements of these designs to reduce any manual work, including component prototyping and measurement. It's a logical

Environmental perception based on sensorics like radar is essential for the realization of assisted and automated driving.

Satellite radar for redundant 360-degree coverage of the vehicle's surroundings

starting point to Yadhu's approach to "go layer by layer to accurately address the inherent complexity involved."

Once the radar design is completed with the help of HFSS software, the system is integrated into the vehicle behind the bumper. In one instance, it was determined that a secondary surface next to the radar was affecting the performance of the electromagnetic waves emanating from the radar. Here, the challenge was to understand how the performance of the radar was deteriorating due to the fascia, or decorative vehicle panels.

"Analysis becomes more complex when examining the mounting scenario, because now you also have to think about the influence of the chassis as well," says Yadhu. "In this instance, electromagnetic waves encounter multiple reflections between the sensor, the fascia, and also the chassis, which lead to effects like wave scattering and ghost targets."

To account for these discrepancies, the team must do some optimization. This may require varying the application of layers of paint on a bumper or adjusting sensor position to conform to the key performance indicators of the standards that the team has in mind.

SIMULATION CUTS THROUGH ALL THE CROSS TALK

Up until now, we've only been discussing the performance of one sensor. But in reality there are lots of sensors and electronics in a vehicle, which introduces the possibility that they might communicate with each other. It's a phenomenon known as cross talk, or electromagnetic interference. Ultimately, this activity can hamper radar performance.

"Radar integration is typically a complex environment in radar applications, as electromagnetic waves are prone to electromagnetic scattering due to reflections," says Yadhu. "They're the types of interactions that make a radio frequency engineer's life difficult. Electromagnetic simulation is a window into understanding complex effects due to multipart reflections on a sensor, as well as the cross talk or electromagnetic interference happening between multiple sensors and electronics that interfere with vehicle perception."

Then there's the larger driving environment to consider. Cross talk can also occur between sensor systems as vehicles encounter each other on the road. To counter these types of interactions, Continental considers more

> ***"Running HFSS software on the cloud scaled well, enabling engineers at Continental to run large simulations with greater accuracy and speed. Simulations in this environment were at least 18 times faster than the previous tool they were using. Consequently, in decreasing overall simulation time, the team could complete projects much faster, thereby increasing productivity and finding efficiencies that resulted in a significant cost savings."***

dynamic scenarios like these with the help of Ansys AVxcelerate Sensors autonomous sensor simulation software.

Using AVxcelerate Sensors software, it's possible to extend radar functionality testing to virtual test drives in a realistic environment to understand vehicle perception as a function of any additional effects. This enables Continental to consider radar performance not only related to cross talk but to obstacle detection and weather events, to name a couple. For example, the team can use the software to understand how a snow-covered bumper affects electromagnetic waves emanating from a vehicle's radar.

ONE COMPREHENSIVE, CLOUD-BASED WORKFLOW FOR ALL

This work culminated in the creation of an Ansys-powered toolchain, enabling Continental to quickly scale up to address perception challenges for customers in a high-performance computing (HPC) environment faster.

Running HFSS software on the cloud scaled well, enabling engineers at Continental to run large simulations with greater accuracy and speed. Simulations in this environment were at least 18 times faster than the previous tool they were using. Consequently, in decreasing overall simulation time, the team could complete projects much faster, thereby increasing productivity and finding efficiencies that resulted in a significant cost savings.

The team leverages a variety of computational resources to power Ansys simulations, including an on-premises single-node machine and an on-premises HPC cluster on the cloud, enabling the team to double its capacity when needed. As the complexity of its projects continues to grow, Continental anticipates scaling up cloud usage to meet these increasing demands.

These efforts are really paying off for Continental. The implementation of an Ansys toolchain for several hundred product lines across various projects will save automotive manufacturers in vehicle testing. The toolchain itself can also be further monetized as a simulation work product to help advance radar solutions.

LEARN MORE

Explore autonomous engineering solutions at Ansys.

ansys.com/technology-trends/autonomous-engineering

Volkswagen
Advances Automated Steering

See how Volkswagen and Ansys navigate electronic power steering requirements with a new automotive workflow.

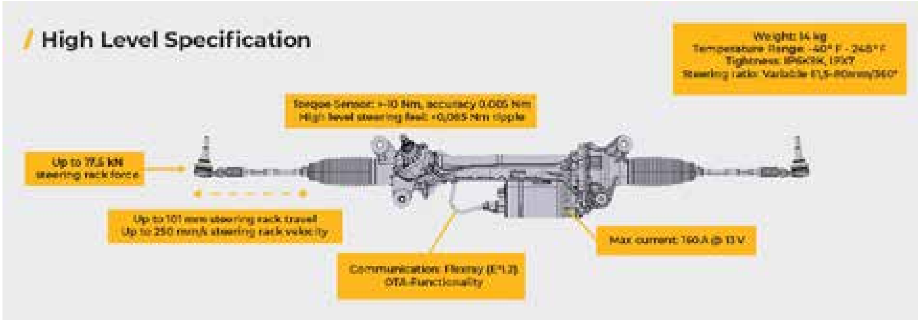
By **LOTHAR PFEIFER**, Senior Manager Application Engineering, Ansys

“The software tooling we developed especially for the use within our safety-critical development projects adds value to our toolchain. Ansys products are a crucial part of our qualification foundation.”

— **DR. JOHANNES GRAU**, head of software systems and tools, Volkswagen AG

While we’re not there yet, recent statistics suggest that mainstream acceptance of self-driving cars, rideshares, and delivery services may be just around the corner. According to the McKinsey Center for Future Mobility, autonomous driving could create $300 billion to $400 billion in revenue by 2035. This is good news for original equipment manufacturers (OEMs) and tier suppliers already invested in autonomous vehicle (AV) development. However, their success depends on several things, including the acquisition of new technological capabilities and the ability to address concerns about safety.

In the development of its advanced electronic power steering (EPS) system, Volkswagen intends to keep pace with a rapidly changing automotive landscape and its evolution to automated driving. The company relies on Ansys software to quickly bring it up to speed on EPS performance and safety to meet requirement thresholds while enhancing the precise, responsive handling that the brand is known for.



High performance: Volkswagen Premium Platform Electronic steering system

“The software tooling we developed especially for the use within our safety-critical development projects adds value to our toolchain,” says Dr. Johannes Grau, head of software systems and tools at Volkswagen AG. “Ansys products are a crucial part of our qualification foundation.”

BUILDING ON AUTOMOTIVE EXPERTISE WITH THE FUTURE IN MIND

Today’s EPS systems are more complex than ever, with the ability to enable wide control of the steering process in different scenarios. Consequently, modern cars are capable of many automated functions already, including lane-keeping assist and temporarily automated driving in highway scenarios, self-guided parking, and even automatic driverless summoning.

Looking into the future, the next evolutionary step will be a steer-by-wire system: a system with no mechanical connection between the driver and the front wheels. These steering systems will enable highly automated driving (SAE Level 3+) and eventually evolve to driverless control without a steering wheel or human fallback. This perspective demonstrates a need for fail-operational systems that maintain vehicle control in all possible scenarios.

Steering system development is important work for Volkswagen, as ride and handling are qualities largely defined by steering feel. Any operational variance often comes down to differences in fractions of milliseconds as a function of vehicle software. These seemingly undetectable differences still unconsciously felt by drivers today frequently lead to clear judgments about performance. With automated driving, a lack of driver input makes this evaluation infinitely more complicated.

Currently, Volkswagen is developing an advanced modular steering system that can be integrated into its Premium Platform Electric (PPE) vehicles. Adding an additional software component into the mix helps deliver a customizable "sport" feel crucial to driver experience. Notably, the steering system software will need to deliver behavior that could be applied to model-specific experiences yet remain consistent with overall brand expectations for performance across the PPE lineup. In doing so, Volkswagen mitigates on-road risks associated with the AV function, including a sudden loss of steering assistance or unintended steering.

To meet the complexity required to execute successful EPS development in an automated driving environment, testing was needed across multiple domains and multiphysics. System hardware, software, and mechanics must all be considered. It's a monumental task for the approximately 150 Volkswagen engineers responsible for testing, validation, and verification of more than 8,000 requirements against a small, cost-efficient electronic control unit (ECU) generating 750,000 lines of code. Complicating matters, the execution of all the test cases needed for back-to-back analysis of software system components takes more than 24 hours. To remain competitive in terms of both time and cost, Volkswagen needed to step up the pace in the streamlining of both processes and products.

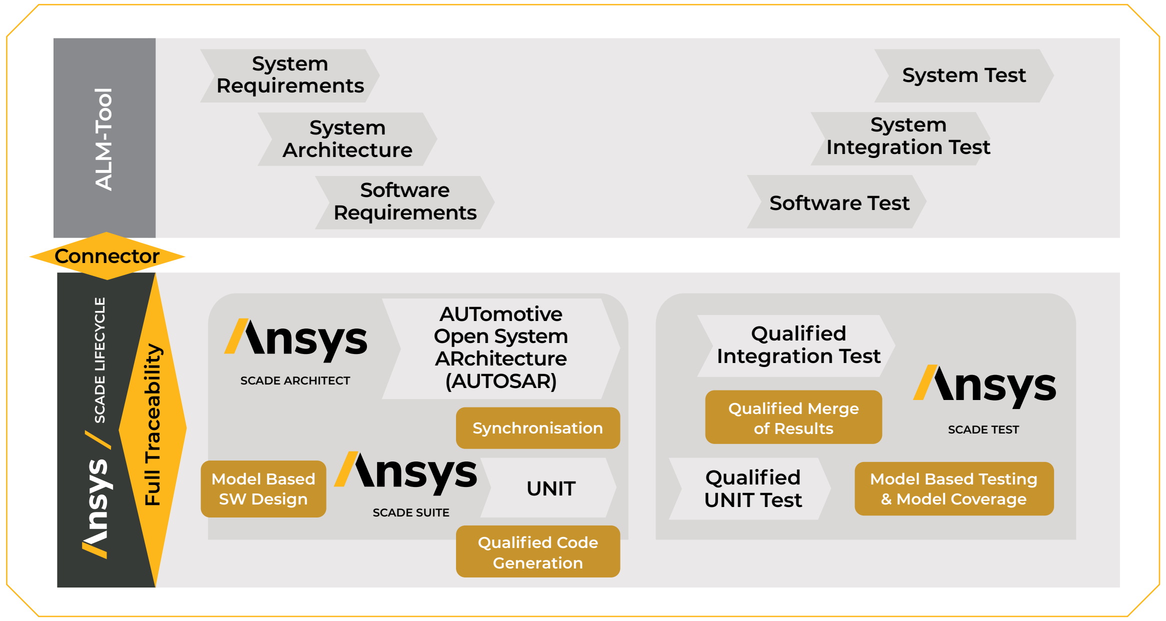
"So, you have high complexity and high variability in a solution that needs to be very adaptable, but it also needs to be cost-sensitive, and it needs to be safe," says Soeren Schreiner, senior application engineer at Ansys. "Safety is the factor that makes up most of the development cost."

ACHIEVING ISO 26262 ASIL-D AND ASPICE L2 COMPLIANCE IN A SINGLE TOOLCHAIN

Autonomous technology relies on a combination of hardware and software to perform without driver input. In this instance, AV hardware is responsible for data collection, which is organized and compiled by the system software. This information is then processed via machine learning algorithms, or lines of code trained to interpret real-world scenarios.

To make a case for safety, Volkswagen engineers must actively prove they developed system software following mandatory safety standards. It requires compliance with ISO 26262, an internationally recognized standard for functional safety of electrical or electronic vehicle systems issued by the International Organization for Standardization (ISO). ASIL-D is the element of ISO 26262 that establishes the framework used to assist development of safety-related electrical and electronic (E/E) systems like EPS.

Additionally, Volkswagen's steering system must comply with ASPICE L2 requirements. ASPICE defines best practices for embedded software in automotive development. At Level 2 (L2), it verifies



Safety critical development processes: Volkswagen Premium Platform Electronic steering system

that work products can be reliably delivered that nearly or entirely achieve ASPICE standards.

With help from Ansys SCADE Architect, SCADE Suite, SCADE Test, and SCADE LifeCycle development tools, it was possible to create an end-to-end model-based system and software design toolchain. The new toolchain supports Volkswagen in developing and deploying software efficiently while adhering to ISO 26262 ASIL-D and ASPICE L2 safety constraints as part of a highly complex and safety-relevant system.

"What we developed with Volkswagen is a very efficient and very flexible workflow," says Schreiner. "This process enables us to specify and maintain complex multilevel software architecture models that are automatically synchronized with the software design models and functional test projects, all while enabling full requirements traceability."

In facilitating the toolchain, SCADE Suite and SCADE Test software also reduced the number of activities necessary for Volkswagen to achieve compliance.

"Using software development tools where software tool qualification is part of the tool development adds value to our toolchain," says Grau. "Qualified tools like Ansys SCADE Suite software introduce possibilities to reduce review effort within our safety-relevant development process."

CRACKING THE SECRET CODE WITH SCADE SOFTWARE SOLUTIONS

Software in the SCADE platform was central in establishing Volkswagen's model-based EPS system and software design toolchain. These features make it uniquely positioned to advance the safety of AVs:

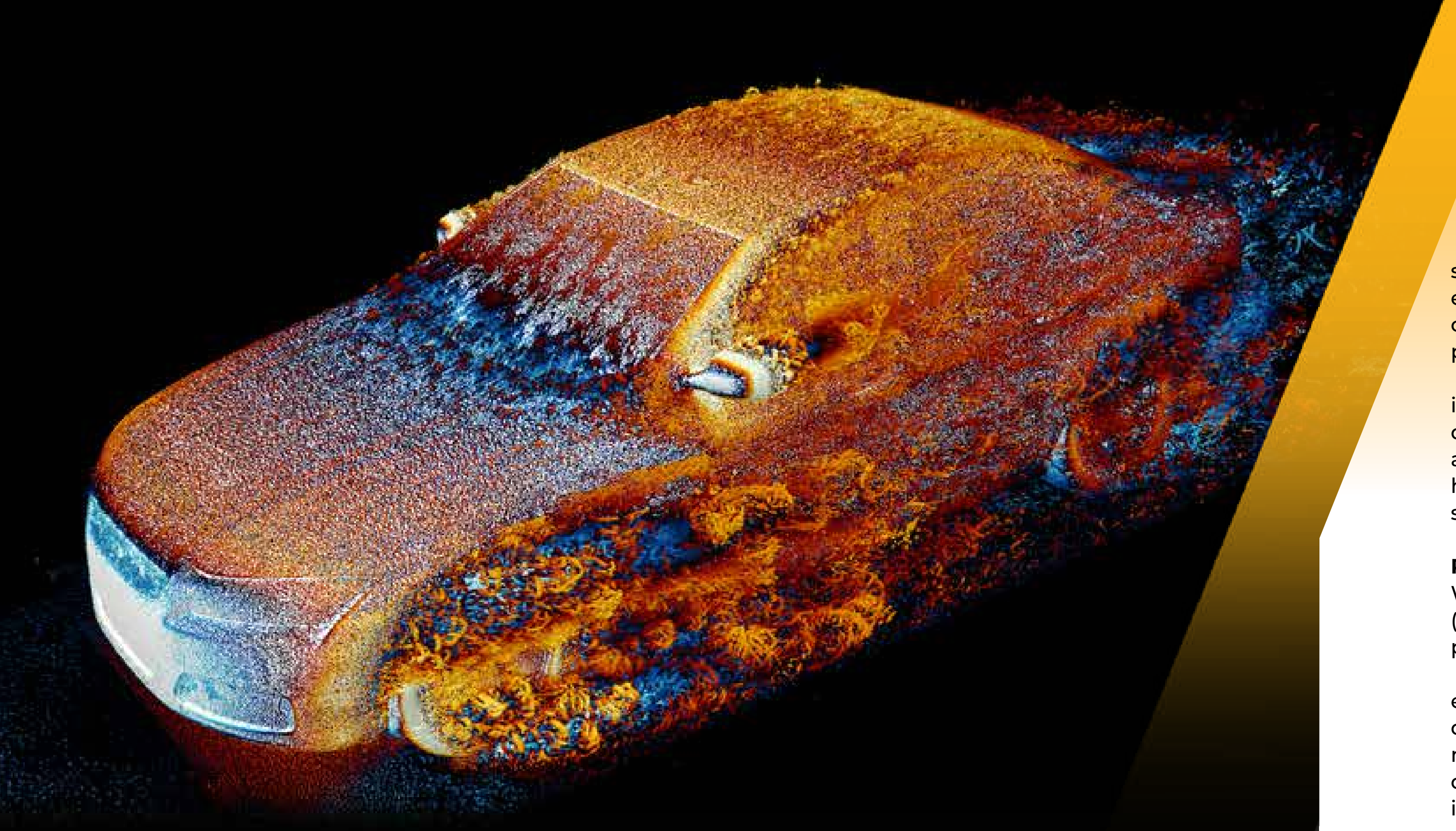
- Fully qualified code generation, model-based testing, and reporting, which enables Volkswagen to claim that all ISO 26262-relevant activities on the model level (testing, coverage, reviews) do not have to be repeated for the source code. This enables engineers to skip back-to-back tests normally required to demonstrate how a model behaves, as indicated by the code.
- AUTOSAR, or AUTomotive Open System ARchitecture-compliant software generation, which develops and establishes open, standardized architecture for ECUs for greater scalability. This standard is used mainly for fitting interfaces together, which enables components built at different companies or tier suppliers to be assembled and successfully communicate with each other.

Ansys delivers state-of-the-art tools that derisk the safety-critical software certification process for OEMs in SCADE Suite software, an ISO 26262-qualified model-based development toolchain.

LEARN MORE

Sign up for our ISO 26262 webinar.

ansys.com/webinars/iso-26262-safety-analysis-streamline-your-path-to-functional-safety



The Need for Speed and Safety

Electric and autonomous vehicles rely on simulation to speed up development and increase safety.

By **STEVE DEFIBAUGH**, Manager, Product Marketing, Ansys, and **KRISHNA SAMAVEDAM**, Lead Product Manager, Ansys

In the race to put more electric vehicles (EVs) and autonomous vehicles (AVs) on the road, reducing time to market can be a huge competitive advantage, meaning automotive engineers don't have a minute to spare.

While depending on simulation to fast-track the development and optimization cycle and improve product safety is nothing new, yesterday's single-core computing environment has struggled to keep up with the massive, hardware-intensive computation models required for complicated EV and AV designs.

When it comes to modeling the interaction of vehicle components across millions of scenarios or simulating an advanced driver-assistance system (ADAS), traditional processing methods can be too time-consuming. Because any constraints, whether software- or hardware-related, can distract engineers from the task at hand, Ansys is constantly exploring how to deliver the best cost-performance ratio for different solvers.

Partnering with some of the biggest names in automotive software and operating system development, artificial intelligence computing, and cloud solutions, Ansys has demonstrated how to deliver high-confidence simulations, sometimes as much as 53X faster than before.

PUSHING THE BOUNDARIES

While both EVs and internal combustion engine (ICE) vehicles rely heavily on software, EVs often push the boundaries of software-defined features.

Consider mission-critical systems like electronic control units (ECUs). Because these devices manage engine operations, safety measures, braking systems, keyless entry, and driver comfort, they must respond to events in real time. That requirement makes task distribution and synchronization important considerations when embedded software engineers develop code.

In addition, ECUs must comply with AUTOSAR, or AUTomotive Open System ARchitecture. AUTOSAR is the global development partnership of automakers and software companies whose purpose is to establish a standardized software architecture for automotive ECUs.

Not only do these computation-heavy challenges require more sophisticated software engineering, but solving them is inherently a slow process. A collaboration between Ansys and AUTOSAR specialist Elektrobit has delivered a new way to streamline ECU development. And it's so effective that in a real-world test case, it shaved processing time by 60%.

By combining the Ansys SCADE embedded software product collection, which automatically generates code-compliant software, with the Elektrobit tresos Safety operating system (ensuring an AUTOSAR-compliant standard software stack), the companies created an automated process for generating and verifying embedded software cores using multicore environments. This method optimizes the synchronization and sequencing of tasks, produces verified software code, and meets stringent AUTOSAR standards with the lowest possible investment of time, money, and computing resources.

As proof, the Ansys-Elektrobit team carried out a test on a battery management system (BMS). BMSs are crucial for ensuring the safe operation of EVs. They monitor and control parameters, such as cell voltage, temperature, and state of charge (SOC), to prevent thermal runaway, overcharging, and other potential hazards.

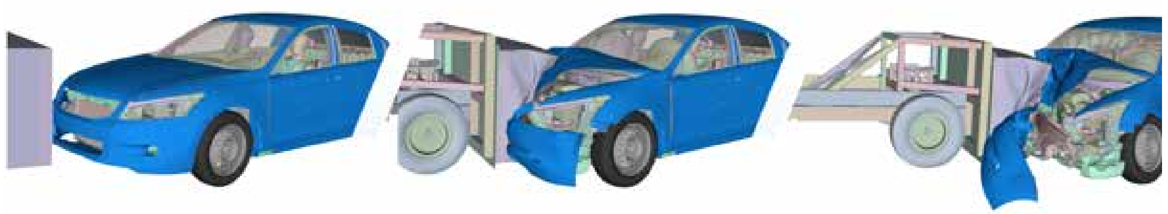
They are also notoriously challenging to simulate due to the complex interplay of physical, chemical, and electrical processes.

In the BMS test case, computation on a single processing core resulted in a runtime of 4.64 milliseconds. In a multicore environment, however, the same computation took just 1.9 milliseconds, translating to a 60% reduction in processing time — significant savings for overburdened software engineering teams and a key to faster market launches.

USING HPC CLUSTERS

While the right software and multicore environment can accelerate innovation for embedded software engineers, for many other engineers the answer to faster simulation lies with high-performance computing (HPC) clusters, interconnected computers working together to solve a single problem.

The HPC environment can handle massive amounts of data and perform complex calculations at high speeds, chiefly by distributing tasks across the whole processing array. But even with those advantages, it can still take significant runtime to keep up with automotive use cases. What's more, HPC clusters are often expensive and quickly outdated. In response, two alternatives have emerged: using graphics processing unit (GPU) computing



A frontal offset crashworthiness evaluation is a common use of Ansys LS-DYNA nonlinear dynamics structural simulation software.

or having multiple application-specific solvers powered by the perpetually refreshed cloud.

USING GPUS

GPUs were originally designed for rendering graphics, but their highly parallel architecture and ability to perform thousands of independent calculations simultaneously make them suitable for a wide range of applications. That includes increasing throughput for computational fluid dynamics (CFD) simulations.

Ansys Fluent fluid simulation software is widely used in automotive design to model and analyze fluids phenomena. Fluent CFD is known for its efficient HPC capabilities, scaling to thousands of central processing unit (CPU) cores. However, to determine the optimal computing environment to speed up the solver's simulations, Ansys recently participated in a benchmark study with NVIDIA and Supermicro on external automotive aerodynamics. What the companies found demonstrates that GPU-based computing can provide substantial performance gains for complex simulations like CFD.

The simulation model involved a very detailed representation of the car's external shape, with 250 million individual cells used to define the geometry. This level of detail was necessary to accurately capture the complex flow patterns around the car, which can significantly impact its aerodynamic performance.

When a third-party benchmarking consultant ran the large-eddy simulation (a CFD technique used to simulate turbulent flows) using four NVIDIA H100 GPUs, there was a 12.6X improvement in speed compared with 512 CPU cores. Doubling the number of GPUs to eight nearly halved solve time. The linear trend in scale-up from 12.6X to 24.2X suggests that adding more GPUs could continue to yield significant solve time improvements.

ACCELERATING SOLVE TIME

Ansys, NVIDIA, and Supermicro also collaborated on a benchmarking study to assess Ansys LS-DYNA nonlinear dynamics structural simulation software in a Supermicro ARS-121LDNR computing environment equipped with the NVIDIA Grace CPU Superchip.

LS-DYNA software is an explicit simulation application, meaning that it is used mainly to analyze sudden impacts, such as crashes, drops, explosions, and other severe loading events. It generates some of the biggest simulations done today, evaluating hundreds of virtual test scenarios with models composed of millions of elements or nodes. The NVIDIA Grace CPU Superchip is a new type of processor designed for data center-scale computing, offering significant performance improvements over traditional CPUs.

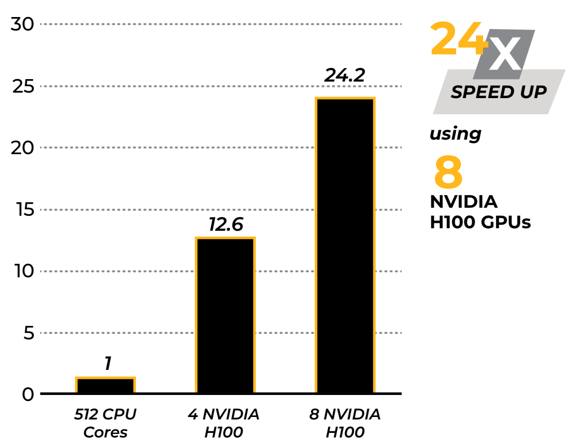
The study involved recreating a virtual frontal car crash to assess safety compliance when a vehicle hits an offset deformable barrier. Leveraging this powerful software and hardware combination resulted in 4X speed-up.

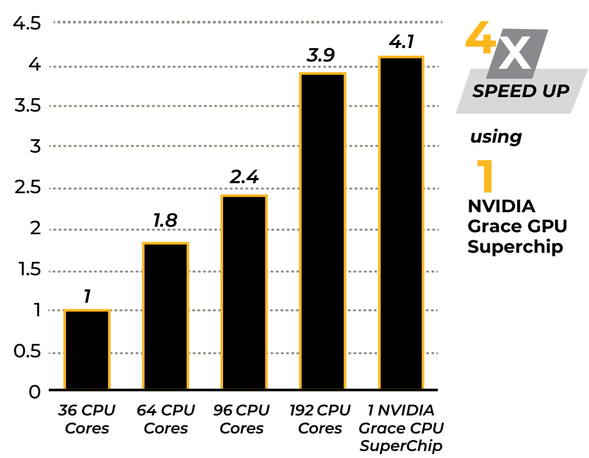
PREDICT AT THE SPEED OF AI

Simulation can also be used to increase the speed of artificial intelligence (AI) training. The faster AI is trained, the faster and more accurate those simulations become. Ansys AI offerings include the Ansys SimAI platform and Ansys AI+ add-on modules for existing simulation products.

Combining AI and simulation provides accelerated prediction of aerodynamic performance across design changes 10-100X faster, even when the geometry structure is inconsistent, by leveraging previous CFD simulations used in earlier design phases or previous car generations.

When simulation software, AI, and high-performance computing are combined, the results are even more impressive. In the benchmarks performed in conjunction with NVIDIA and Supermicro, Ansys optiSLang AI+ optimization software showed an amazing speed boost. By training optiSLang software with simulation data derived from small parametric design studies that may take days to create, multiple AI models using different variables can then be run in seconds or minutes. A baseline result was calculated by finding the time it would take to generate 80 design points for two 5G mmWave antenna modules simulated with Ansys HFSS software on 12 CPU cores and 8 GPUs. When an optiSLang AI+ model was used to calculate how long it would take to generate the same quantity of design points, the benchmark testing showed an astounding 1,600X speed increase.





MEETING THE DEMANDS OF COMPLEXITY

Improving performance is essential, and so is outpacing the competition. But when it comes to in-depth automotive product studies, fixed computing infrastructures can lack sufficient capacity for large simulations, or it takes days, weeks, or even months to achieve high-fidelity results. Upgrades are out there, but having to balance costs with budgetary limits may put these out of reach for many engineering departments.

To optimize runtimes and costs, Ansys has partnered with cloud service provider Amazon Web Services (AWS) to deliver the Ansys Gateway powered by AWS cloud engineering solution, a scalable platform purpose-built for the demands of complex simulations, with plug-and-play simplicity.

ACCELERATING INNOVATION WITH GPU SUPERCOMPUTING

Ansys recently announced another exciting milestone in CFD simulation that was achieved in collaboration with NVIDIA and Texas Advanced Computing Center (TACC). This work involved using the 320 NVIDIA GH200 Grace Hopper Superchip nodes on the Vista supercomputer at TACC to run a highly complex automotive external aerodynamics simulation.

This simulation tackled a 2.4 billion-cell model, achieving extraordinary results, including a 110X speedup over traditional central processing unit (CPU)-based approaches and performance equivalent to more than 225,000 CPU cores. This breakthrough cuts simulation time from nearly a month to just over six hours, redefining the potential for overnight high-fidelity CFD analyses and helping set a new standard in the industry.

For those in engineering and product development, this graphics processing unit (GPU)-driven leap forward offers more than just faster results — it opens the door to simulations of unprecedented scale and complexity that can deliver insights previously out of reach.

Learn more: ansys.com/blog/reaching-new-hpc-heights-with-ansys-nvidia.

With the Ansys Gateway powered by AWS solution, product development teams can easily and efficiently solve large, complex problems in the cloud. Subscribers have flexible, affordable access to the most advanced, state-of-the-art software (including some preconfigured for easy deployment) and hardware, choosing from an array of available processor types, processing cores, and node configurations. The Ansys Gateway powered by AWS solution allows Ansys simulation software to run on thousands of computer processors simultaneously. This significantly speeds up simulations without requiring expensive hardware or increasing costs.

To confirm the effectiveness of the Ansys Gateway powered by AWS solution, Ansys completed two studies using LS-DYNA software. The model for a three-car, front-impact simulation was used and included more than 20 million elements. What Ansys discovered was that when it comes to using the cloud, configuration matters. AWS instance type Amazon EC2 hpc6a.48xlarge delivered faster results at a lower cost compared with the instance types Amazon EC2 c6i.32xlarge and Amazon EC2 c5n.18xlarge. With an optimized cloud configuration, Ansys found that users can achieve up to an 11X acceleration in simulation runtime for less money.

Because Ansys software is tightly integrated with the AWS cloud and runs side by side with other simulation workflow tools in the cloud, engineers can avoid switching back and forth between platforms to complete tasks. So not only does the Ansys Gateway powered by AWS solution shorten solution times — it streamlines job submissions, handoffs, and other process steps.

EFFICIENT, POWERFUL, AND FAST

Engineers recognize that simulation is more efficient than building prototypes. But sophisticated vehicles like EVs and AVs require more computing resources than their predecessors. By drastically reducing solve time, Ansys is giving automotive engineers the ability to evaluate more scenarios for safe driving while shaving the time and expenses of physical testing.

LEARN MORE

Download the e-book "How to Accelerate Ansys Multiphysics Simulation Software with Turnkey Hardware Systems."

ansys.com/resource-center/brochure/accelerate-multiphysics-simulation-turnkey-hardware

HEAD-UP DISPLAYS

Are Ready for Their Moment in the Sun

By **MIKE GROVE**, Manager Application Engineering, Ansys, and
STEVEN LACAVA,
Lead Application Engineer, Ansys

As major automakers invest in next-generation head-up displays, simulation can help address safety challenges.

To win in an increasingly crowded global market, automotive manufacturers need to differentiate themselves by offering innovative, next-generation technologies that help deliver a safe, comfortable driving experience. Head-up displays (HUDs) are emerging as a key area of innovation and competitive differentiation.

To help drivers keep their eyes on the road and minimize distraction, HUDs project critical information like speedometer readings, fuel levels, navigation guidance, and traffic warnings on the windshield or specialized mirrors in the driver's line of sight. A form of augmented reality, HUDs have been adapted from the aviation industry for commercial automobiles as an important component of today's advanced driver-assistance system (ADAS) platforms.

We can accurately "see" the impact of the stray light in a virtual world that replicates human vision — that is, with glare, depth of field, etc. Engineers can ask themselves, "Are the resulting optical phenomena merely an annoyance or an actual threat to the safety of driving?"

As drivers embrace this leading-edge technology, the market for HUDs is exploding. In fact, it's projected to nearly quadruple in size over the next eight years, growing from $1.6 billion in 2023 to $7 billion in 2032.

The world's biggest automakers are paying attention — and investing accordingly. Their focus is on expanding the currently relatively small area of HUDs to span the entire windshield, minimizing the need for drivers to ever look away from the road. Ford, BMW, and General Motors are all investing in patents and prototypes for full-windshield displays.

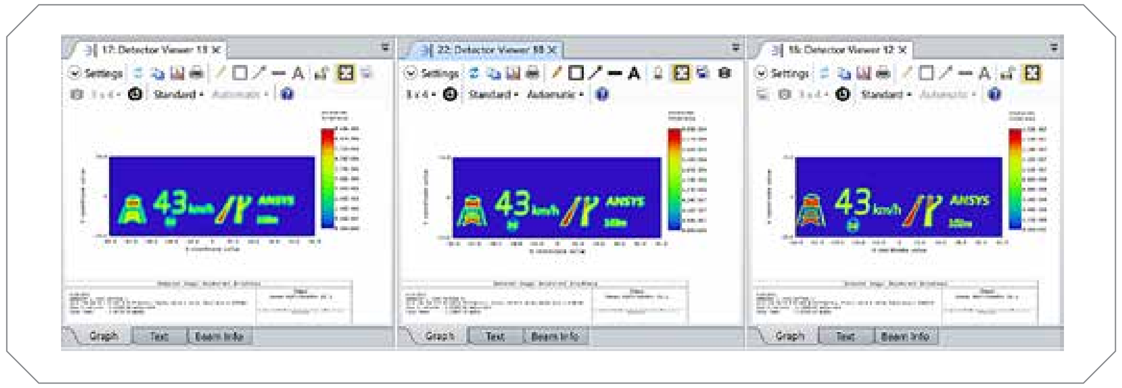
Perhaps the most ambitious development effort is being led by Hyundai, which plans to introduce windshield-spanning HUDs as early as the 2027 model year. Hyundai is also introducing a redesigned cabin that eliminates the dashboard, making the HUD's glass area even bigger.

BRINGING DESIGN OPTIMIZATION TO LIGHT VIA ANSYS

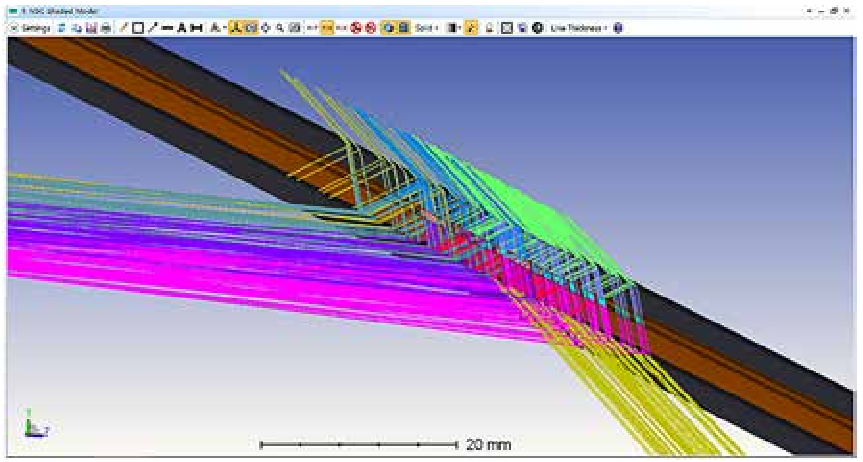
The development of HUDs has always been characterized by complex design challenges, principally because human perception is involved. Cross-functional design teams must not only address practical concerns like glass strength and projection system costs but differences in human behavior and visual ability. Designers must consider a wide range of legibility and lighting concerns, such as ghosting, distortion, warping, and chromatic aberration.

One of the greatest sources of uncertainty is stray light, which is defined as any unintended light that's sensed by a detector or perceived by a human. If stray light comes from the HUD's own optical components — for example, if light bounces off the windshield coating in an unexpected way — it can cause ghost reflections that confuse drivers or block their vision through the glass. Stray light can also originate from nonoptical components, such as the sun or oncoming headlights, causing unintended glare.

Obviously, as the surface area of a HUD increases, so does the risk of stray light interfering with the visibility of both display data and the road ahead. As HUD design has matured as a science, automotive engineering teams now have a range of tools and best practices at their disposal to mitigate stray



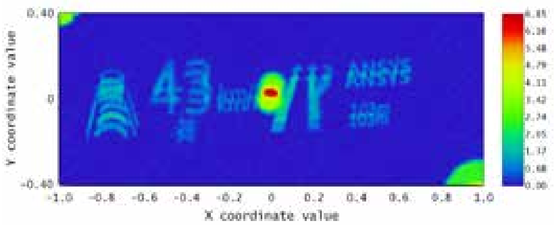
These images illustrate how, through refining the optimizer's functions of merit, image quality can be improved. The ghosting effect can be corrected or mitigated using Ansys Zemax OpticStudio optical system design and analysis software. From left to right, the images show the original system, an intermediate improvement, and an optimized system.



Stray light can originate from within the head-up display (HUD) itself. Here, a substrate in the layered glass assembly creates an unwanted reflection, or glare, for the car's driver.

light and its effects. They can change the angles, materials, substrates, coatings, and position of the HUD's optical components. Engineers can also incorporate light traps — mechanical catches for undesired light paths — into their HUD designs.

But a tough question remains: How can HUD development teams accurately replicate the full range of human perception, identify every possible source of stray light, and eliminate unwanted optical phenomena before the costly prototyping and physical testing stages? The answer is engineering simulation.



This image demonstrates exactly how an external source — the sun — can hinder the ability to read the HUD's displayed data and cause damage to the picture generation unit (PGU).

Simulation is the only fast, feasible, and cost-effective way to model the HUD's many components, replicate their performance under thousands of potential operating parameters, and make design adjustments in a low-risk virtual environment to minimize stray light and its effects. Engineering metrics can help designers meet a predefined specification, but understanding how the human experience actually affects display legibility is critical in ensuring the highest standard of automotive safety.

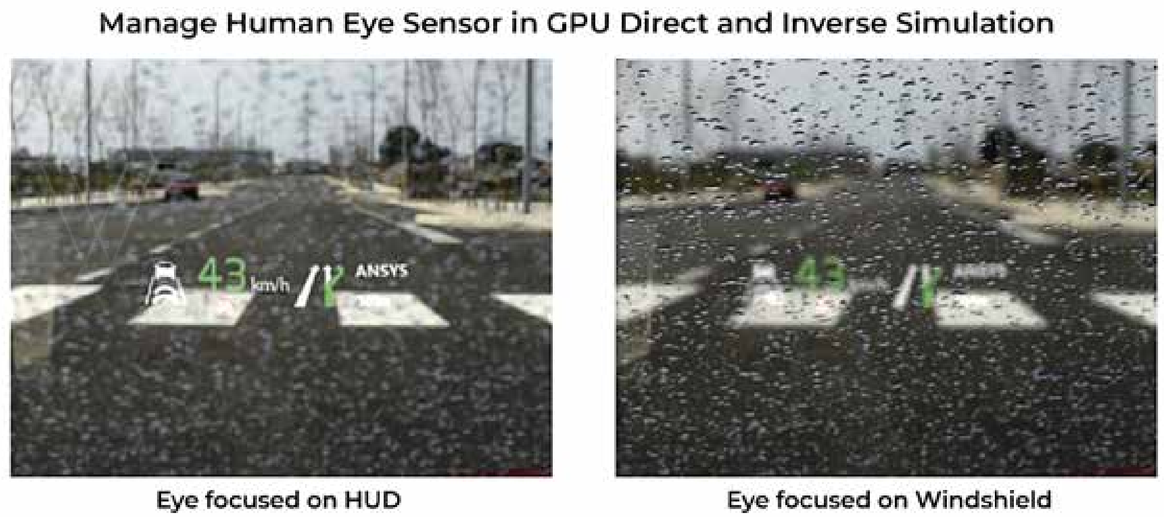
As a simulation leader, Ansys offers two advanced solutions — Ansys Zemax OpticStudio optical system design and analysis software and Ansys Speos CAD integrated optical and lighting simulation software — to accurately replicate the real-world performance of even the most advanced and largest HUD systems.

COMBINING THE ART OF PERCEPTION WITH THE SCIENCE OF OPTICS

To understand how OpticStudio software and Speos software work together to detect and minimize stray light, let's consider an example simulation created by the specialists at Ansys. It applies these two Ansys solutions to optimize the design of a HUD projected onto an automotive mirror.

First, engineers can conduct an optimization of the HUD system in OpticStudio software to achieve the expected optical performance while mitigating stray light caused by the optical components. This can originate from inside or outside the HUD itself, in the form of ghosting or a sun hot spot, causing the projected image to be illegible or, worse, damage the picture generation unit (PGU). Adjusting the mirror shapes/angles, materials, and coatings can greatly minimize these effects. Coating selection can be very important as well, such as adding cold-mirror films to mitigate PGU heat.

Next, engineers move this data into Speos software to conduct a comprehensive system-level analysis of the HUD in a real-world driving situation, which includes bringing in the additional mechanical housing and other nonoptical geometries. Engineers begin by determining worst-case stray light generation conditions — not just in the HUD system but also stray light originating from the external world.



Human eye depth of field accommodation, a challenge when visualizing a HUD virtual image through a windshield with raindrops

Then they simulate the effects of that stray light hitting the HUD's glass surface, mechanical housing, or dashboard. Glare from any of these objects hinders not only the visibility of the display but potentially the driver's unobstructed view of the road ahead. It is here where we also validate the visual experience from a human driver's point of view. We can accurately "see" the impact of the stray light in a virtual world that replicates human vision — that is, with glare, depth of field, etc. Engineers can ask themselves, "Are the resulting optical phenomena merely an annoyance or an actual threat to the safety of driving?"

In either case, designers can also use Speos software to apply design corrections that mitigate the effects of the stray light. For instance, designers may vary the display material characteristics to minimize glare or reflection. Designers can test the effects of using more diffuse and light-absorbing materials.

Not only does simulation via Ansys enable easy, rapid design changes — it enables the kind of cross-functional collaboration that's required to develop next-gen HUDs. By allowing diverse team members to dynamically visualize the real-world performance of their designs, collaboratively iterate, and create successful virtual prototypes, Ansys-powered simulation maximizes design confidence, teamwork, and the level of innovation.

DRIVING DESIGN LEADERSHIP AND SAFETY LEADERSHIP

Automakers find themselves in a challenging position today. Market demand is driving them to quickly launch innovative ADAS safety features like HUDs. But as they race to release vehicle models and digital technologies that differentiate their brands, automotive manufacturers can't shortchange their physics calculations or analytic rigor.

With so much riding on HUDs, simulation via Ansys offers the best of both worlds: a comprehensive, complex analysis of system performance under actual driving conditions, combined with a fast, cost-effective approach to design and verification. Safety can be considered at the earliest phase of the HUD design cycle, and iterative modeling can continue until the design is ready for physical testing.

All major automakers have their sights squarely focused on HUD development as displays become bigger and more advanced in their capabilities. Accomplishing these ambitious plans means incorporating OpticStudio software and Speos software into the toolbox, along with other leading best practices in automotive design.

LEARN MORE

Watch the Ansys HUD webinar series.

ansys.com/resource-center/webinar/take-the-lead-the-hud-revolution-in-automotive

The Future of Vehicle Lighting: *Optics Simulation Leads the Way*

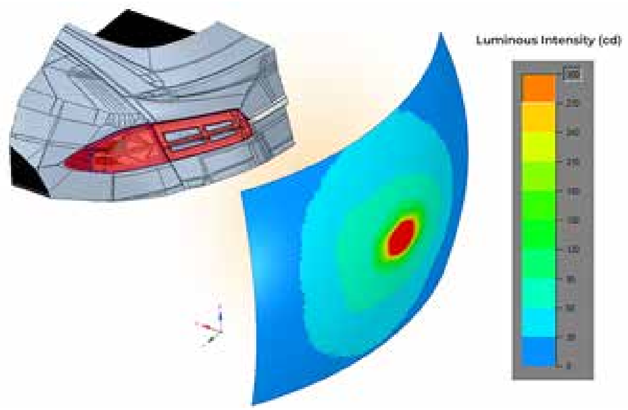
By **Kerry Herbert**, Senior Product Marketing Manager, Ansys

Vehicle lighting technology has seen significant evolution over the past few decades. What started as simple incandescent bulbs has progressed to sophisticated light-emitting diode (LED) systems, adaptive lighting, and even fully digital lighting solutions. As the automotive industry shifts toward more connected, autonomous, and electric vehicles, demand for innovative lighting solutions is greater than ever. Ansys is at the forefront of this revolution, particularly with its advanced Ansys Optics suite of products, including Ansys Lumerical solvers, Ansys Speos optical and lighting simulation software, and Ansys Zemax OpticStudio optical system design and analysis software.

THE EVOLUTION OF VEHICLE LIGHTING

From Incandescent to LED

The journey of vehicle lighting began with basic incandescent bulbs. These were simple and reliable but not particularly efficient or durable. The introduction of halogen lamps in the 1960s offered improvements in brightness and longevity. However, it wasn't until the advent of LED technology that vehicle lighting would transform significantly. LEDs brought several advantages: They were energy-efficient, had longer life spans, and offered greater design flexibility. This flexibility has enabled automakers to experiment with lighting designs, integrating them into a vehicle's overall aesthetic and functional design.



Photometric simulation of the stop light function

Adaptive Lighting and Beyond

The next major leap in vehicle lighting was the development of adaptive lighting systems. These systems, often integrated with a vehicle's sensors and cameras, can adjust the direction, intensity, and spread of the light beam based on driving conditions. For instance, adaptive headlights can pivot to illuminate the road ahead when the vehicle is turning or automatically switch between high and low beams depending on traffic conditions.

The rise of electric vehicles (EVs) and autonomous vehicles (AVs) is further pushing the boundaries of vehicle lighting technology. With fewer design constraints compared with traditional combustion engine vehicles, EVs offer more opportunities for innovative lighting solutions. Autonomous vehicles, on the other hand, rely heavily on advanced sensor systems, many of which can be integrated with lighting systems to enhance vehicle safety and communication with others on the road.

VEHICLE LIGHTING TRENDS

Digital Lighting Systems

Digital lighting is set to change the automotive industry. These systems use micro-LEDs or organic LEDs (OLEDs) to create complex lighting patterns and animations. Digital lighting can enhance vehicle communication, for example, by projecting signals or messages onto a road to interact with pedestrians and other vehicles. This will be crucial as we move toward higher levels of vehicle autonomy, in which clear communication between the vehicle and its surroundings will be essential.

Laser and Matrix Lighting

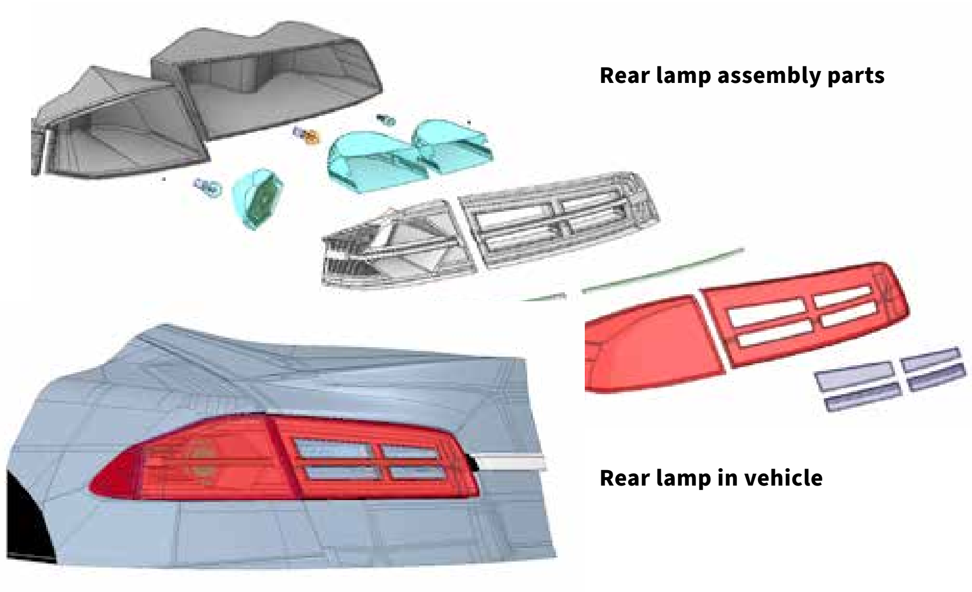
Laser lighting and matrix LED systems represent the cutting edge of vehicle headlight technology. Laser headlights offer greater brightness and range than traditional LED lights, enabling safer driving at higher speeds and in poor visibility conditions. Matrix LED systems, on the other hand, consist of an array of LEDs that can be individually controlled to create precise lighting patterns. This gives better control over light distribution, minimizing glare for oncoming drivers while maximizing road illumination.

> ***“As vehicles become more autonomous, the integration between lighting systems and a vehicle’s sensor suite will become increasingly important. Ansys Optics supports this integration by providing tools for simulating how lighting interacts with the vehicle’s cameras, lidar, and other sensors.”***

Augmented Reality and Head-up Displays
The us of augmented reality (AR) in vehicles is another exciting area in which lighting technology is playing a crucial role. AR head-up displays (HUDs) project critical driving information directly onto a windshield, allowing drivers to access this data without taking their eyes off the road. Future AR systems could be integrated with advanced lighting solutions, such as projecting navigational cues onto the road or highlighting potential hazards in real time.

DRIVING INNOVATION IN VEHICLE LIGHTING

Comprehensive Simulation Tools
The Ansys Optics collection is a comprehensive suite of simulation tools that enable automotive engineers to design, test, and optimize vehicle lighting systems in a virtual environment. These tools cover everything from the optical design of individual components to the integration of lighting systems with the overall vehicle design. One of the key advantages of using the capabilities of the Ansys Optics product collection is its ability to simulate real-world conditions with high accuracy. Engineers can test how different lighting designs perform under various driving conditions, such as different weather conditions, road types, and traffic scenarios. This helps to ensure that a lighting system not only meets regulatory requirements but delivers optimal performance in real-world situations.



Supporting Advanced Lighting Technologies
The Ansys Optics collection is particularly well suited for developing advanced lighting technologies, such as matrix LEDs, laser lights, and digital lighting systems. The product collection enables engineers to simulate the complex interactions between light and different materials, including how light is reflected, refracted, and absorbed. This is critical for optimizing the performance of these advanced lighting systems and ensuring they deliver the desired lighting effects.

For example, in the case of matrix LED systems, Ansys Optics products can simulate how each individual LED interacts with the surrounding optics to produce precise lighting patterns. This level of detail is essential for developing adaptive lighting systems that can dynamically adjust the light distribution based on the driving environment.

Integration With Autonomous Vehicle Systems
As vehicles become more autonomous, the integration between lighting systems and a vehicle’s sensor suite will become increasingly important. Ansys Optics products support this integration by providing tools for simulating how lighting interacts with the vehicle’s cameras, lidar, and other sensors. This helps ensure that the lighting system enhances the performance of these sensors rather than interfering with them.

For example, Ansys Optics products can be used to simulate how different lighting conditions affect the performance of a vehicle’s cameras and lidar systems. This is critical for ensuring that an autonomous vehicle can accurately detect and respond to its surroundings, even in challenging lighting conditions.

Virtual Prototyping and Testing
One of the key benefits of Ansys Optics products is their ability to support virtual prototyping and testing. This enables automotive engineers to test lighting designs in a virtual environment before committing to physical prototypes. This not only speeds up the development process but reduces costs by minimizing the need for expensive physical prototypes.

In addition, Ansys Optics supports the development of digital twins, which are virtual replicas of a physical lighting system. These digital twins can be used to monitor the performance of the lighting system in real time, enabling predictive maintenance and optimization throughout the vehicle’s life cycle.

A SMARTER, SAFER FUTURE

The future of vehicle lighting is bright, with advanced technologies — such as digital lighting, matrix LEDs, and AR HUDs — set to revolutionize the driving experience. As the automotive industry continues to evolve, so too will demands on vehicle lighting systems. By enabling comprehensive simulation, virtual prototyping, and integration with autonomous vehicle systems, the Ansys Optics collection is helping to ensure that the vehicles of the future are not only safer and more efficient but more connected and intelligent.

Whether you’re an automotive engineer, a designer, or simply a technology enthusiast, advancements in vehicle lighting are exciting developments to watch as we drive toward a smarter, safer, and more visually stunning automotive future.

LEARN MORE

Explore Ansys Optics solutions.

ansys.com/products/optics

Testing critical sun positions from the driver's perspective using Ansys Speos optical and lighting simulation software

Optimize the Interior Automotive Lighting Experience

By **Gwenael Moysan**, Manager, Application Engineering, Ansys

When we talk about optimizing interior lighting for human perception, we're really talking about two focus areas: safety and driver experience. When interior lighting is designed for the best possible experience, drivers are better equipped to face challenging or unexpected driving conditions and experience less fatigue. Aside from its functional benefits, interior lighting can make a vehicle sleek, modern, relaxing, or simply cool. Today, lighting has a central role in vehicle styling. (Ever heard someone say, "Light is the new chrome?")

Interior lighting encompasses satellite navigation/GPS, overhead, storage, reading, and ambient lighting — like light guides or light pipes. Each of these lighting types has a role in driver comfort and safety. Engineers need to balance optics requirements, like homogeneity, with other core specifications related to performance and cost. With the help of multiphysics simulation, engineers can account for the complexity of human-centered design while adhering to core engineering design constraints.

"With simulation, engineers can evaluate components like light guides in situ to observe how light behaves. From there, they can identify opportunities to correct defects."

DESIGN CONSIDERATIONS FOR AMBIENT LIGHTING

Engineers face many optical challenges in the pursuit of the best possible lighting configurations and material choices for their vehicle designs. The following factors have a strong influence over the driver's experience with ambient lighting in a vehicle.

Homogeneity

Whether it is a display backlighting, a light guide, or a simple reading light, designers generally want light to be distributed uniformly to achieve a clean appearance. That homogeneity is achieved by spreading out prisms or microdots on the transmitting material to extract light from it. Optimizing the position of these elements is key to achieving the desired aspect. Diffusive films and graining on surfaces help perfect the look, and simulation plays an important role in selecting the best material.

Light Leakage

With simulation, engineers can evaluate components like light guides in situ to observe how light behaves (Figure 1). From there, they can identify opportunities to correct defects. Optimizing prisms and interior components improves the light guide itself, but without integrating the guide into the system, it's impossible to get a realistic understanding of light's behavior. Performing this kind of analysis earlier in the design process provides more opportunity for cost-conscious corrections.

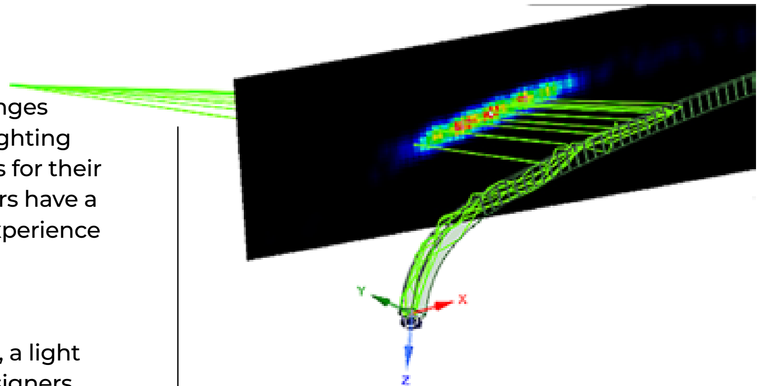


Figure 1. Tracing rays in the 3D view can help identify light leakage causes.

Colorimetry

Through simulation, engineers can measure color coordinates (Figure 2) in different CIE color

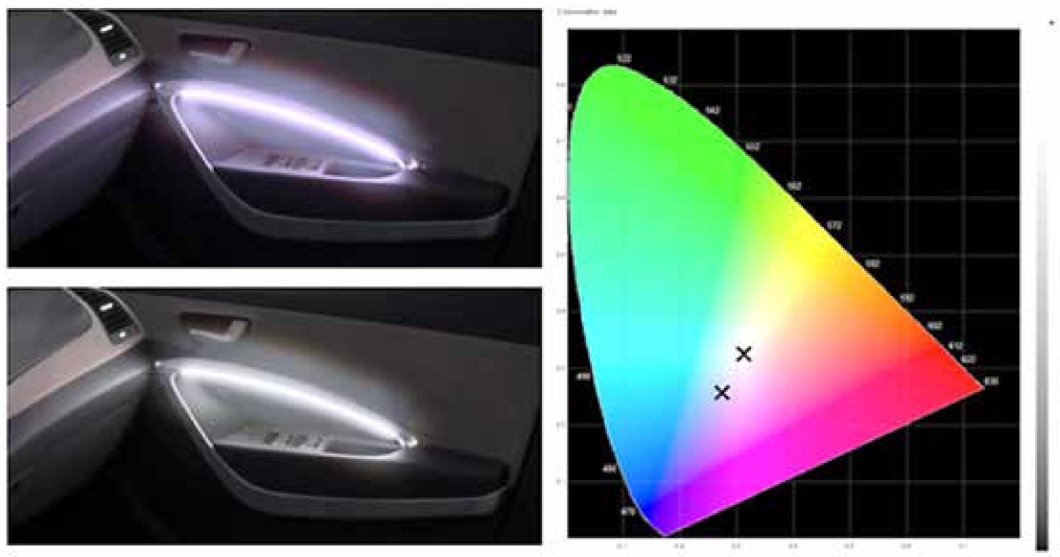


Figure 2. Color shift before (top left) and after (bottom left) the RGB modifications with the corresponding CIE 1931 color coordinates (right).

spaces to ensure they meet specifications and assess the quality of the lighting source.

Legibility of a Display

For any given relative visual performance (see ISO 15008:2003), engineers improve readability by implementing displays with as high a resolution (and as low a cost) as possible. Simulation software offers relative visual performance testing to calculate contrast while accounting for character size, background color, foreground color, and distance. Testing helps engineers understand whether text or images are readable for drivers.

Sun Reflections

Performing tests in the dark or in harsh sun offers a more accurate understanding of light source quality because it accounts for riskier conditions. If the driver can't see the navigational map anymore due to the sun's reflection, it can be a

Figure 3. Tail lamp simulation results from Ansys Speos software.

safety concern. Simulation can help engineers identify critical sun positions when light reaches the driver's eyes. From there, engineers can measure the unified glare rating to understand where glare could occur and how manageable, or unmanageable, it might be for the driver.

DESIGN CONSIDERATIONS FOR DASHBOARD VEILING GLARE

When sunlight hits the dashboard of a vehicle and reflects back at the driver and passengers, they experience glare. By setting a consistent sun position, engineers can run simulations with different leathers and plastics on the dashboard to better understand the level of veiling glare passengers might experience. Engineers can also ensure that decorative chrome elements are stylish and functional without disturbing the driver or creating a potential safety risk at critical sun positions. Many different sun positions can be evaluated for one given trim material.

Effect of Polarized Sunglasses

Many displays use polarized light, so when someone in the vehicle dons polarized sunglasses, it could impede their ability to read the display. Beyond exploring polarization on the inside of the vehicle, manufacturers also turn to simulation to test polarization coatings for windshields. These coatings reflect the rays they don't want to enter the vehicle.

Luminance

Simulating light quantities like irradiance or intensity is important when designing a vehicle, but the light perceived by the human eye matters most. Simulating luminance is critical for measuring the amount of light that reaches a given point. Engineers can take it a step further by displaying luminance alongside what the human eye would perceive based on parameters like reaction time, eye conditions, and eye age. For example, perceived glare effect is different depending on the age of the observer. In addition to testing against regulations or measurable specifications, simulating for human vision enables engineers to experience the product virtually, as if it were in front of them (Figure 3).

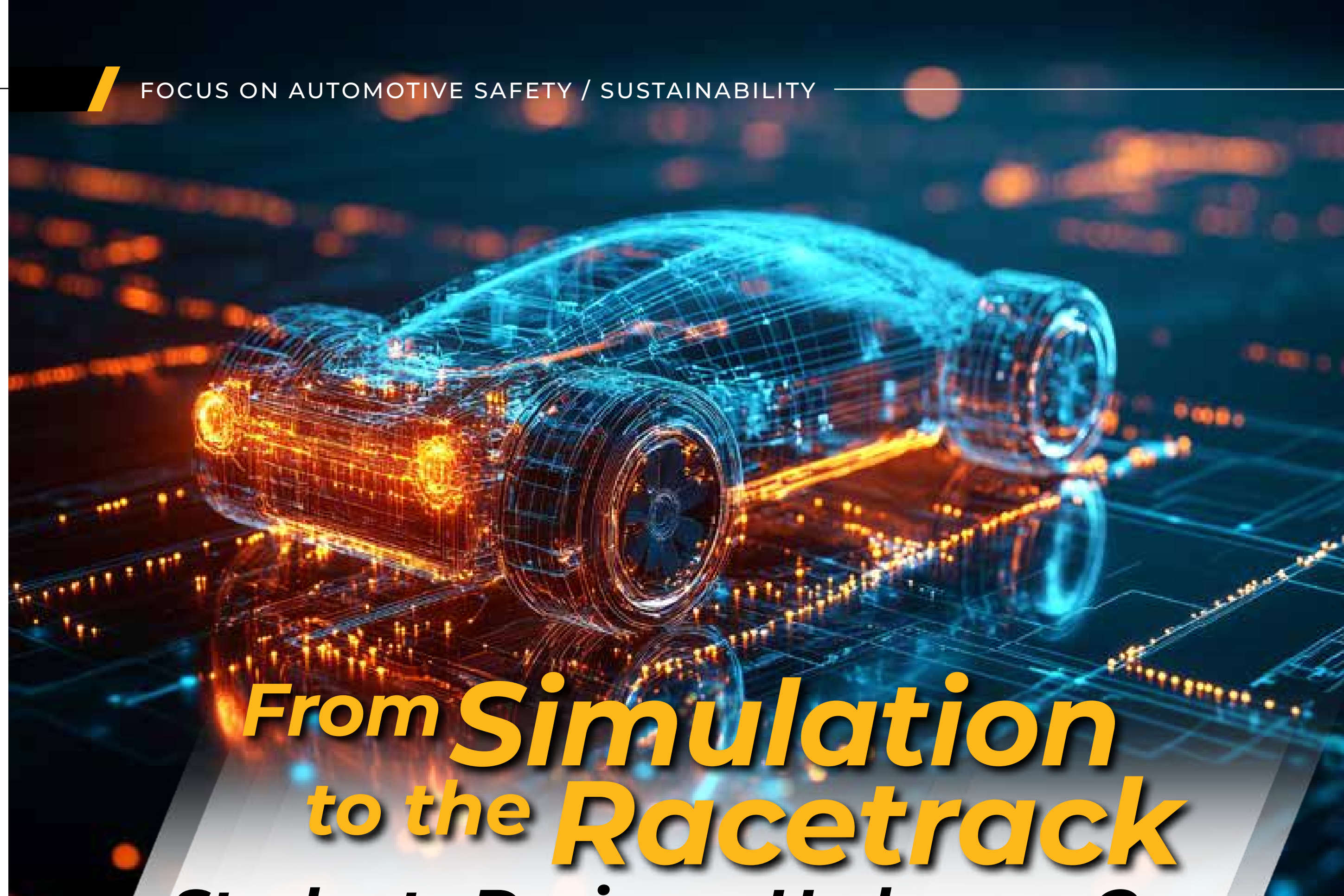
DESIGNING FOR THE FUTURE

As technology continues to develop, interior lighting technologies like head-up displays (HUDs) can play an important role in helping drivers and passengers become more comfortable with autonomous functions. HUDs provide feedback using environmental detection and openly display the information that the vehicle's sensors are perceiving. This kind of transparency can have a trust-building effect for drivers. Some manufacturers are working to build trust with pedestrians, too, by projecting symbols like marked crosswalks when an autonomous vehicle has come to a stop.

LEARN MORE

Watch the webinar.

ansys.com/resource-center/webinar/real-time-optical-simulation-reliable-innovative-automotive-lighting-designs



From Simulation to the Racetrack
Students Design a Hydrogen Car

By **SUSAN COLEMAN**, Senior Director Academic and Startup Programs, Ansys, and **CATY FAIRCLOUGH**, Corporate Communications Manager, Ansys

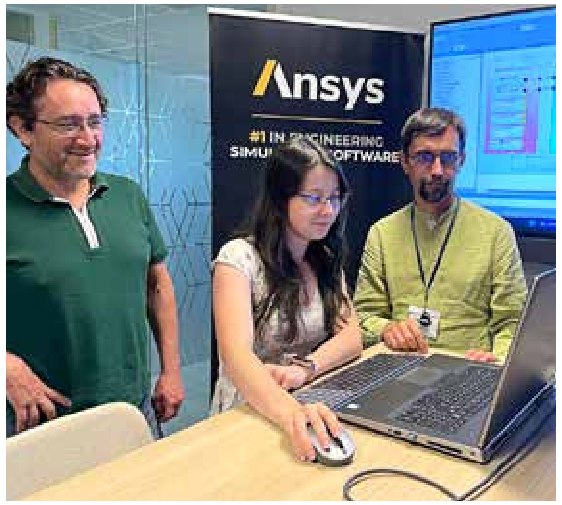
Twenty-five teams wait in anticipation to race their wooden vehicles. It's 1985 in France, and these teams are about to participate in the very first Shell Eco-marathon. The goal? To travel the farthest distance using as little energy as possible, advancing the future of sustainable mobility and energy optimization.

Now, almost 40 years later, the Shell Eco-marathon continues with the same goal; however, the teams and cars participating look a little different. The Shell Eco-marathon has expanded to become a global competition with over 300 teams participating annually. The participating teams are turning to new, innovative fuels and technologies to design, build, and drive the most energy-efficient vehicles.

One of these teams is the Hydrogreen student team from Lublin University of Technology in Poland. The Hydrogreen team is a well-established participant in the Shell Eco-marathon, having participated 10 times with over 150 members. With access to Ansys simulation tools through a student team partnership under the Ansys Academic Program, the team competes with its high-performance, hydrogen-powered vehicle called HYDROS. Under the guidance of professor Jacek Czarnigowski, students apply the

POLITECHNIKA LUBELSKA

The Hydrogreen student team with the HYDROS car (top) and its logo (bottom)



The Hydrogreen team using Ansys software

knowledge and skills they have acquired in their studies to develop the car, which also enables them to deepen their knowledge. Through this experience, the students have the chance to not only work with emerging technology but become empowered to think creatively, Czarnigowski says.

Over a decade of participation, the Hydrogreen team has taken HYDROS from a sketch on a piece of paper to a functional vehicle that is constantly being improved upon in terms of mechanics, electronics, and control.

RAPIDLY ADAPTING TO CHANGE WITH ANSYS SOLUTIONS

The latest HYDROS consists of two independent electrical systems with three energy sources — a lithium-ion battery, supercapacitors, and a hydrogen fuel cell — that drive several power consumers and are distributed around the vehicle. When updating the design each year, the team focuses on:

- Meeting the strict safety requirements that come with using hydrogen fuel.
- Minimizing the energy consumption for every trip, thus aligning with the goals of the Shell Eco-marathon. This involves both efficiently managing the energy flow and consuming the least amount of energy possible.

"These requirements mean that designing the architecture of such a system requires very good planning," says Czarnigowski. To achieve this safe, effective design, the Hydrogreen team chose the Ansys SCADE embedded software product collection, mainly using the Ansys SCADE Architect systems and software architecture modeling application in the past year.

"Ansys SCADE Architect software allows us to design our system in a way that ensures flexibility to change, the possibility of group work, and — most importantly — compliance with the security requirements of embedded systems," says Czarnigowski. Using this software, the team designed and developed HYDROS' vehicle control and management software (VCMS). And this was just the beginning for using simulation in this year's competition.

For its first step as a participant in the Shell Eco-marathon, the Hydrogreen team needed to pass the technical verification stage, which investigates the whole HYDROS vehicle system. This stage was particularly challenging this year because the judges made a few last-minute rule changes, such as forbidding carbon-fiber wheels and addressing safety concerns around hydrogen leakage.

Despite this hurdle, the Hydrogreen team rapidly adapted and proved that its design was safe by showcasing its results. By using SCADE solutions, the team easily updated its design and produced good documentation for each change requested by the judges. "A well-developed and well-documented architecture helped us pass the inspection," says Czarnigowski.

As a result, out of the 14 cars intending to take part in the marathon this year, the Hydrogreen team was one of 10 that passed these challenging requirements. Not only did it pass, but Weronika Nowak, a driver on the team with an IT specialty, says that it was one of the first teams to pass the technical inspection.

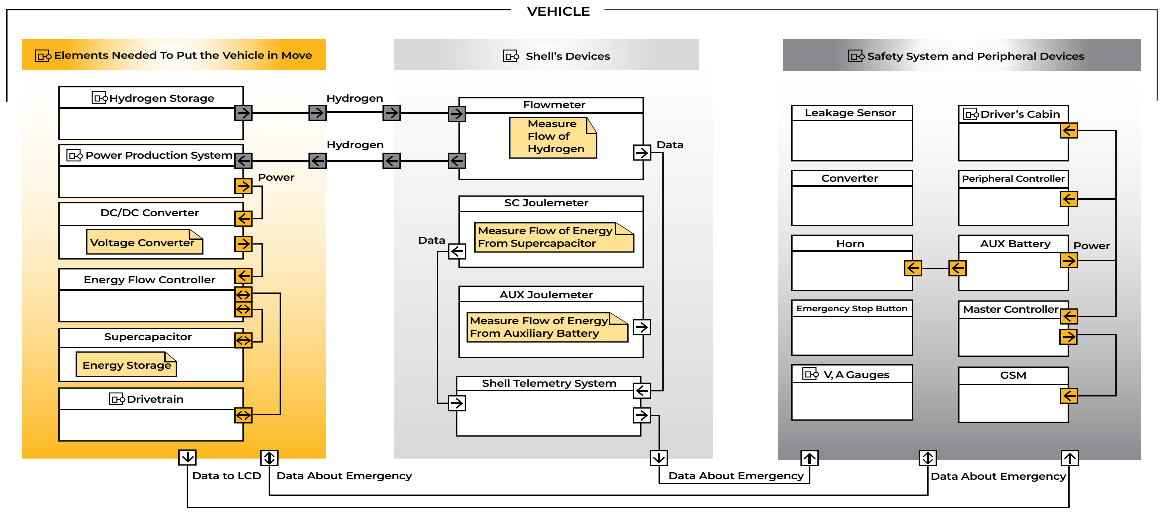
USING THE POWER OF SIMULATION TO COLLABORATE ACROSS DISCIPLINES

Making HYDROS successful requires a wide range of skill sets. "The team brings together students from mechanical engineering, electrical engineering, computer science, mechatronics,

HYDROS being inspected at the Shell Eco-marathon

"Ansys SCADE Architect software allows us to design our system in a way that ensures flexibility to change, the possibility of group work, and — most importantly — compliance with the security requirements of embedded systems."

— **JACEK CZARNIGOWSKI**, professor, Lublin University of Technology



Graphic depicting how the Lublin University of Technology in Poland team's HYDROS vehicle functions

environmental protection, marketing, management, and basic engineering to work toward a common goal," says Czarnigowski.

In a group like this, team members often approach problems from different directions and use the languages of different disciplines. SCADE solutions serve as a great tool for the Hydrogreen team to better communicate and collaborate. With its SCADE models, the team could have its system design all in one place and better share information between different groups.

In this way, Czarnigowski says SCADE solutions form a "common language" among students, enabling the whole group, no matter the discipline, to experience the fun of science.

ADVANCING CAREERS AND THE HYDROS DESIGN

When asked about the Hydrogreen team's next steps, Czarnigowski says it is going to build HYDROS 2.0. To do so, team members plan on expanding their use of Ansys products to include Ansys Fluent fluid simulation software to design and optimize the car body; Ansys Mechanical structural finite element analysis (FEA) analysis software to design a lightweight, durable monocoque structure, suspension, and control system; and Ansys SCADE Suite and SCADE Display model-based design tools to design control code and human-machine interface components and then automatically generate the corresponding code to be executed in the HYDRO 2.0 prototype. In particular, the team plans to develop algorithms for controlling energy flow in conjunction with system safety, says Czarnigowski. Through this, the team hopes to optimize performance and improve results.

As for the students themselves, team members often use the experiences they gained during this project as stepping stones to careers in this field. "Participation in the prestigious Shell Eco-marathon competition and the Hydrogreen team, which is well known in Poland, opens up opportunities for internships and later employment in good companies all over the world," Czarnigowski says.

The teamwork, self-confidence, ability to work under pressure, experience in interdisciplinary collaboration, and time management skills gained are also of great importance.

Looking to the future, Lublin University of Technology also hopes to support more women as they consider careers in technology. As such, the university is launching a mentorship program and hopes talented students like Nowak inspire women who are interested in science, technology, engineering, and mathematics (STEM) careers, such as those pursued by the Hydrogreen team.

LEARN MORE

Learn about the Ansys Student design team partnerships.

ansys.com/academic/students

Simulation in the News

Now Safety Managers Can Streamline, Accelerate, and Improve Automotive Safety Activities With a Single Tool

The Ansys Digital Safety Manager safety process optimization solution is a new way to digitize safety analysis and engineering from development to deployment to operation.

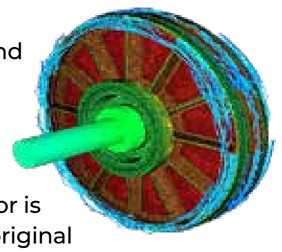
Faulty airbag deployments, unintended accelerations, and vehicle fires — over the years, all these safety-related incidents have cost companies millions of dollars. The trick for original equipment manufacturers (OEMs) and tier suppliers, of course, is mitigating risk upfront to prevent these incidents from happening.

The Ansys Digital Safety Manager solution drives safety process optimization, acting as a central hub for gathering data, managing resources, planning, and automating many process steps to deliver a comprehensive view on safety. Because it's an open platform, Digital Safety Manager software can be used with other tools, including Ansys medini analyze safety analysis software, for traceability all along the development chain. Data integration relies on a simple approach to linking files from other software into Digital Safety Manager software to extract whatever information is needed, then accurately represent it in a single, shareable report.

Digital Safety Manager software can be especially helpful in supporting autonomous vehicle (AV) applications, as they involve aspects of electrification and artificial intelligence/machine learning (AI/ML) that can be huge pain points for OEMs, safetywise. All of a safety manager's activities around AVs can be supported by this new tool to plan and control the process, whether it's automating specific verification and validation steps or soliciting information via the tool in support of these types of activities for end-to-end traceability.

Learn more: *ansys.com/products/safety-analysis/ansys-digital-safety-manager*

WEG Uses Ansys Simulation To Design Revolutionary Industrial Motor



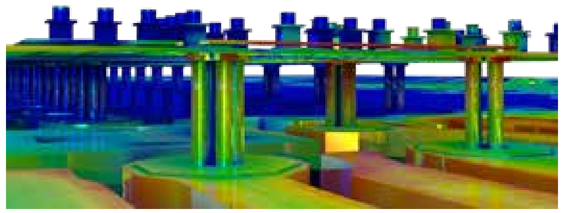
WEG, a global leader in electrical technologies and automation, used Ansys simulation solutions to develop a revolutionary industrial motor. The W80 AXgen electric motor is used in a wide range of original equipment manufacturer (OEM) industrial applications including air compressors, water pump systems, and generators.

With support and additional services provided by Ansys Apex Channel Partner ESSS, WEG is pioneering a new path forward by introducing axial flux motors to the industrial equipment market. Axial flux motors offer a more optimized and efficient alternative to radial flux motors due to their higher power density and specific torque. Some resulting advantages include space and weight savings, high efficiency levels, and improved durability.

WEG leveraged multiple Ansys multiphysics simulation solutions for W80 AXgen, including Ansys Fluent fluid simulation software, Ansys Electronics simulation solutions, Ansys Mechanical finite element analysis software, and Ansys Granta materials information, selection, and data management.

Ansys Government Initiatives To Join Microelectronics Commons To Support National Security

Ansys has been awarded a contract to supply digital engineering solutions to Microelectronics Commons to advance national security. The Commons network will have access to nearly 90% of the Ansys simulation suite to drive the next wave of innovation.



The Commons program, supported by the U.S. Department of Defense, leads a national effort to lower barriers to manufacturing for researchers and innovators. By providing technology and expertise, Ansys will help researchers design chips that are predictively accurate, secure, and reliable.

To help elevate the domestic microelectronics landscape and bolster the widespread adoption of simulation, Ansys will provide the Ansys Learning Hub to participating technology hubs and their members. Academic institutions within the network will rely on Ansys simulation to educate the next generation of the semiconductor workforce in the critical areas of 5G/6G, artificial intelligence (AI), electromagnetic (EM) spectrum dominance, quantum technology, and more.

How Simulation Can Help Optimize and Accelerate Pharmaceutical Development

Via techforgood.net

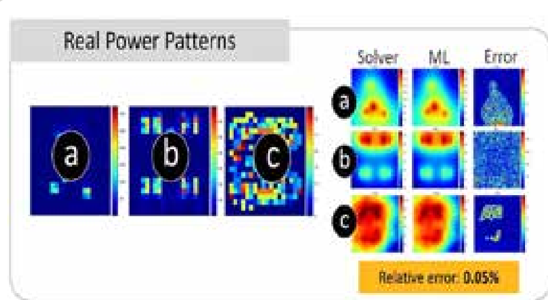
Pharmaceutical development companies are responsible for scaling up bioreactors to a commercial manufacturing level. But scaling biologics is an unpredictable task due to the difference in bioreactor sizes, as well as the cells' sensitivity to any changes more broadly.

This is where engineering simulation comes in, namely computational fluid dynamics (CFD). By leveraging CFD, teams can model hydrodynamic profiles in bioreactors across different conditions to assess how small-scale data will apply on a larger level. Then, these CFD models can be used to predict selected outputs at each scale and act as virtual sensors to provide inputs.

Having visibility into variables and predicted outputs will help ensure that the overall pharmaceutical development process is optimized and mitigate the risk of errors. As such, engineering simulation can help slash development times and decrease overall time to market, which can be crucial to supporting public health and saving lives.

Ansys To Drive Major Advances in AI-powered Semiconductor Design Using NVIDIA AI

Via engineering.com



Ansys announced it is integrating the NVIDIA Modulus AI framework into Ansys semiconductor simulation products to deliver AI functionality that significantly speeds up design optimization. This will enable engineers to create customized and generative AI surrogate models that accelerate design iterations and explore a larger design space. The technology integration will enhance the outcome for a wide range of products, including GPUs, HPC chips, AI chips, smartphone processors, and advanced analog integrated circuits.

NVIDIA Modulus is a physics-AI framework to train and deploy models that combine physics-based domain knowledge with simulation data, allowing users to create customized AI engines tailored to their needs. As AI becomes integrated into computer-aided engineering workflows, it is important for users to have a seamless and integrated pipeline that allows data generated by solvers to flow to AI frameworks used to train models. Integrating the NVIDIA Modulus framework into the Ansys SeaScape platform will enable customers to use high-fidelity data generated by Ansys tools to train their AI engines and then use the newly created engine for more robust design exploration.