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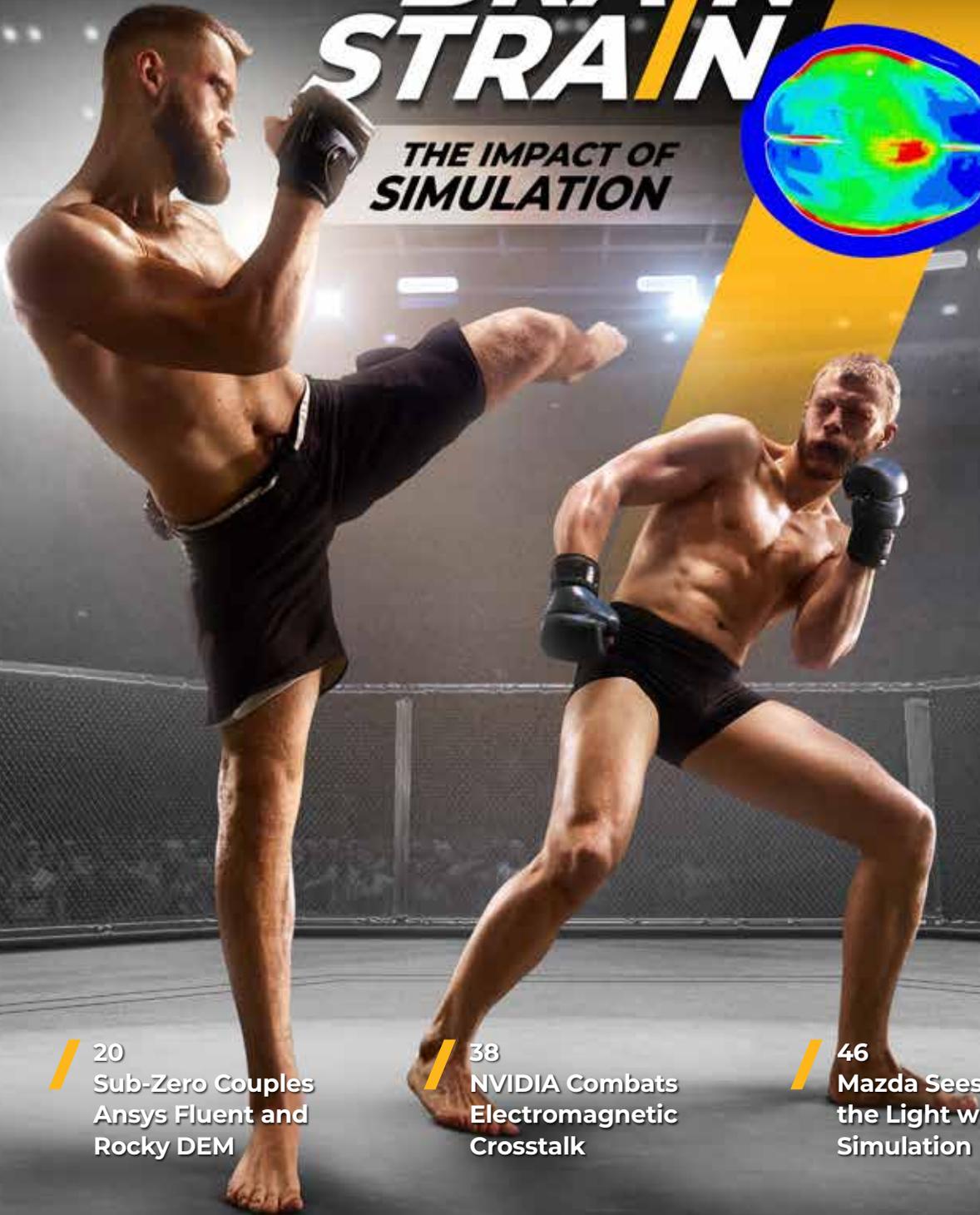
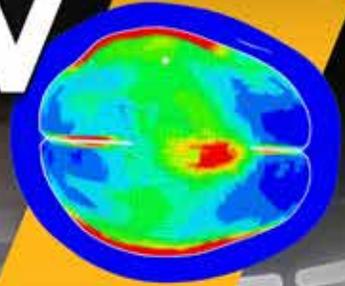
# ADVANTAGE

EXCELLENCE IN ENGINEERING SIMULATION

ISSUE 2 / 2020

## BRAIN STRAIN

THE IMPACT OF SIMULATION



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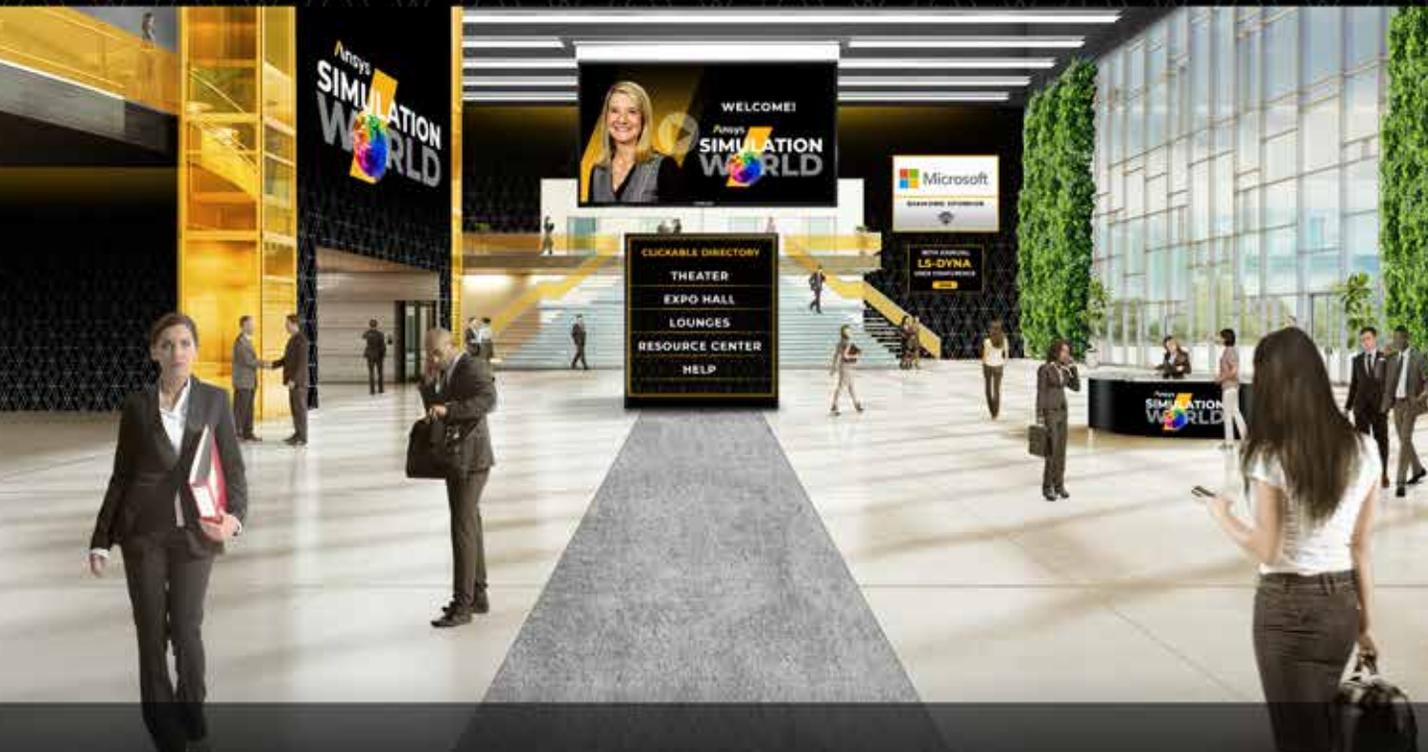
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# Engineering Agility in the COVID-19 Era

In the wake of COVID-19, 88% of organizations are requesting or requiring employees to telecommute. And companies of all sizes are gearing up for their employees to work from home indefinitely, even after the pandemic subsides. COVID-19 inspired many companies — including Ansys — to pivot and become more agile.

COVID-19 created challenges for supporting our geographically distributed customers. In April, Ansys had scheduled a one-day, in-person engineering workshop, attracting customers and Ansys engineers worldwide — but the lockdown prevented travel.

Ansys pivoted to a virtual meeting that enabled the event to occur as scheduled. Eliminating business travel made the team more productive and agile. By going virtual, they've scaled up the number of workshops, providing more support than ever.

Agility applied to Ansys conference production as well. On June 10 and 11, 2020, Ansys hosted Simulation World, the largest engineering simulation virtual conference in the world. Highly immersive and interactive, Simulation World replicated an Ansys symposia experience via a desktop or mobile device. The event promoted continuous simulation education in a fun environment, and is still available for free on demand at [simulation-world.com](http://simulation-world.com).

## ENABLING DESIGN AGILITY

Ansys' customers faced daunting productivity obstacles at the start of the COVID-19 pandemic. Unable to access their office's on-premise high-performance computing (HPC) resources, how could engineering teams run complex simulations?

Using cloud-based HPC platforms like Ansys

Cloud helped them avoid downloading huge software programs and provided virtually unlimited compute power — enabling Ansys customers to run high-fidelity simulations faster to achieve peak accuracy.

Ansys Cloud also improved efficiency. For example, a simulation may generate a 100-petabyte file. Files that big require laborious data migration to a file sharing service for teammates to access them. Ansys Cloud eliminates that time-consuming process.

As an engineer enters a design into Ansys Cloud and simulates it, teammates can monitor the progress in real time and work together to quickly modify the design, greatly increasing their productivity. This enables them to rapidly finalize designs, slashing months off design cycles and speeding high-quality products to market.

## CREATE COLLABORATIVE AND AGILE TEAMS

As COVID-19 forced Ansys' customers to distribute their engineering teams, they needed to overcome communication and collaboration challenges resulting from geographic separation and engineering silos. This disconnect created many unnecessary steps in the design process, introducing inefficiencies and long turnaround times. And because some engineers had



**Prith Banerjee**  
Chief Technology Officer, Ansys

no shared storage repository, designs couldn't be accessed, leading to more project miscommunication.

For example, when developing a car, automakers don't ask an engineer to submit one design and perform a single simulation. They employ hundreds of engineers to generate thousands of car designs and simulations. Based all over the world, the engineers must manually track all their simulation processes and data. This can create tremendous confusion about data storage and version control on multiple projects.

To increase their agility, engineers leveraged Ansys Minerva, powered by Aras — a knowledge management application platform — to access simulation data in a central hub, improve decision-making and enhance traceability. Minerva streamlined communication and drove broad simulation sharing and collaboration among engineers, substantially reducing costs and expediting production.

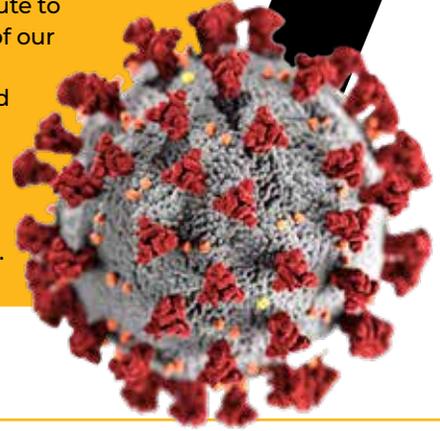
During this unprecedented time, when many are experiencing connectivity or computing capacity challenges, Ansys is proud to help our customers continue to develop products that will change the world. Learn more about Ansys programs here: [engage.ansys.com/covid-19](https://engage.ansys.com/covid-19). 🚀

# Simulation Provides COVID-19 Insights, Aids Equipment Design

During the COVID-19 pandemic, Ansys is striving to positively contribute to the battle against coronavirus by supporting the ongoing initiatives of our customers and partners. We are fully committed to helping affected communities through the use of our software, available resources and collective employee knowledge.

See below for a sampling of customer and partner initiatives that are underway in the fight against the virus, and for additional educational resources.

Learn more at [ansys.com/about-ansys/covid-19-simulation-insights](https://ansys.com/about-ansys/covid-19-simulation-insights).

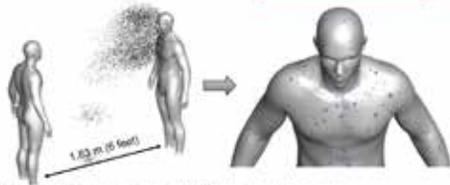


## SIMULATION-BASED INSIGHTS

### Static Air with 1.83m (6 feet) Social Distance

Time = 5.50 s

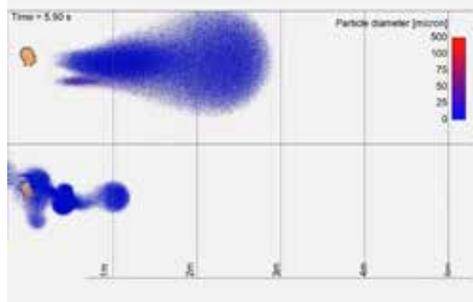
1.83 m (6 feet) is not sufficient



Note: Droplet sizes are enlarged for better visualization purpose

### CONSIDER WIND WHEN SOCIAL DISTANCING

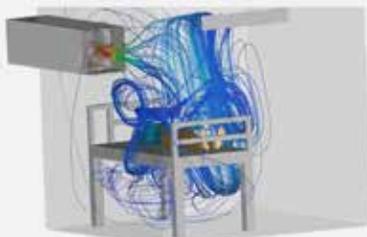
A peer-reviewed study led by Professor Yu Feng from Oklahoma State University investigated the influence of wind on droplets exuded when coughing or sneezing. Simulation demonstrates how droplets travel from person to person in the event of a gentle, a light and a moderate wind, with and without a mask.



### REDUCE TRANSMISSION RISK WITH CLOTH MASKS

People are turning to homemade, reusable cloth face masks as a protective measure to reduce the risk of transmission of COVID-19. Simulations illustrate that cloth masks have the potential to limit the spread of droplets from sneezing and coughing and to eliminate the reach of more dangerous larger droplets.

### Designing a Negative Pressure Room to Minimize Contamination

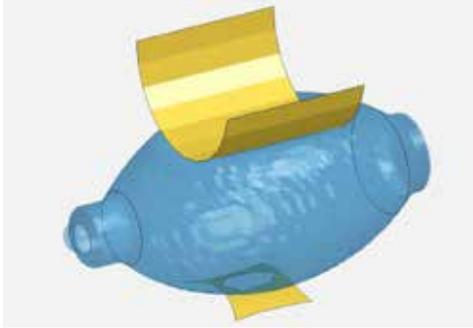


Ventilation System - No Louver - 500cfm  
Undirect inlet + higher blower capacity  
Undesired Flow Field

### DEVELOP A NEGATIVE PRESSURE ROOM

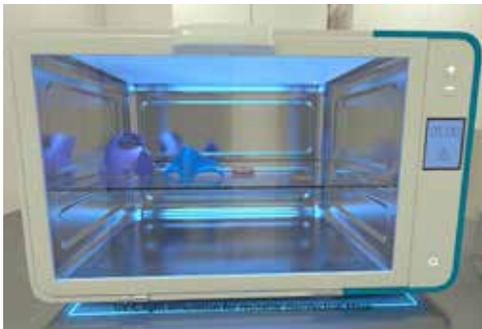
Negative pressure rooms (NPRs) can help to reduce healthcare staff's exposure to the virus while attending patients. Simulation demonstrates different room designs of NPRs and enables teams to optimize the room design, inlet vent placement and blower capacity to avoid oral and nasal plumes from recirculating in the room.

## APPLICATIONS SUPPORTING THE FIGHT



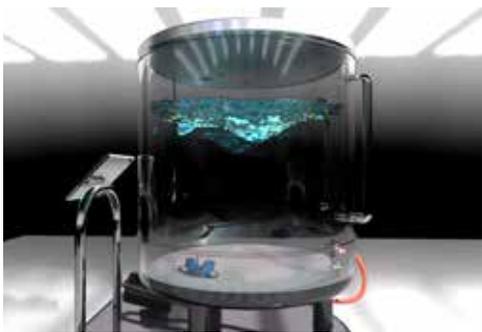
### QUICKLY DESIGN SAFE, RELIABLE VENTILATORS

Bessel LLC worked with Texas Tech University Health Sciences Center at El Paso (TTUHSC) and the University of Texas at El Paso (UTEP) to develop the Texas Power Bag Breather (Texas Breather™). Working with Ansys simulation solutions, in a matter of a few weeks, a new emergency care device was designed and extensively tested.\*



### DECONTAMINATE MASKS WITH UV-C TREATMENT

Time-effective ultra-violet decontamination of worn masks is a promising solution to prevent a shortage of clean masks for healthcare workers. Simulation enables sterilizer designers to ensure that each potentially contaminated personal protective equipment (PPE) surface will receive the necessary dose of UV irradiation.



### SCALING UP VACCINE PRODUCTION

Once a vaccine has been identified, one of the biggest challenges facing the biopharma industry is scaling up the production of the vaccine from laboratory to industrial scale. By using simulation in a virtual environment, drug companies can increase their chances of getting the scale-up process right the first time.

### Videos, downloads and more at:

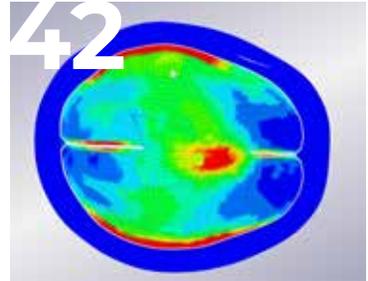
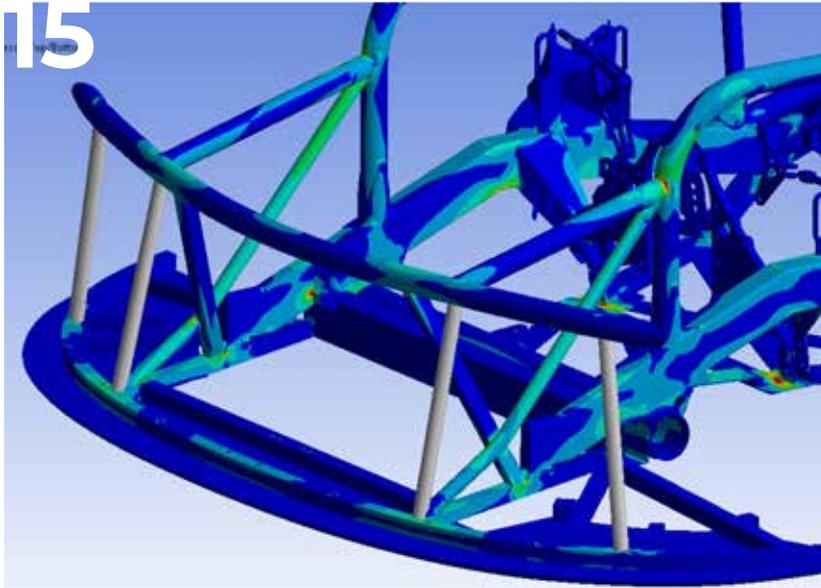
[ansys.com/about-ansys/covid-19-simulation-insights](https://ansys.com/about-ansys/covid-19-simulation-insights)

### DISCLAIMERS

These simulations were designed to replicate physical behaviors under specific circumstances. They should not be considered medical guidance and do not account for environmental variants, such as wind or humidity.

*\* An FDA Emergency Use Authorization is pending. The Texas Breather™ has not been cleared or approved by the U.S. FDA or any other regulatory agency. The Texas Breather™ is not currently authorized for emergency use.*

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

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# ***SIMULATION: Leading the Pack***

By **Xiao Hu**  
Principal Application Engineer  
Ansys, Ann Arbor, U.S.A.

Lithium-ion battery packs are the heart of the coming electrical vehicle (EV) revolution. IEA, the International Energy Agency, thinks the number of electric passenger vehicles could exceed 130 million or even 250 million

vehicles by 2030, depending on policy changes and industry pledge fulfillment.<sup>1</sup> In its 2018 prediction, OPEC, the Organization of Petroleum Exporting Countries, more conservatively estimated 300 million electric vehicles in the global car fleet by 2040.<sup>2</sup> In its Electric Vehicle Outlook 2019, Bloomberg New Energy Finance (BNEF) was more bullish on EVs, predicting 500 million passenger EVs on the road by 2040, which would be about 32% of the world's passenger vehicles.<sup>3</sup> They may disagree on timing and numbers, but analysts and automotive industry investments all point to a bright future for EVs.

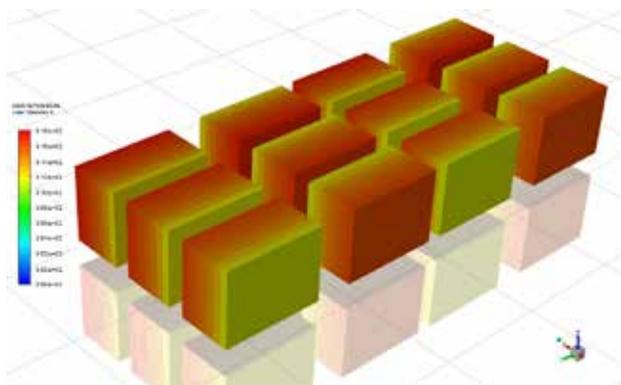
**B**efore EV sales can compete with those of cars with internal combustion engines, they must approach price parity. And, because EV battery packs make up the lion's share of EV costs, the pressure is on engineering teams to quickly and cost-effectively optimize battery performance. To do that requires simulation. One of the key applications in simulation performed by battery designers is the electro-thermal coupled (ETC) analysis. There are two types of ETC analyses.

The first couples a thermal computational fluid dynamics (CFD) model with a battery sub-model for electrical performance. A popular choice of such a sub-model is a battery equivalent circuit model (ECM). This type of ETC is commonly referred to as battery thermal management analysis.

Battery thermal management analysis benefits from an ETC that involves a high-resolution CFD simulation. Ansys Fluent software can simulate the temperature distribution in a battery pack, as well as the entire battery cooling system with a battery ECM for heat generation, to allow for battery thermal management optimization.

The second type of ETC is tailored for system applications, in which the battery ECM is also used for the electrical side, but is coupled with a fast thermal model. Many system applications do not require a high-fidelity temperature solution in a battery pack. In fact, for system-level applications, that high fidelity provides extraneous detail and demands more computational resources. For such a system application, a different approach is needed. A popular choice for thermal analysis in system applications is a thermal network model.

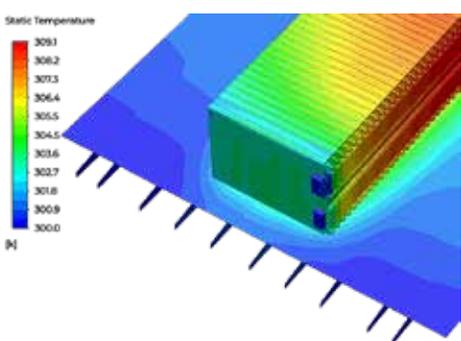
However, it can be difficult to create an accurate thermal network model because it requires a significant level of expertise. Plus, it is still relatively time-consuming and prone to errors. Another methodology, reduced-order modeling (ROM), can be used to replace the thermal network approach to develop a battery pack simulation for system applications. This ROM approach can speed up ETC by an order of magnitude compared to using the thermal network approach, and it takes less than half a man-hour to create the thermal ROM. The ROM methodology is also more accurate than the thermal network model.



**By using Ansys Fluent and Ansys Twin Builder, an entire battery pack can be simulated in far less time than with other popular techniques.**

## MULTIPLE USE CASES FOR SYSTEM-LEVEL BATTERY PACK COUPLING

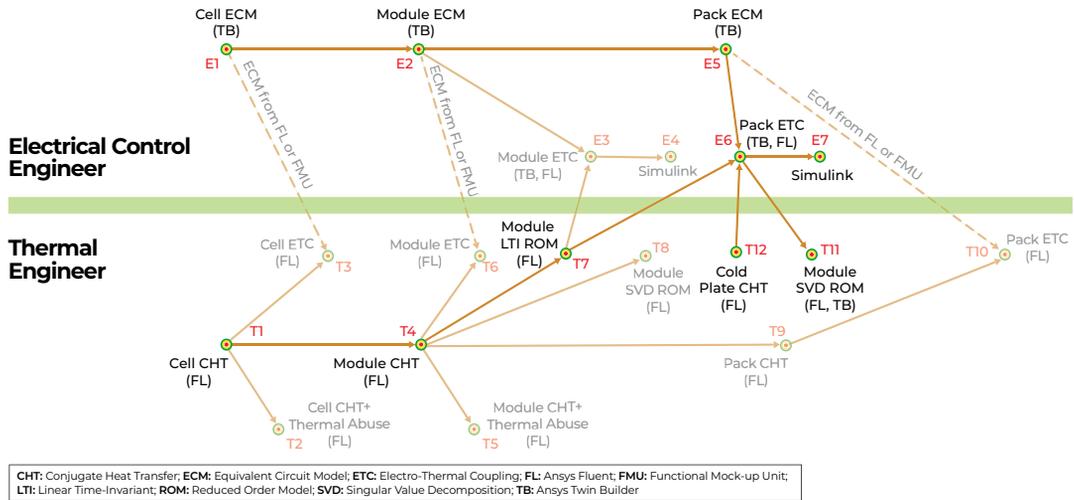
A battery ETC for system applications demands speed and accuracy. In some cases, it demands real-time or close to real-time performance with compromised accuracy. In other cases, it requires improved accuracy at the cost of speed.



**A thermal simulation of a battery module shows temperature variation in a module. The impact of such variation on battery electrical performance is simulated using ROM coupled with ECM. The ROM is calibrated using the CFD results shown.**

For example, a system integration engineer may need a battery ETC model to drive the entire electric powertrain system or a subset of it at close to real-time performance. The battery analysis, being a component in the entire system, cannot be allowed to consume more than its share of computational resources. For the entire system model to function at an acceptable speed, the battery module or even entire battery pack may be lumped into one single battery ETC. In such a scaled battery model, there is only one set of electrical parameters for the entire pack; for instance, there is one state-of-charge (SoC) value to represent the entire pack and perhaps one temperature for each battery module or even for the pack.

For battery management system (BMS) designers, on the other hand, a detailed battery ETC model is required to test the battery BMS algorithm (see “Using Ansys MBSE Solutions for Battery Management



**A chart showing the pathway toward faster electro-thermal coupling via a methodology that expands reduced order modeling techniques to the battery pack level.**

System Applications” on page 10). The battery ETC model would need to accurately capture the temperature for each cell to be able to make sure that cell-to-cell temperature variation is lower than the acceptable level. Such a battery ETC model would also need to monitor electrical performance, for instance the SoC, for each cell. As a result, it would demand a completely discretized pack ETC model.

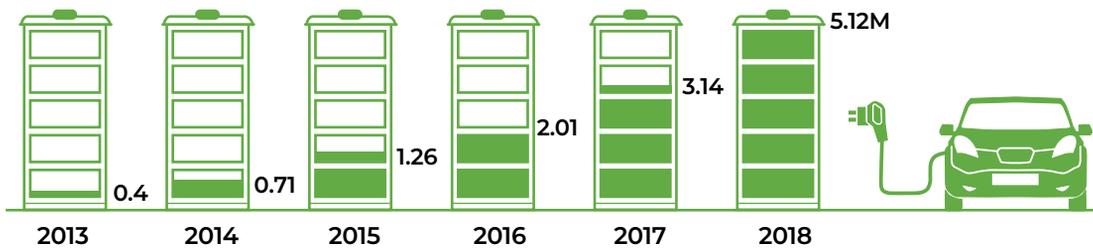
The above examples represent two extreme cases, but there are many applications that demand a level of discretization somewhere in the middle. A methodology for battery pack-level ETC should offer the flexibility to satisfy the requirements of both extreme cases and everything in between. Ansys has developed a methodology to accommodate all of them.

**USING REDUCED-ORDER MODELING FOR BATTERY COUPLING**

To demonstrate the methodology, Ansys engineers start with a proposed battery pack ETC model that consists of an electrical part and a thermal part. The electrical part uses the battery ECM model with different levels of discretization. The thermal part uses ROMs calibrated from high-fidelity CFD results. The ROMs also provide a different level of discretization. The cooling effect of each module is modeled using heat transfer coefficients (HTCs).

The battery ECM is an industry standard for simulating battery electrical performance. A battery ECM can be used at the battery cell, module and pack levels to predict battery range, peak power and drive-cycle performance. Ansys Twin Builder provides a wizard to help customers build a battery ECM. The ECM from Ansys Twin Builder could be state of charge, temperature, discharge/charge and rate dependent. The wizard builds the cell-level ECM typically from hybrid pulse power characterization (HPPC) data. It could also build a cell-level ECM from customer parameters. The ECM from Twin Builder accommodates both 4P (one resistor-capacitor) and 6P (two RCs) types of ECM models. The wizard can also build a module-level ECM from a cell-level ECM given a module configuration of mSnP. (A battery module

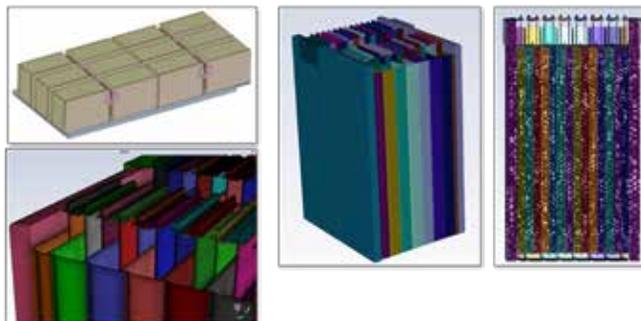
**MILLIONS OF ELECTRIC CAR DEPLOYMENTS**



**The global stock of electric passenger cars passed 5 million in 2018, according to IEA, an organization focused on sustainability.**

consists of n parallel branches with each branch having m cells.) At the module level, the wizard builds a discretized version for BMS applications in which detailed information for each cell is necessary, or a scaled version for system integration applications in which fast simulation is important. An engineer can complete a pack ECM in just a few minutes using Twin Builder.

Using ROMs for conjugate heat transfer (CHT) is a tried-and-true technique that has been used in electronics for many years. The new methodology adopts this technique for the thermal part of a battery pack ETC. ROMs require training data to determine the thermal impedance of the battery system. In this methodology, Ansys engineers use Fluent to make a high-fidelity CHT model of the battery module to create the required training data. One CFD model for a module of 14S1P configuration (14 cells in series with 1 parallel branch) can be created using Fluent in half a day. The training data generation takes a couple of CPU hours. From the training data, a thermal ROM can be generated in a couple of minutes. Once the ROM is created, the CFD model is no longer needed for simulation. The ROM can be used to simulate temperature given any transient heat source.

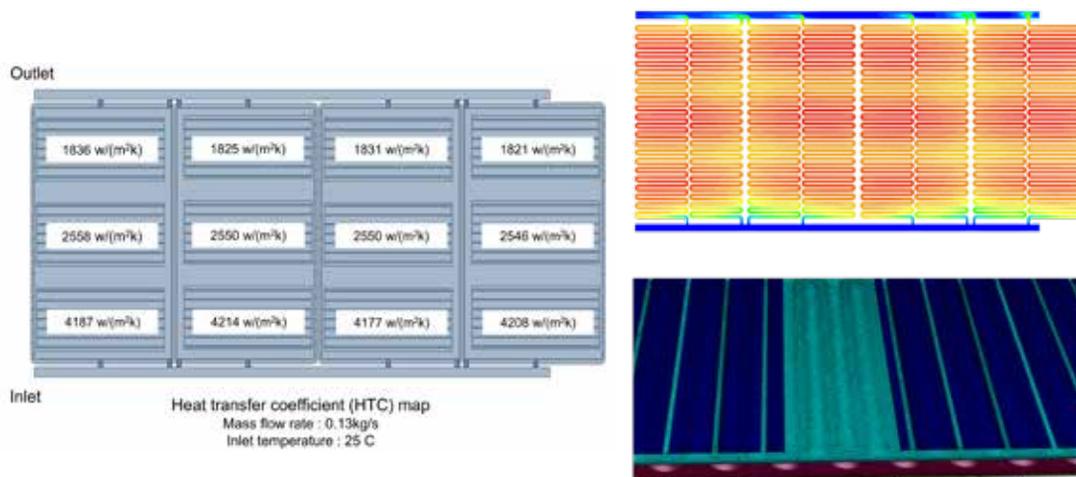


**A template has been created inside Ansys Fluent to facilitate meshing a module. Only one module mesh is required, and different modules use different HTC boundaries.**

Such a method can then be extended to the pack level. Because each module has the same geometry but sits at a different location on the cold plate, there is no need to create a pack CFD model. Instead, the thermal ROM is created for one module only. Different modules will have different heat transfer coefficient boundaries depending on where they sit on the cold plate. In this example, 12 thermal ROMs are each connected with their different HTC boundaries present in 12 different modules sitting at different locations on the cold plate.

Because the HTC varies based on where each module sits on the battery cold plate, the cold plate must be meshed to account for the variability. A cold plate CHT analysis is a typical application of CFD. An unstructured CFD code like Fluent is well-suited to this analysis. After the cold plate CHT analysis, post-processing can be done to calculate the HTC for each module.

Once the ECM for the pack and the thermal ROMs for each module are created, it is simply a matter of connecting them together to create a two-way coupled ETC for the pack. A fully discretized version of a pack ETC has a run-time performance close to real time. A scaled version could run much faster depending on the amount of scaling adopted in the pack ETC model.



**A heat transfer coefficient map of a cold plate (left) shows significant differences across the plate that must be accounted for in order to develop an electro-thermal coupling model for the entire pack.**

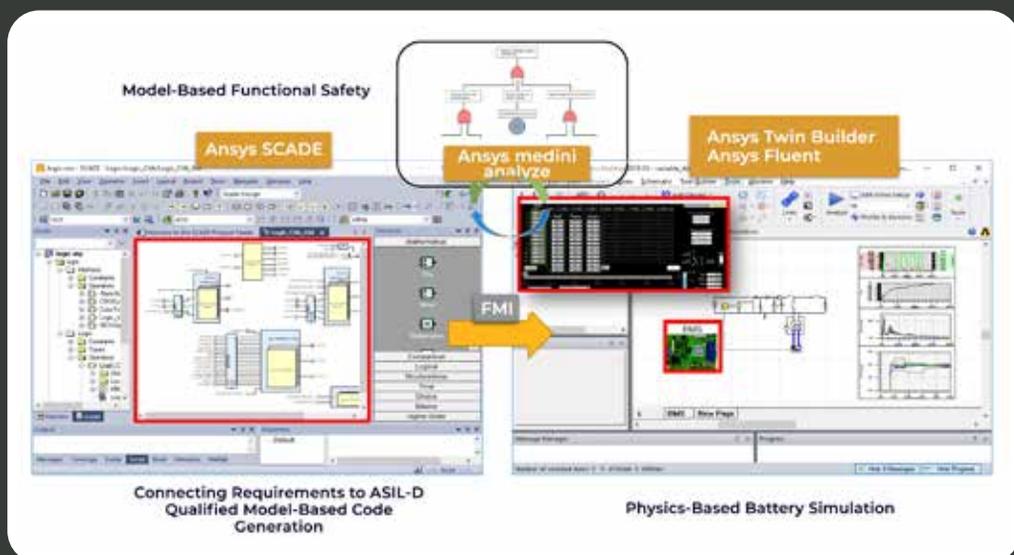
## USING ANSYS MBSE SOLUTIONS FOR BATTERY MANAGEMENT SYSTEM APPLICATIONS

Behind every complex system, there is a need for an intelligent software controller that manages the performance and the safety of the system. This is the role of a battery management system (BMS).

A BMS is a sophisticated, software-driven control center of an electric vehicle. It is responsible for, among other functions, monitoring the cell voltage and temperature and preserving healthy operating conditions; monitoring the state of the system connectivity; measuring current; calculating state of charge (SoC) and state of health (SoH); balancing electrical input and output among cells; and establishing connections between the battery and the powertrain or the charging system. In general, a BMS independently ensures the smooth, safe operation of a battery-powered vehicle at optimal performance conditions. It distributes resources where they can be put to best use and notifies the operator of potential problems well in advance. In a worst-case scenario, the BMS could physically disconnect batteries in the system to prevent damage or catastrophic failure that could endanger passengers in the vehicle.

As depicted below, Ansys medini analyze ensures the safety of the BMS design, Ansys SCADE Suite produces and verifies the embedded control software, and Ansys Twin Builder enables engineers to test and validate a complete electrical system in an EV for efficiency and reliability. This combination of design and simulation tools is essential for the development of an ISO 26262–certified BMS component.

In this development framework, Ansys Twin Builder performs integrated, system-level simulation in a real-time closed loop of the detailed battery ETC model with the BMS software component. This system-level simulation allows battery and BMS designers to understand how the different components work together, and also supports the tuning of different system parameters for an optimal system response.



Once the pack-level ETC is simulated and the results are obtained, a detailed transient thermal analysis could be performed on any module using CFD, allowing it to be studied more closely. Plus, now that the CFD has the correct heat source from the system-level simulation, its results are more accurate. Better yet, a singular-value decomposition (SVD) ROM could be used to calculate the temperature using the correct heat source from the system-level model. The SVD ROM results differ from the CFD results by just a few percent, and it takes only minutes to simulate a 4-million polygon model.

### **BENEFITS OF USING ANSYS BATTERY SIMULATION TECHNOLOGY**

Ansys battery electro-thermal coupled models can also be seamlessly integrated into an existing system-level workflow. The ECM, the thermal ROM and the entire pack ETC model could be interconnected to third-party solutions via a functional mockup unit (FMU). This provides the flexibility to use Ansys battery models in other system tools. Let us take a look at two real-world examples. In the first example, Volkswagen Motorsport used Ansys battery ETC techniques on a pack for system integration. In the second example, A123, a leading cell manufacturer, used the Ansys battery model for BMS design.

When VW Motorsport engineers were challenged to build an electric vehicle in less than a year to compete in the 2018 Pikes Peak International Hill Climb, they needed an efficient method to design and validate the battery model. They used Ansys Fluent CFD results to identify the module thermal ROM. A temperature-sensitized battery-module ECM and the module thermal ROM were then two-way coupled in Ansys Twin Builder to form the complete battery module model. The modules were then connected to form a complete battery pack model for system-level simulation in a third-party solution. Their temperature results were excellent, all within 3 degrees, and the SoC results were within 10% of error compared with test results. The simulation method not only helped VW engineers meet their tight deadline, the resulting ID. R Pikes Peak race car crossed the finish line in record time. Learn more here: [ansys.com/pikespeak](https://ansys.com/pikespeak).

A123 Systems LLC used the ROM methodology to build a discretized thermal ROM for a liquid-cooled, 48V battery pack. The accuracy and efficiency of the ROM were first validated by comparison with 3D simulation. The error from the ROM has shown to be negligible compared with the 3D CFD simulation. The thermal network was then compared with the ROM approach, and the errors from the thermal network were much higher compared with the ROM. Comparing the two methods' workflows, ROM is a more systematic approach and less error prone. The discretized thermal ROM is then exported into a third-party system tool to develop a current derate algorithm for the BMS. The methodology demonstrated high capability and potential for dynamic identification of components overheating to protect the battery pack.

As automakers increasingly turn to electric powertrains, engineers will increasingly turn to time-saving techniques to optimize battery packs. The battery electro-thermal coupled model using ROM that Ansys has developed with its customers makes system-level battery pack applications more efficient, accurate and pervasive. ▲



**BMS for Safer Electric Vehicles Webinar**  
[ansys.com/BMS](https://ansys.com/BMS)

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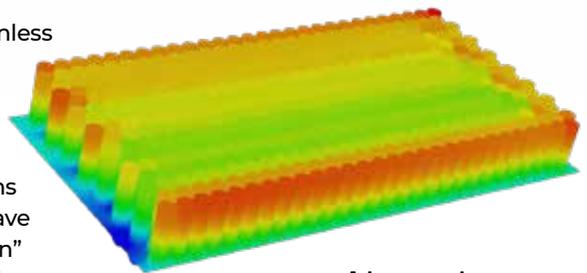
# Digital Twin Prevents Drain on Battery Pack Simulation Time

By **Azita Soleymani**, Director, Electronic Cooling Solutions, Santa Clara, U.S.A.

The global shift to electric vehicles (EVs) is coming, and unless alternative technology emerges, it will be fueled by high-capacity lithium-ion (Li-ion) batteries.

Making the hundreds of millions of Li-ion batteries the world will eventually need for electric mobility is a massive undertaking full of technical challenges. Concerns about battery pack size, weight, cost and sustainability have to be resolved before there can be a mass rollout of “green” cars. So do issues about battery life span and safety, which can be affected by thermal conditions. Among other benefits, regulating cell and battery pack temperature within a given range can increase the number of cycles a battery can achieve, making performance more dependable. More important, an effective thermal solution can reduce the possibility of catastrophic battery failure.

Electronic Cooling Solutions, Inc., provides thermal management expertise to the electronics industry, rapidly identifying and resolving thermal questions using analytic and optimization tools, including Ansys simulation software.



**A temperature profile of a battery module**

Recently, the company used Ansys Fluent and Ansys Twin Builder to investigate design optimization of a battery pack thermal system. Simulation enabled Electronic Cooling Solutions to:

- Develop and validate the best operating setup for user comfort and safety
- Validate the design for aggressive scenarios such as fast driving, cold start and fast charging
- Conduct troubleshooting
- Predict performance decay with age

### MONITORING BATTERY PACKS FOR PREVENTIVE MAINTENANCE

Operating an EV requires an enormous amount of energy, which is why the battery is such an important — and expensive — component. It is not unusual for the battery to represent as much as 50% of the total cost of the EV.

There are two main types of Li-ion battery cells: cylindrical and prismatic. Cylindrical cells are small, typically measuring 2 cm in diameter and 7 cm in height, and there can easily be thousands of them in an average battery pack. Typically, the cells are organized into clusters called modules. Multiple modules form a pack.

Unlike most electronic integrated circuits and microchips in electronic devices, the optimal temperature range for Li-ion battery packs is quite narrow and varies depending upon cell supplier, charge and discharge mode, and other factors. To ensure performance — and to avoid irreversible damage — the average temperature of the cells and the temperature difference among them should be within a target range.

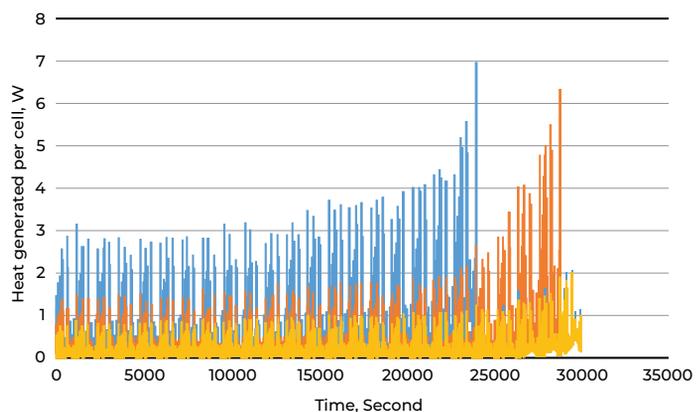
Battery packs are designed with separators to keep electrodes from touching one another and generating heat. Unfortunately, separators can fail for a number of reasons: A side-impact collision can tear them, an electrical shock can pierce or puncture them, and extreme temperatures, either ambient or related to the car's operation, can cause the separator to collapse. If any of these events occur, it can lead to thermal runaway. As a result, the battery begins smoking, catches on fire or even explodes. As for the car, it can be a total loss.

To prevent these problems, Electronic Cooling Solutions characterized a robust, reliable and cost-efficient battery pack temperature monitoring system. Because a Li-ion battery pack is a highly convoluted multiphysics system, the company had to take into account a variety of key factors, such as analyzing in transient fashion:

- Heat generation as a function of the design of the battery pack's busbars, which are used for local high current power distribution, and the speed of electrochemical reactions, which is dependent upon temperature, state of charge (SoC), electric current and electrochemistry properties of the cell
- Heat removal rate as a function of coolant flow rate, design of cooling system and change of coolant physical properties with temperature
- Three-dimensional spread of dissipated heat

A design of experiment (DOE) approach had to incorporate a range of conditions to ensure that all thermal requirements were met: fast charging, cold start, charging at low temperature, discharging when the charge was low and different drive cycles.

Using conventional computational fluid dynamics (CFD) to validate design is not practical because



**This graph shows the typical heat-generation data from an equivalent circuit model of Li-ion cells. Color indicates the impact of operating temperature on the rate of heat generation.**

of the large number of cases that have to be considered. Although it is possible to perform and link 1D and 3D simulations, each method has limitations that could cause design problems. For example, although 1D simulation is fast and allows for multiphysics analysis, it doesn't include 3D visualization of the problem. On the other hand, 3D transient simulation can be computationally expensive, considering the large number of cases.

To overcome those issues, Electronic Cooling Solutions developed a digital twin that provided the accuracy and reliability of 3D simulations and the computational speed of 1D.

**DIGITAL TWIN ENABLES REAL-TIME ANALYSES**

The company used Twin Builder to capture live sensor data and develop a digital twin model of Li-ion battery packs that captured real-time behavior in a real-time environment. This allowed engineers to conduct in-depth root cause analyses on various inputs and operating conditions, including initial SoC, temperature, coolant flow rate, and different charge and discharge profiles.

To generate the digital twin, engineers began by characterizing battery cell performance.

Considering the highly convoluted multiphysics nature of Li-ion battery cells, the thermal load of each battery cell at one instant in time depends on the cell type (manufacturing parameters), SoC, cell temperature, charge/discharge mode, magnitude of electric current extracted from cells and aging. Typically, each cell is represented by a 2RC model (with one resistance and voltage source in series). Engineers also conducted hybrid pulse power characterization (HPPC) tests to characterize and estimate the cell parameters.

Next, they used Twin Builder to create an equivalent circuit model (ECM) of a battery cell that accounted for all electrochemistry behavior, and then applied the model to real-time heat generation. The ECM approach is based on the battery cell's impedance response — that is, its resistance to alternating current — under different external conditions.

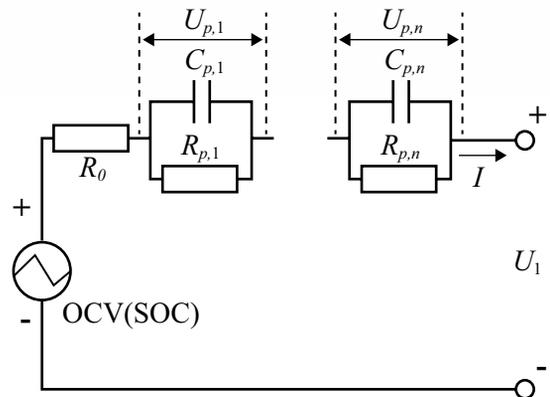
Engineers then performed transient 3D simulation using Fluent to generate response curves at the battery pack level. They fed the response curves into the reduced order model (ROM) application of Fluent to create the ROM of the battery pack. Linking the ROM and ECM of the battery cell in Twin Builder produced a digital twin model of the battery pack. It has the accuracy of the conventional 3D analysis and the speed of 1D system-level analysis.

Electronic Cooling Solutions validated the developed model by comparing results against available test data. They then used the model to evaluate design feasibility under various operations and to optimize and troubleshoot the design.

**THERMAL MANAGEMENT CRITICAL FOR MAINSTREAM ELECTRIC VEHICLES**

Thermal management of Li-ion batteries is a daunting task that can be computationally expensive and time-consuming. But with more than half of the new cars on the road expected to be all-electric by 2040,<sup>1</sup> vehicle reliability and driver safety depend on it.

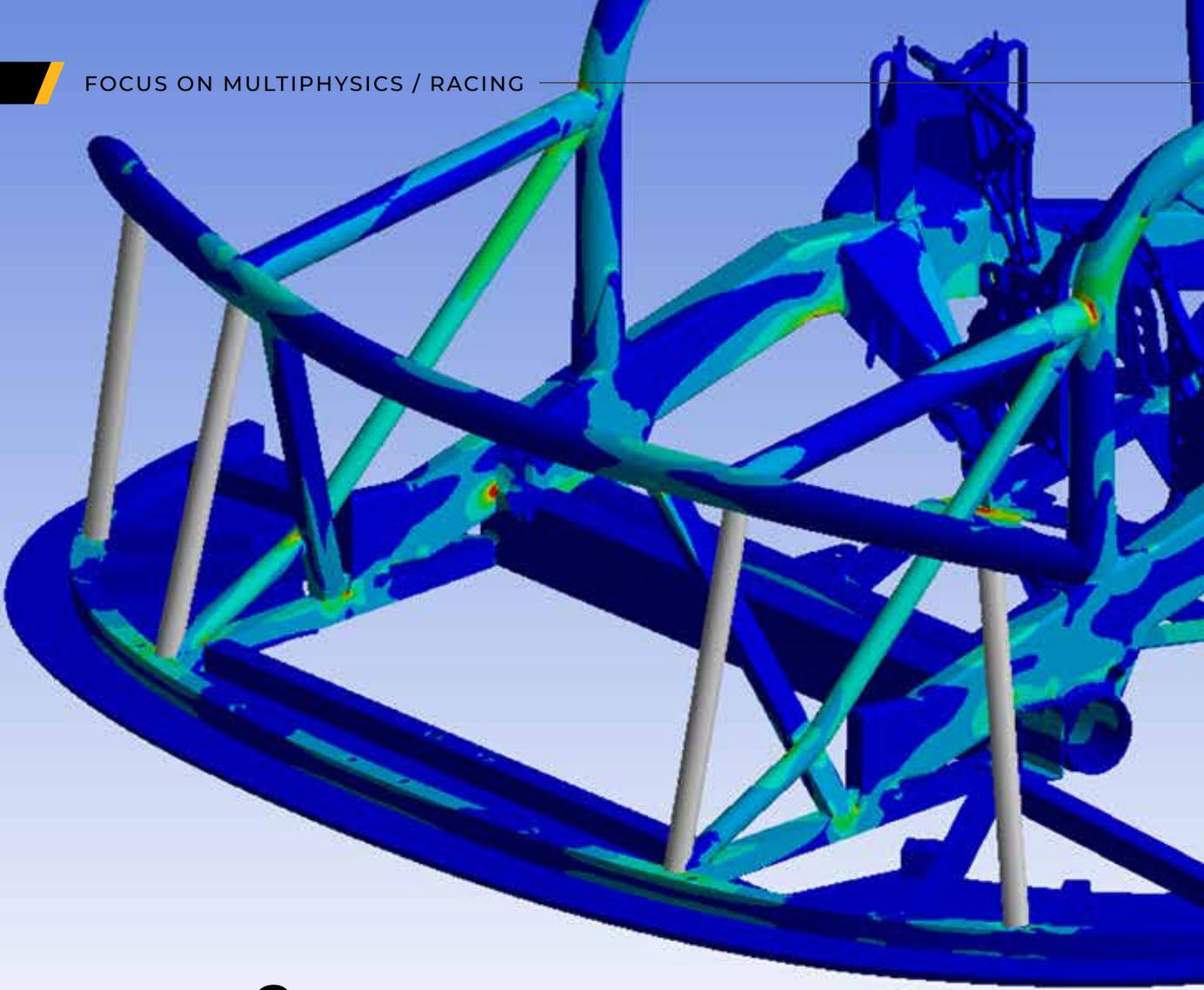
By relying on Ansys results-driven software, Electronic Cooling Solutions was able to consider the critical design elements required for an effective thermal monitoring system and significantly reduce the calculation time from weeks to hours compared to other approaches. This resulted in significant time-to-market reduction. Electronic Cooling Solutions provided their client with recommendations for a high-performance product designed to help bring EVs into the mainstream — and bring the future closer to reality. ▲



**The 2RC model representing the Li-ion battery cells' temporal thermal and electrical performance**

**SOURCE**

1. "By 2040, more than half of new cars will be electric," Bloomberg New Energy Finance via CNN.com, Sept. 6, 2019

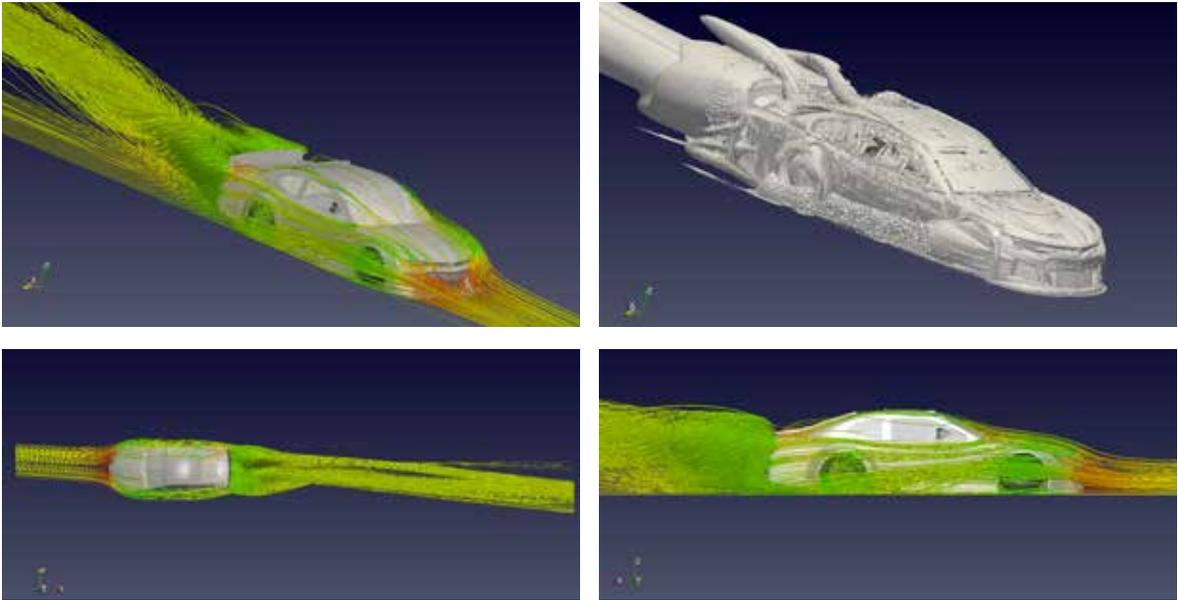


# *Simulate, Compete, Repeat*

By **Eric Warren**  
Chief Technology Officer  
and  
**Eric Kominek**  
Chief Designer  
Richard Childress Racing

From basic aerodynamics to critical decision-making tools, simulation has come a long way with NASCAR teams over the past decade. Before that, teams depended mostly on the experience and hunches of the team

leader to determine what adjustments to make. Now, at Richard Childress Racing (RCR), it's rare for a change to be made to a car without management first asking: "What does the simulation show?"



**RCR engineers respond to new rules and prepare for race day using Ansys simulation software.**

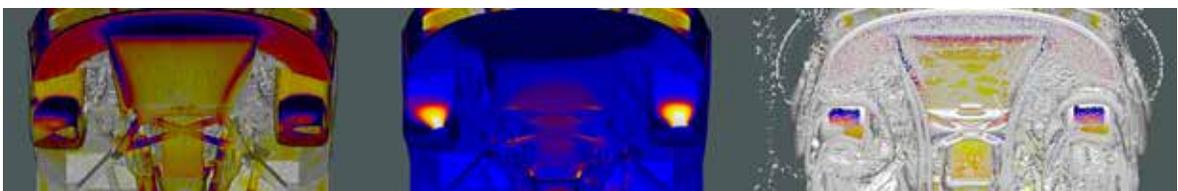
**DATA-DRIVEN DECISIONS**

The modern NASCAR vehicle is one of the most complex engineering systems on wheels. It’s not a “set it and forget it” system, either. NASCAR race cars require significant modifications on a weekly basis. Each Monday during the normal 36-race season (2020 includes some midweek races to make up for weekends lost to the COVID-19 pandemic and shutdown), engineers compile and analyze the results of the previous race, along with driver feedback and tons of race-day data collected from sensors on the car. They then begin tuning the car for the upcoming challenge the following Sunday.

Each racetrack is different — ranging from 2.5-mile super speedways at Daytona and Talladega to half-mile short tracks — with bank angles from 5 to 33 degrees. Track surfaces and weather conditions change weekly. There are more than 15 different tire construction and compound combinations on each side of the car that vary each week from track to track. Teams are tasked with choosing the proper tire camber, steering alignment and operating tire pressures for the predicted racing conditions.

The engineering team must combine all these factors to determine the best setup for their car for that week’s track, all before Sunday. They get some feedback from drivers after practice runs on Friday and qualifying runs on Saturday, but increasingly they depend on simulations to get their car in optimal shape for the race. This is especially true for the races run after the COVID-19 shutdown, where the teams are required to “show up and race” with no practice or qualifying runs and therefore no time on the track to check to make sure the car is handling correctly.

Engineers at RCR adopted Ansys Fluent computational fluid dynamics (CFD) software and Ansys Mechanical about five years ago to make their Chevrolet Camaro race cars more aerodynamic. In today’s world of professional racing, that requires the ability to create aerodynamic shapes and lightweight structural components, design flexibility into those shapes and structures so they deform under loads and temperatures, and optimize overall lap-time performance while maintaining the high strength needed. More recently, RCR engineers have added Ansys’ adjoint solver, which enables



**RCR uses Ansys Fluent to understand the complex airflow underneath the race car.**

multi-objective shape optimization and topology optimization. RCR engineers are also using high-performance computing (HPC) to handle the high-resolution simulations (with mesh counts reaching 500 million per car) they run each week.

### MEETING THE DEMANDS OF RULES CHANGES

As if the variables involved in racing cars 200 mph on different tracks each week were not enough, NASCAR officials issue a rule package every year that details the design parameters each racing team must meet to be eligible to race. In October 2018, a dramatically different rules package for the 2019 NASCAR Cup Series season was released, instructing the teams to reduce engine horsepower from 750 hp to 550 hp for all tracks over 1 mile in length. The dimensions of the spoiler at the rear of the car were increased from 2.75 inches tall to 8 inches by 61 inches to add drag. The new rules also called for the addition of a tapered spacer in front to reduce air flow to the engine, thereby controlling its combustion efficiency and setting its maximum power.

Why would a racing organization want to slow cars down? Two main reasons emerged. First, speeds were getting dangerously fast along the straightaways, resulting in cars weighing almost 3,500 pounds entering the corners at 218 mph. The momentum, equal to the mass times the velocity, was placing extreme stress on the braking and suspension systems, leading to potentially dangerous situations. Second, it seemed that the results of races were more in the hands of the engineers than the drivers. The team with the most money could fine-tune the downforce on the car to go faster. As NASCAR Executive Vice President and Chief Racing Development Officer Steve O'Donnell explained on NASCAR.com in October 2018: "For us, it's really a focus on getting back to a true focus on the drivers and what NASCAR is all about — close side-by-side racing and trying to deliver more of that."

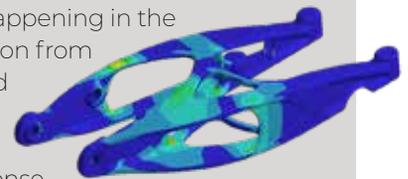
### BALANCING DRAG AND DOWNFORCE

The new rules greatly increased the importance of drag in the aerodynamic equation for stock car racing. Prior to 2019 at most NASCAR tracks, the primary consideration from an aerodynamics point of view was how much downforce you could produce, because air pushing the car down onto the track harder results in more lateral grip produced by the tires, which makes the car go faster. Drag was only a major factor at the Daytona and Talladega super speedways, where the long straightaways and high banking made low drag a key to reaching top speeds.

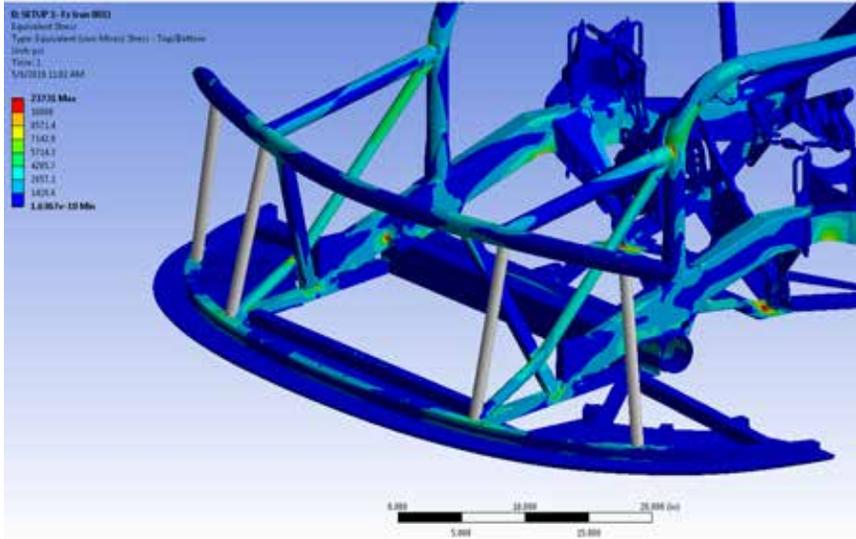
## SOLVING AN UNEXPECTED CONSEQUENCE OF THE NEW RULES

Just when a race car engineer thinks he's seen everything and has met all compliance requirements, a new problem appears. The gear shifter bracket in NASCAR vehicles can be tailored for a driver's needs, and in 2019 one RCR driver had a longer bracket than the others. For some reason, this bracket was lasting for only two or three races before cracks appeared and it had to be replaced. Data showed that the load on the shifter was not even close to that needed to crack the part; besides, the cracking was happening in the opposite direction from the load applied by the driver.

Using modal harmonic response analysis tools in Ansys Mechanical, RCR engineers found an unexpected vibration at a certain frequency that was causing the cracking. This vibration resulted from the 2019 rules changes — the lower horsepower engine was running at a higher rpm for a longer time, which caused vibration in the bracket. Once they knew the cause, the engineers used Ansys topology optimization to develop a very different looking "organic" shifter bracket that lasted for the rest of the season without cracking.



**When cracks appeared in a gear shifter bracket, RCR engineers used Ansys Mechanical to find the cause and then designed an optimized bracket (shown above).**



**RCR engineers took aerodynamic pressure into account when simulating a new splitter bar in Ansys Mechanical.**

In 2019, racing teams now had to look at trade-offs between drag and downforce. A decade ago, that would have involved transporting the car to a wind tunnel and spending \$3,500 per hour just to rent the wind tunnel, independent of the costs of test parts and personnel required to run the tests. Typical wind tunnel tests measure downforce and drag, but CFD simulations yield more data while also enabling engineers to envision the whole flow field, all at a much lower cost.

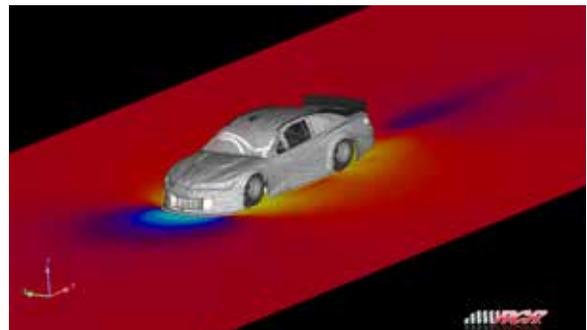
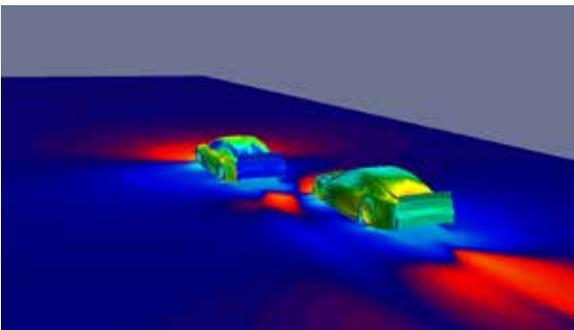
Naturally, engineers initially focused their simulations on improving their own cars to comply with the rules, but it soon became apparent that this was not enough. Race cars in tight packs affect each other's drag and downforce, so they started using CFD to study two-car aerodynamic interactions.

RCR engineers began using Ansys Fluent to run high-resolution simulations of their car positioned in many different locations around another car to create an aero map. The map revealed which relative positions gave them

an advantage or put them at an aerodynamic disadvantage in relation to another car. RCR drivers then used this information to position themselves advantageously when driving in a tight bunch of cars. With a knowledge of the CFD results, a driver knows where he needs to be to "side draft" and slow another car down just by positioning his car correctly.

**RUNNING RACE WEEK  
MULTIPHYSICS SIMULATIONS**

RCR engineers normally start configuring a car for a race about three or four weeks beforehand. Drivers practice their skills on simulators to get a feel for how the car will perform ahead of time on a high-resolution model of a given racetrack, accurate to 2 cm. As soon as the car is unloaded at the track, everyone is instantly trying to determine how close the simulations are to reality and deciding how they need to react to any discrepancies. They might make changes to the tire pressure, camber, springs, brakes or other components.



**Multiple- and single-car interactions are simulated to prepare for different race scenarios.**

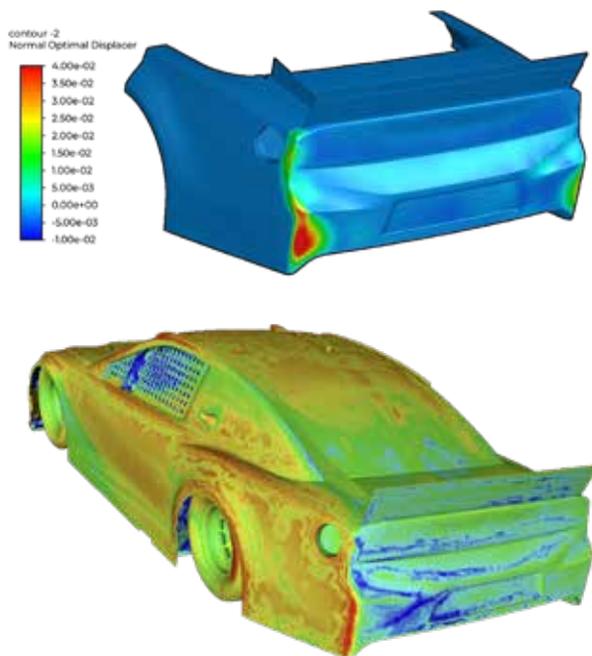
Depending on the track, higher downforce on the front or rear of the vehicle might improve its performance, especially in the turns. RCR engineers use multiphysics simulations, based on Fluent and Ansys Mechanical, to adjust the overall balance of the car. For instance, by simulating the aerodynamic and mechanical loads on the chassis and making physical changes to the car based on them, they can cause the chassis and the front part of the car to bend as much as several inches as it goes into a corner to keep the front of the car down. Similar changes could be made to the rear of the car if conditions called for it.

For these simulations, RCR engineers export the surface plot of the pressure on the splitter (effectively a flat underwing in the front of the car below the radiator) or the spoiler in back from the CFD simulations and import them into Mechanical for structural analysis of these surfaces and the body supports. It's critical to keep the splitter close to the track while preventing contact with the ground, because contact stalls the air in front of the car. So, they map the pressure onto the surface of the splitter in Mechanical and then use finite element analysis (FEA) simulations to make sure it is stiff enough to handle that pressure while allowing the suspension loads to move in the right direction. Similarly, they perform CFD simulations to get the pressure loads on the rear of the car and then run FEA simulations to ensure that the rear body mounting stiffness is optimized to handle the downforce.

Simulations continue throughout the race weekend. When they were performed using onsite computer clusters, engineers had access to 100 processors and required a lot of equipment and IT staff to run a single CFD simulation in three to four days. Ansys HPC in the cloud has given the engineers more scalability: If RCR engineers need to solve a problem in hours instead of days, they can use HPC to easily scale up to 50,000 cores and finish the simulation quickly.

### REAL-TIME DATA ANALYTICS

During the race, every team receives data five times per second (5 Hz) including the GPS line and lateral and longitudinal acceleration data, among other information. They receive this data not only for their own car but also for every competitor's car by mutual agreement. Previously, each team was spending lots of money independently capturing the radio transmissions of their competitors to get this data, so they all got together and decided to share it freely to save money.



**By using advanced adjoint solution techniques, Ansys Fluent can both identify sensitive geometry changes and actually morph the surface into an optimized shape.**

Having all this data on hand has led racing teams to use data analytics, digital twins and artificial intelligence tools on race day to gain an advantage. They can now take real-time data coming from a car and create actionable data on the spot. Teams are looking at the other guys' steering, brake and throttle data to see where they need to improve their own car's performance.

During the race, machine learning and cloud computing is taking place as AI becomes incorporated into racing. For example, RCR has strategy optimization software that predicts the right call for when to pit based on how fast the tires are wearing and how the weather is changing, among other factors. Simulations like these using data from their own car and the rest of the field help RCR engineers take advantage of their strengths and opponents' weaknesses.

So, although the 2018–2019 rules changes did bring the drivers' skills and daring back into the equation, making for a more exciting race for the fans, the engineers are busier than ever as those rules continue in the 2020 season. CFD, FEA and multiphysics simulations, topology optimization, HPC, machine learning and AI are all part of the package. Simulation is leading the way to the checkered flag. 🏁



# Custom Fitting a Solution for Custom-Fit Kitchen Appliances

High-end kitchen designs camouflage appliances within their luxurious facades, restricting air flow and trapping dust and dirt. Coupled CFD-DEM is being used to investigate dirt accumulation.

By **Anderson Bortoletto**  
Principal Engineer  
Advanced Product Group  
Sub-Zero Group Inc.  
Madison, U.S.A.

**B**uilt-in appliances fill today's high-end kitchens, in which seamless integration with cabinetry can pose technical challenges related to airflow restriction in a machine's compartment. This problem is exacerbated by dirt accumulation on the condenser (heat exchanger), which can affect appliance performance.

Experimental evaluation of dirt accumulation on condensers is time-consuming and expensive. Consequently, Sub-Zero is coupling computational fluid dynamics (CFD) and discrete element modeling (DEM) to quickly gain insight on the mechanisms behind dirt accumulation in an effort to design a more robust heat exchanger.

Sub-Zero, which began producing commercial freezer units three-quarters of a century ago, has re-imagined residential refrigeration with units built to last 20-plus years. Where the family kitchen once held a big, bulky appliance, today's luxury home sports smaller, custom-fit modules that locate refrigeration where it makes the most sense — with options from freezers to ice makers to wine/beverage centers.

From an engineering standpoint, camouflaged refrigerators wrapped in cabinetry that hinders air flow is an ill-fated scenario for a component meant to remove heat. Add fiber (pet hair, lint, etc.), dust and grease accumulation at inaccessible sites, and you've created an ideal recipe for failure.

### FOULANT AS A RECIPE

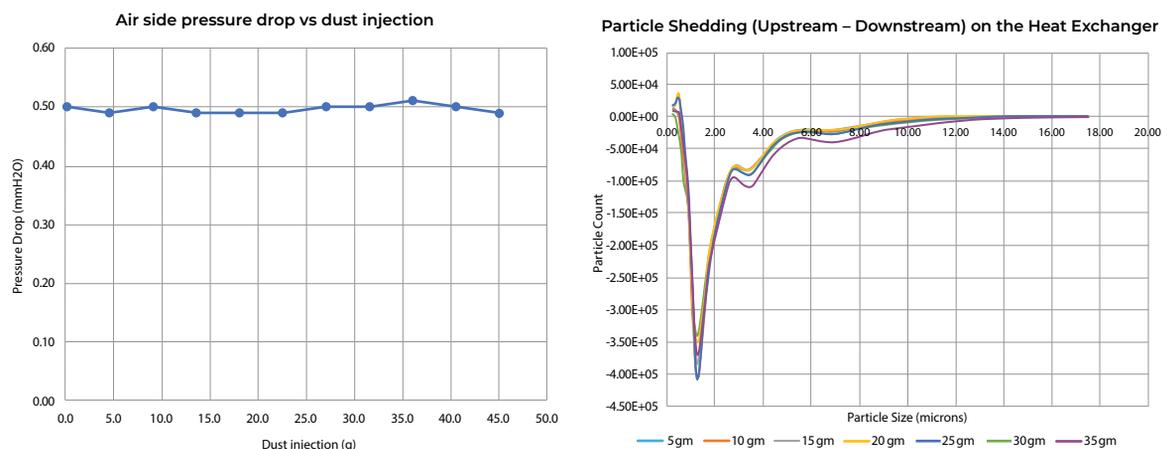
One of the first steps in Sub-Zero's heat exchanger investigation was figuring out how to define and represent relevant airborne materials, collectively referred to as foulant. At the time, the research team had been using CFD to model simple spherical dust specks within an air stream, but needed to include non-spherical dirt particles, high-aspect-ratio hair, and flexible fibers like cotton. These require DEM software, which offers accurate particle physics to predict behavior in a reasonable solve time.

The company's engineers chose Rocky DEM for its ability to accurately model the foulant recipe, speed up computations using multiple graphics processing units (GPUs), and seamlessly integrate with the company's Ansys multiphysics simulation portfolio. The team initially used Ansys CFD to model the heat exchanger's fluid flow, which affects overall efficiency. DEM would yield information on particle deposition, fluid forces acting on particles, such as drag, and adhesion forces, ultimately assessing how the heat exchanger design affects particle behavior.

### ONE-WAY STREET?

Originally, the team theorized that the simulation project would require a two-way coupled CFD-DEM approach, with Ansys Workbench as the main platform. In theory, dirt accumulation over time would affect airflow around the heat exchanger, causing foulant to build up even further and eventually affecting efficiency. If the change in efficiency was large, performing a two-way analysis would enable modeling the effect of the foulant on fluid flow and the effect

**Compared to bench-top component-level testing, overall foulant simulation can produce savings of up to 10% of total development costs — along with reduced time to market.**



**Figure 1. Experimental results proved that one-way coupling would be sufficient for accurate simulation results, simplifying the analysis. Left: air-side pressure drop following dust injection; right: particle shedding over time**

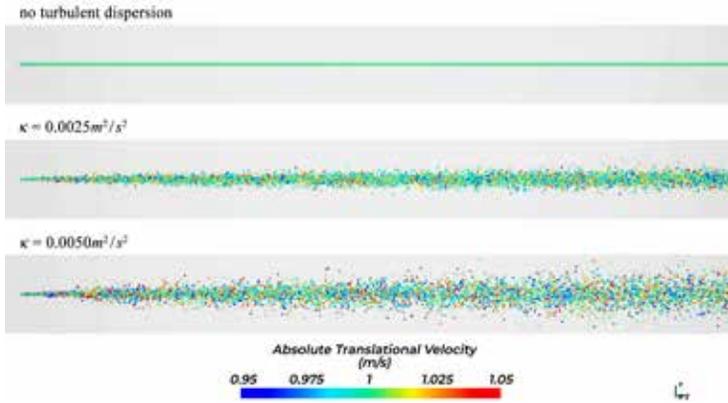
of fluid flow on foulant deposition. However, in this case, the effect of the foulant on fluid flow was small enough to be considered negligible, as physical experiments showed.

A physical wind-tunnel experiment tested air-side pressure drop across a heat exchange sample as particles (dust + 5% cotton-linter fibers) were injected (figure 1). The test also studied the component's ability to transfer heat during foulant accumulation and subsequent particle shedding. Results revealed minimal

changes in pressure drop and heat transfer. As to particle deposition, once deposition reaches a specific value, airflow is sufficient to shed particles, stopping further accumulation.

Though experiments are cumbersome and expensive, they sometimes provide insight that can help to simplify a modeling approach, as testing did in this case. In a different situation, a greasy or oily heat exchanger might exhibit greater particle adhesion, requiring two-way

coupling, thereby lengthening and complicating the analysis process. Bench testing provided the confidence needed to proceed with one-way CFD-DEM simulation.



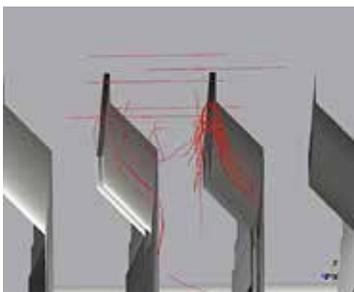
**Figure 2. Particle movement is smooth and uninterrupted when there is nothing to interrupt air flow (top). Running turbulent dispersion in the Fluent-Rocky simulation ensures naturally occurring vortexes and eddies, which randomly arise and ebb.**

### PHYSICS FOOD FOR THOUGHT

The engineering team leveraged the capabilities of a coupled Ansys Fluent-Rocky DEM solution to predict adhesion forces on high-aspect-ratio cotton-linter fibers, modeling electrostatic forces using Rocky's adhesion model. The Coulomb force — exerted by stationary objects bearing electric charge on other stationary objects bearing electric charge — is turned on when particles move closer than the adhesive distance. The force was set up to apply to particle-boundary, particle-particle, fiber-fiber and fiber-dust contact.

Because airflow within the heat exchanger is nonuniform and particles are small, it was critical to instruct Fluent to run turbulent dispersion, duplicating real element behavior in the Rocky model (figure 2). Without it, simulation results produce an average flow field for every time step instead of naturally occurring turbulence. In reality, an area that blocks circulation (the wake of a tube, for example) produces near-zero recirculation velocity; though most particles are drawn to a higher-velocity region, specks that flow to this zone will accumulate. Therefore, fluctuating velocity — discrete piece-wise constant functions of time, computed according to the local turbulence field (turbulent kinetic energy and dissipation) — is added to the average fluid velocity:  $\mathbf{u}f - \bar{\mathbf{u}}f + \hat{\mathbf{u}}f$  in which total velocity ( $\mathbf{u}f$ ) equals the average velocity from Fluent's flow field ( $\bar{\mathbf{u}}f$ ) plus fluctuating velocity ( $\hat{\mathbf{u}}f$ ), which captures drag force that affects very tiny particles in the wake of edges.

Rocky has built-in capabilities to realistically model fibrous materials. The software utilizes a sphero-cylinder element joined by virtual bonds. Users can adjust flexibility by controlling the Young's Modulus (YM) ratio (figure 3), producing linear and angular bond deformation as well as forces and moments on adjacent elements to resist normal, tangential, bending and torsional deformations. Unfortunately, there is negligible literature



**Figure 3. Rocky simulation of fibers falling, noodle-like, and catching on the heat exchanger fin's leading edge. Adjusting the Young's Modulus ratio produced a range of bending options, from exceptionally flexible to rigid.**

on pet or human hair flexibility parameters, so experiments were conducted to calibrate the exact Young's Modulus ratio.

A CFD hexahedral mesh contained 7.02 million flow-aligned cells, a smaller number of elements than tetrahedral meshing would require yet fine enough to capture a viscous sublayer. It incorporated  $Y^+$  for the SST turbulence  $k-\omega$  model. The Fluent model was simulated in a transient run using air as a compressible fluid phase. Average velocity and pressure fields were exported to Rocky for one-way coupled simulation (figure 4).

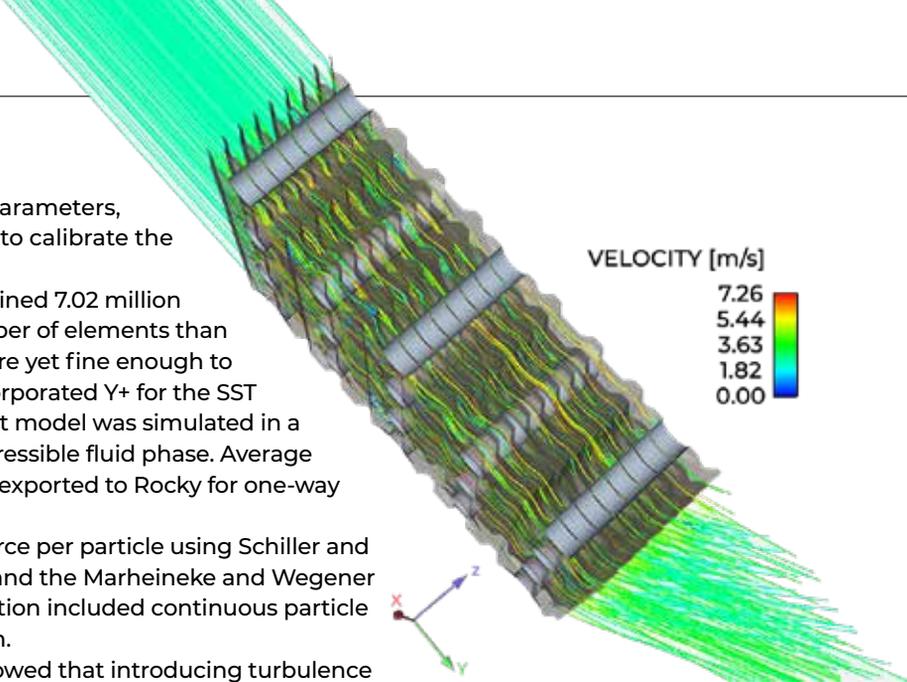
Rocky DEM computed drag force per particle using Schiller and Naumann drag laws for spheres and the Marheineke and Wegener drag model for fibers. The simulation included continuous particle injection with random orientation.

Coupled simulation results showed that introducing turbulence dispersion to the computation increases the number of collisions between particles and walls — and intensifies dust and fiber accumulation. Adhesion force played a major role as well: The higher the adhesion force, the more mass that is deposited.

Sub-Zero's future efforts include validating these simulation results with wind-tunnel testing. The process will form the framework for modeling particle accumulation on proposed heat exchanger concepts. It is critical that the Sub-Zero team gains insight about foulant movement and deposition to enable kitchen designers to exercise full creativity. For example, a component with large leading edges (like current heat exchangers) holds more surface area that can catch dirt. A heat exchanger located at the bottom of the refrigerator captures larger dust particles due to gravitational effects.

How does an R&D team develop a better refrigerator design, one that is robust to dirt accumulation, based on particle flow discoveries?

Ansys Fluent and Rocky DEM can greatly assist Sub-Zero in this effort. This real physics technology provides amazing insight without the cost of excessive physical experiments. Compared to bench-top component-level testing, overall foulant simulation (once the framework is set in place) can produce savings of up to 10% of total development costs — along with reduced time to market, since results are available in a week, compared to months. The greatest savings will be seen on long-term testing programs that deploy prototypes in the field. **▲**



**Figure 4. Ansys Fluent velocity simulation results**



**Particulate Modeling with Rocky DEM webinar**  
[ansys.com/DEM](https://ansys.com/DEM)



**A macro view of the non-spherical dirt particles and fibers that foul condensers**

# Simulation-Driven Design Makes Waves

By Ansys Advantage Staff

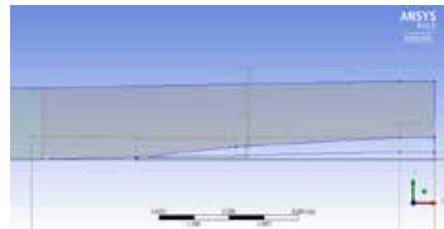
**Jakob Bergmeier surfing at the UNIT surf pool in September 2018**

([www.surf-pool.com](http://www.surf-pool.com), photo credit: Paul Schöpplenberg)

**M**unich, Germany, may be best known as the world's beer capital, but the landlocked city is also famous for another form of liquid refreshment: river surfing. The wet and often wild sport was invented in the Floßlände channel in Munich in the 1970s, and grew in popularity when a wave formed, somewhat by accident, on the Eisbach River as it flowed through the English Garden.

To calm the rushing river's current as it flowed through that tranquil park in central Munich, engineers placed concrete blocks into the water. The blocks had the unintended consequence of creating a fast, shallow, surfable wave. Surf fans began amplifying the wave's force by tethering planks along the sides to narrow the channel. The result was Eisbachwelle, now Germany's premier river surf destination.

Unlike surfing on dynamic coastal waves, river surfing is done on standing waves, tidal bores or upstream waves. And while that might give the impression that river surfing is a tame facsimile of the ocean experience, the fact is that Eisbachwelle can be a bumpy ride, suitable for seasoned surfers only. Beginners can fine-tune their skills on the stationary wave at Floßlände, which is smoother and safer than the Eisbachwelle. Taking the entire concept of stationary waves into a new dimension is Surf Langenfeld, where surfers of all levels can catch waves on the world's first standing deep-water wave on a lake. It was built by UNIT Parktech A.G., in 2017.



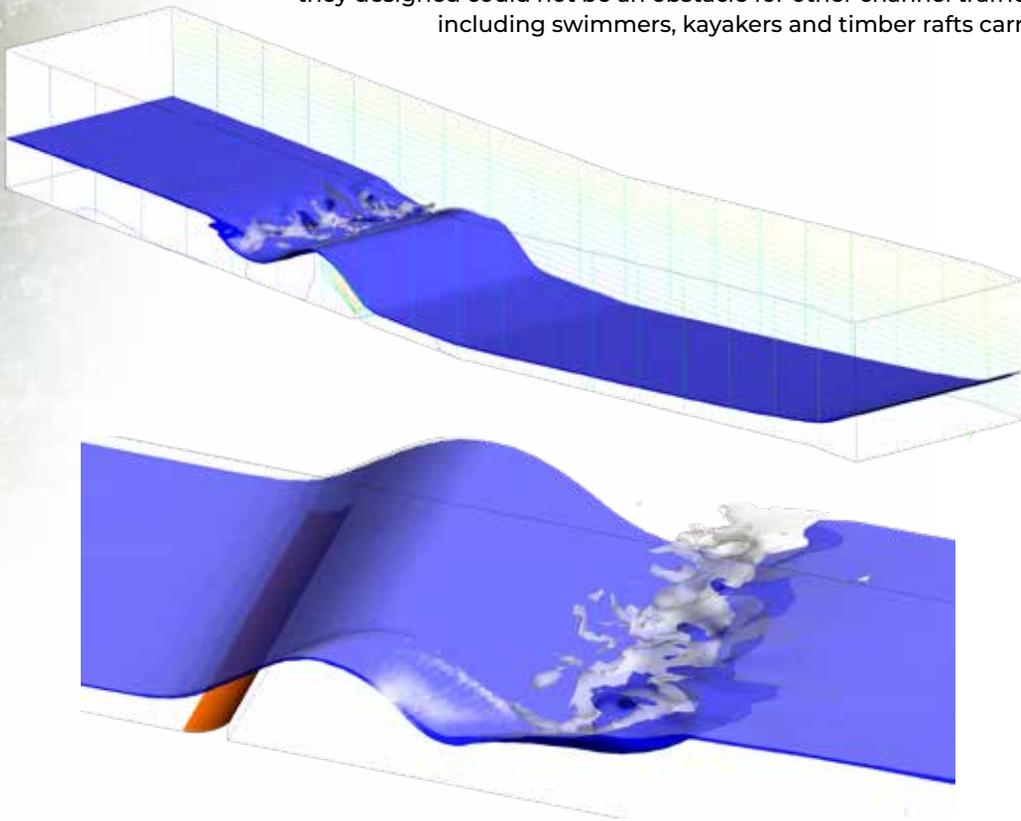
**The geometry of the channel and wave generation device is fully parameterized. Structured meshes and computational fluid dynamics setups are automatically generated.**

Dr. Robert Meier-Staude, a professor of mechanical and process engineering at the University of Munich, and his team used Ansys Workbench and Ansys CFX to revitalize Floßblände in 2014. In 2017, they enlisted the same simulation software to produce the world's most powerful artificial wave at Surf Langenfeld in the Rhineland. Both were completely simulation-driven designs that resulted in the production of polyurethane lamella devices — a solution that has worked well under considerably different conditions at both Floßblände and Surf Langenfeld.

### AN OLD WAVE BECOMES CURRENT AGAIN

The gentler of Munich's stationary river waves, Floßblände was a popular tourist destination for new and less experienced surfers for more than 40 years — until 2014, when local authorities reduced the amount of water flowing into it and nearby construction projects made conditions even worse. At that point, the wave became unsurfable.

River surfers themselves, the team led by Meier-Staude was determined to figure out what contributed to the sensitivity of flow conditions and then to develop a device that would produce a surfable wave using less water. To further complicate the project, whatever they designed could not be an obstacle for other channel traffic, including swimmers, kayakers and timber rafts carrying

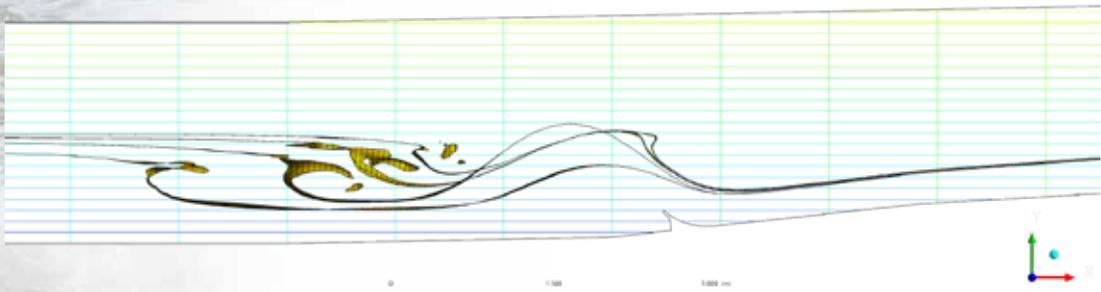


**The left side of the top 3D transient calculation of the wave shows the symmetry plane with contour lines of the “yimpuls.” The right marks the channel wall. From the calculation, we should expect a perfect “green face” of the wave. The bottom detail view (flow from left to right) from the wall side of the channel assists in studying how the sidewall affects the wave.**

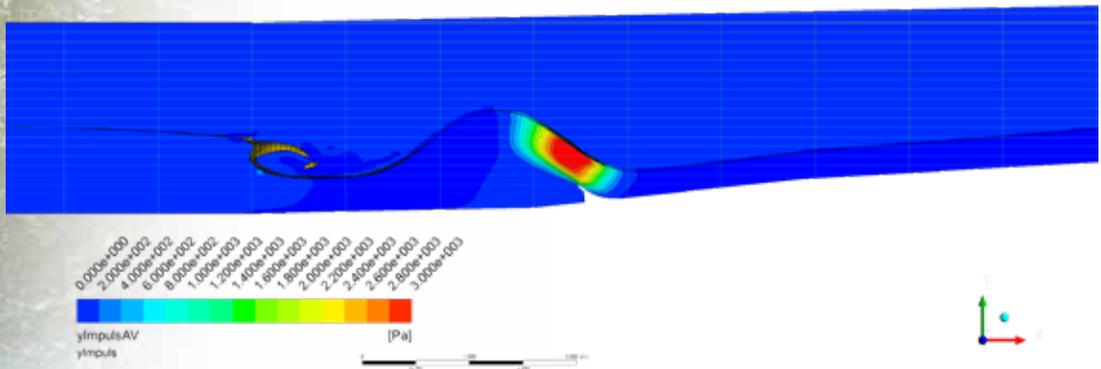
tourists. The solution relied on a fully parameterized virtual prototype without real-world testing or physical prototyping.

The first step was establishing the criteria for a “good wave,” which included defining the control and pressure inputs. Because the greater the pressure, the more exciting the ride would be, the team concluded that for the wave to be surfable, vertical pressure had to be at least 3,000 pascals (Pa), which compares to a 3-foot ocean wave traveling at a speed of 5 meters per second.

To design this powerful wave using a minimum amount of water, Meier-Staude and his team turned to Ansys CFD. By enabling qualitative and quantitative parameter studies, Ansys CFD was key to understanding the mechanisms that would form the wave and to calculating



**Parameter studies of the wave surface as a function of the downstream height of the water; the wave the surfer loves most is the wave just before it breaks.**



**Vertical dynamic pressure of the flow “yImpuls” for an optimized device: Maximum wave height and wave power are achieved with a minimum amount of water and minimal device height. The red area meets the design criteria (the sweet spot for the surfer) with an yImpuls of yImpuls > 3,000 Pa. This area should be surfable for surfers weighing 80 kg (176 pounds) or more.**

the fluid forces on the wave-forming device, an apparatus that had to be strong enough to withstand the waves but pliable enough to not endanger other channel users.

To start, the team produced 2D simulations of flow conditions based on various amounts of water moving into the channel. By testing various upstream and downstream water heights, they determined the optimal difference needed between the two to create enough energy to produce the wave.

Ansys software provided both the fine mesh resolution and the crucial boundary layer resolution required to simulate the wave. 3D calculations offered insight into the effect of sidewalls. Because the results were nearly the same whether they used steady-state or transient simulations, the team finalized the virtual prototype with steady-state simulations, which reduced calculation time and compute power requirements.

In 2015, the city of Munich agreed to test the team’s wave generation device, installing a series of 27 thin sheets of polypropylene (PP) — referred to as lamellas — on a succession of curved wood pieces. The lamellas have sufficient elasticity that the wave remains stable for surfers but channel traffic can push them to the ground and out of the way.

The reinvigorated wave at Floßblände can be surfed with a 5-foot, 3-inch shortboard. It has been working exactly as designed for more than five years.

### THE WORLD’S MOST POWERFUL MAN-MADE WAVE

Thanks to the success at Floßblände, in 2016 UNIT Parktech, a German company specializing in the construction and design of wakepark features, asked Meier-Staude to develop a surfable wave in a lake at a water-skiing facility. The first-of-its-kind request was unusual enough, but on top of that, the company wanted Langenfeld to have the most powerful stationary wave anywhere.

To achieve the ambitious goal, Meier-Staude and master's candidate Jakob Bergmeier once again turned to simulation-driven design. Leveraging the lessons from Floßblände, they developed a prototype surf pool from fully parameterized geometries. Considerations were similar to the earlier project, including flow angles, water volume and water height, both upstream and downstream. But this time, they also had to model a vertical lift system — a pump delivering as much as 10,000 pascals of force — that would generate and preserve the integrity of a wave over a steep ridge in an area 20 m wide and 50 m long. In addition, the surf pool had to be energy-efficient.

Bergmeier and Meier-Staude began by designing 2D and 3D flow, then used Ansys CFD to simulate operation, optimization, and starting and stopping the wave. The design incorporated the same kind of energy-efficient pumps used in water treatment plants. The pumps raise the lake water about 1.2 meters above surface level in the contained area of the surf pool; gravity drives the water quickly over an HDPE lamella covering a ramp, and the hydraulic jump phenomenon generates a deep-water wave in standing water — a 4-foot wave for beginners and a 5-foot, 3-inch wave for advanced surfers.

### CONCEPT TO COMPLETION IN MONTHS

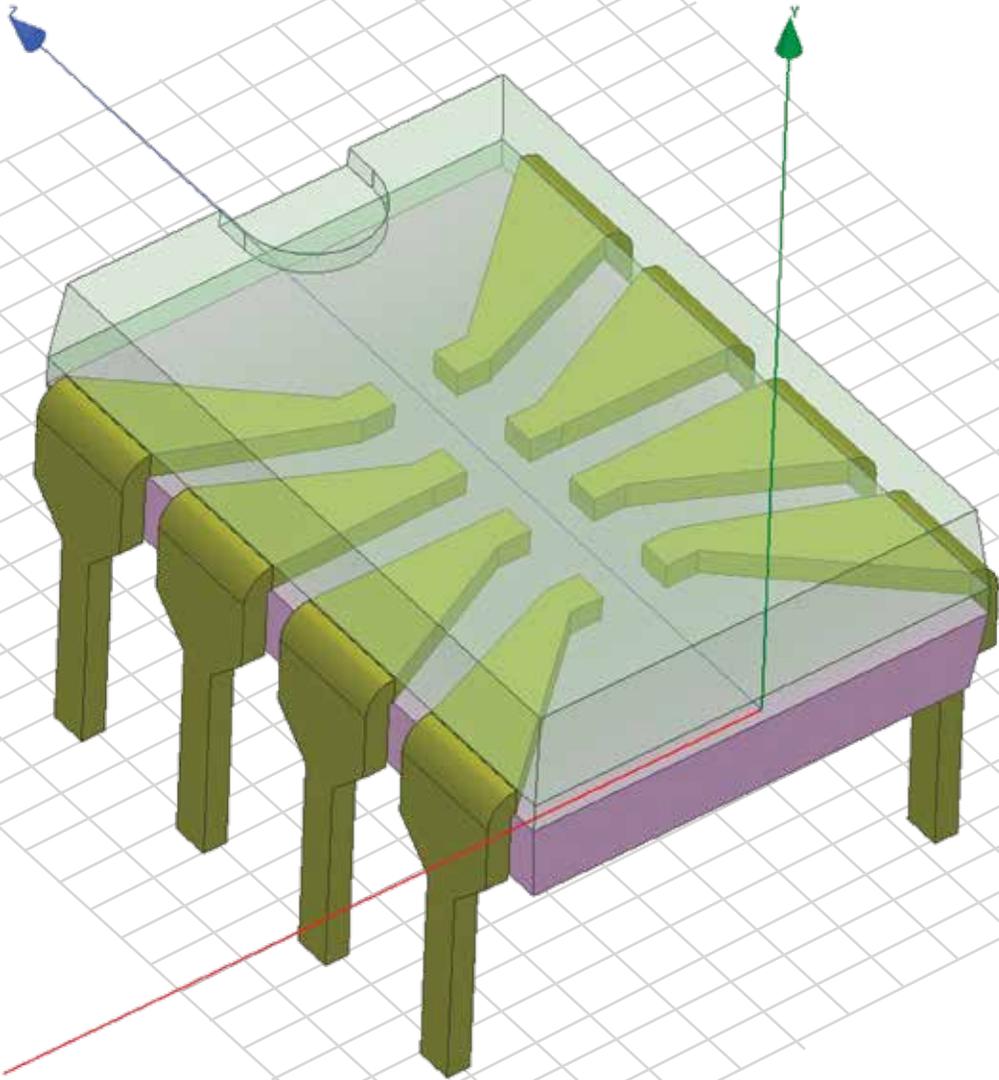
Simulation for the design of the Langenfeld surf pool took about four months; building it took just a few more. In less than a year, the most powerful artificial wave in a lake was ready for surfing. Since then, UNIT Parktech has fine-tuned their technology and installed an even larger surf pool in Milan, Italy.

Compared to the traditional iterative method of beginning with a model, simulating it and then going back to refine the model, using Ansys software for simulation-led design considerably shortened the time from concept to completion. But more than that, without virtual prototyping, neither project would have been possible.

In essence, simulation really made waves, overcoming water flow conditions and enabling surfing where it was never before possible. ▲



**Hannes Herrmann, the first surfer on the New-Thalkirchen wave on July 1, 2015**  
*(photo credit: Philipp Altenhöfer)*



# Think Outside the Package

By **Christina DiMarino**  
Ph.D., Assistant Professor  
Virginia Polytechnic Institute  
and State University  
Blacksburg, U.S.A.

**A**t Virginia Tech, big things come in small packages. In this case, an exploration of the multiphysics of tiny electronics packages, facilitated by Ansys Q3D Extractor and Ansys Icepak, provides big insights into the ways that electrical engineering, mechanical engineering and materials sciences are all interconnected when it comes to delivering improvements in the power electronics realm.

Google the phrase “electronics packaging” and you’ll see hundreds of cardboard boxes. Some of them are very attractive, but attractive cardboard boxes are not what we’re exploring in Virginia Tech’s ECE 4984/5984: Electronics Packaging course. The electronics packaging that interests us has to do with the physical forms housing semiconductor devices such as integrated circuits or power semiconductor devices like transistors or diodes. They’re tiny little things, some less than 1 mm<sup>2</sup> in size, but they present

# What students can learn from Q3D Extractor in just 10 minutes — for that's all it takes, even on their personal computers, to perform a TO electromagnetic field simulation — is eye-opening for them.

multiphysics challenges that are big enough to give our graduate and undergraduate engineering students a perspective on the interplay of engineering disciplines that few other classes provide.

In the past, my students would have had to perform quite a few calculations to gain even a fraction of this perspective, but today they gain much greater insight through use of Ansys Q3D Extractor and Ansys Icepak.

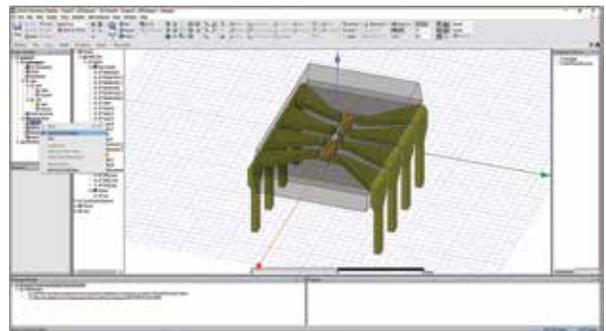
## A WORLD OF INTERACTIONS IN A GRAIN OF PLASTIC

Why would anyone want to spend a term looking at electronics packaging? The short answer is that the packaging itself has a significant impact on the performance of the components embedded within it. Packages are far more than semiconductors and integrated circuits enclosed in some plastic black box with a number of tiny metallic feet. They embody the evolution of fabrication techniques, materials, and multiphysics challenges that arise from an onward march toward ever smaller designs.

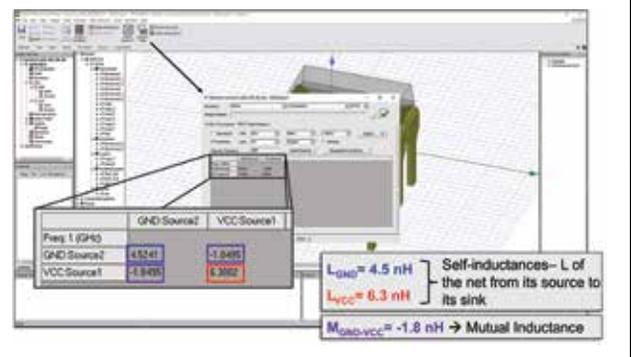
Fundamentally, a package provides four things for the electronics embedded within:

1. Protection from environmental variables, such as humidity, heat, chemicals and corrosion
2. Interconnection of electrical signals
3. Power distribution to the electronic devices and circuits
4. Thermal management, ensuring that heat is dissipated away from the semiconductor devices within the package so that they can operate reliably and efficiently throughout the lifetime of the device

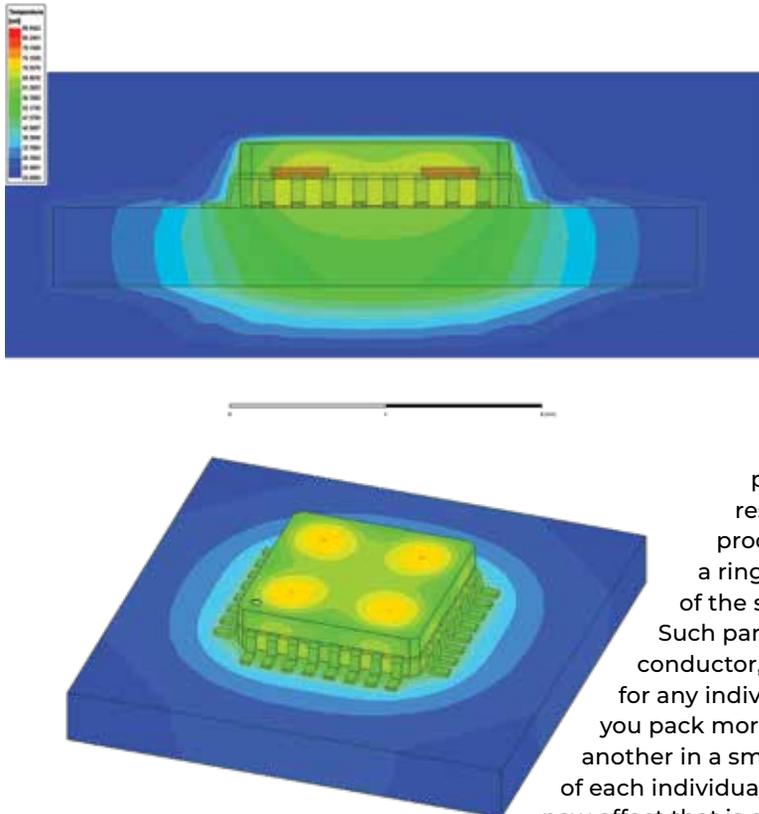
Over time, as these chips have grown more efficient, manufacturers have discovered that they can shrink the size of the chip without increasing the heat produced by the components themselves. As a result, the chips end up creating the same amount of heat, but it is concentrated in a smaller area, increasing the heat flux. From an engineering design perspective, this creates a real multiphysics challenge: How can you optimize the design of the package to enable optimal performance of the components within while optimizing the dissipation of heat? The answers are bound up in a complex interplay of electrical engineering (EE), mechanical engineering (ME) and materials science (MS) — and what might appear to be the best answer from an EE perspective may not necessarily appear to be the best answer from an ME or MS



Virginia Tech students use Ansys Electronics Desktop to load a transistor outline package into Q3D Extractor.



VA Tech students use Ansys Q3D Extractor to verify their calculations to determine DC resistance and DC inductance of various paths and components in the package.



**VA Tech students use Ansys Icepak to create temperature plots of the quad flat package (QFP) with four smaller die and mold material for the package.**

perspective. Nor might any of these individual answers be the best answer when considered in light of the usage scenario for which the package is intended. Moreover, heat flux is only one of the challenges that engineers face as the forms get smaller. Another arises from the proximity of the elements within the package. Every real-world element (as opposed to a theoretically perfect element) has what are known as parasitic qualities — a

parasitic inductance or a parasitic resistance, for example — that produce unintended effects, such as a ringing that can affect the switching of the semiconductor device itself.

Such parasitic qualities are inherent in a conductor, and they can be readily calculated for any individual component. However, when you pack more and more conductors next to one another in a smaller form, the parasitic qualities of each individual element interact to create a new effect that is different from — and not just the sum of — the individual parasitic effects. Sometimes the compounded effects are beneficial; other times they are detrimental. How do you know which it will be? You test. You analyze. You refine.

#### **GAINING INSIGHTS WITH ANSYS**

Simulation software from Ansys is key to helping students in ECE 4984/5984 gain insights that can help them understand all these dynamics and, in turn, help them learn how to approach the multiphysics challenges inherent in electronics packaging. In one assignment, teams of students analyze the electrical and thermal performance of a transistor outline (TO) package, which is a standard package for power electronics. The first part of the project requires them to perform a series of calculations to determine DC resistance and DC inductance of various paths and components in the package. They're asked to identify which path has the largest resistance and which loop has the largest inductance — and then to explain their answers, based on their calculations. Then they're asked to identify which component contributes most resistance to the gate path and the drain path, which component contributes the most inductance to the power loop and so on — and to justify their conclusions using the values they have calculated. Ultimately, I ask them to explain how the DC resistances and inductances could be reduced and to speculate on what effect their changes would have on package performance.

Then they load the TO package into Q3D Extractor to verify their findings. It is always interesting.

In the software, they're asked to identify and explain the differences between their calculated results and those shown by the electromagnetic field simulations presented in Q3D Extractor. We've spent one to one and a half class periods

learning how to use the software, so they're ready for this. Those differences they discover are sometimes dramatic, and I want them to figure out how the discrepancies arose. Sometimes the smallest things — not taking into account a bend in a lead, for example — can lead to a significant difference between the calculated value and that arising from simulation. Then they're asked to simulate AC resistances and inductances using Q3D Extractor and to answer a number of questions about how the AC and DC values compare. What students can learn from Q3D Extractor in just 10 minutes — for that's all it takes, even on their personal computers, to perform a TO electromagnetic field simulation — is eye-opening for them. In many cases, the software verifies what they thought they knew while in other cases it exposes things they hadn't fully taken into consideration. Q3D Extractor provides them with a way to explore alternatives quickly and to see how subtle changes ripple throughout the fabric of a package.

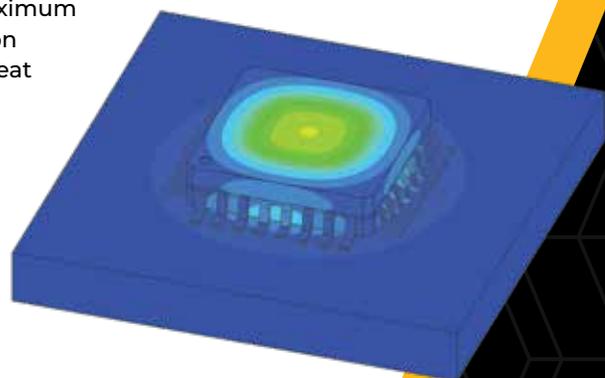
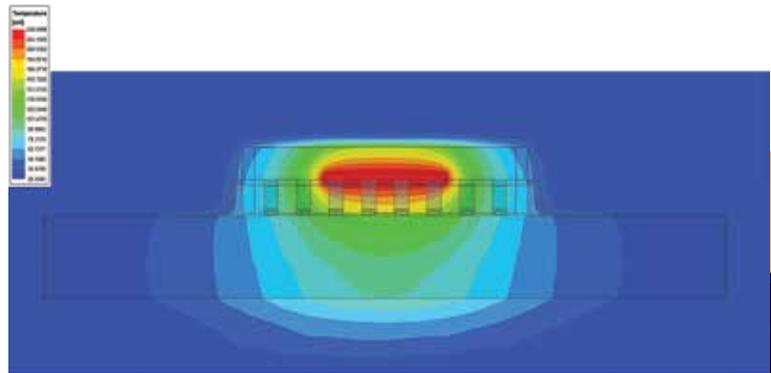
### ADDING ICEPAK ANALYSIS

As part of this team project, students also use Ansys Icepak to gain greater insight into the thermal characteristics of the TO package. As before, they're asked to calculate a number of results in advance. Where do they expect the most heat to be dissipated on the TO and why? Which path will have the lowest thermal resistance and which component will cause the greatest resistance in that path? How could that be reduced?

Once they have calculated answers to these questions and spent another class period learning how to use Icepak, they load the TO model and run thermal simulations to validate their answers. Again, this is always insightful for rarely is there a perfect match between what a student expected and what the simulation software shows.

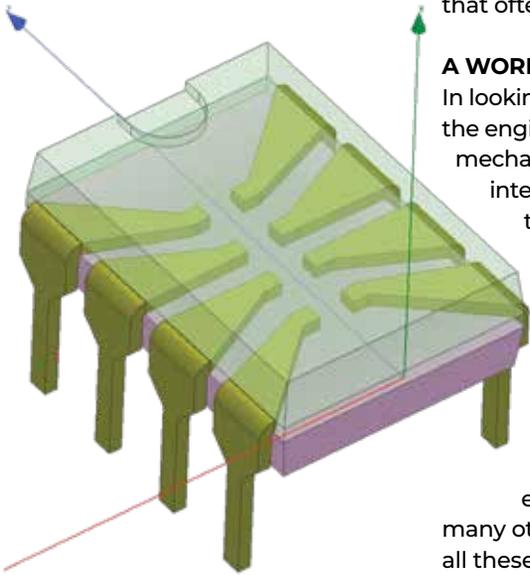
They then run a variety of simulations to explore the answers to other questions. What is the maximum junction temperature for each die? Where on the package does the greatest amount of heat transfer take place? Was that where it was expected? Where is the least amount of heat transfer taking place and what could be done to the package to improve heat removal?

With the tools from Ansys, the answers to these questions are readily accessible. The 3D heatmaps provide far more insight than the 1D and 2D insights that typically arise from manual calculations. It becomes easy to see how the thermal dynamics and the materials used in the package affect its electrical characteristics and performance. Similarly, it becomes easy to see how the electrical characteristics of the



**VA Tech students can use Ansys Icepak to compare various temperature plots of the QFP. Shown here are temperature plots of the QFP with the leads.**

***In looking at the physics of a tiny little chip, students from across the engineering discipline ... see a world of interactions and variations that force them to start looking at the practical application of their disciplines in a new way.***



**Teams of VA Tech students use Ansys Electronics Desktop and Ansys Icepak to analyze the electrical and thermal performance of a transistor outline (TO) package.**

components inside the package can affect the materials and the thermal characteristics of the package itself. Indeed, what they gain is insight into a multidimensional, multiphysics interaction that often goes beyond what they've encountered in other classes.

#### **A WORLD OF COMPLEX INTERACTIONS EXPOSED**

In looking at the physics of a tiny little chip, students from across the engineering discipline — from electrical engineering to mechanical engineering to materials sciences — see a world of interactions and variations that force them to start looking at the practical application of their disciplines in a new way.

The concepts and technologies they're focusing on within their undergraduate or graduate tracks — the electrical characteristics of an integrated circuit or the physical properties of different materials — don't exist in a vacuum. Physics doesn't stop at the edge of their discipline.

Accordingly, we focus on the multiphysics that integrate electrical engineering, mechanical engineering and materials sciences. There are not many other courses where we can look at the interplay of all these disciplines and their physics at the same time, but it really is an important lesson for those students who are keen to leave school and get a job in industry, particularly if they take positions in companies that are incorporating electronics packaging into the products they are building.

So far, the engineering students at Virginia Tech seem to agree on its value. The first year I taught this course, I had hoped to enroll as many as 10 students — but demand was such that I ended up enrolling 15 students. The next year that I taught the course, nearly 40 students enrolled. We're taking complex, real-world projects, breaking them down into small pieces, and then using powerful tools like those from Ansys to help us understand how the interaction of many different engineering disciplines can help us find better solutions. It's a big idea, so, naturally, a tiny package stuffed with semiconductors provides a perfect vehicle through which to explore it. ▲



**Ansys Multiphysics  
Webinar**

[ansys.com/icepak-webinar](https://ansys.com/icepak-webinar)

# Just-In-Time Physics Education

**By Ansys Advantage Staff**

Ansys Innovation Courses present hard-to-grasp physics concepts in an easy-to-follow, online format. The newly launched, free, undergraduate-level courses use 3D simulation to illuminate forces and flows, and bring invisible phenomena — radiation heat transfer, for example — to light.

Designed with students, early-career engineers and educators in mind, the Innovation Courses deliver on-demand project-based learning to anyone, anywhere. Students can access the self-paced courses to strengthen their understanding of a particular concept or explore new topics of interest. Graduates, preparing for a master’s degree or new employment, can use the courses as physics refreshers.

For professors teaching in or out of the classroom, the courses can easily be assigned as homework or self-study to their students. Additionally, educators can understand how simulation can be used earlier in their own course curriculum to start moving toward a state where theory overlaps with simulation in an on-demand manner versus a more traditional theory first, simulation second teaching method.

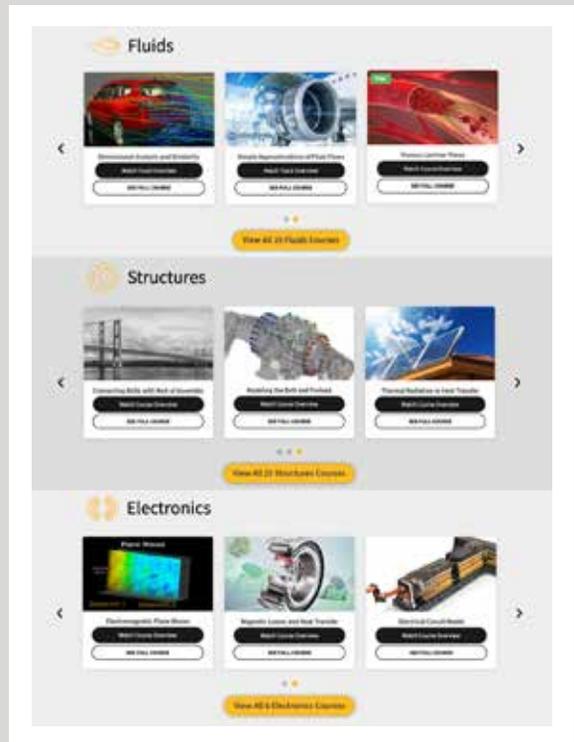
## TAKE A SNEAK PEEK AT THE SIMULATION SYLLABUS

Created by the Ansys ACE (professional services) team in collaboration with the Ansys Academic Program, the Innovation Courses are offered individually or organized into learning tracks. Heat Transfer in Structures, Fundamental Electromagnetics and Basics of Fluid Dynamics are just a few examples of the many tracks rolling out in 2020. Each will cover a variety of topics: For example, mechanics courses will explore preloaded bolted joints, thermal strain, hyperelasticity, harmonic response analysis and more. And, while the content in a particular course will reference or dive deeper into content presented earlier in the track, learners and educators need not access courses sequentially.

The courses consist of several lessons, which can be started and paused. Each lesson usually contains a series of short, minute-long simulations and explanatory text, plus a longer, five- to 10-minute video “lecture.” A PDF handout of each lecture is also included, so students may follow along, make notes or use it as a resource after the lesson concludes. The homework section may contain quizzes or a video tutorial, with accompanying downloadable data files so that students can DIY-it. Free student software, available through the Ansys Academic Program, can further enrich these at-home assignments.

The Innovation Courses also provide professors with an effortless way to introduce students to simulation earlier in their college curricula. The content seamlessly marries physics theory, laws and equations with the simulation setups and solutions students will need to learn before graduation to help jump-start their careers.

The first set of courses is available at [ansys.com/courses](https://ansys.com/courses). Check back often: A multitude of new courses will be added monthly. ▲



# POWERED by Partnership

Since 1982, the groundbreaking compressor designs launched by Embraco, the Brazilian hermetic compressors for refrigeration reference brand, have been fueled by a close relationship with its academic partner, Universidade Federal de Santa Catarina (UFSC). Working collaboratively via a shared engineering simulation platform, they have introduced innovations that have changed the nature of compressor design, including variable running velocities that conserve energy.

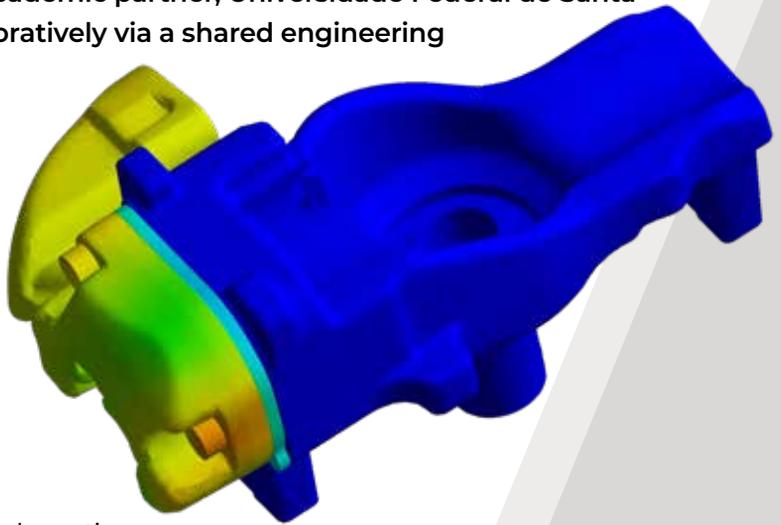
**By Ansys Advantage Staff**

**F**ounded in 1971 in Joinville, Brazil, Embraco was created with a straightforward goal: to provide a domestic source of compressors for the Brazilian refrigeration market. Today, as part of Nidec Global Appliance, a division of Nidec Group, the company is a global leader in compressor design, supplying next-generation compressors to OEMs in the household, food service and grocery refrigeration segments.

According to Rinaldo Puff, fellow researcher at Nidec Global Appliance, the foundation for the company's current success began in 1982 when the engineering team made two critical decisions. First, the company became one of the earliest adopters of engineering simulation in the worldwide refrigeration industry. Second, they formed a partnership with Universidade Federal de Santa Catarina (UFSC), a local university with an outstanding reputation for research and development.

Over the 38 years since, Nidec Global Appliance and UFSC have collaborated on engineering innovations that have revolutionized the refrigeration industry — including a linear compressor design that offers significant maintenance benefits over traditional reciprocating designs. More recently, the team introduced a variable-velocity compressor built to address customer concerns about energy efficiency by continuously changing its cycling speed.

The global compressor market is no stranger to disruption. "Every few years, customers demand a better design with greater cooling capacity, lighter weight, lower noise levels and reduced energy needs,"



**Professor Alvaro Toubes Prata, Universidade Federal de Santa Catarina (UFSC)**



**Rinaldo Puff, fellow researcher, Nidec Global Appliance**

**“Design for Six Sigma, and our use of Ansys software for multiphysics analysis and virtual prototyping, ensures that the product design is verified and optimized well before we invest in a physical prototype build.”**

— Rinaldo Puff, Nidec Global Appliance

explains Puff. “We are constantly striving to be first-to-market with the next big innovation, whether that means new materials, new electrical efficiencies or mechanical improvements.”

### BRIDGING FUNDAMENTAL AND APPLIED SCIENCE

Puff, who holds 33 patents for compressor innovations, notes that the Nidec Global Appliance–UFSC team’s engineering projects have been commercially successful because the team focuses on answering demonstrated market needs with innovation.

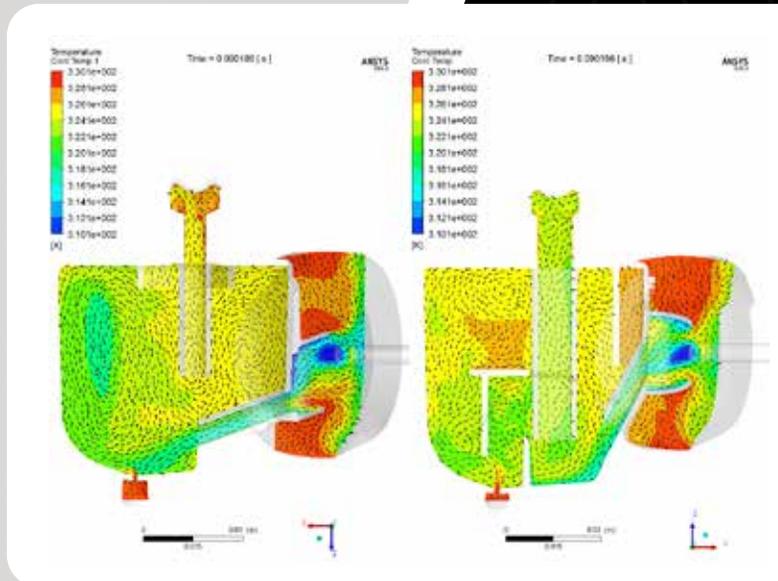
“The variable-velocity compressor is a great example of a customer-driven improvement,” he says. “Refrigerator manufacturers were looking for a way to decrease overall energy consumption to satisfy consumers and also meet stricter regulatory standards. The work with UFSC increased internal knowledge, helping in the creation of several product families, including the variable-capacity compressor designed to work at changing speeds while maintaining adequate cooling output. This pioneering design has resulted in significant energy savings, without sacrificing cooling performance.”

Professor Alvaro Toubes Prata had just earned his doctorate in mechanical engineering and joined the UFSC faculty when the company approached the university to explore a partnership in 1982. Today, he heads the team of faculty and student researchers at UFSC who support Nidec Global Appliance R&D initiatives.

“What makes this collaboration work is that it brings UFSC’s fundamental engineering knowledge — our expertise in mechanical engineering, fluid dynamics and other areas — together with practical applications for that knowledge,” says Prata. “When Nidec Global Appliance first introduced this idea, UFSC had absolutely no experience in compressor design. But we loved the challenge of applying our theoretical understanding to a real-world problem.”

According to Prata, the partners’ projects over the past 38 years have been focused on three major objectives:

1. Incremental improvements at the component level, such as changing the geometry of one component slightly to achieve a desired performance result



**Nidec Global Appliance has multiple engineering teams working together in real time on Ansys multiphysics simulations to speed the development process.**

## COLLABORATION BEGINS AT HOME

In addition to its groundbreaking partnership with Universidade Federal de Santa Catarina, Nidec Global Appliance has won industry awards that recognize the innovative nature of its internal R&D organizational structure, which is also highly collaborative in nature.

“Nidec Global Appliance is unique in the way we bring multiple functions together in real time to work on development projects,” says Rinaldo Puff, fellow researcher. “Unlike most engineering teams, which design products incrementally and sequentially, we have multiple engineering teams — in structural analysis, thermodynamics, fluids and other areas — working together in real time, on multiple aspects of a new compressor design. This not only speeds the development process, but it ensures we arrive at the best possible solution, in which all performance trade-offs are optimized.”

Puff points out that all of Nidec Global Appliance’s engineering disciplines are brought together for the development of all new products, so that every design aspect can be optimized — and the impact of every physical force can be completely understood from the earliest design stages.

“Specialists with functional knowledge share information with each other on a daily basis, working with a common toolset that includes simulation software,” says Puff. “We believe strongly in the Design for Six Sigma approach, in which advanced technologies are leveraged to anticipate trade-offs — and ensure that the countereffects of decisions in one area do not negatively impact the overall design. Design for Six Sigma, and our use of Ansys software for multiphysics analysis and virtual prototyping, ensures that the product design is verified and optimized well before we invest in a physical prototype build.”

Puff says Nidec Global Appliance’s cross-functional, interdisciplinary approach is unique in the global refrigeration industry — and a key reason the company has been successful.

“Innovation and collaboration are in our culture and DNA,” Puff concludes. “That commitment is transmitted to the outside world in everything we do. In my opinion, that is why we have been recognized by the industry, and are respected by both our customers and our competitors.”

2. Design updates to improve the product as a whole, like re-engineering the valve design based on new operating parameters for the entire product
3. A ground-up re-imagining and redesign of the entire product, as when they fundamentally changed the design of a compressor from a reciprocating design to a rotary design using a rolling piston

“Over 38 years, we have completed a surprising number of R&D projects with Nidec Global Appliance that have changed the compressor category,” says Prata. “Not only is it gratifying to perfect a new design and impact an entire product category, but that work increases UFSC’s broader scientific knowledge — and can ultimately impact society as a whole.”

How do the partners choose where to focus their efforts? Puff notes that Nidec Global Appliance and UFSC meet regularly to discuss emerging market needs and technology trends.

“We might get feedback from a customer, or someone from UFSC

might attend an engineering conference — and that provides the initial inspiration. Often, we end up investing heavily in an idea, but we also explore and discard some potential projects,” Puff explains.



**Nidec Global Appliance says its FMFT is the first commercial refrigeration bivolt compressor and one of the world’s most efficient in its capacity range. It reduces energy consumption by up to 30%.**

## ENGINEERING SIMULATION: A PLATFORM FOR COLLABORATION

Both Puff and Prata agree that the team's use of Ansys simulation solutions as a common platform has helped support collaboration, as well as accelerate the research and development process.

"Ansys simulations are critical tools because, like our team, they bridge fundamental and applied science. Whether we are testing a theory about fluid flows in general or verifying the effects of a certain flow velocity on a specific valve geometry, Ansys software is one of the best available tools. It also supports the kinds of multiphysics, system-level studies we need to replicate all the complexities of compressor operation," Prata points out. Both partners use a full range of simulation software, including structural, computational fluid dynamics and electromagnetics solutions.

"Handing off projects with UFSC is much easier because we are standardizing our engineering efforts via Ansys solutions," Puff concurs. "We are speaking a common language and sharing the same perspective on the inner workings of the compressor. There is no need to explain various tests and findings, because we are all fluent in engineering simulation via Ansys."

Just as UFSC's master's and doctoral students are benefiting from the opportunity to work on real applied engineering challenges, they also are being trained daily in the industry's leading simulation tools.

"The Nidec partnership is preparing our students to work in the real world after graduation by giving them the skills they need to succeed, including engineering simulation," Prata emphasizes. "An unexpected result is that many of our graduates have gone on to work for Nidec Global Appliance's in-house product development team — which is a benefit for both these students and the company. This knowledge pipeline means that the company's technical leadership just keeps growing and growing."

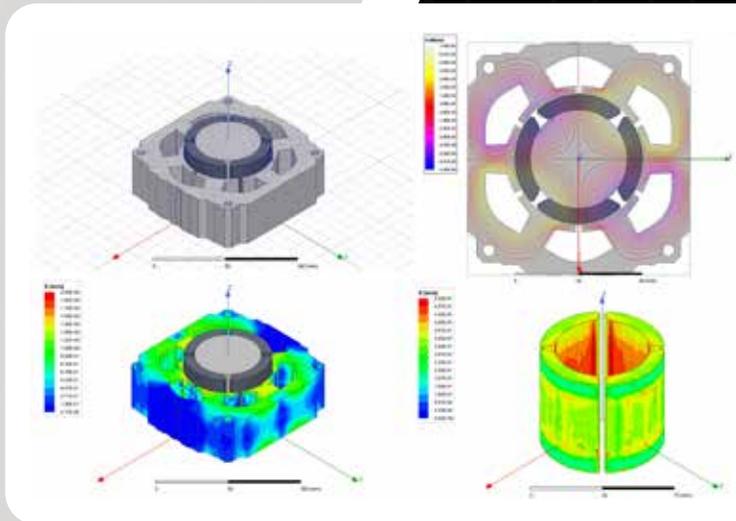
## THE RIGHT PARTNER, THE RIGHT TOOLS

As a result of their long partnership, not only is Nidec Global Appliance a market reference in compressors with Embraco's products, but UFSC has become the center of engineering research on refrigeration in Brazil. For both partners, this is only the beginning.

"We cannot rest on the results to date," stresses Puff. "We must continually seek out new technologies and best practices that take our compressors' performance to the next level." As just one example, Puff notes that Nidec Global Appliance and UFSC are exploring the concept of the digital twin — installing Internet of Things (IoT) sensors on a working compressor to create a real-time, virtual product model that engineers can study and learn from.

What advice would Puff offer to other companies seeking to establish product leadership in a competitive industry?

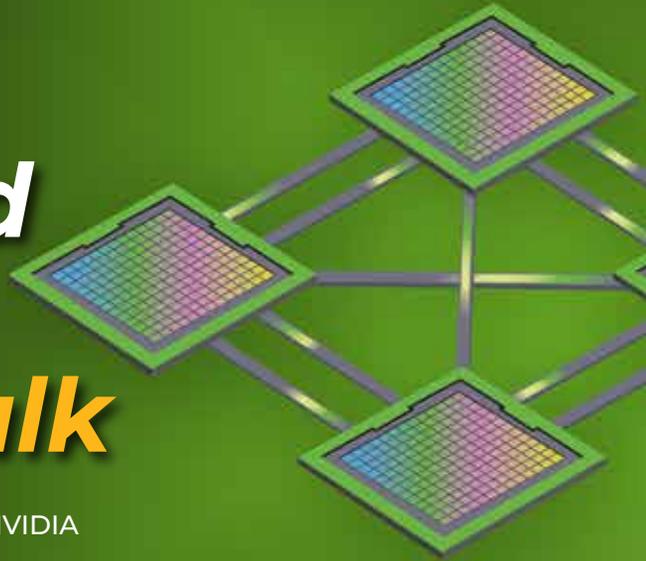
"Obviously we believe in identifying and capitalizing on the newest thinking via a partnership with the world's leading engineering experts — meaning our collaborators at UFSC," he says. "But, equally important, both partners must identify and capitalize on the best-available engineering technologies. You never know what you can accomplish by forming an expert team and supporting that team with best-in-class technologies and practices." ▲



**Nidec Global Appliance and UFSC collaborate more efficiently on the Ansys platform.**

# Optimize High-Speed Serial Links for Crosstalk

By Dai Dai, Mixed-Signal IC Design Manager, NVIDIA Santa Clara, U.S.A.



Today's system-on-chip (SoC) designs — regardless of application — just keep getting more complex. Specifically, high-speed chips become even more daunting when it comes to rooting out electromagnetic (EM) crosstalk and achieving an efficient power distribution network in a reasonable amount of time.

Consider, for example:

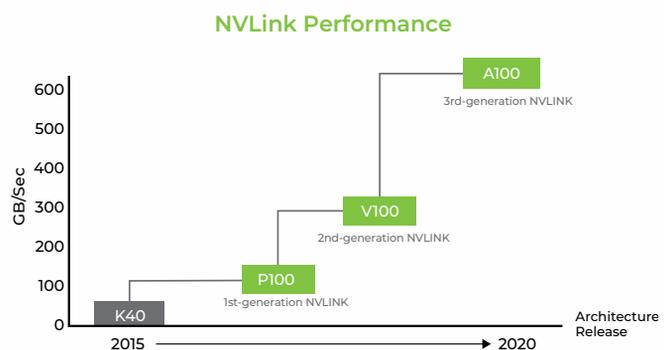
- Engineers in the automotive sector struggle with 80 GHz millimeter-wave radar chips with lots of on-die EM complexity. Crosstalk is of course an enormous concern on devices where safety is critical in the end product.
- In 5G cellular, engineers contend with an EM nightmare: lots of radios on the same die. Some teams have to simulate for 5,000 different frequency intermodulation products on a single 5G transceiver.
- Teams designing high-performance artificial intelligence chips like graphics processing units (GPUs) have to deal with multi-gigabit-per-second input/output and the noise that can create.
- High-bandwidth memory and processor cores have to deal with complex multilayer silicon interposers that connect core and memory.

All these chips have two common denominators: high speed and high frequency.

When it comes to high-speed, chip-to-chip serial link design, we have been doubling throughput as fast as every two years, but we have to do it in the same area constraints. That means more tightly packed data links, which increases the risk of crosstalk.

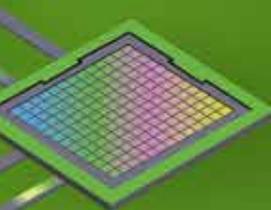
Additionally, the latest GPU designs have widely employed interposers. Those interposers can cause additional crosstalk. If you don't take into account the interposer, it will come back to bite you because you'll have interposers on top of your inductors creating that coupling.

Also, because of large bump pitches (from 150  $\mu\text{m}$  to 200  $\mu\text{m}$ ) and a limited number of bumps in a constrained area, it can be challenging when you want to separate noisy power domains, for instance the digital power and analog power domains. To do so, you need multiple power and



**NVIDIA's NVLink technology road map shows throughput doubled over a two-year period. The tightly packed data links increase the risk of crosstalk.**

***With RaptorX and Exalto, we were able to do a very large-scale extraction efficiently in a short time that allowed us to push the physical design to its limit while minimizing the associated risks.***



ground bumps. When you have a large number of bumps, it's hard to route power and ground cleanly. That worsens the crosstalk potential. You have to analyze what type of coupling is coming from power and ground for critical mass.

**KNOWLEDGE IS KEY**

To improve signal integrity and power consumption, we need to be EM-aware. Because our team is constantly pushing the envelope on high-speed, high-frequency design, we've built an effective, efficient methodology to root out crosstalk issues in a way that does not bog down our schedule or tie down too many engineering resources.

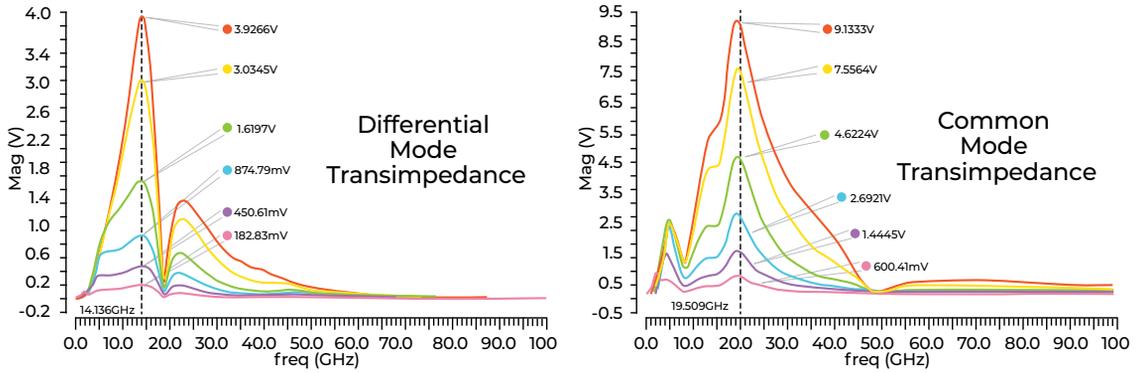
NVIDIA'S design methodology is hierarchical. We first classify everything into different categories, the most critical being high-speed signaling and clocking nets. We start with traditional resistance and capacitance extraction with coupling (RCc) extraction as part of a top-level simulation approach. In this initial exploration, we don't need a lot of detail, but we do need fast turnaround time while we examine high-speed signals and clock nets and adjacent top-metal structures, as well as the power and ground distribution network. We turned to Ansys Totem, which does power grid weakness analysis, point-to-point checks, and a variety of early-stage static and dynamic IR and EM analyses that can highlight design weakness.

To perform additional analysis and optimization in the methodology, the team relied on Ansys RaptorX and Ansys Exalto to examine high-speed signal and clock nets; critical passives such as T-coils, inductors and bumps; power and ground; and other aggressors and victims that might cause EM crosstalk.

RaptorX is a post-layout RLCK extraction software solution that enables IC design engineers to accurately predict electromagnetic coupling effects during the signoff phase. It can capture unknown crosstalk among different blocks in the design hierarchy by extracting lumped-element parasitics and generating an accurate model for electrical, magnetic and substrate coupling. And Exalto integrates the above function with conventional RC extraction flow and makes it easier to use for designers.

Let's look at some examples of how we implemented the methodology to explore crosstalk in various parts of our design and in turn optimized those designs based on the results.

	RCc/Totem	Ansys RaptorX	Ansys Exalto
High-Speed Signal/Clock Nets w/ Adjacent Top-Metal Structures	●	●	●
Critical Passive Components (Inductor/T-Coil/Bump/Time, etc.)		●	●
Power/GND Distribution Network (PDN) w/ High di/dt	●	●	
Other Potential EM Crosstalk Aggressors/Victims		●	
Other Nets	●		



**Plots show both differential- and common-mode crosstalk from a power delivery network to sensitive receiver signal nets vs. effective decoupling capacitors. Different colors in the figures mean that different amounts of decaps were used in the configurations.**

### DATAPATH CROSSTALK ANALYSIS

The image below is a partial floorplan of a high-speed receiver in a recent NVIDIA GPU design. Because of area constraints and power-efficiency considerations, the inductors and T-coil have a limited keep-out region compared to conventional RF designs. You can't afford a large region for these passive structures because you will have to space out all your high-speed circuitry. That in turn makes your overall design power-inefficient. To capture adjacent crosstalk effects, we used RaptorX to extract all critical nets and adjacent power/ground as n-port, with the partial layout including only the top, thick metal layers.

We extracted the entire area as a model. We put different ports in different locations, and ran S-parameter simulation as well as transient simulation to determine the crosstalk effects. Once we had the results, we reoptimized the layout and decoupling capacitor (decap) placements to minimize the crosstalk effect.

We wanted to try to reduce crosstalk effects at the frequency of interest by 2-10 times by putting decaps at correct locations; based on the transient wave forms at the bottom, we can see that the transient effects after optimization are reduced to 3 millivolts. It's still there, but we minimized the impact based on our analysis.

### POWER-CLOCK LINE CHALLENGES

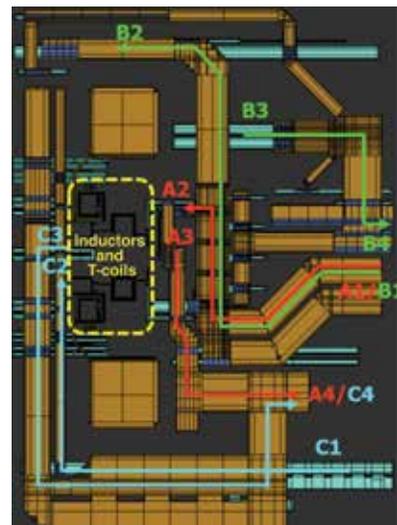
Another big issue is crosstalk from power to high-speed clock lines. With SerDes (serializer/deserializer) design, often one phase-locked loop (PLL) will drive critical high-speed clocks to multiple different data lanes. This clock distribution can run for several millimeters depending on the application. Because of the area constraint, it's hard to avoid noisy ground and power running in parallel with the clock lines. Even if you have proper shielding on the side of the clock, it's not enough. You'll still experience severe magnetic crosstalk from those power lines.

To capture the big picture, you have to put multiple data lanes together to include the entire clock distribution network. To do that, you need to extract more than 50 and sometimes as many as 100 ports. You can only really do this with RaptorX.

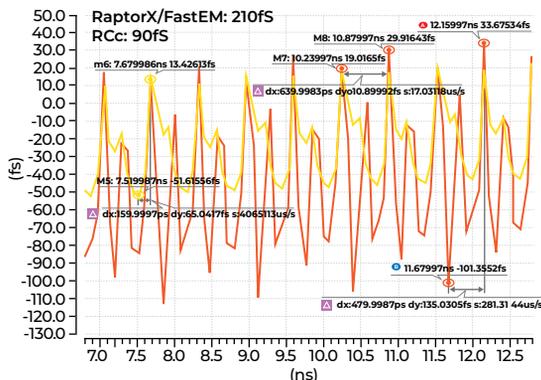
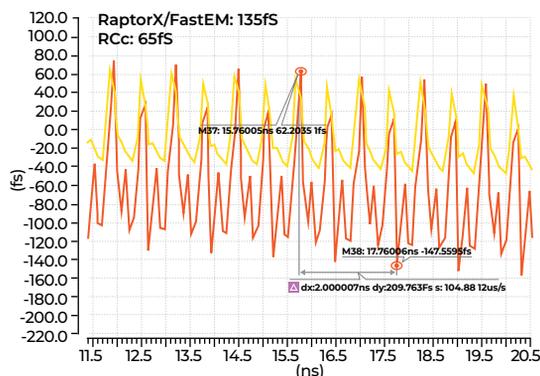
When you extract the whole thing with power, ground and clock using RaptorX, you see much worse crosstalk jitter from the power and ground lines.

The two comparative plots allow NVIDIA to look at jitter. They show the same simulation at different locations. The yellow ones are based on RCc extraction.

Even after optimization, we're seeing instantaneous jitter



**A partial floorplan of a high-speed receiver in an NVIDIA GPU design shows the limited keep-out region of on-chip passive components (inductors/T-coils).**



**Two comparative plots allow NVIDIA to look at jitter. They show the same simulation at different locations. The yellow lines are based on RCc extraction.**

that is twice as bad as with RCc-only numbers. This effect is hard to eliminate completely, but with the proper setup and tool, you can predict it and include it in your jitter budget along with other random jitter (RJ) and deterministic jitter (DJ). If you ignore that, you'll have a surprise in store for you when silicon comes back. We need this Ansys tool to ensure that we capture all effects from this sort of coupling.

### HOW TO OPTIMIZE POWER DISTRIBUTION

The figure below represents an optimization of a power delivery network (PDN) we performed using a combination of RaptorX and Exalto. Our analysis included both inductive top-metal layers as well as a bottom resistive lower via and metal. We put ports on all access points, including bumps, decoupling caps, current sinks and sources.

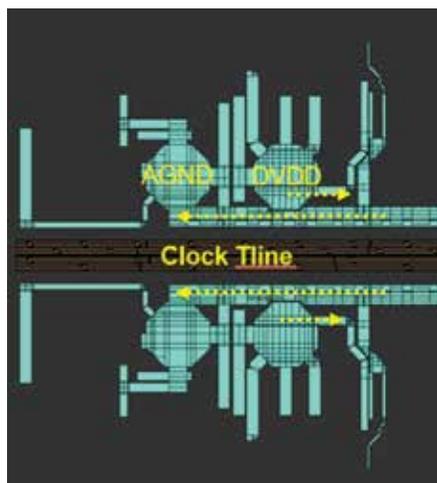
The decaps are optimized to reduce dependence on long, top-metal routings for high-frequency current delivery, while keeping high area efficiency. The current return path is planned carefully in parallel with the delivering path to minimize loop enclosure and reduce flux/routing inductance.

With this optimization, we were able to reduce the supply ripple induced by di/dt (the rate of change of the current) by 40%.

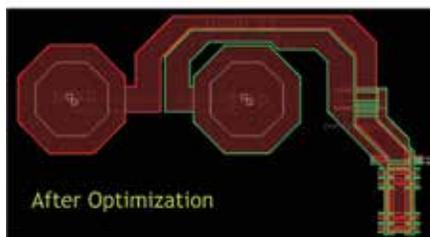
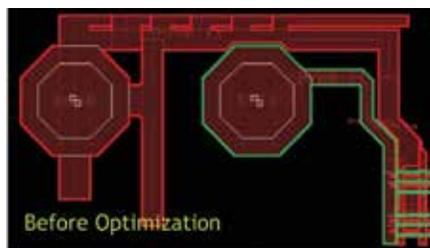
### EFFICIENCY AT SCALE

With advanced SerDes design, there are high-speed impairments that can't be captured with simple RCc extraction as frequencies keep increasing. These impairments include EM crosstalk and di/dt-induced supply noise.

We used a combination of RCc and EM tools to properly model all these. With RaptorX and Exalto, we were able to do a very large-scale extraction efficiently in a short time that allowed us to push the physical design to its limit while minimizing the associated risks. The end result was a power-efficient design. ▲



**RaptorX enables NVIDIA to extract long clock routings plus the power delivery network over multiple lanes with a large number of ports.**



**NVIDIA used Ansys RaptorX and Ansys Exalto to optimize a power delivery network.**

# SUDDEN IMPACT:

## *Simulating MMA Head Shots*

By **Stephen Tiernan**

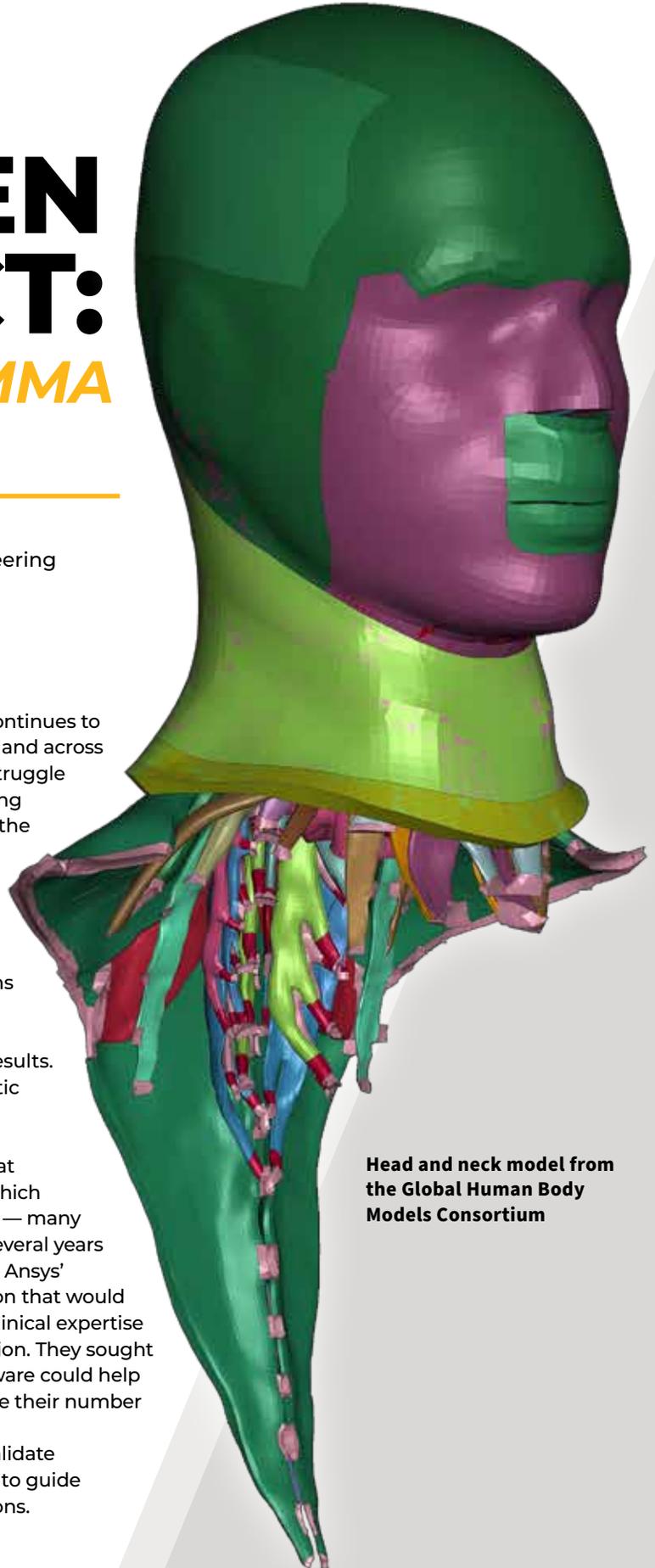
Senior Lecturer of Mechanical Engineering  
Institute of Technology Tallaght  
Dublin, Ireland

**A**s the number of head injuries continues to accelerate in mixed martial arts and across many other sports, physicians struggle to accurately diagnose concussions. Using Ansys LS-DYNA, doctors can determine the magnitude and location of brain strains, enabling them to improve concussion treatment.

Clinicians are unclear about how to measure the damage incurred by head impacts and diagnose concussions as magnetic resonance images (MRIs), computed tomography (CT) scans and blood tests often deliver inconclusive results. Concussions are a mild form of traumatic brain injury typically suffered in sports activities.

Dr. Michael Power leads clinical care at Beaumont Hospital in Dublin, Ireland, which specializes in treatment of head injuries — many of which occur during contact sports. Several years ago, he aligned with CADFEM Ireland — Ansys' channel partner in Ireland — on a mission that would combine engineering simulation with clinical expertise to research the mechanisms of concussion. They sought to understand whether simulation software could help define the causes of concussions, reduce their number and improve concussion treatment.

A successful demonstration would validate simulation as a crucial tool for clinicians to guide management of sport-related concussions.



**Head and neck model from the Global Human Body Models Consortium**

CADFEM Ireland, together with Institute of Technology Tallaght (ITT) researchers, welcomed the challenge. The team relied on science to quantify head impacts, which required brain strain measurements and Ansys LS-DYNA simulations, with CADFEM Ireland providing technical support, Amazon Cloud services and software licensing.

The concussion research also incorporated Dr. Matthew Campbell's Genetics Department team at Trinity College Dublin (TCD) who pioneered a novel method that analyzes contrast-enhanced MRI images to determine blood-brain barrier changes of MMA fighters pre- and post-fight. Additionally, doctors at St. James Hospital Dublin medically screened the fighters before and after the fights.

Researchers collected head acceleration data during mixed martial arts (MMA) matches and used that information in a finite element analysis (FEA) of a human head digital model to identify and measure strains on the brain. MMA is a full-contact competitive sport featuring a combination of fighting styles spanning boxing, kickboxing, karate, wrestling, judo and jiu jitsu. Fighters wear lightweight gloves but no head protection.

Researchers studied MMA fighters because frequent blows to the head in matches would enable the collection of significant head acceleration data, providing unique insights into head movement following impact.

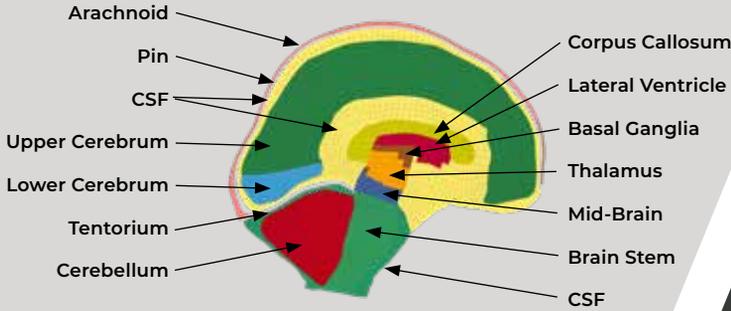
The simulation strain data, MRI data and medical screenings enabled the group to understand the nature, severity and location of the brain changes that occurred following severe head impacts.

**GEARING UP WITH SENSORS**

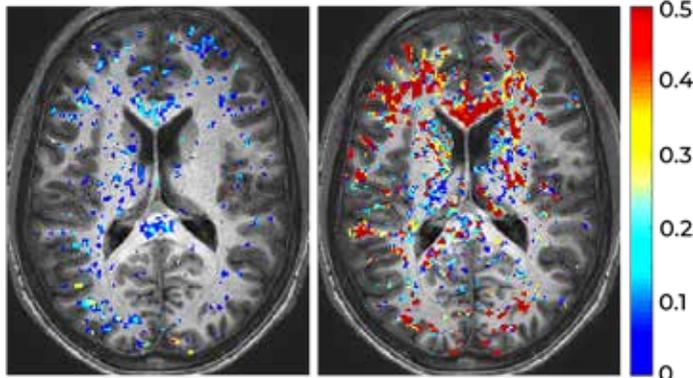
To effectively measure head accelerations and severity of impacts, researchers needed an accelerometer for capturing input data. They evaluated numerous accelerometers ranging from sensors affixed to an athlete's ear to sensors attached to headbands. These sensors produced some slippage between the sensor and the skull that affected the accuracy.

Researchers ultimately selected a mouthguard device with six degrees of freedom (DOF). It included a tri-axial accelerometer and gyroscope that recorded linear acceleration and angular velocity of impacts. Engineered by Stanford University, the mouthguards were created using a dental impression that helped it closely couple with the fighter's skull for improved accuracy.

But sensor data alone cannot tell the full story. Researchers used a digital version of the human model developed by the Global Human Body Models Consortium (GHBMC) — a state-of-the-art full-body model developed by a conglomeration of automotive manufacturers and American universities — to decipher strain, pressure and stress. Using the whole body proved unnecessary because short-duration acceleration impacts — typically between five and 10 milliseconds — affect only the head and neck. By reducing the model and isolating the head and neck, researchers decreased computational time. The revised model, comprising approximately



**Sagittal section of head and neck model from the Global Human Body Models Consortium**



**MRI of concussed MMA fighter, pre- and post-event**

## PREVIEWING THE FUTURE: MAKING SPORTS SAFER

Leveraging mouthguard sensors and LS-DYNA simulation data extends beyond MMA because instrumented mouthguards will soon become commercially available. Athletes will have access to their acceleration data — but what will they do with it? What does the data mean?

Today, when an athlete experiences a high-acceleration impact, the player leaves the game, allowing doctors to perform a clinical assessment and determine when the player can return. In the future, by applying an LS-DYNA simulation-based workflow, clinicians can obtain a player's acceleration level, rapidly run the model in the cloud, convert that into strain levels and calculate the levels across different parts of the brain. Receiving that data, the doctor can make a clinical interpretation and a highly accurate assessment for determining when the player can return to the game.

Using this technology, an athlete's acceleration-level data could be collected and stored in the cloud over years, to be used later for clinical analysis. For example, when a player visits a hospital following a severe impact, the clinician could access the player's acceleration-level history, assess the most recent strain level, arrive at a diagnosis and deliver an accurate assessment.

Another potential use would be to monitor and manage children's health in sports. Kids could wear inexpensive sensor-equipped mouthguards that would alert parents via text message if their child suffered a serious impact.

As the child matures, the cloud could be used to collect and store brain strains that occur during sports activities. This data would enable doctors to run many models over time, helping them to ascertain the accumulation of strain and damage.

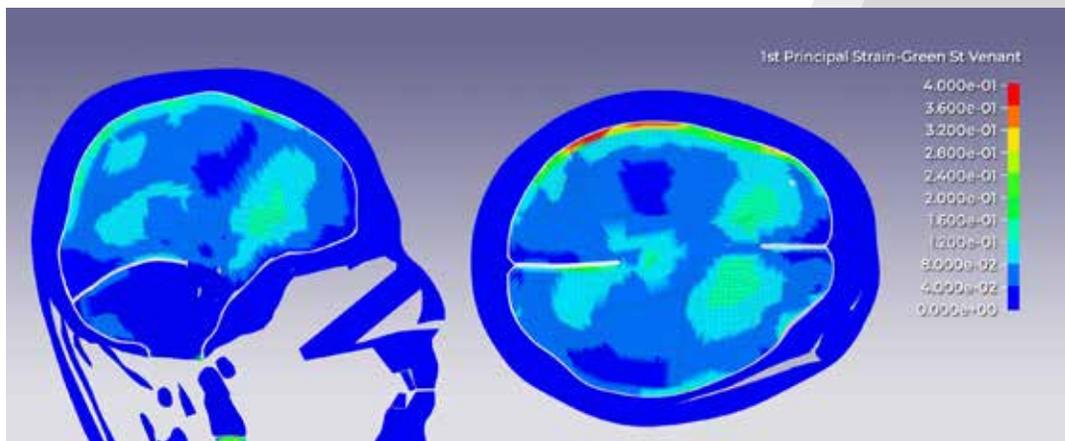
And as the cloud stores the data, it could also update the person's digital twin — their virtual copy. The two would be digitally intertwined, enabling people to stream mouthguard sensor data to their virtual counterparts, which, in turn, generates predictive, informed insights for clinicians.

200,000 elements, measured accelerations that focused on a head's center of gravity.

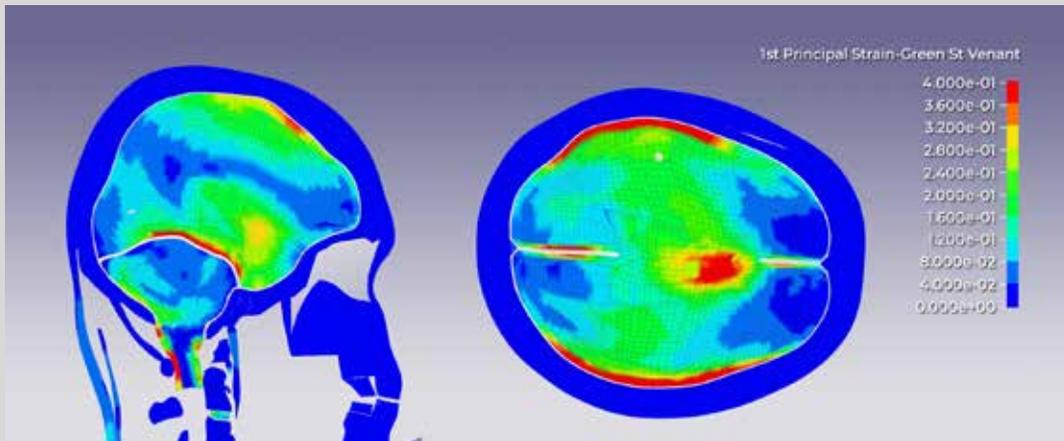
Researchers selected LS-DYNA simulation software — one of the few explicit solvers capable of measuring head impacts of very short duration — to run on the GHBM. This would help determine the location and magnitude of strains experienced by the brain and enable understanding of what causes damage and concussions.

### ANATOMY OF AN MMA FIGHT

For the study, researchers analyzed 25 elite amateur and professional MMA fighters, recording more than 400 head impacts across eight sparring sessions and eight competitive matches.



**Brain strain of an uninjured MMA fighter showing the sagittal and transverse sections**



**Brain strain of concussed MMA fighter showing the sagittal and transverse sections**

During fights, microchips within fighter mouthguards collected linear data at 1,000 Hz and angular velocity at 8,000 Hz, filtering the data with a fourth-order Butterworth low-pass filter equipped with a cutoff frequency of 300 Hz. Mouthguards recorded data only when linear acceleration levels surpassed 10 g. Researchers leveraged numerical differentiation to calculate rotational acceleration.

Following each fight, researchers connected the mouthguards to a laptop via Bluetooth, downloading tremendous amounts of head acceleration data.

Next, researchers synchronized the acceleration data with fight video recordings, analyzing the videos frame by frame to find and select impacts with the highest angular acceleration levels — typically above 20 g to 30 g — as those often produce concussions.

LS-DYNA was then used to run the selected impact loads on the head of the digital GHBM's model, transposing the data to nodes at the head's center of gravity and also into a coordinate system that exhibited the same coordinate system of the model. Additionally, the angular velocity data was differentiated to obtain the angular acceleration. The simulation required just three and a half hours to run, using 36 cores on Amazon Cloud.

Comparing fighters' pre-season MRI scans and post-fight MRI scans with the simulation data enabled researchers to correlate the high-strain areas to reveal if impacts disrupted the blood-brain barrier in those areas, causing a concussion.

### LS-DYNA SIMULATION WINS BIG

LS-DYNA proved vital for determining the location and magnitude of brain strains, as well as providing detailed insights on the mechanism of the impact, which would not be possible without simulation. Results revealed that fighters are far more vulnerable to side-head impacts, which create more strains. Following a side hit, as the head suddenly twists, its rotational acceleration sends dangerous mechanical vibrations to the collosum area of the brain — a bundle of nerves that acts as the communication center, connecting the brain's left and right hemispheres. Damage to the corpus collosum area of the brain disrupts data transmission between hemispheres, potentially leading to concussions and severe neurological issues.

Just as important, LS-DYNA also helped researchers establish strains, strain rates and pressure data to define the thresholds below which injuries do not occur.

Additionally, this research marked the first time LS-DYNA and MRI imaging established a correlation to show blood-brain barrier damage within a particular location. That validation drove further confidence in the simulation model.

Clinicians and sports authorities ultimately strive to prevent serious head injuries. That can be accomplished once they better understand the blows that could potentially lead to serious trauma, and simulation enhances that understanding.

This method of traumatic brain injury research could be applied to other sports to develop enhanced equipment, such as reinforced helmets that could counter the consequences of side-head impact. Furthermore, by analyzing the most dangerous blows, the related sports authorities could adjust rules to prevent dangerous impacts in the future. ▲

# Mazda Sees the Light with Ansys SPEOS

By Ansys Advantage Staff

**MAZDA MOTOR CORPORATION** marked the 100th anniversary of its founding on Jan. 30, 2020. Since 2010, the company's cars have been developed using its vehicle optimization platform, SKYACTIV, which includes many new technologies. The company has aggressively invested in computer-aided engineering (CAE) to efficiently develop SKYACTIV. Ansys SPEOS 3D optical analysis software played an important role in the development of the interiors and lights of the MAZDA3, which launched in 2019 as the first model of its new generation of vehicles.

**ANSYS SPEOS PROVIDES ACCURATE EVALUATION**

In automobile lighting technology, design degrees of freedom have greatly improved since transitioning to LEDs. Before this transition, light performance was determined to some extent based on the knowledge of the supplier. The supplier would propose a new light using various tools. However, Mazda had no idea how to independently judge the recommendations. Mazda also had to ensure that it was satisfying various legal regulations and functionality requirements. To move forward, Mazda needed to evaluate the actual light illumination early in the development cycle.

“In other development fields, such as collision safety and vibration noise, we used simulation-based performance verification and model-based development in the design stage,” says Minoru Inoue, technical leader in Mazda’s Interior & Exterior Components Technology Development group. “Meanwhile, in the development of interior and exterior equipment, including lights, verification was mostly conducted using an actual vehicle,

**BY THE NUMBERS**

- Capital:** 284 billion yen (\$2.7 billion)
- Employees:** 23,087 (unconsolidated)
- Vehicles sold:** (fiscal year ended March 2019): Approximately 1.57 million
- Sales:** 3.565 trillion yen (\$33,949 billion)

so we knew that we were far behind in the optical development. That is why we always wanted to evaluate the human senses, such as feeling comfortable and looking good, based on the physical quantity to front-load the development.”

“We also liked Ansys SPEOS because its simulation allows us to evaluate different physical quantities — luminance required in the visual lighting evaluation and luminous intensity required to satisfy the legal and regulatory check — at the same time in a single



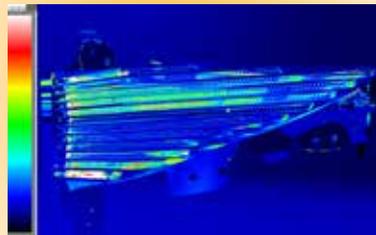
**DESIGN**



**Visual Appearance Evaluation Using Ansys SPEOS**



**SIMULATION IN THE DEVELOPMENT PHASE**



**Ansys SPEOS was used for interior and exterior lighting simulation at Mazda Motor Corporation. The company’s use of model-based development results in fewer prototypes, saving time and lowering costs. SPEOS also provided a means to quantify the user experience, which justified engineering change orders and improved workflow efficiency.**



**ACTUAL VEHICLE**

analysis,” adds Yoshiaki Nakaya, assistant manager in Mazda’s Exterior Components Development group.

“Mazda is still backing model-based development, but we recommend proceeding with development after understanding the mechanism [principle or basis] of part design — even if it is conducted by the supplier,” says Inoue. “I prepared a document and explained to people within our organization that this tool teaches us technologies and leads to efficient development. I successfully convinced them.”

Before the implementation of SPEOS, Mazda prototyped a principle model concept multiple times before beginning a detailed design after a development direction was set. Then, Mazda engineers made another prototype and finally created the actual vehicle model using the final design data. Consequently, Mazda spent a lot of money on repeated prototyping. It cost a few to 10 million yen (about \$95,000) to create each molding die of a lamp, for example.

With SPEOS, the company successfully reduced the number of prototypes it needed. On average, Mazda is able to remove two or three prototypes from its production process because SPEOS allows engineers to find and correct issues in the design.

“For example, a light leak that ends up illuminating outside the area you want to illuminate is difficult to find in computer-aided design (CAD) data, and even an experienced engineer sometimes overlooks it,” says Nakaya. “In an Ansys SPEOS simulation, however, we can check such an error from different angles. There is now almost no leak, resulting in less rework.”

### QUANTIFY HUMAN SENSES FOR AN OPTIMAL USER EXPERIENCE

The Mazda Vehicle Testing & Research Department carries out both experiments and research, while the Craftsmanship Development



## AN INNOVATIVE HISTORY

**Mazda Motor Corporation** was founded as Toyo Cork Kogyo Co., Ltd. in 1920. In 1927, it was renamed Toyo Kogyo Co., Ltd. and prototyped a two-cycle 250 cc engine in 1929. The company soon became a three-wheel truck manufacturer, producing three-wheel trucks from the pre-World War II period to the postwar era. Toyo Kogyo unveiled its successful R360 Coupe, a four-seater minicar in November 1960, and the Mazda Cosmo equipped with a rotary combustion engine in 1967. They also launched the Mazda 626 (Mazda6 at present) and Savanna in the 1970s and the Eunos Roadster (Mazda MX-5 at present) in 1989 after changing the company name to Mazda Motor Corporation in 1984. Mazda then added popular cars such as Mazda 121 (Mazda2 at present) and Mazda 323 (known as the Mazda Protegé in the U.S.A. and now as Mazda3) to its lineup of vehicles. The company started a restructuring plan in 2013 for highly efficient development and production, proactively introducing computer-aided engineering.

Group studies the human body, senses, recognition and expressions to account for details such as the visibility and texture of display equipment.

Asami Yonezawa, senior specialist in Mazda’s Craftsmanship Development group, oversaw antiglare development when SPEOS was introduced. Her group chose SPEOS because of a sun glare problem. Sunlight reflected off the silver plating around the center louver in some models, which caused glare while driving. Fixing the problem required the shape of the plated parts to be changed, resulting in about 10 million yen in additional costs to modify the mold. The same symptom was also found in other models, so the group had to take some measures even before modifying the mold.

Veteran engineers reshaped the plated parts based on their experience, so there was no quantified data to show how much light is dazzling to the human eye. Even specialists who evaluated the glare, such as Yonezawa, only visually checked but could not quantify it. The company wanted a way to measure the glare.

SPEOS met all three evaluation criteria set by Mazda:

1. Accurately analyze light amount and wavelength
2. Accurately analyze reflectance properties
3. Reproduce and quantify luminance distribution in two dimensions

“Our conventional tool converted 3D data created by the design styling and design divisions into another file, so when we made a mesh, it resulted in degraded accuracy,” says Yonezawa. “Because Ansys SPEOS allows us to use our 3D CAD product as an add-on, we can perform a simulation without sacrificing the accuracy. This is one of the key aspects we liked.”

Yonezawa’s group was also working on another issue: The reflection of in-vehicle parts on the inside of the windshield made it difficult for drivers to see through the windshield. Being unable to show the design issues quantitatively, Yonezawa had difficulty making the designer understand the necessity of an improvement. However, SPEOS allows quantitative evaluation, which she could use to ask the designer for improvements.

The group proactively used SPEOS to design the lights and interiors in the MAZDA3. In test drives for journalists held worldwide when announcing the launch, the drivers noted that the MAZDA3 had clear views.

#### **MORE EFFICIENT SUPPLIER RELATIONS**

Since the introduction of SPEOS, Mazda has seen changes in business relationships with its suppliers. In the past, Mazda used a one-way development process for lights. For example, the

company would provide a design concept and a lighting image to the supplier so they could make a proposal based on their knowledge. Today, Mazda is not involved in detailed design but performs a simulation and makes its own proposal to the supplier.

“What makes it different from the traditional development style is that we can prepare a concept in a stage where an area around the light has not yet been designed, which leads to cost optimization,” says Nakaya. For example, Mazda engineers can use simulation to optimize lighting mount design for mass production, which saves time and money.

The supplier also seems to like this change to their relationship because determining the specifications in the early stages and preparing the optimum design on both sides can lead to more efficient development. Mazda is now adopting a development process to quickly determine the specifications by sharing the same perspectives in real time between the engineers and the supplier as they simulate with SPEOS together.

Not only does SPEOS improve communication between Mazda and its supplier, but communication between the design and the development divisions inside the company has improved as well.

“It was always difficult to verbally explain how much more the vehicle can improve, but visualizing it with Ansys SPEOS easily convinces the designer,” says Yonezawa. “Once satisfied, the designer is willing to accept the design change. This can be achieved even without making an actual product, which is one of the great advantages.” ▲

**From left: Asami Yonezawa, Yoshiaki Nakaya and Minoru Inoue implemented Ansys SPEOS for interior and exterior lighting simulation at Mazda Motor Corporation.**



# Continental's Guiding Light

By **Vyacheslav Birman**  
Lighting Technology Expert  
Continental Corporation  
and *Ansys Advantage* staff

**W**hile automobile dashboards increasingly use flat panel screens to display information like driving speed, engine temperature and fuel level, many automobile makers also incorporate physical dashboard components. Some automakers employ a hybrid digital-analog approach to meet customers' needs. Others want to give drivers the retro feel of luxurious classic cars that digital readouts can't match. Like a person who wears a stylish wristwatch when they could easily read the time on their cell phone, some people will opt for analog aesthetics.

Continental Corporation has been helping automobile manufacturers distinguish their dashboard components over the years by designing illuminated pointers, horseshoe-shaped speed displays and lighted rectangular panels



powered by lightguides. The simplest lightguide is a fiber optics cable illuminated by an LED at one end and transmitting that light out the other end. But it quickly gets more complicated. A simple arrow-shaped pointer with a "tip to tail" design made of polycarbonate (PC) or poly methyl methacrylate (PMMA) must be designed so that it is evenly illuminated from tip to tail, with no bright or dark spots, which involves the physics of total internal reflection (TIR) and controlled light leakage throughout the pointer. At this level, a physics-based optical simulation solver like Ansys SPEOS is required to analyze light propagation and scattering to produce virtual prototypes.

The most challenging dashboard pointer ever designed by Continental engineers involved a 3D, bowl-shaped speedometer gauge with a pointer that extended horizontally from the center until it reached the highly sloping walls



of the bowl, at which point the pointer had to bend at a 45-degree angle. The horizontal section of the pointer extending from the origin to the bend was not illuminated. Evenly illuminating the upward sloping section from the bend to the tip of the pointer was a challenge that required almost 50 iterations of SPEOS simulations to get right.

### CONTROLLING LIGHT LOSS

For total internal reflection (TIR), the surfaces of the lightguide must be polished to optical-level smoothness. Roughening the surface can change the angle at which incoming light rays impinge on the surface; those striking at less than the critical angle will pass through the surface as light leakage. Designers use this phenomenon by modifying surface roughness to cause light loss to illuminate a gauge or pointer.

Another, more common, method is to change the 3D geometry of the pointer so that the thickness of the pointer — its cross section at various points and the angles of its top, bottom and sides — varies in such a way as to promote

## THE PHYSICS OF LIGHTGUIDES

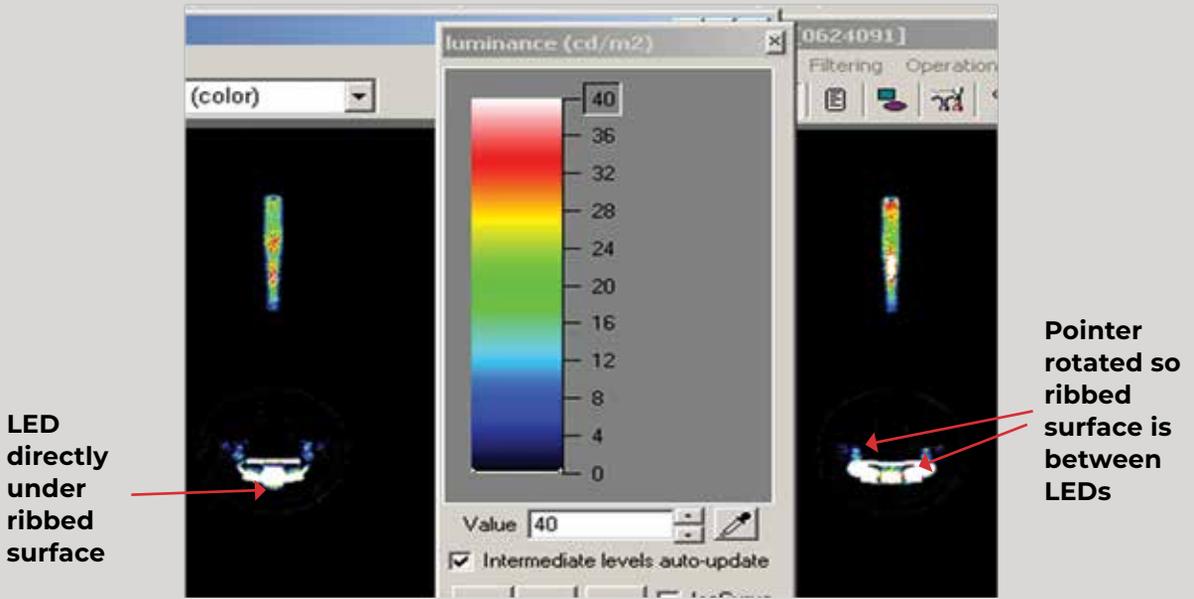
Lightguides use the principle of total internal reflection (TIR), which occurs when light propagating through a material strikes the internal boundary of the material at an angle greater than a critical angle. If the refractive index — a measure of the bending of a ray of light when passing from one medium into another — of the air outside the lightguide is lower than that of the material of which the lightguide is made, and the angle at which the light wave strikes the boundary is greater than the critical angle, the wave bounces off the surface like a mirror and is reflected internally.

If you are designing a lightguide for a subsea transatlantic cable to transmit large amounts of data over thousands of miles, maximizing the internal reflection is critical — you don't want to lose crucial information through the surface of the fiber optics cable along the way. Information in the form of light waves entering one end of the cable should exit the other end with no leakage in between.

But if you want to light up the pointer on a dashboard speedometer, you want the light to leak in a controlled manner to evenly illuminate the pointer. If the light was totally internally reflected, the pointer would not light up.



**A 3D model of the speedometer pointer (top) and the actual pointer**



The results of final simulations performed for two pointer positions: the LED at the edges (right) and the LED underneath the middle of the receiving portion of the pointer (left)

uniform loss of light through the top surface that will be visible to the driver.

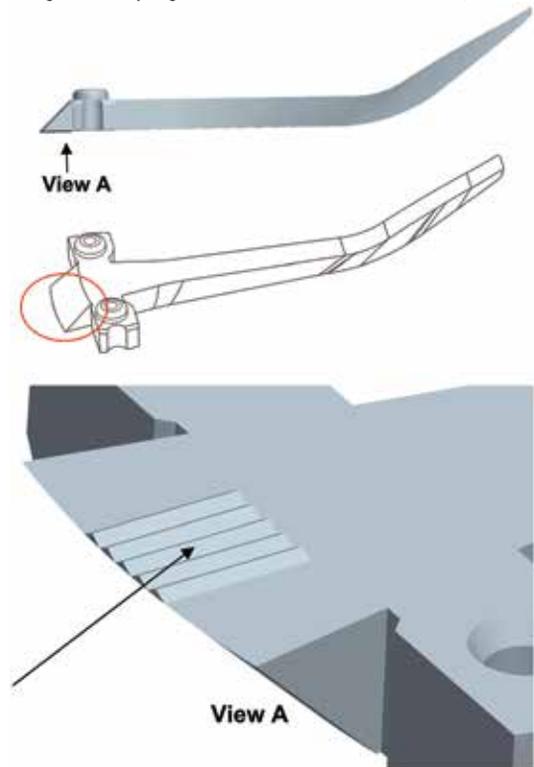
**SOLVING THE CHALLENGES OF A 45-DEGREE POINTER**

The abrupt change from 0 to 45 degrees over a small region in the proposed pointer was challenging enough that other companies turned the project down before illumination engineers at Continental decided to take it on. The main problem was a bright spot that appeared at the beginning of the bent area, as more light escaped through the extreme angle. Minimizing the brightness in that area was a primary goal.

In addition to the bend problem, a large number of pointer design parameters had to be optimized: the shape of the light housing dome, the shape and roughness of the receiving surface (the section of the pointer that receives the light, located at the beginning of the pointer in the center of the gauge above a set of LEDs), and the shapes of the reflecting surface and the bottom, top, left and right surfaces of the pointer. In most cases, two variables are used in achieving optimal illumination: the width of the bottom surface of the pointer and its slope.

Mechanical engineers at Continental created an initial geometry for the pointer, after which the illumination engineers imported it into SPEOS. The SPEOS software automatically created a mesh for the geometry. Then the illumination

engineers specified the optical properties of the materials and surfaces, taking advantage of the huge library of materials in SPEOS. In this case they chose polycarbonate as the material, with



Ansys SPEOS helped Continental determine that adding five ribs to the receiving surface would evenly distribute luminance, regardless of the pointer position.

surfaces polished to optical quality. Next, they specified the number of light rays, the location of an observer and the surface at which the observer is looking. Finally, they input the LED intensity — the light flux from LEDs — which depends on the amount of electrical current supplied to the LEDs. SPEOS simulated the luminance that the theoretical observer would see coming from the specified surface.

Running SPEOS simulations on the initial geometry revealed that the bright spot was still visible in the transition area from 0 to 45 degrees. The engineers took two approaches to resolve this. First, they changed the ratio of the top-to-bottom surface near the bend, with the larger top surface tapering into a truncated V shape at the bottom. The narrower the bottom surface, the less light that enters that area, resulting in less light loss, which minimizes the unwanted bright spot. In theory, the ideal shape at the bottom would be a point as at the bottom of a V, but manufacturability concerns dictated that the bottom width be at least 0.5 mm.

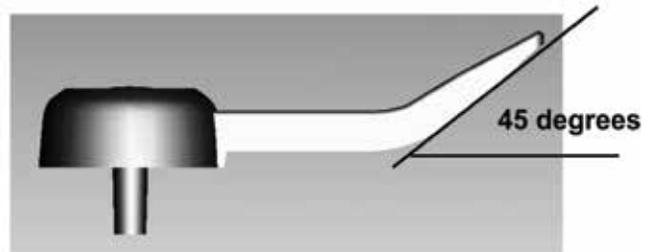
The second approach was to decrease the angle of the bottom surface of the pointer in the bend area. Even though the top slope was 45 degrees, the bottom slope, which is unseen by the driver, can curve more gently. As an approximation, if you assume all the light rays move horizontally, the larger the slope of the surface, the more that rays get reflected upward, so decreasing the slope would mean fewer rays being reflected upward, again minimizing the bright spot.

Furthermore, SPEOS indicated that adding a bump — a slight increase in thickness — on the top surface of the pointer just beyond the start of the bend would increase the percentage of vertically propagating rays experiencing total internal reflection, thereby reducing light loss in this area and minimizing the bright spot.

#### OPTIMIZING LED-POINTER POSITIONING

The receiving surface is a wide section at the base of the pointer that receives the light from an LED (or LEDs) underneath it. For this design, six LEDs were arranged on a circular base beneath the receiving surface.

Because the pointer, and therefore the receiving surface, changes its angular position as the pointer moves around the gauge — due to increasing or decreasing speed — the receiving surface is sometimes directly over an LED and sometimes between LEDs. As a result, the luminance distribution varied with pointer angle, an undesirable effect. The engineers decided to place vertical ribs on the underside of the receiving surface to redistribute the light reflected from the LEDs horizontally, thereby minimizing



**Designing a speedometer needle, or pointer, with a 45-degree angle to follow the bowl-shaped contour of a speedometer created lightguide illumination challenges that Continental used Ansys SPEOS to solve.**

the variance in luminance caused by the relative position of the receiving surface to the LEDs. Using SPEOS, they ran simulations in which they varied the number of ribs and their spacing, ultimately settling on five ribs placed 0.5 mm apart. This solution resulted in evenly distributed luminance independent of the pointer position; it also minimized the bright spot when the center of the receiving surface was on top of an LED.

#### THE VALUE OF SIMULATION

Continental engineers said they could not have been successful in designing the 3D angled pointer without SPEOS optical simulations. As mentioned, it took nearly 50 virtual iterations using SPEOS to solve the problems of pointer thickness and slope, as well as the LED-pointer orientation problem. Having to build 50 physical prototypes of the pointer would have consumed too much time and money to make the effort worthwhile. Besides, simulations produce more valuable data than physical tests can.

When Continental built a physical pointer prototype, its performance matched very closely with the SPEOS simulations, and their design of this fashionable analog speedometer went into production, making some classic automobile aficionados very happy. ▲

# Collaboration Supports Innovation

By Ansys Advantage Staff

As they apply optical simulation to their 3D prototypes, automotive lighting designers can better understand and optimize their concepts at a much earlier stage, working alongside optical engineers who share the same understanding.

**Ansys and Autodesk have joined forces to launch VRXPERIENCE Light Simulation, a new optical engineering solution that bridges a critical gap in customers' product development workflows. This type of value-added collaboration is the key to unlocking the full potential of today's advanced engineering technologies — and taking customer ROI to a new level.**

**T**he digitalization of the business world — and, in particular, the business of engineering — has equipped companies with a range of advanced technologies that solve critical functional and performance-related problems. From computer-aided design to multiphysics simulation, digitalization has delivered a range of smart, automated tools that have truly revolutionized the product development process, generating a huge return on investment (ROI) for customers.

While the first wave of the digital revolution focused on acquiring and leveraging solutions across the product development team, the

second wave focuses on maximizing that initial ROI via the tighter integration of those solutions.

"Individual processes have been optimized via tools such as simulation and virtual prototyping," explains Eric Bantegnie, vice president of the systems and platform business unit at Ansys. "Now it's time to drive increased value from those solutions by looking at the remaining sources of efficiencies. Increasingly, we're finding those at the integration points — the handoffs from one best-in-class tool to another."

Increasing the integration efficiencies of tools requires a new approach based on collaboration. A case in point: Recently, Ansys partnered



with Autodesk to address a key pain point for automotive lighting designers and engineers. The two companies have seamlessly integrated Autodesk VRED, a 3D visualization solution for studio designers, and Ansys VRXPERIENCE Light Simulation, a solution providing access to Ansys SPEOS physics-based lighting simulation, used by the optical engineers who bring automotive lighting design to life.

“In talking with customers, we realized that there was a lack of collaboration and communication between automotive lighting designers and optical engineers,” says Thomas Heermann, associate vice president, automotive and conceptual design, at Autodesk.

“Lighting designers would create these aesthetically beautiful concepts in Autodesk VRED,” continues Heermann. “Then they would hand them off for engineering and analysis in SPEOS, where the designs could be proven physically impractical, noncompliant or otherwise flawed. What followed was a lot of time-consuming, costly, iterative handoffs until the

aesthetic vision could be balanced with physics-based, practical considerations.”

In the old workflow, significant corrections were often required at a relatively late stage to adjust lighting designs for safety and regulatory compliance, as well as cost-effective production and manufacturability. Weeks or even months of tedious, back-and-forth design updates and engineering analysis might be needed to satisfy both the original design intent and physical considerations.

Even worse, process gaps meant that a new car model could be released with a lighting defect that was overlooked — resulting in a potential recall and significant damage to an automaker’s brand image and reputation. “Since the majority of the world’s automotive lighting teams use both Ansys and Autodesk solutions, this was not an isolated problem,” Bantegnie points out. “Instead, it was a pressing challenge that both technology providers recognized in talking with our customers. We realized we needed to create a more efficient, seamless and accurate engineering process for automotive lighting teams.”

#### **BALANCE LIGHTING FORM WITH FUNCTION**

Autodesk and Ansys partnered to address this customer need and add value for their shared customers. The resulting solution, VRXPERIENCE Light Simulation, brings the powerful capabilities of Ansys optical simulation into the design studio for the first time. From their earliest lighting concepts, automotive designers can test the physical soundness and practicality of their ideas — reducing design iterations to cut significant time and costs from the development cycle.

Equally important, the Ansys–Autodesk collaboration supports a new level of customer innovation, which is incredibly important in today’s global automotive industry.

“Lighting is increasingly an expression of both an automaker’s brand identity and its design aesthetic,” notes Heermann. “A number of



**Autodesk VRED 3D visualization software helps designers and engineers create product presentations, design reviews and virtual prototypes using interactive ray tracing and analytic render modes.**



**By bringing together Ansys and Autodesk solutions in a single, unified workflow, VRXPERIENCE Light Simulation bridges the gap between design and engineering by delivering engineering-grade light simulation to studio designers.**

studies have shown that lighting features — such as the shape of a car’s headlights — are a crucial part of the consumer’s purchasing decision. In the luxury market, ambient and dynamic interior lighting schemes are not an option today, but a requirement.”

“At the same time,” adds Bantegnie, “lighting has to provide the right level of illumination for safety and the right level of energy efficiency to meet regulatory standards. Our partnership is aimed at rapidly producing extreme lighting innovations that set our customers apart — but are also achievable and high-performing. Our goal is to balance form with function, quickly and cost-effectively, so our customers can deliver innovative designs to the market before their competitors.”

By leveraging VRXPERIENCE Light Simulation, automakers can make digital design trade-offs at an early stage, before the cost of rework escalates. They can explore emerging developments in materials, as well as optics technologies such as light guides, optical fibers, black panels and illuminated fabric. They can test the manufacturability and sustainability of their designs. They can create customized lighting configurations in a fraction of the time involved in traditional, iterative processes, which is critical as large-scale product customization becomes a goal of every industry.

“The world’s automakers are facing incredibly complex challenges as they develop next-generation product systems such as autonomous and electric vehicles,” Bantegnie remarks. “Disruption is constant, whether that means

emerging consumer needs, new materials, advanced manufacturing practices, or new regulations for safety or environmental impact. As technology providers and ecosystem partners, it’s incumbent on Ansys and Autodesk to identify new ways to add value and help address our automotive customers’ needs.”

#### **A CHALLENGING, BUT NECESSARY, CULTURAL CHANGE**

According to both Ansys and Autodesk, the technical challenges involved in integrating their solutions were fairly straightforward. Perhaps a bigger challenge was overcoming the cultural notion that the two companies should be competitors, not partners.

“When simulation and visualization were new concepts, it was easy to characterize our two businesses as rivals,” says Heermann. “But the reality is that we each produce highly specialized, best-in-class tools that occupy their own spaces in the product development process. To drive additional customer value, we need to complement each other’s capabilities and find common ground. We need to work together to identify and address the remaining inefficiencies in the end-to-end product development process.”

“Now that digitalization has delivered enormous benefits — and a huge ROI — via best-in-class solutions, the logical next step is to add new value by connecting those tools,” Bantegnie states. “To drive innovation, manage disruptions and accelerate responsiveness, the functional boundaries and process roadblocks need to be eliminated. The new level of collaboration we’re seeing between automotive lighting designers and optical engineers is a trend that needs to be encouraged across every industry and every product development team.” ▲



**VRXPERIENCE Light Simulation –  
Illuminate Your Design Infographic**  
[ansys.com/illuminate](https://ansys.com/illuminate)

# What's in a Name?

## When Polymers Are More Than Just "Plastic"

**Daniel Carmine Manocchio**  
 Material Technology Manager  
 Kärcher  
 Winnenden, Germany

### *Will a material by any other name still work as well?*

**A**ccurate information about materials is part of the foundation for high-quality, reliable products. But with naming conventions between different suppliers often inconsistent or incomplete, that's the kind of question manufacturers grapple with every day.

The problem is even more complicated for buyers of plastics; despite the industry's standardization efforts, similarly named grades from multiple polymer suppliers can have completely different material properties. This creates costly and time-consuming disruptions to the development process, including requiring additional testing. Yet without those tests, it becomes impossible to specify exact grades on R&D drawings, ensure that parts and products meet ISO and other standards, and comply with regulations.



**Kärcher uses Ansys GRANTA MI to store data from dynamic mechanical analysis. Lab equipment bends the sample with a high-frequency cycle while temperature changes from -100 to 100 degrees C.**

**The company's nine materials engineers and 400-member R&D staff are now saving the equivalent of at least 600 person-days per year searching for information.**



**The “K7” consumer class is a high-pressure cleaner with a water-cooled motor.**

For a small company, the issue is serious enough. But when your business involves approving and purchasing polymers from more than 100 materials suppliers, used in making 3,000 products, validating and managing materials properties data can be a convoluted and potentially unwieldy process.

That is why Kärcher, the market-leading manufacturer of residential and industrial cleaning equipment, uses Ansys GRANTA MI to consolidate and manage information about materials, as well as to store test data for materials and finished parts. The software, available within Ansys Mechanical and Ansys Electronics Desktop, provides easy, clickable access to materials property data and is most commonly used for design and simulation.

Beginning with 1.5 million data points, Kärcher's materials engineers used GRANTA MI to build comprehensive records about every polymer grade the company buys for 20 facilities worldwide. This has enabled them to compare and substitute materials more efficiently while reducing unnecessary or superfluous testing. Altogether, better materials intelligence has made Kärcher more agile, further solidifying its market position.

#### **FIFTY SHADES OF YELLOW**

All the factors that make a brand stand out rely on the right materials, batch after consistent batch. In Kärcher's case, that includes the distinctive yellow hue of its equipment.

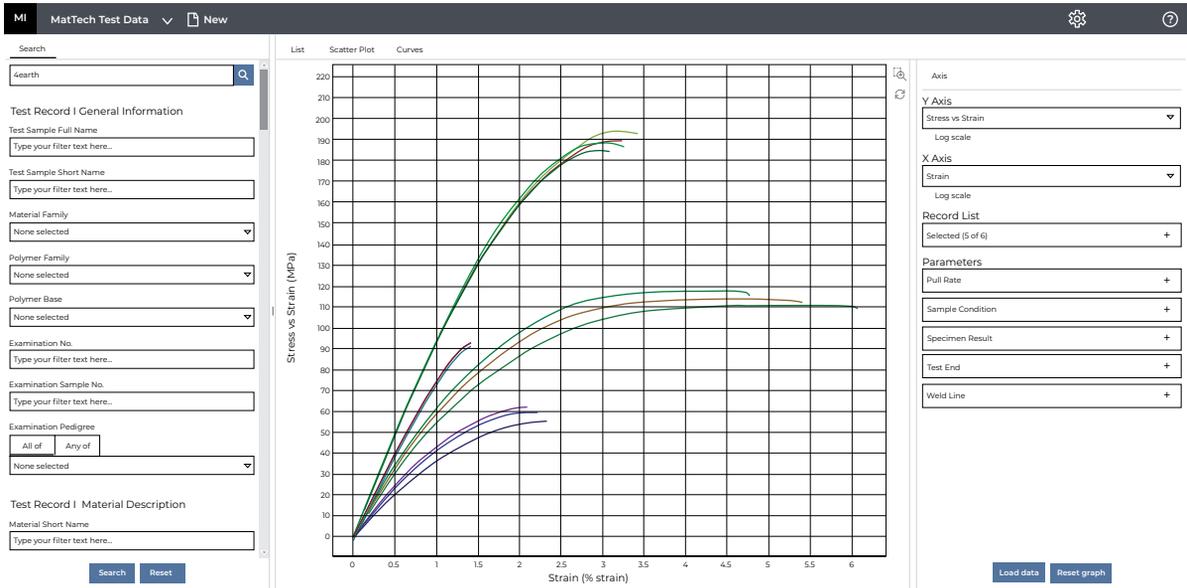
The suppliers who provide Kärcher's polymeric components can either buy the materials already tinted or can dye them before injection molding by adding color concentrate, a so-called masterbatch. Information about how the polymer was colored is usually represented by a code, but that detail is often left off material data sheets. Failure to provide the exact grade name can affect certification of the final part, and that can be a time-consuming and expensive problem to fix.

In the U.S., for example, the materials used in the electrical appliances Kärcher manufactures must be UL-listed, meaning they meet specifically designed requirements. Conforming to UL is no easy task, especially because the rules are stringent and complex. In some cases, UL listings are valid only if the polymer is colored by the original material producer. When a natural-colored polymer has been dyed with a masterbatch, its UL listing persists only if the masterbatch is also UL-listed for that polymer. Incomplete data sheets make it extremely difficult for Kärcher to conform to UL requirements without product certification tests that can delay time to market.

To overcome this issue, Kärcher engineers are storing UL listing information in each material record in GRANTA MI and linking records to one another. But that is not the only color-related data they are maintaining. GRANTA MI has also given them a way to benchmark approved colors from multiple suppliers and ensure precise color-matching. By storing the color measurements for color chips, test samples and final parts in the test records, then feeding that information into the material records, Kärcher teams can quickly determine if a color is matched correctly or not, and avoid winding up with 50 shades of yellow.

#### **TIME SPENT UPFRONT SAVES HUNDREDS OF HOURS**

Color information represents just a fraction of the 35 GB of data Kärcher stores in GRANTA MI. The company's database incorporates comprehensive material properties information, including tensile testing, hardness test results, elastomer testing, chemical analyses regarding hazardous substances, and more, and everything is interconnected and easily accessible. Among other benefits, this has



**Stress versus strain curves from tensile testing under different conditions, presented in Ansys GRANTA MI Explore.**

provided a sound framework for better, faster failure analysis; access to proper material definitions and all former examination reports saves Kärcher approximately 10% to 15% per case.

Implementing GRANTA MI was surprisingly efficient and straightforward, thanks to Ansys consulting, extremely deep training and the software's broad range of features. That's not to say the process wasn't time-consuming, however: It took roughly 250 person-days to build up the database and migrate 20 years' worth of legacy data into the system. But considering that the company's nine materials engineers and 400-member R&D staff are now saving the equivalent of at least 600 person-days per year searching for information — and are equipped to spend less time solving problems — those were hours well spent.

Fortunately, a year after installing GRANTA MI, Kärcher implemented Jira as a digitalization tool for internal workflows. This enabled the company to end paper ordering and begin semi-automated data entry. Interconnecting the lab, GRANTA MI and Jira means engineers can handle examination data and reports with little effort. In addition, there is greater consistency across the organization, and the risk of providing the wrong data by mistake is reduced to near zero. Results of tensile testing and chemical analyses regarding hazardous substances are automatically processed by an Excel script and then uploaded to GRANTA MI, while results of color measurements, aging experiments and information about retained samples are entered manually in script-assisted Excel templates.

### A SIMPLE, SCALABLE SOLUTION

In the two years since it was implemented in what might be described as an off-label application for a simulation product, GRANTA MI has proven to be a simple and scalable way for Kärcher engineers to manage materials properties data. Adding attributes and functionality is easy, and data can be structured according to users' needs. Kärcher's materials lab performs approximately 1,000 material examinations each year, and everything from the orders for testing to the data to the final report is now housed in one easily accessible location.

With Ansys GRANTA MI, Kärcher engineers have insight into everything materials related. And now they know exactly what is in each and every material, regardless of its name. ▲



**The Business Case for  
Material Intelligence**  
[ansys.com/grantami](https://ansys.com/grantami)

# Charge Up ISO Certification via **medini analyze**

LITHIUM BALANCE, a startup company based in Denmark, has used Ansys medini analyze to accelerate and streamline the ISO 26262 certification process for its battery management system (BMS) solutions. Because ISO certification is critical to supplying BMS products to global electric vehicle manufacturers, medini analyze represents a significant competitive advantage in an increasingly crowded marketplace.

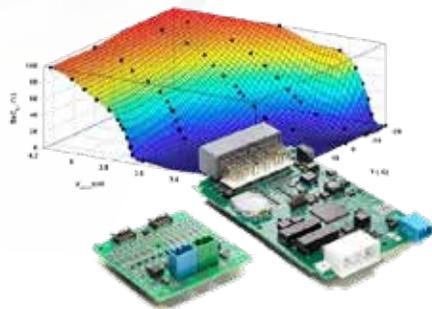
By **Ole Tidemann**,  
Functional Safety and ISO Certification  
26262 Manager, LITHIUM BALANCE A/S  
Smørum, Denmark

**L**ITHIUM BALANCE A/S was founded in 2006 with a straightforward goal: to provide the first genuinely effective, reliable battery management system (BMS) for the lithium ion batteries that power electric and hybrid automobiles.

Though this goal is straightforward, it is not simple. The BMS is a sophisticated control center that monitors and manages the charging, energy storage and daily operation of automotive batteries. In the event of any disruption or failure — such as overheating — the BMS must act intelligently to shut down the battery, while ensuring that the safe operation of the vehicle is not affected.

**The LITHIUM BALANCE BMS, including an indication of how the battery capacity (state of charge) is automatically calibrated.**

Obviously, the BMS is crucial to the functional safety of the entire vehicle, which means that solutions from LITHIUM BALANCE must meet the stringent demands of ISO 26262 to be sold broadly into the global automotive marketplace. While LITHIUM BALANCE has delivered more than 800 BMS solutions to customers and won awards for innovation, its ISO 26262 certification will open much larger sales opportunities for the startup business.





### **POWERING THROUGH THE COMPLEXITIES OF CERTIFICATION**

As any supplier to the global automotive industry knows, achieving ISO certification is a complex process that can take years. It requires extensive verification and documentation. With the pressure placed on automakers to introduce electric and hybrid vehicles quickly — to meet both government standards and consumer demand for greener alternatives — the LITHIUM BALANCE engineering team needed to minimize the time involved in gaining ISO certification. The company's success depends not only on developing safe, verified BMS solutions, but in launching them as quickly as possible.

In 2017, the functional safety team at LITHIUM BALANCE began using Ansys medini analyze to accelerate and streamline the process of ISO certification. An easy-to-use, model-based tool, medini analyze helps LITHIUM BALANCE identify battery failure rates and mechanisms across thousands of operating scenarios, then document how the BMS will respond to each of these events.

Deep analytic capabilities offered by medini analyze verify that there will be an appropriate response to every foreseeable battery failure. The

result? A clear, visual demonstration that BMS solutions from LITHIUM BALANCE are verified for functional safety under virtually every operating scenario. ISO reviewers have already given LITHIUM BALANCE positive feedback about the company's use of medini analyze to submit the required proof of functional safety and obtain approvals.

The rigor of the analysis and documentation process in medini analyze has proven invaluable not just in achieving ISO certification, but in making sales to customers who need verification of a specific BMS solution's safe performance. Medini analyze offers clear visibility into the functional safety analysis process at LITHIUM BALANCE, and its technical breadth and depth have been a key selling point with customers to date.

### **SAVING ENERGY, TIME AND COSTS**

Prior to using medini analyze, the functional safety team at LITHIUM BALANCE was adapting Excel spreadsheets to the task, a common practice in the worldwide auto industry. This process was not only time-consuming, but it also involved significant manual labor and was prone to human error.

Because medini analyze is an automated tool designed specifically for documentation, it has resulted in greater accuracy while enabling LITHIUM BALANCE to identify any functional safety shortfalls at a very early stage of BMS design.

Any issues flagged by medini analyze can be quickly addressed by the engineering team, then the modeling can be repeated — resulting in a closed loop of continually enhanced functional safety. For instance, if the failure rate of a single BMS component is improved, it is reflected automatically and universally by medini analyze. Any design updates that impact functional safety are made and reflected easily. This level of flexibility and agility is essential in supporting



**BMS system testing at LITHIUM BALANCE**



### The latest ISO 26262-certified BMS generation from LITHIUM BALANCE

LITHIUM BALANCE's commitment to product innovation.

In addition, because many of LITHIUM BALANCE's BMS designs are customer-specific, yet built on a common product platform, medini analyze offers a flexible, accessible repository of functional safety data that can be customized for each new BMS product iteration.

Functional safety team members have been able to easily master this intuitive solution, resulting in rapid adoption of medini analyze at LITHIUM BALANCE. The company has been able to minimize the human resources devoted to the complex process of ISO certification, allowing team members to devote their time to more strategic engineering work.

Perhaps the most significant benefit in today's crowded automotive market is the speed at which LITHIUM BALANCE has been able to accomplish the complicated modeling, verification and documentation work involved in gaining ISO certification.

Not only does the company need to build and test fewer physical prototypes, but medini analyze efficiently manages the challenging administrative requirements involved in ISO certification. As just one example, there are approximately 80 functional safety documents required for automotive industry certification. For the 20 most mission-critical documents, involving deep analysis, medini analyze has cut the delivery time by 50% — a tremendous advantage.

#### DRIVING TOWARD A CRUCIAL MILESTONE

LITHIUM BALANCE earned its ISO certification in July, marking a strategically important milestone that places the company on equal footing with much larger, more established businesses that are supplying BMS products to the global marketplace. In addition, by establishing the organization's functional safety leadership, ISO certification positions LITHIUM BALANCE to

develop BMS solutions for new markets and applications, including drones, robots and industrial equipment.

Just as BMS solutions from LITHIUM BALANCE are known for their innovative technology and high performance, the company's product development team routinely leverages the most advanced, highest-performing engineering technologies, including simulation via Ansys solutions. Because medini analyze manages and automates the process of compliance, industry certification is engineered into the company's BMS solutions from the earliest stages of design — supporting LITHIUM BALANCE's leadership in the area of functional safety.



#### Assembly of battery sub-modules at LITHIUM BALANCE

In the global automotive industry, there is no measure more important than safety. Backed by the capabilities of medini analyze, LITHIUM BALANCE can offer both customers and ISO certification managers numerical, quantitative proof that its BMS solutions will perform reliably and safely under a range of operating parameters. This advantage is proving priceless as LITHIUM BALANCE works to gain a leadership position in supplying cutting-edge battery management systems to the world's automakers. ▲

# Simulation in the News

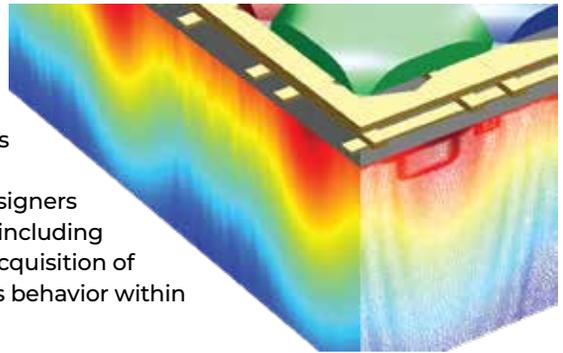


## Ansys Acquires Photonic Simulation Leader Lumerical Electro Optics

Electro Optics, April 2020

Ansys has entered into a definitive agreement to acquire Lumerical Inc., a developer of photonic design and simulation tools. The acquisition will add best-in-class photonics products to the Ansys multiphysics portfolio, providing customers with a full set of solutions to solve their next-generation product challenges.

Lumerical's photonic simulation products enable designers to model the most challenging problems in photonics, including interacting optical, electrical and thermal effects. The acquisition of Lumerical is enabling Ansys customers to predict light's behavior within complex photonic structures and systems.



### Samsung Foundry Certifies Ansys RaptorH

April 2020

The certification enables Ansys to help Samsung designers and Samsung Foundry customers more accurately analyze and mitigate risks from electromagnetic (EM) effects when adopting Samsung's new signoff flow — significantly expediting the advancement of artificial intelligence, high-performance computing and 5G semiconductor designs.

### Ansys RedHawk-SC Achieves Certification on All TSMC Advanced Process Technologies

May 2020

Ansys achieved certification for its next-generation system-on-chip (SoC) power noise signoff platform for all TSMC's advanced process technologies. This helps mutual customers verify the power requirements and reliability of the world's largest chips for artificial intelligence, machine learning, 5G mobile and high-performance computing (HPC) applications.

### Ansys Named a 2020 Women on Boards Winning Company

Barron's, March 2020

Ansys has been recognized by 2020 Women on Boards as a Winning "W" Company for having 20% or more board seats held by women. This is the first year Ansys has been recognized by 2020 Women on Boards for board diversity. 2020 Women on Boards is a nonprofit grassroots campaign committed to increasing the percentage of women who serve on company boards to 20% or greater by 2020. Nearly one-fourth of public companies in the U.S. have no female directors on their boards. Ansys' nine-member board includes three women.

### U.S. Army Leverages Ansys, L3Harris Software

Avionics International, March 2020

Under a cooperative research and development agreement, Ansys and L3Harris Technologies are working with the U.S. Army Combat Capabilities Development Command (CCDC) Aviation & Missile Center (AvMC) to advance the use of the Future Airborne Capabilities Environment (FACE) technical standard in military cockpit displays.

# Enter the “Art of Simulation” Competition

June 2020

To help commemorate its 50th anniversary, Ansys is celebrating the achievements of its customers and student community with the inaugural Art of Simulation image competition. Ansys users are invited to submit designs created with Ansys simulation solutions in 16 categories. A panel of Ansys judges will choose the top 10 entries in each category to compete in the semifinals, where Ansys users worldwide will evaluate the entries. The winning images will be showcased on the Ansys website, News Center and social channels. They may also be featured in upcoming Ansys digital campaigns and in Ansys publications. Winners will receive a trophy that honors their accomplishment and a digital badge. Simulations captured as high-resolution images may be submitted until Oct. 2, 2020, at 5 p.m. EDT. For more information, visit [ansys.com/artofsim](https://ansys.com/artofsim).



The aim of the two-year Cooperative Research and Development Agreement (CRADA) is to use L3Harris Technologies and Ansys-developed software aligned to FACE Technical Standard hosted on a Crew Mission System (CMS) platform for a next-generation cockpit display station. Through the CRADA, Ansys will supply its SCADE software toolset while L3Harris is making its FliteScene digital moving map software available for research and development.

## EDF Group to Collaborate with Ansys on Low-Carbon Power Generation Technology

Chief Sustainability Officer, *March 2020*

EDF will be using Ansys' suite of solutions in the design of state-of-the-art nuclear power stations, which will allow paradigm-shifting ultra-efficient power output. The Company will use Ansys' multiphysics solutions, which allow the user to simulate the real-world functionality and possible restrictions/interactions of a complex system in its natural environment.

## Slashing Avionics Software Development Time by Over 50%

Digital Engineering, *March 2020*

Physical Optics Corporation (POC) is using Ansys simulation software solutions to develop avionics for U.S. military aircraft. Ansys SCADE Solutions for ARINC 661 Applications will enable POC to reduce development time and accelerate certification. U.S. Department of Defense legacy aircraft equipped with aging avionics and controls require costly upgrades to

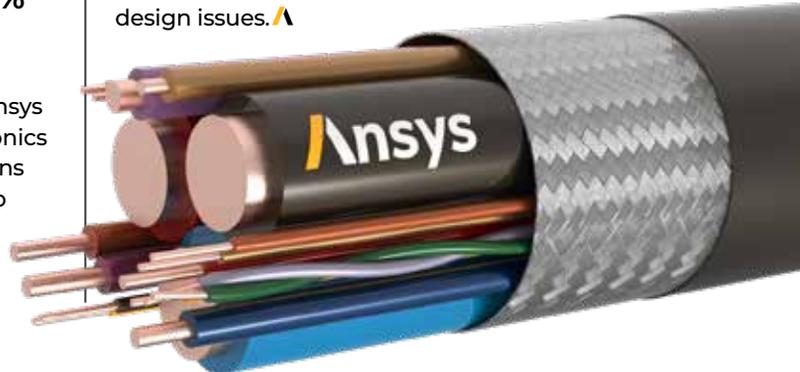
add new capabilities. As avionics software becomes increasingly sophisticated, complying with complex requirements, satisfying safety standards and reducing costs present major development challenges.

Ansys SCADE for ARINC 661 provides model-based software development and automatic qualified code generation to quickly create and certify avionics software. Development time can be greatly reduced while adhering to ARINC 661, DO-178C and the FACE Technical Standard.

## Ansys and Electro Magnetic Applications Partner on Cable Harness Workflow

June 2020

Electro Magnetic Applications, Inc. (EMA) and Ansys are partnering to deliver an enhanced design-to-validation workflow for certifying cable harness models in aircraft and automobiles. The workflow greatly reduces electromagnetic interference (EMI) risks to cable harnesses, slashes development time, speeds certification and expedites new products to market faster than ever. EMA and Ansys' new workflow, Ansys EMA3D Cable, is a platform-level EMC cable modeling solution for overcoming EMC design issues. 



ANSYS

THE ART OF

SIMULATION

COMPETITION 2020



**SHOWCASE YOUR SIMULATION  
SUPERPOWER!**

## FOUR EASY STEPS TO ENTER

### 1 SIMULATE

Create a simulation in one of  
16 categories

### 2 EXPORT

Export a high-resolution  
photo for your entry

### 3 SUBMIT

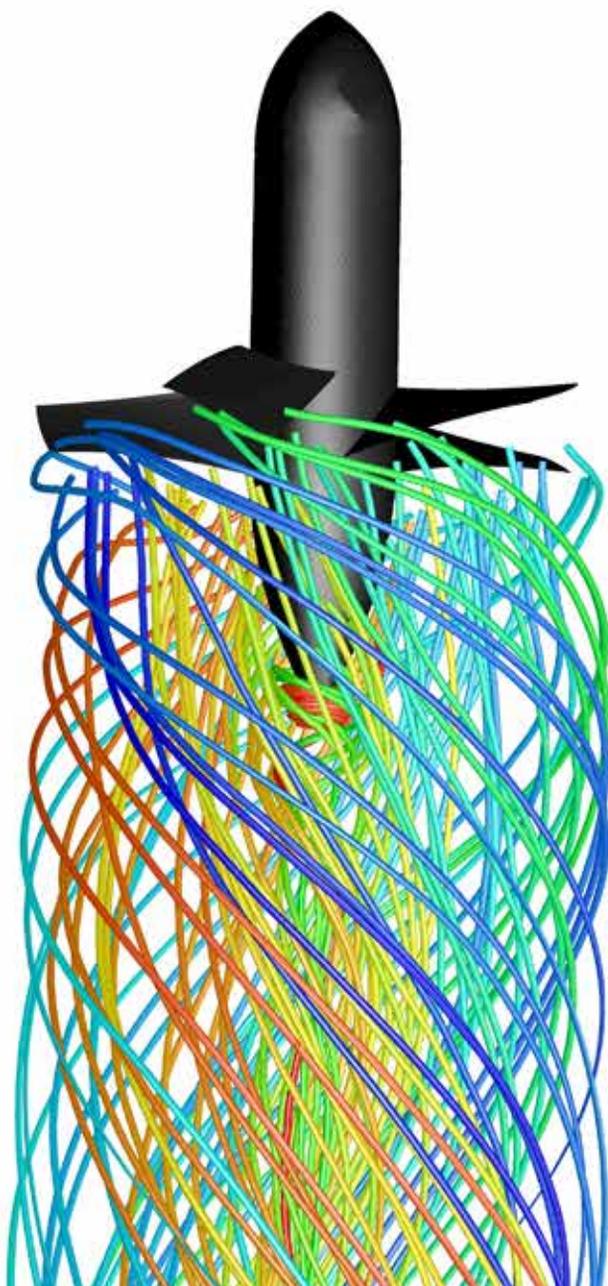
Submit your entry before  
**October 2, 2020** at 5 p.m. EDT

### 4 VOTE

Vote on the top simulation  
images from each category

**16 winners** (one for each category) will  
be determined by **November 13, 2020**.

Full Rules and Entry Form at  
[ansys.com/artofsim](https://www.ansys.com/artofsim)





**Ansys**

**ACCELERATE  
INNOVATION**

**ANSYS 2020 R2 ENHANCEMENTS  
SPEED UP COLLABORATIVE DESIGN  
AND EXPEDITE PRODUCT DELIVERY**

- Virtual Desktop Infrastructure Support in Ansys Cloud
- Digital Twin Updates for Remote Monitoring and Predictive Maintenance
- Design and Develop Autonomous Vehicle Embedded Software
- New Thermal and Vibration Analysis Coupled with Electromagnetic Field Simulation Software to Support Electrification
- Advanced Phased Array Antenna Analysis to Advance 5G and Integrated Circuits
- Integrated Circuit, Package and Board Workflows for More Complex Electronics

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**2020/R2**