Ansys

ADVANTAGE

EXCELLENCE IN ENGINEERING SIMULATION

ISSUE 2 / 2021

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Simulation World 2021:
There's Still Time to See What You Missed

With more than 200 sessions, countless attendee networking opportunities, exhibitor booth visits and a fully interactive Smart City to explore in the span of a few days, it's impossible for you to have experienced everything Simulation World 2021 had to offer. But you don't have to miss out on the 65+ hours of content from Simulation World. Much of it is available on demand for a limited time.

Don't know where to begin? Start by registering for Simulation World on demand at simulationworld.com to catch these eight elite sessions that were among the most well attended.

EIGHT GREAT ON-DEMAND PRESENTATIONS

/ **1.** In his ***Opening Keynote***, Ajei Gopal, Ansys president and CEO, outlines how engineers across industries are driving an economic recovery by delivering innovations in electrification, 5G and telecommunications, the Industrial Internet of Things (IIoT), and autonomy. Using real-world examples, Gopal shows how engineering leaders are driving top-line growth and bottom-line savings by using simulation as their superpower.

/ **2.** Ferdinando Cannizzo, head of GT Racing Car Design & Development, Ferrari Competizioni GT, explains how their engineers optimize aerodynamics quickly — increasing their engineering productivity by 300% — to get vehicle design innovations on the track before the competition. Check out the ***Ferrari: Innovating & Winning with Ansys Simulation Technology*** session to learn more.

/ **3.** In the ***CTO Roundtable: Digital Twin*** session, Ansys CTO Prith Banerjee is joined by Sam George, corporate VP of Azure IoT, Microsoft; Donato Matinez Perez de Rojas, group CTO, Navantia; Tauseef Salma, group CTO, Flowserve; and Hakan Yilmaz, CTO, Aerospace, Honeywell, to discuss the benefits of digital twins, implementation challenges, and how those challenges are already being met.

/ **4.** Carol Erikson, VP of engineering, Space Systems at Northrop Grumman, presented ***5 "Megatrends" That Will Have the Biggest Impact on the Simulation Industry.*** No spoliers here. You'll have to register for Simulation World to hear this preeminent engineer's predictions.

/ **5.** In ***Simulate Mighty Things - How Simulation Helps JPL to Expand the Frontier of Space Exploration***, Larry James, Lt. Gen. USAF (Retired), deputy director, NASA Jet Propulsion Laboratory, gives you a behind-the-scenes look at how NASA/JPL uses simulation to remain at the forefront of robotic space exploration.

/ **6.** Watch Tier 1 automotive supplier Marelli's Hardware Engineering Manager Fabio Alpiovezza and CAE Manager R&D Francesco Lelli show how they use simulation to accelerate development in the ***Design and Optimization of Electric Powertrains with Ansys*** session.

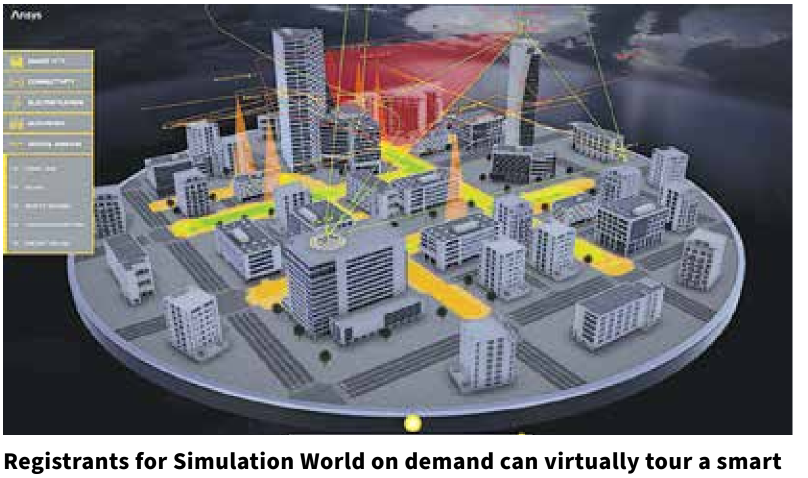
/ **7.** In the ***Application of Ansys Fluent for Optimization of Non-Newtonian Fluid Flow Through a Slot Die for Battery Manufacturing*** session, Battery Engineer Xuechun Qian explains how Panasonic Energy of North America uses simulation to maximize battery cell production at the Tesla Gigafactory.

/ **8.** And, finally, learn how Aditya Dubey, mechanical developer, Siemens, estimates fracture mechanics by watching ***3D Crack Propagation Simulation Using Ansys S.M.A.R.T FM Tool on Large Gas Turbine Casing Components***.

MUCH MORE AVAILABLE

The sessions above are just a small sampling of what is available to Simulation World registrants. In addition to the 200+ sessions across a dozen different tracks, you can access a fully interactive Smart City to see how simulation technologies are at the heart of the most disruptive innovations and visit our exhibitors' virtual trade booths.

Join tens of thousands of your colleagues who already registered to attend. The virtual conference will be available on demand for a limited time, so take advantage of this digital format to be informed and inspried at your convenience — no plane ticket, hotel or registration fee required. Register for Simulation World on demand at simulationworld.com.



Registrants for Simulation World on demand can virtually tour a smart city and experience how simulation enables innovation.

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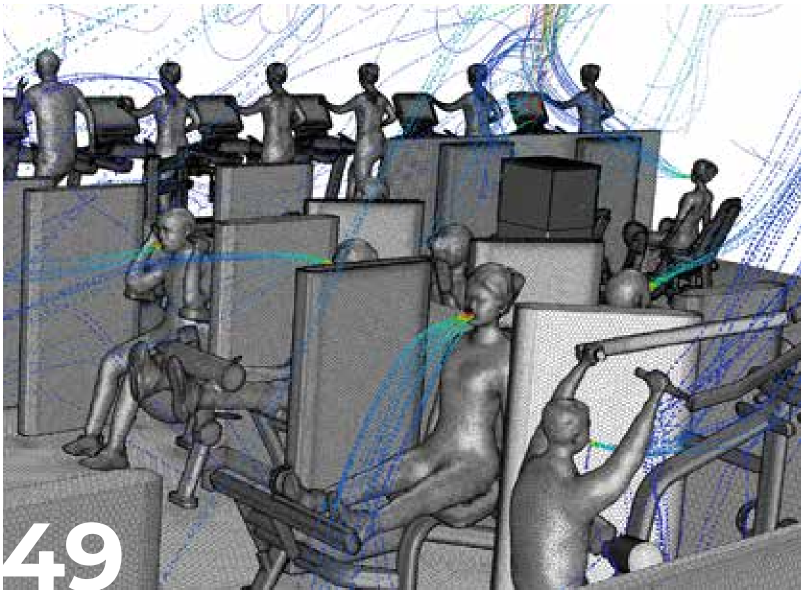

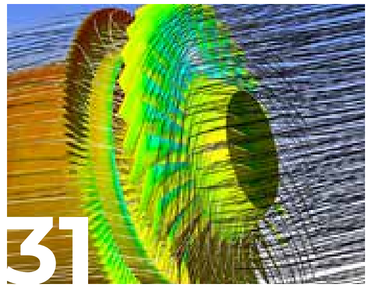

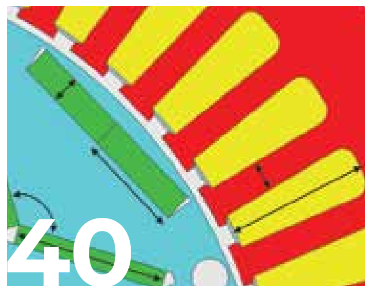

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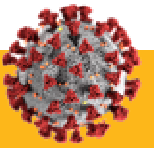

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ADVANTAGE

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

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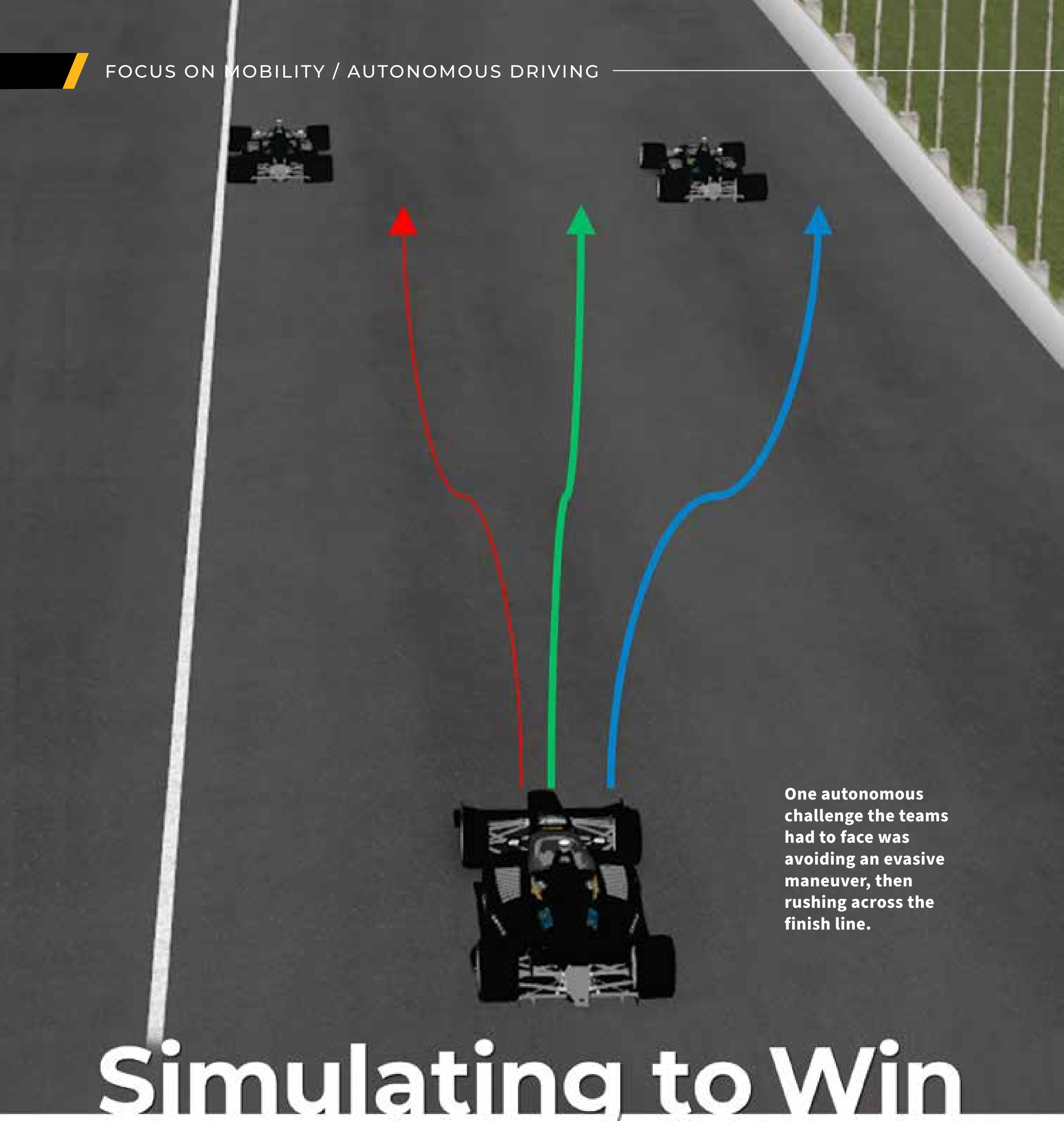
If you've ever seen a rocket launch, flown on an airplane, driven a car, used a computer, touched a mobile device, crossed a bridge, or put on wearable technology, chances are you've used a product where Ansys software played a critical role in its creation.

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



One autonomous challenge the teams had to face was avoiding an evasive maneuver, then rushing across the finish line.

Simulating to Win
the Indy Autonomous Challenge

By Ansys Advantage Staff

On June 30, 2021, autonomous Indy Cars will race around the Indianapolis Motor Speedway at speeds of up to 180 mph, making history as the first high-speed driverless race. As the exclusive simulation sponsor for the Indy Autonomous Challenge (IAC), Ansys has supplied 485 students on 40 teams from universities around the world with Ansys SCADE software to generate the embedded control code that will guide the autonomous vehicles on the course. The teams also have access to Ansys VRXPERIENCE, which they can use as a virtual reality driving simulator to test their embedded software in a safe virtual space before putting real race cars on the track. The winner will receive a $1 million prize and bragging rights as the first autonomous racing champion in the world.

> ***"We looked at learning the Ansys simulation environment as a challenge, but an interesting one. We didn't back off and we tried to get the best from it. SCADE and VRXPERIENCE are very powerful, very interesting tools."***

To help these teams get ready for the IAC, Ansys has held a series of "hackathons." These hackathons are designed to show the engineers how to use simulation to design autonomous control code and test it in scenarios of gradually increasing difficulty using virtual cars racing on a virtual model of the Indianapolis Motor Speedway.

"The IAC is a test bed for developing autonomous technology and the brain power that goes into it," says Tarun Tejpal, Ansys' industry marketing director for transportation. "An autonomous race car is basically a supercomputer on wheels. The teams have to optimize that supercomputer and the only way you can do that is with Ansys simulation technology." He notes that the hardware and software have been coming together over the last decade to bring autonomous driving closer to reality. "Now it's just a matter of human ingenuity," he says. "By putting these student teams in a competitive situation, they will exponentially innovate the autonomous technology that will eventually be used in commercial automobiles."

Teams have been making great progress to date as evidenced by their performance at the hackathons. To give you an idea about what the journey has been like for one team, we talked to Gianluca Papa and Filippo Parravicini, both Ph.D. candidates from the poliMOVE team from Politecnico di Milano, Italy, about their experiences with the IAC. They have 30 members, including doctorate and master's degree candidates, most of whom have automation and control engineering backgrounds, together with a few students from the mathematics, aerospace, mechanical engineering and computer science departments. Oh, and don't forget their advisor, Prof. Sergio Matteo Savaresi, who was "super enthusiastic" about the project from the start, according to Papa and Parravicini.

THE HACKATHONS

Hackathon #1

At the first hackathon held last year, Ansys simulation experts introduced the teams to Ansys SCADE and Ansys VRXPERIENCE. The experts taught them how to use the software to begin developing embedded code to guide their virtual autonomous cars around a high-fidelity model of the Indianapolis Motor Speedway.

"We have a pretty strong background in vehicle dynamics control, but this was our first experience with autonomous racing. So, we were starting basically from scratch," says Parravicini. "We looked at

Renderings representing different camera views around an Indy Autonomous Challenge race car.

learning the Ansys simulation environment as a challenge, but an interesting one. We didn't back off and we tried to get the best from it. SCADE and VRXPERIENCE are very powerful, very interesting tools."

Hackathon #2

During the second hackathon in September 2020, the teams were expected to demonstrate their virtual race car driving on the Indy track, powered by SCADE embedded software. In the first heat, each team occupied the race track alone and tried to post the fastest lap. In the second heat, two other race cars were placed on the track in front of the team's car and they had to try to pass without crashing while still posting a fast time.

Achieving the fastest lap requires a team that can find the best line around the racecourse. In the event, some teams seemed to wander slowly back and forth between the inner boundary of the track and the outer wall, staying within the boundaries all the time but sacrificing speed to do so. A couple cars made unexpected excursions into the infield of the track or crashed into the wall, disqualifying them from this hackathon with a DNF (Did Not Finish) result.

In the first heat, involving 21 cars, the poliMOVE car hugged the inside line of the racecourse as close as possible throughout the whole race, leading to a first place finish in a time of 1:14:75, just beating out the Crimson Autonomous Racing (University of Alabama) and the Black & Gold (Purdue University and West Point) racing teams who tied for second place at 1:14:85.

"What we're looking for is the minimum lap time trajectory," Papa says, explaining the team's strategy. "It doesn't matter for us if it's the shortest path. If there's a longer one but with a higher speed, we take that path. In the VRXPERIENCE driving simulator, we try to iterate our work and find the optimal trajectory. Our goal is to do our best in every lap, at every time, in every situation."

In the second heat, involving 18 cars, most teams opted to pass the two cars in front of them on the outside, with a couple passing between the two cars and a couple taking a low line under both of the cars. One team crashed into a lead car when trying to pass. This heat was conducted on the straightaway between the second and third turns of the Motorway, a much shorter run than the first heat.

Team poliMOVE passed between the two cars and registered a time of 13:850, which put them in a tie for first place with eight other teams in the second heat. Their combined performance in both heats — 50 points for first place in each — gave them a perfect score of 100 for the day, making them the winners of Hackathon #2.

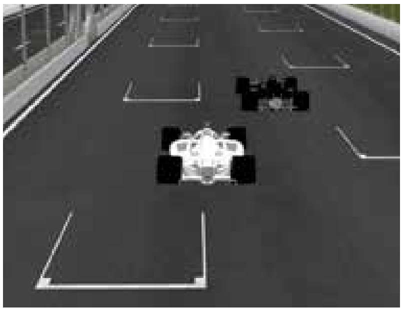
Hackathon #3

By the time of this hackathon on January 21, poliMOVE was looking like the team to beat, with several teams close behind them. This time the teams would be competing head-to-head, two at a time on the same course, so the task was more complex: finding the best line while avoiding an encounter with the other car.

In preparation for this hackathon, the poliMOVE team increased the number of simulations they ran. In the process, besides enjoying the ease of using SCADE's graphical interface to develop embedded code in a blockwise manner, poliMOVE engineers found another feature they liked best.

"You have the ability to include entire pieces of C code inside your main scheme in SCADE," says Parravicini. "This is one of the things that we are exploiting the most to give us more control over the autonomous performance of our race car."

“When you’re done with your development process with SCADE, you have an executable file and you run it. You make it talk to VRXPERIENCE, you see the results, you analyze your data and then you go back to SCADE.”



SCADE generates C code from a block diagram, including any custom blocks poliMOVE engineers might create. “When you’re done with your development process with SCADE, you have an executable file and you run it. You make it talk to VRXPERIENCE, you see the results, you analyze your data and then you go back to SCADE.” Papa says.

All these iterations paid off again in the hackathon. This time, each of the 18 teams that competed was paired with another for a set of two head-to-head heats, which required them to complete five laps without incident while staying within the boundaries of the track. poliMOVE drew TUM Autonomous Motorsports from the Technical University of Munich as their opponent.

In the first heat, poliMOVE set the record for the fastest lap of the entire competition, with a time of 46:384 on laps 2, 3 and 4 to beat TUM. In the second heat, TUM made an aggressive, track-crossing maneuver in front of poliMOVE at the start of lap one, which caused the poliMOVE car to slow down to avoid a collision. Though they again beat TUM, the loss of time in the first lap caused poliMOVE to finish second in Hackathon #3 to Crimson Autonomous Racing of the University of Alabama.

“If you look at Hackathon #3, you can see that, in general, we are quite aggressive, and we are always looking for the optimal line,” says Papa. “We are not afraid of potential interaction and potential overtakes. I don’t know if this is the winning solution — only time will tell.”

“But if something dangerous is happening, this second heat showed that we slowed down to avoid that situation, and we always try to do that in the optimal way,” Parravicini notes. “You always have a compromise between performance and safety. But, in the end, you have to try to win, right?”

AUTONOMOUS CHALLENGES AHEAD

Though they are certainly happy with their performance so far in the IAC virtual events, Papa and Parravicini know that the biggest challenges are up ahead for all the teams. The teams will be given the keys to a real race car in June, and they will have to transfer their software from the virtual world to the real one. The poliMOVE team will send a small group over to the United States to start testing the software on an actual race car. They will have a lot of work to do.

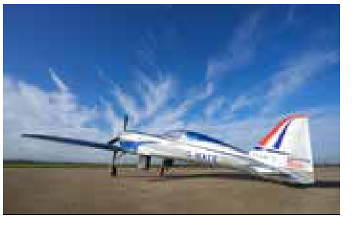
“The current simulation environment using virtual cars on a virtual track is valuable, but it is clearly skipping the perception part of the autonomous racing challenge,” says Parravicini. “In the virtual races, you have very nice sensors that very nicely tell you exactly where the opponents are, their speed and their orientation. When you get to the real car, of course, there’s a whole different situation. You have to understand how all the sensors are working. You have to understand and take into account all of the possible non-idealities of the sensors’ operation and then try to fuse all of the information and get the best from each sensor to obtain the best possible estimation of what’s happening around you.”

Given all that, will they be able to win the IAC? “That,” says Parravicini, “is the million-dollar question.”

The Sky's the Limit

By **Douglas Campbell,** Technical Director, Electroflight, Gloucestershire, UK

Together, Rolls-Royce and Electroflight are ushering in the third age of aviation, with an all-electric aircraft capable of speeds exceeding 300 mph. A primary challenge is optimizing the 1,047-pound (475 kg) battery pack for structural strength, thermal management and other critical performance criteria. As the team raced to introduce the world's fastest zero-emissions aircraft, multiphysics simulation, via Ansys, played a crucial role by accelerating battery development and verification.



Rolls-Royce is an aviation pioneer, but the company is focused on the future with an innovative all-electric aircraft. If propeller planes and jets represented the first two ages of aviation, then the third age is certainly focused on sustainable design and zero emissions.

Developed as part of Roll-Royce's ACCEL initiative — which stands for Accelerating the Electrification of Flight — later thei year, the aircraft will attempt to shatter the existing 210-mph speed record for an all-electric design. The airframe has already reached speeds of over 300 mph, fitted with a traditional internal combustion engine, so the ACCEL team has high hopes. Just as impressive as the aircraft's speed is its range. It is capable of making the 200-mile trip from London to Paris on a single battery charge. In addition, a further objective for both the Rolls-Royce and Electroflight teams was to track and document the sustainability for the overall project, which they are proud to have offset, to make the project net zero emissions.

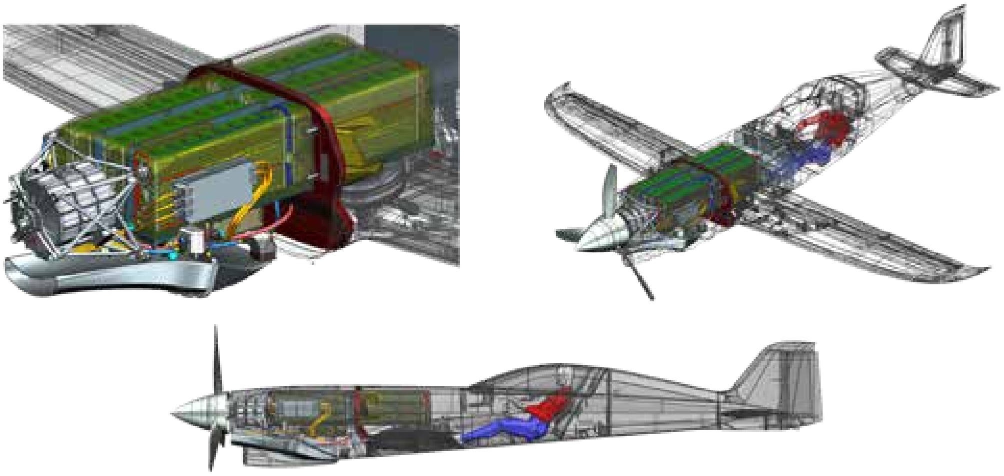
"A BATTERY WITH WINGS"

Energy-storage performance at this level requires novel engineering approaches and revolutionary battery design. Instead of relying on in-house resources, Rolls-Royce turned to Electroflight, a Gloucestershire, UK, startup that develops high reliability energy storage solutions for aerospace electrification applications.

The resulting lithium-ion battery pack incorporates three separate battery assemblies that provide electricity to three high-power electric motors, developed by Oxford-based YASA, a manufacturer of lightweight electric motors and controllers. Based on a proprietary axial-flux design, YASA has been able to deliver a small, lightweight engine configuration that produces more than 500 hp, to support the aircraft's record-breaking speeds.

While a lightweight engine design may be achievable, even the most power-dense lithium-ion batteries are — by necessity — heavy. With more than 6,000 battery cells and an impressive 90% energy efficiency, the battery assembly, designed by Electroflight, produces enough energy to power 250 homes. It also weighs in at 1,047 pounds (475 kg) and commands a great deal of space in the aircraft's fuselage — leading some observers to call the aircraft "a battery with wings."

The battery's size and weight might be viewed as disadvantages, but Rolls-Royce and Electroflight capitalized on these features by leveraging the battery pack as a key structural element for the one-seater aircraft. This meant the airframe and the battery pack had to be optimized simultaneously to ensure that both elements were integrated to balance energy and propulsion with lift.



Due to its size and weight, the battery assembly functions as a critical structural element in the one-seater aircraft's relatively small fuselage. That means balancing energy performance with mechanical considerations such as stiffness and resonance, along with sustainability.

“Energy-storage performance at this level requires novel engineering approaches and revolutionary battery design. Instead of relying on in-house resources, Rolls-Royce turned to Electroflight.”

Another potential downside of the battery pack? The well-documented thermal effects of lithium-ion batteries. To manage the battery packs’ natural propensity to generate heat, Electroflight engineers designed an innovative cooling system that pumps a liquid coolant mixture, composed of water and glycol, through plates between the batteries. Thermal loads are managed as the lithium-ion cells contact the cooling plate, even during the high-power demands of the aircraft performance.

Electroflight’s advanced battery management system gathers thousands of data points per second, providing the pilots with the information needed to extract maximum performance from the battery system when making record attempts. With safety in mind, the Electroflight team engineered the aircraft to land safely with just a single battery pack in operation.

DESIGN ACCELERATION VIA SIMULATION

To model and solve many of the advanced challenges involved in the battery assembly’s design, Electroflight relied on a suite of Ansys simulation solutions, including Ansys Mechanical, Ansys Discovery, Ansys Fluent and Ansys Granta Materials Selector. Engineering simulation helped the Electroflight team address three critical issues: materials selection, structural integrity and balanced cooling.

With the battery pack’s sheer size, relative to the aircraft itself, Electroflight concluded that the pack needed to be a structural member for the small craft, transferring flight loads from the power system to the airframe throughout the aircraft operating and performance cycles. Fulfilling this function required careful analysis and optimization of the battery assembly design. The team wanted to minimize weight, while also ensuring both effective transfer of the flight loads and avoiding vibration modes that may align with any of the system operational frequencies.

Supporting the Electroflight team, Ansys provides full structural and frequency analysis of the battery assembly using Ansys Mechanical. This led to various adjustments to the assembly design, notably the design of new clamps to adjust the stiffness of the full assembly, avoiding resonant frequencies aligned with the propellor operating frequencies.

The individual battery cells are mounted in a compact, back-to-back arrangement located on a polymer mounting plate. The 3D printed frame material originally intended for use was found to have reduced stiffness properties as temperatures increased. Electroflight needed to select a material with a glass transition temperature that was greater than the battery operating temperature, which was a difficult challenge. The team used Granta to down-select materials based on specific requirements. Using Ansys Mechanical and Granta, a 30% glass fiber-filled polycarbonate was identified to be the optimal material. Simulation helped the team meet this difficult material challenge during the design phase.

OPTIMIZATION KEEPS IT COOL

Because thermal load is a central concern for lithium-ion batteries, Electroflight engineers leveraged Discovery and Fluent to model the battery cooling system and study the thermal performance for the full battery assembly in real-world operation conditions. The team applied adjoint solution methods in Fluent, which were developed specifically for confined inner flows, to characterize the battery's innovative cooling system performance. The software automatically explored the operating envelope for a given design, morphing the arrangement to a more-optimal shape, guiding the Electroflight team to an optimized design. Because adjoint simulation provided a roadmap showing which regions of the battery were most sensitive to overheating, developers could focus their efforts accordingly.

Together, the Ansys solutions helped the Electroflight team understand a host of sophisticated issues —from sustainability and manufacturability, to operating limitations — and optimize the battery design accordingly. The team was under significant time and cost pressures to meet the milestones associated with the recent test flights, and simulation via Ansys helped solve key engineering challenges rapidly and effectively. Ansys not only helped Electroflight verify the battery pack's final design prior to the test flights, but answer a number of incredibly complex questions on the way there.

SUSTAINABILITY TAKES FLIGHT

As the global aerospace industry looks ahead, clearly any new aircraft designs must be as carbon-neutral as possible. This creates an entirely new set of challenges for engineering teams, from materials selection to the many facets of energy production and efficiency. Granta tools were able to support this sustainability effort, developing new processing and approaches to fully understand and minimize the project environmental footprint.

Backed by Rolls-Royce's tradition of aviation leadership and Electroflight's unique expertise in battery systems — and armed with best-in-class tools from Ansys — the Electroflight team is successfully taking on those challenges. With a series of test flights now completed, the partners' confidence in the future of sustainable aviation is soaring.

The Nordic Air Racing team poses with their Air Race E plane that is under construction.
Image courtesy of Nordic Air Racing

Electrifying the Future of Air Racing with Simulation

By Ansys Advantage Staff

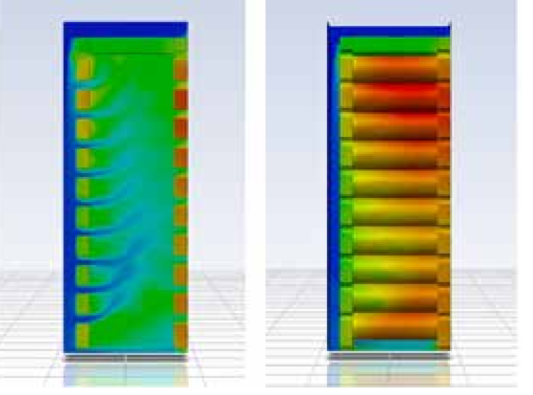
It's arguably the most exciting motor sport in the world, it's been going on for more than a century, and you probably have never heard of it.

Imagine eight compact, single-seat electric-powered propeller airplanes taking off at once, flying to a height of about 30 feet, and racing wingtip-to-wingtip around a 3-mile oval at speeds of up to 250 mph, and you will get a sense of the adrenaline-fueled excitement competitive air racing creates. Air racing has been championed globally since 2013 by Jeff Zaltman, CEO of Air Race Events, whose Air Race 1 has served as the world championship of air racing since 2015

and continues to go from strength to strength.

Like other elite motor sports such as automotive Formula 1, Air Racing provides a test bed for cutting-edge technology. With the growing importance of sustainability, just as Formula 1 created an electric equivalent with its Formula E series, Zaltman has launched Air Race E, where the planes are 100% electric, to help accelerate the aviation industry's push to become even more sustainable. Ansys is the Official Simulation Software Partner of Air Race E, making simulation software, training and consultation available to the competing teams.

Ansys is helping to advance the state of the art of aircraft electrification by offering a comprehensive suite of multiphysics simulation tools to address some of the toughest engineering challenges the teams will face — including battery and battery management systems, power electronics, the electric motor, and the overall integration of the electrified powertrain system into the airframe. For some teams, this involves designing the entire aircraft from scratch; for others, it means integrating these electric systems into an existing airframe.



Left: Air distribution through the battery module. Right: Static temperature distribution in single battery module.

Image courtesy of Nordic Air Racing

"Simulation is the only way to accelerate the design and development process such that their electric aircraft are certified to fly in time for the first qualifying events scheduled for the latter half of 2021."

"These teams need to go from an idea to an airplane that is ready to race in an incredibly short time frame. Simulation is the only way to accelerate the design and development process such that their electric aircraft are certified to fly in time for the first qualifying events scheduled for the latter half of 2021," says Roberto Bifulco, the Ansys technical account manager responsible for coordinating Ansys' participation in the race. "Our software can help them achieve this goal, and we can also learn from the problems they need to solve, so it's a win–win and one of the reasons Ansys decided to sponsor Air Race E."

AIR RACING BUILDS AN ELECTRIC FUTURE

The first air race, the Prix de Lagatinerie, was held in France in 1909, just six years after the Wright brothers made the first controlled heavier-than-air flight at Kitty Hawk, North Carolina, in 1903. Air racing has continued in various forms ever since, often involving just one plane at a time racing against the clock.

Zaltman founded the Air Race 1 World Cup in 2013. He presided over the inaugural race in 2014 and the first World Cup of Air Racing in 2015. Teams race small, single-seat, propeller-driven Cassutt Special airplanes, which they modify within specific parameters to try to gain an advantage.

In Air Race E, the rules prescribe the platform each team must use. The requirements for the airframe, wings and weight of the aircraft are the same as for Air Race 1. With the substitution of electric power for an internal combustion engine, specifications for batteries include power not exceeding 150 kW (with an extra 25 kW boost capacity available over 30 seconds) and a maximum voltage of 800 V. In a 4-lap, 25 km (15.5 mile) race, the battery must be able to perform at full power for 5 minutes, with 10 minutes of reserve at minimum power. The goal is for total powertrain weight to not exceed 180 kg.

TWO APPROACHES TO TECHNOLOGICAL CHALLENGES

"Designing a winning plane is not very straightforward," says Dmitri Karelin, Technical Project Manager at Air Race E. "You can't just go for the maximum power and say, oh, that should do it.

The most powerful motor requires a bigger battery, which adds weight and may cause your plane to be slower than that of another team who uses a smaller motor and a smaller, lighter battery."

Given these trade-offs, there is a lot of room for design variations within the rules, and each team will approach the challenges in a different way.

When Zaltman launched Air Race E in 2018, he attracted some of the teams already racing fossil-fuel–powered planes in Air Race 1 competitions, but he also stirred up interest among people who had never participated in air racing before. This has created two types of teams facing different challenges: the retrofitters and the build-it-from-scratchers.

Volumetric meshing of battery pack to power electric airplane *Image courtesy of Nordic Air Racing*

Because simulation is new to many of the race participants, who are used to performing physical testing on new designs, Ansys held webinars in January 2021 to introduce all the teams to the simulation capabilities they can access and how to use them to overcome some of these challenges. We talked to two teams with different approaches to see how they are progressing.

Retrofitting

Nordic Air Racing of Norway brings together two organizations: Electric Aircraft Propulsion and Equator Aircraft. The team currently has 10 members, including volunteers. "We want to explore electric aviation at a higher level, and Air Race E gives us the opportunity to do that," says Sathvik Rao, an engineer on the Nordic Air Racing team. "By entering an air race competition, you get to learn a lot and share your knowledge about the common problems that each team is facing and try to resolve them. That's the mindset. Electrical aviation is in its infant stages, and it's important to nurture it at the grassroots level right now."

With no prior air racing experience, Nordic Air Racing bought a used Cassutt Special airplane to retrofit. Rao identifies five major challenges that they are facing:

- Changing the external geometry of the plane by giving the plane a longer, thinner nose
- Balancing the plane's center of gravity because they are swapping out a heavy internal combustion engine for a much lighter electric motor
- Determining how best to cool the motor and batteries, both of which will be located in the engine compartment of the fuselage
- Developing a composite-based motor compartment to make the plane lighter
- Optimizing the battery design and performance

Nordic Air Racing is using Ansys Mechanical and Ansys Fluent to modify the nose of the plane to see how far they can maintain laminar flow over the fuselage and minimize the overall drag values. Mechanical is also being used to analyze the center of gravity problem. They have opted for air cooling through the whole thermal system, using a cowl, or air scoop, in the propeller hub that will let the air flow into and out of the system without producing too much cooling drag. Fluent is helping them to analyze the air flow in this region. Ansys Composite PrepPost will be used in developing the composite motor compartment.

That leaves the challenge of optimizing the battery performance. "You can speak to engineers in any industry based on electrification and ask about their main problem," Karelin says. "The answer that everyone would give you? 'It's the battery.' The battery is always the big challenge, the big danger and the big complexity in the system. That's because the battery cannot be damaged and it cannot be overheated while you are flying. It's a matter of safety. So the teams will rely on simulation."

While Rao had used Ansys simulation solutions before in his aerodynamics engineering studies and thesis, which gave him some background for the Fluent thermal flow analyses, he was new to Ansys' electronics and battery simulation solutions. It's been an eye-opening experience for him. "I was quite surprised to see how Ansys software can integrate each and every parameter requirement for any sector, such as current, voltage, temp distribution and structural reliability of batteries," Rao says. He is looking forward to taking advantage of these simulation capabilities in the near future as Nordic Air Racing tackles the battery challenge.

Building from Scratch

TeamNL 3D printed this model on a 1:10 scale.

If you don't have a plane to start with, obviously you have more work ahead of you. TeamNL in the Netherlands, with four members currently, didn't let that stop them. "We just wanted to go for it all the way and design a plane so we can integrate it completely correctly," says Rick Boerma, a lead engineer and longtime glider pilot on TeamNL. "We decided to integrate the batteries into the wings and then integrate the motors with the airframe to avoid having to modify an existing airframe, weight- and balance-wise. Starting from scratch can sometimes be an advantage."

Boerma was familiar with Ansys software but had not used it before. "When Ansys decided to sponsor Air Race E, they said, 'Hey, do you want to use this software?'" he says. "If you put that kind of a deal in front of us, who can say no?"

TeamNL sees the challenge as "one big packaging optimization task." Because they have a small team (more volunteers are welcome!) and time and money are short, they have to choose the best components they can afford and put them together in the most efficient manner. Boerma says they want to keep the weight of the plane as low as possible, but to achieve the power to fly fast you need a big battery. If you use two small batteries, the current load is too high. So they are using relatively heavy batteries and trying to get the volume and the weight right.

"The battery is always the big challenge, the big danger and the big complexity in the system. That's because the battery cannot be damaged and it cannot be overheated while you are flying. It's a matter of safety. So the teams will rely on simulation."

They are using Ansys Discovery to develop the structure of the plane and achieve the right center of gravity with these weight loads. "It's amazing what Discovery can do," Boerma says. "I was really eager to get my hands on it. The speed of it and the ease of using it with the integrated Ansys SpaceClaim is really awesome. You can have a geometry and if you don't like that hole there, you can just fill it in, and in five seconds you see the new stress distribution. I can even do topology optimization to get the shapes right."

Exporting the geometry obtained in Discovery to Ansys Mechanical is just a few clicks away, so they will use Mechanical to give them the extra couple percent of accuracy to ensure they have a safe design. "Race pilots always want to push things further than they are allowed to," Boerma says. "But safety is of course the number one priority in aviation. Of course, we want to go as fast as possible and try to win the race, but number one is getting the pilot back on the ground."

THE NEAR FUTURE OF AIR RACING

Initial trial heats of Air Race E will be held in the last half of 2021 with the teams that have their electric-powered planes ready to go at that point. Sixteen teams have signed up for the competition, but there's still time to get involved if you want to start your own team, because Air Race E will continue to evolve beyond its World Championship of Electric Air Racing planned for 2022. Ansys experts will be there to help all teams learn how to use simulation to solve their challenges throughout the process.

An Air Race event

"Teams are in a race against time to get a plane ready for 2022, so being able to simulate plane and battery designs will prevent them from spending too much time going down a particular path and then having to backtrack," Karelin says. "Being able to test a design change instantly is a big money saver, and these teams must certainly spend their money wisely."

Steering the Future of Mobility with Composites

By Ansys Advantage staff

All products have an environmental impact, a fact customers are increasingly aware of as they take an interest in their carbon footprints. In the automotive industry, there is a global push to reach zero vehicle emissions by 2050 to satisfy consumer demand and increasingly stricter environmental laws. To do so, leading vehicle manufacturers and their partners are embracing lightweighting and electrification. Composite materials are key to making vehicles lighter so they can use smaller engines that consume less energy and produce fewer emissions.

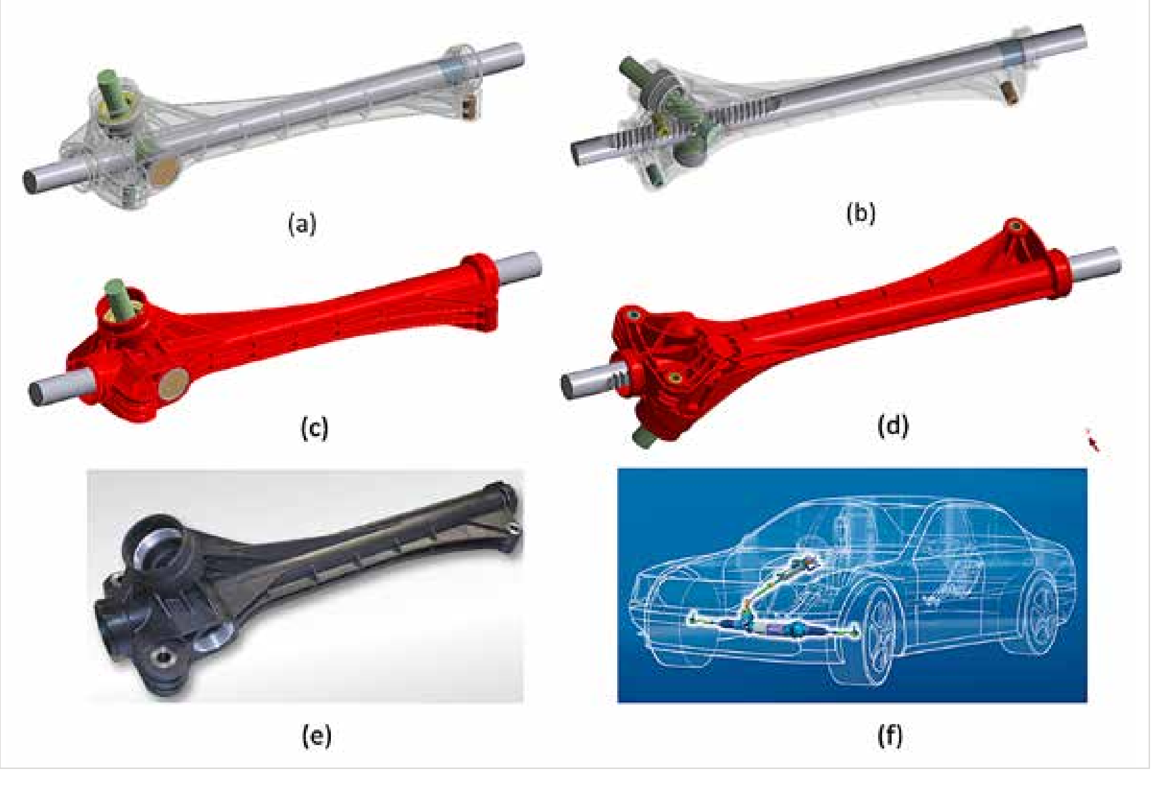


Figure 1. The servo-assisted steering system developed by thyssenkrupp Presta. (a) and (b) details of the steering system mechanics; (c) and (d) in red the reinforced-plastic steering housing; (e) photo of the manufactured plastic steering housing; (f) servo-assisted steering system within the vehicle. The integrity of the servo-assisted steering system housing is critical to ensure the safety of the vehicle occupants. Images courtesy of thyssenkrupp Presta.

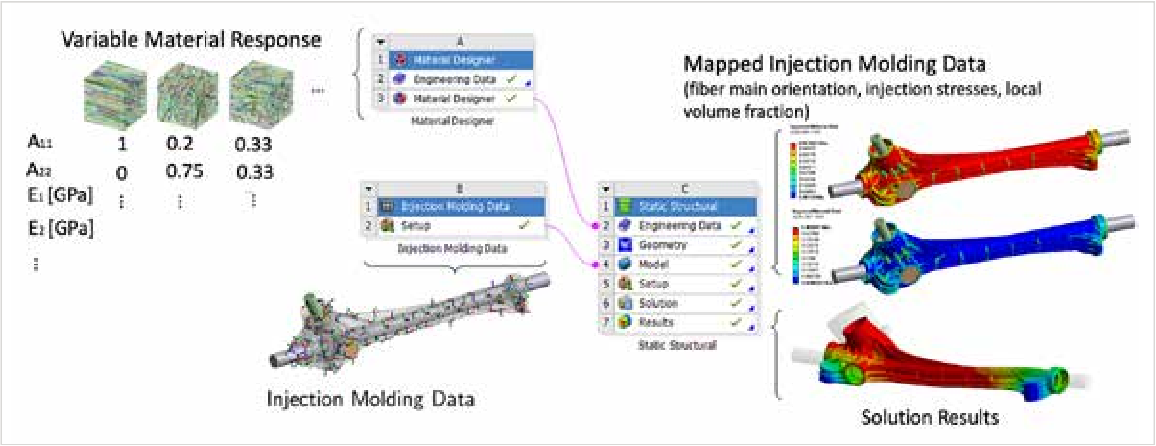


Figure 2. Workflow for building the multiscale model in Ansys Mechanical with the help of Ansys Material Designer

The principal applications of composites in the automotive sector are for under-the-hood components and exteriors, using prepreg (carbon or glass fibers laminates), typically in luxury and medium-volume cars. However, for the high-volume production models, an increasingly adopted technique is the manufacturing of safety and structural critical components through injection molding with short-fiber reinforced plastics. Body panels, frames, housings, support structures, bumpers and seat structures are all being manufactured with short-fiber reinforced plastics. With the growth of electromobility, the demand for lightweight components is expected to rise even more.

Injection molding is an ideal process for fabricating large numbers of geometrically complex parts. Many everyday items from sectors beyond automotive are injection-molded: mobile phone housings, television cabinets, compact discs and lunchboxes are just a few examples. An essential characteristic of injection molding is that it may not be possible to fix a part defect in production by simply varying process conditions. Frequently, the mold must be modified to overcome a problem. This is expensive and costs valuable time. It is far better to avoid problems in the design phase than to fix them in production. Furthermore, injection molding is strongly dependent on the ability to precisely predict the mechanical behavior of the processed parts in the application, and to accurately reproduce their microstructure, which varies throughout the parts influencing the local material properties. Simulation of the structural response of injection-molded plastic parts is highly valuable to industry.

FIBER-REINFORCED PLASTICS WORKFLOW

In fiber-reinforced plastics, the geometry, volume (or mass) fraction, thermo-mechanical properties, orientation distribution of the fibers, and the polymer matrix's thermo-mechanical properties significantly affect the mechanical and thermal performances of the composite material. Therefore, the idea of material modeling for predicting the macroscopic behavior of the injection-molded composite materials from the mechanics and physics at the microscopic level is becoming increasingly important.

One example of a product design and development workflow for fiber-reinforced plastics available within Ansys comes from thyssenkrupp Presta AG, whose injection-molded housing for a servo-assisted steering system is made of short-fiber reinforced glass-fiber composite.

Located in Liechtenstein, thyssenkrupp Presta AG is a first-tier OEM supplier for the automotive industry and it belongs to and is the management company of the thyssenkrupp Steering business unit of the German conglomerate thyssenkrupp. thyssenkrupp Presta AG is investing heavily in research and development to face the new trends that are overhauling the automotive industry. Its core focus is in the chassis area, particularly in electric-powered steering and steer-by-wire

Figure 3. The main fiber directions are shown in red, mapped to the meshed geometry of the plastic housing using the orientation tensor in output from the injection molding simulation.

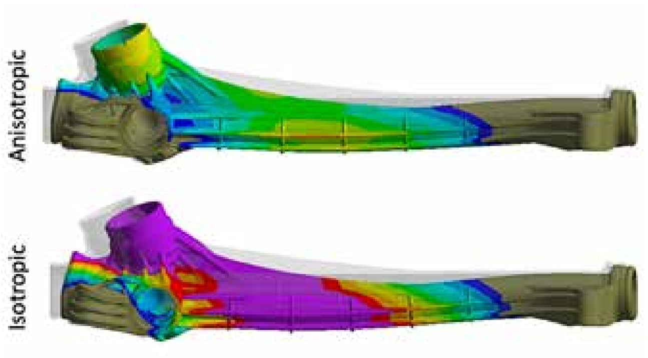


Figure 4. Total displacement in the case scenario for the anisotropic and Isotropic (simplified) model. The same color bands are used for both models.

systems. thyssenkrupp Presta AG uses Ansys Mechanical to create 3D digital twins of the components and optimize them to bring extreme reliability to its customers. Nine out of 10 premium-class cars include components from the company and, in general, one out of four vehicles in the world has thyssenkrupp Presta AG technology inside.

SHIFT TO A REINFORCED-PLASTIC STEERING HOUSING

In the last decade, there has been a technological change in the steering market from steering systems with hydraulic assistance to steering systems with electrical assistance. Besides gear components, the steering housing is one of the most high-load components, which is why it is traditionally made of aluminum. The technological change toward electrically assisted steering and the further development of affordable high-performance plastics have resulted in a multitude of new application possibilities.

The housing element of a servo-assisted steering system produced by thyssenkrupp Presta AG, which was originally made of aluminum, was substituted in the new design by an element of similar shape made with glass-fiber-reinforced high-performance plastic. The challenges included developing the plastic-compatible design, and meeting both OEM specifications and price expectations.

The servo-assisted steering system, the plastic housing and its location within the vehicle are shown in Figure 1. The steering support is provided by the power assistance located on the steering column. Metal inserts are used for highly stressed areas at several screw connections of the steering gear. The glass-fiber reinforced plastic is characterized by high resistance to all typical engine compartment reagents. It has good aging properties, with negligibly small changes in toughness and tensile elastic modulus. However, different from isotropic metals, this new material is not only anisotropic but also heterogeneous, thus anisotropic properties are dependent on the microstructure, which varies locally because of the injection molding process. Therefore, simulating the stress distribution in the housing element under the corresponding workload is a real challenge for a simulation engineer.

MEETING THE SIMULATION CHALLENGE WITH A MULTISCALE MODEL

Multiscale techniques have traditionally encountered a limited application in modeling the mechanics behavior of fiber-reinforced plastics because of large memory and computing power requirements for such simulations. Recently, Ansys Material Designer has enabled a multiscale modeling approach for short-fiber composites with a lower computational demand. The evaluation of homogenized material properties for all the possible microstructural configurations (stored in a variable material data) is decoupled from the subsequent assignment to the finite element representation of a plastic part (see Figure 2), which is realized in the downstream analysis according to the given microstructure (fiber orientation tensor) locally present in the part as a result of the manufacturing process. This local fiber orientation state can be imported from injection simulations or experimental CT scan data. While evaluating the possible microstructures in Material Designer, the nonlinearities of the material response are captured through a phenomenological strain-rate–independent model combining an orientation-dependent anisotropic Hill yield criterion with a nonlinear isotropic hardening law, both fitted against experimental data in accordance with the ISO 527 standard.

14 cores	Anisotropic	Isotropic
Solution Time	18 hrs 28 min	17 hrs 34 min
Memory Used	334.3 GB	323.3 GB
Result File Size	14.8 GB	17.8 GB

Table 1. Performance of the anisotropic model (using the Ansys workflow for fiber-reinforced plastics) against the isotropic (simplified) model

This variable material response as a function of all the possible orientations is then combined in Mechanical with the local fiber orientation imported in Ansys Workbench through the

Injection Molding Data system, an interface that allows the user to import text-based orientation data files of injection molding simulations into the Ansys simulation environment. The injection process data is parsed, processed and then transferred to a downstream Mechanical system where it is applied in the form of element orientations as shown in Figure 3. During the mapping process onto the Ansys mesh of the plastic housing, the team considered the principal fiber directions and the two largest eigenvalues of the fiber orientation tensor. Additionally, local variation of the nominal fiber volume fraction and the presence of injection stresses can be considered but were neglected here.

MORE ACCURACY WITHOUT MORE SIMULATION TIME

The simulation where the steering housing was accurately modeled as anisotropic and accounting for the local fiber orientations was compared to a simulation where a simplified equivalent isotropic material model was applied to the housing, thus neglecting the presence of the local orientation of the reinforcing fibers. For the equivalent isotropic material, material properties are those where the fibers have a fully randomized orientation. This is a very common engineering approach, usually followed in absence of specialized workflows like those available within Ansys and used here within the more accurate anisotropic material model.

As shown in Table 1, the use of the more accurate workflow for short-fiber reinforced plastics does not increase significantly the computational burden of the simulation in terms of solution time, memory needed or size of the result files required by Ansys. However, the simplified isotropic model behaves as excessively compliant (Figure 4), with 50% higher values of predicted maximum deformation when compared to the displacement values shown by the anisotropic model.

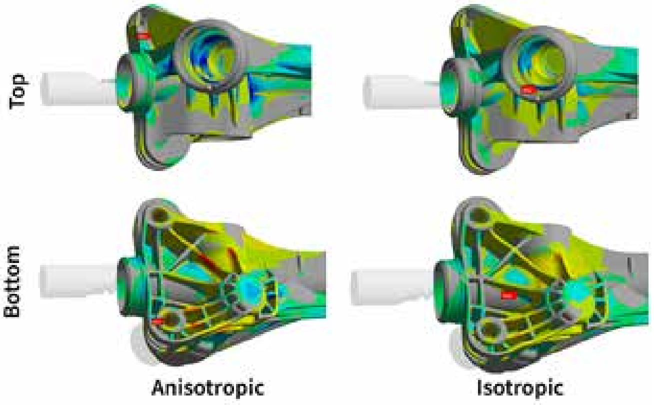


Figure 5. Effective stress analysis in the case scenario for the anisotropic and isotropic (simplified) model. The same color bands are used for both models. The stress patterns appear different in the two models, in particular (as the anisotropic model highlights), the ribs at the bottom of the housing and one of the attachment points. Note the change of critical location between the anisotropic and the isotropic model.

Figure 5 contains plots of the effective stress results obtained for the same geometry, but the two different types of material models are considered in the analysis for the housing. It is evident that with the higher stiffness of the anisotropic model, internal stresses become fixed inside, have higher values and influence the strength of the housing more. Effective stresses at the critical locations (in red in the figure) appear 40%–50% higher in the anisotropic model when compared to the simplified isotropic one. Taking into account the elasto-plastic anisotropy and the heterogeneity in the distribution of local fiber orientations significantly changes the critically loaded material points, with the results shown for the more accurate model correctly capturing the physical reality as has been verified by experimental tests conducted by thyssenkrupp Presta AG.

These results show that the use of the workflow for short-fiber reinforced plastics leads to more realistic results and prevents a gross underestimation of the stress level in the steering housing and overestimation of the deformation in the steering system in the simulation load case scenario, which would be possible with more common simplified engineering approaches. The greater accuracy of the Ansys workflow for fiber-reinforced plastics only minimally increases the computational requirements for such complex multiscale simulations. The Ansys software helped thyssenkrupp Presta AG to reach the targeted 50% weight reduction with respect to the original metal part and to assess all the mechanical performance and OEM requirements.

Using Ansys gave thyssenkrupp Presta AG confidence in plastic housing design even before its actual manufacturing. The adoption of an innovative and lightweight plastic housing for its steering system supports both the ecological and the economical goals of thyssenkrupp Presta AG and helps the company lead the evolution of steering systems for the automotive market of tomorrow.

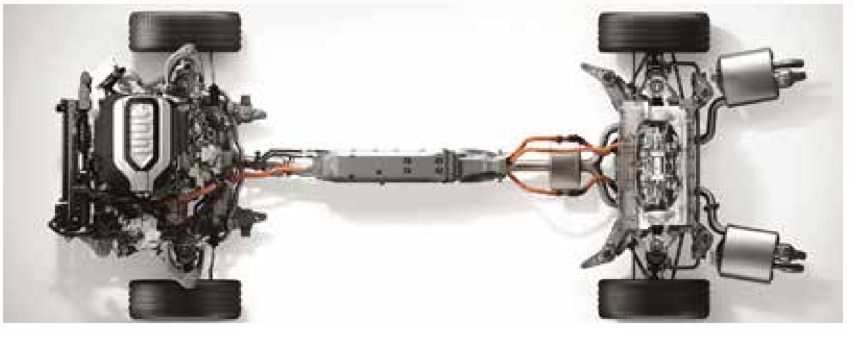
Honda Motor Improves Development Efficiency with a Materials Database

By Ansys Advantage Staff

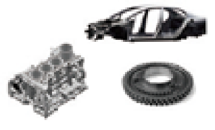
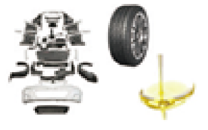
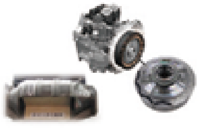
The transformation of the automotive industry toward lighter vehicles, hybrid and electric powertrains, more advanced driver assistance systems (ADAS), and more luxurious interiors touches every part of the global engineering workflow, including:

- New manufacturing methods
- Development of high-efficiency, lightweight engines and motors
- Reduction in vehicle body weight
- Noise reduction

One element of design spans every engineering discipline involved in automotive development: materials. Automobile manufacturers are researching and developing new materials to differentiate their brands and are working with suppliers to ensure that the best, most sustainable material choices are being made, creating an enormous amount of materials data to track and manage.



Source: Honda Motor Co.

	Metals	Polymers	Magnetics and catalysts	Chemical
Parts	 Body, cylinder block, gear, etc.	 Bumper, tire, oil, engine cover, etc.	 Rotor, stator, converter, etc.	 Door, color, seat, etc.
Material	Steel, aluminum, magnesium	Resin, rubber, oil, long life coolant	Ceramics, magnet, precious metal	Adhesive paint, fabric
Demanded properties	Fatigue, strength, elongation, rigidity, weldability, heat resistance, etc.	Environmental resistance, wear resistance, fluidity, etc.	Core loss, flux density, conversion efficiency, etc.	Adhesive strength, anti-corrosion performance, viscosity, etc.

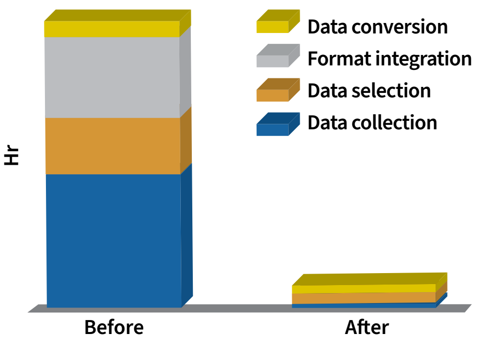
Materials classification and required properties

Tsuyoshi Ito, who works in Honda Motor's Automobile Operations, was so convinced of the importance of materials that he began building a materials information management system himself. Ito is assistant chief engineer in the Power Unit Materials Section of the Materials Development Division, Automobile Development Supervisory Unit, in the company's Monozukuri Center. Ito then recommended that the company license Ansys Granta MI, materials information management software, to centrally manage materials information owned by each individual, and use materials informatics, which integrates collected information with a statistical method, to create new value in the materials field.

IMPORTANCE OF A CROSS-DIVISIONAL MATERIALS INFORMATION MANAGEMENT SYSTEM

Ito has developed aluminum structural parts for engines since joining Honda R&D, the research and development division of the Honda Group, to address development issues from a materials point of view. In his work, he uses computer-aided engineering (CAE) to develop methods to predict heat-treatment residual stress, evaluate high-cycle fatigue strength and test various materials.

With the introduction of Granta MI, Honda Motor has built a full-featured materials information management system, making their materials information much more sophisticated. The need for lightweighting has driven the adoption of lighter materials for engines and bodies, such as resin and magnesium, and additive manufacturing technology has been studied to develop the new materials with unconventional properties. In model-based development, which is common in the automotive industry, simulation (CAE) is used for one-dimensional analysis and crash analysis, which require more advanced material models.



Change in data cleansing time after implementing Ansys Granta MI

Changes in the social environment also place greater importance on materials management. In an age when people with different values and nationalities work together, the way companies share their information and know-how directly translates into profit. In materials development, attention is also focused on data-oriented research, which uses not only an experiment, a theory and a simulation, but also a statistical treatment.

For these reasons, there was a rise in demand for information sharing or integration with development systems across categories. At the time Ito built his own database, however, the company had no comprehensive materials information management system. Materials data was collected in an unorganized way by each department or individual.

"First, manage scattered materials data centrally to increase the efficiency of data sharing," says Ito, explaining the steps toward mining value from materials data. "Then, use it for data science or data engineering and ultimately develop materials using materials informatics so that we can create new value."

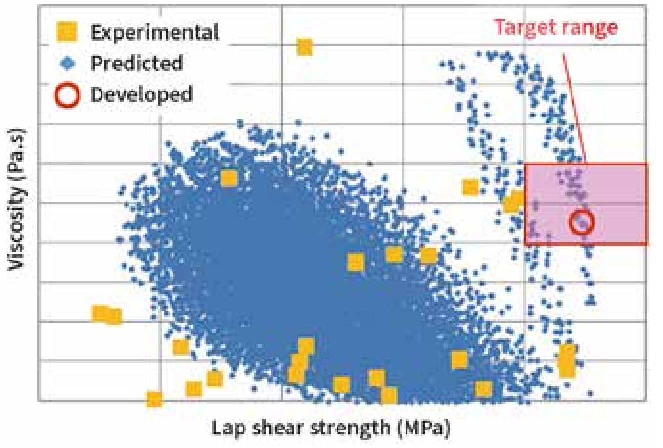
ANSYS GRANTA MI SOLVES MATERIALS DATABASE CREATION CHALLENGES

The range of materials used in automobile development is wide, so Ito categorized the current data issues when building a materials information management system into the following large materials groups: metal, organic, functional and chemical. All groups contain various materials, each of which has a different manufacturing process and different demand characteristics and must be handled with special skills. Therefore, a person needs to be assigned to each specific material, leading to the unorganized management of materials data. Necessary materials data also varies from person to person, depending on roles such as design, CAE and materials.

Ito listed the following four possible problems in materials information management system management and operation:

1. Input template items must be frequently changed to support materials data and manufacturing technologies that are updated on a daily basis.
2. Data expression inconsistency due to input by multiple people must be corrected.
3. A hierarchy required to organize a large amount of materials data must be added or modified.
4. Data must be output so that it can be freely utilized.

Ito's group chose the Granta MI Enterprise solution to solve these problems. The materials information management system automatically updates added or modified input items to the input template, eliminating the need to create items again. All specific item data can be output and used, and also modified and put back into the system, which makes it easy to edit a large amount of data or change a hierarchy.



Property-predicted results of adhesive materials

"I compared Ansys Granta MI to other similar database software in terms of input, display, search, output, management and cost," Ito says. "Because of its huge comparative advantage, including extra functions to automatically create a link between records and overlap graphs contained in multiple records, we chose Granta MI."

MATERIALS ANALYTICS REDUCES DEVELOPMENT TIME

Since introducing Granta MI, Ito has promoted the materials information management system throughout the company. First, he divided the system structure into areas where users with different roles, such as designers and design experts, can store their specific data. Then, he added access control to the areas and linked them to each other so that data can be handled by all users. For easier access rights management, an intermediate team was created, which enables an administrator to manage user access rights to the database for each team. By using Granta MI to make material models available for simulation purposes, it increases CAE work efficiency and reduces materials testing, typically duplicated by different departments. Material property acquisition costs were reduced by an estimated 40% for simulation models.

There are also user-friendly features available to prevent misunderstandings or expression inconsistency among people who input data, such as showing the description of each term in a

4 DATA PROBLEMS TO SOLVE

1. Changing materials data and manufacturing technologies require frequent updates to input template fields.
2. Multiple people from different teams and specialties are inputting inconsistent data.
3. There is no data hierarchy to organize the large amounts of materials data that needs to be added/modified.
4. There is a lack of data availability to the right people.

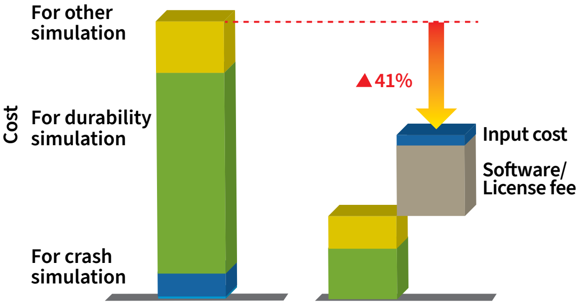
MATERIAL BENEFITS AT HONDA

1. Reducing the total data cleansing time by 80% improved operations efficiency.
2. With Ansys Granta MI, material models are available for simulation purposes, which increases CAE work efficiency and reduces materials testing, typically duplicated by different departments. Material property acquisition costs were reduced by an estimated 40% for simulation models.
3. Reducing the number of prototype materials and tests by 50% compared with conventional trial-and-error reduced development time.
4. Promoting in-house use of design studies with standard physical property values, lead to higher design quality and reduced development rework.

template and adding a function to select data from a list. This improves data quantity and quality, while streamlining data input.

The organized materials information management system allows the company to discover cases that could lead to new value creation using materials informatics. Materials informatics is an efficient materials development method that integrates materials data with machine learning, unlike conventional trial-and-error materials development. The most important thing in materials informatics is data quantity and quality. However, data collection, conversion and organization (data cleansing) generally require many man-hours, which is a serious problem in machine learning.

Honda Motor reviewed the effect of using materials informatics for designing a formulation in materials development. In general, materials properties change depending on infinite formulations, so many prototypes must be created and tested to achieve the target properties. Therefore, the company output the formulation information, test results and property information of materials stored in the materials information management system and input them for machine learning. The machine learning algorithm mechanically calculates properties in an unknown formulation, narrowing down formulation candidates to obtain the target properties.



Materials properties measurement costs were reduced by about 40% via Ansys Granta MI.

The results showed that the prediction was highly accurate because there were only small errors between the predicted and actual values of the properties of the selected materials. Compared to conventional trial-and-error development, the machine learning approach is proven to reduce the number of prototype materials and tests by about half.

Based on these results, Honda Motor decided to promote materials development using materials informatics by securing a large amount of materials data collected by materials experts, enhancing the materials information management system and increasing the number of database users. The company also plans to actively publish data to designers and analysts, and to integrate the database with a development environment, such as product lifecycle management (PLM), so that it can be used as a development platform.

"To operate a materials information management system in a company, it is important to first select a materials database tool suited for the usage purpose, tool coverage and corporate culture," says Ito. "It is also necessary to design a database structure and give access control with consideration for user specialties and roles and conduct various promotional activities. Regarding utilization for materials development, storing data systematically to a materials information management system greatly reduces data cleansing, which results in more opportunities to use materials informatics."

Reference

Honda R&D Technical Review, Vol. 32 No. 2, "Materials Database for Efficient Development Using Materials Informatics," Tsuyoshi Ito, Tatsuko Ishii, Akira Honda, Nao Sugimoto, Yoichi Toyooka, Itsuru Furusawa

The Triggo vehicle transforms from cruising mode (left) to maneuvering mode (right) in just one second while driving.

TRIGGO TRANSFORMS FOR MOBILITY AS A SERVICE

By Ansys Advantage Staff

Nobody likes sitting in traffic or searching for a parking spot. What if those time-consuming tasks could be eliminated? Say hello to Triggo, a transforming electric vehicle that changes the geometry of its chassis depending on driving needs.

The vehicle was developed from scratch by a team of dedicated automotive and aeronautic engineers at Triggo, a small Polish startup that has increased its number of employees by 600% since being founded in 2015. Thanks to the Ansys Startup Program, the company will deploy its first pre-production prototypes in early 2021 prior to going into full production.

Triggo was designed to capitalize on the mobility as a service (MaaS) revolution, which is projected to generate nearly $100 billion globally by 2025. Triggo is engineered with a drive-by-wire steering system. In the future, Triggo will be summoned by a customer's cellphone app, then autonomously drive to a pickup location where the user hops in and commutes to their destination.

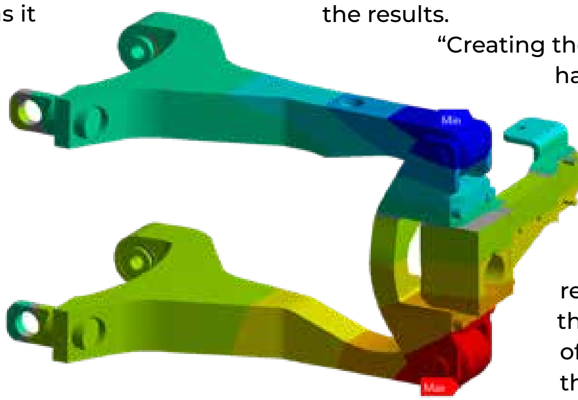
VEHICLE WHEELS ENGINEERED TO RETRACT

Reaching speeds of 90 km/h (56 mph) in cruising mode, Triggo's adaptive, foldable front suspension extends to 148 cm (39 in.) But when it encounters traffic, the magic really happens. Switching to maneuvering mode enables the driver to retract the wheels into the body, producing a maximum width of just 86 cm (slimmer than many motorcycles), letting it rapidly zip between cars and through traffic jams with ease.

And because it's so slender, Triggo requires just one-fifth the width of a traditional parking space, helping the driver park nearly anywhere.

OVERCOMING DESIGN CHALLENGES WITH SIMULATION

The Ansys Startup Program helped Triggo's engineering team overcome several key challenges, including visualizing the vehicle's movement as it transforms from cruising mode to maneuvering mode in just one second. For example, as its wheels fold in, the dampers and springs assume different positions and the mass spreads to different places, delivering a completely different driving experience. Ansys technologies also helped Triggo's team create the vehicle's steel frame, which was topologically optimized to give it a high torsional stiffness while keeping its overall mass low, a crucial parameter for the electric-powered vehicle in terms of prolonging range per charge.



Ansys Mechanical helped Triggo engineers conduct system stiffness analysis, enabling them to measure component durability.

"Thanks to the Ansys Startup Program, we leveraged Ansys Mechanical to precisely measure the durability of the frame and received a holistic view of the entire vehicle to ensure every component worked together seamlessly," said Michał Kowalewski, CEA Engineer at Triggo.

HARNESSING ANSYS STARTUP PROGRAM TECHNOLOGIES

Triggo engineers leveraged several Mechanical models on Ansys Workbench, conducting static structural analysis, linear buckling analysis, and linear and nonlinear dynamics analyses. Additionally, engineers used topology optimization analysis to understand the required modifications needed for achieving the desired stiffness and durability, reduce the overall mass and weight of every component, maximize the battery's energy efficiency, and highlight any manufacturing process limitations.

"The Ansys Startup Program helped our engineering team the most by giving access to the best CAE on the market at a very low price, especially in the early stage of development, when our team had extremely limited resources," said Adam Kutyłowski, head of public relations at Triggo. "This helped them visualize Triggo's design limitations and rapidly develop new solutions to radically improve the vehicle's performance."

After the numerical simulations were run, Ansys Viewer enabled the engineers to review the results.

"Creating the Triggo vehicle would have been impossible without the Ansys Startup Program, and our engineers' relationship with Ansys goes way back. In fact, many of our engineers recently graduated from the Warsaw University of Technology, where they trained to use Ansys simulations," said Kutyłowski. "When we began developing the Triggo car, our engineers knew Ansys technologies would prove instrumental for designing a safe, highly reliable vehicle and significantly reduce the need for creating many expensive prototypes."

One of Triggo's key goals is to meet the European New Car Assessment Program (NCAP) high safety standard. Ansys Mechanical played a pivotal role in helping engineers conduct numerical analysis and properly designing the vehicle's composite body prior to testing, enabling it to satisfy stringent NCAP rollover safety requirements.

MESco, an Ansys Elite channel Partner in Poland, provides support and service to Triggo.

Uncharted Waters: Breaking Sailboat Speed Records

By Ansys Advantage Staff

The current world speed sailing record of 121 kph (75 mph) was set in 2012, but a 40-person team of students and early career engineers from the Swiss Federal Institute of Technology Lausanne (EPFL) is working to blow that long-standing achievement out of the water.

They have designed what they hope will be the world's fastest sailboat, which they're calling the SP80. Their goal is to achieve a history-making average speed of 80 knots (93 mph / 150 kph) over a one-way, 500-meter (one-third mile) distance during the World Sailing Speed Record Council (WSSRC)'s 2022 season.

Considering that the SP80 is expected to go two or three times wind speed, it's not surprising that it looks nothing like a conventional sailboat. It doesn't behave like one, either.

Instead of a conventional sail for propulsion, the SP80 is outfitted with a kitesurf wing, which generates more power while helping the boat remain stable at high speeds. The SP80 also has ventilating hydrofoils — winglike appendages that hook the hull in the water to keep the boat from lifting out completely — that the team simulated, optimized and validated in Ansys Fluent. The hydrofoils are the only parts of the SP80 that actually enter the water.

OPTIMIZING HYDROFOIL DESIGN FOR HIGH SPEEDS

Given the goal of setting a speed record, using a kitesurf wing was an obvious choice, according to Mayeul van den Broek, who co-founded the project with Xavier Lepercq and kitesurfer Benoit Gaudiot in 2018. With that piece of the design puzzle in place, the team spent more than a year looking at different boat configurations. Much of their work centered around optimizing hydrodynamics to ensure that at top speed the boat and the hydrofoils would constantly remain in contact with the water and not send the boat sailing into the air.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First, the team had to understand the effect of cavitation on the hydrofoil's lifting surface. Cavitation occurs when the pressure around the hydrofoil rapidly drops as the boat's speed increases, creating bubbles that lead to small, vapor-filled cavities on the top of the hydrofoil. The vapor bubbles cause instability, draft and vibration that impede acceleration.

Cavitation is a problem for conventional drop-shaped hydrofoil profiles, but it can be controlled with — and may even be prevented by — triangle-shaped ventilating profiles.

However, ventilating hydrofoils are not widely used, and recent research into them is scarce. To determine if the new generation of hydrofoils was the optimal shape for the SP80, the team combined experimental and numerical tests. Gaudiot, who will pilot the SP80 in its attempt to set a new record, began by taking to the water to validate the hydrofoil concept at high speed.

"I had a real feeling of stability at high speeds," he said. "We reached more than 40 knots easily and without struggling to accelerate or stay on the board."

At this point, the team had already tested more than 20 different hydrofoil profiles and started optimizing them using a cavitation tunnel and numerical simulation in Fluent. CADFEM, a leading provider for simulation-based engineering and an Ansys channel partner, advised the students and engineers throughout the simulation process.

To avoid modeling the interaction between the hydrofoil and the free surface, which can be very complex, studies began in 2D. The team then refined all the solver parameters and validated them with experimental data before transposing the settings to a 3D model. Using Fluent enabled them to generate hundreds of simulations in record time. The results obtained from Fluent were fed into a neural network, making it possible to predict the performance of any form of hydrofoil and run optimization algorithms to finally reach the optimal shape for the SP80.

CONSIDERING MORE IDEAS TO GAIN SPEED

The EPFL team has tested a reduced-scale prototype of the SP80. Construction of the unique, futuristic craft has begun.

Gaudiot said Fluent enabled the team to virtually test a large number of designs and explore shapes they might not have thought of otherwise. The group confirmed a performance gain of almost 50%, which translates into more efficiency and thus more speed.

"We're developing something new, and we need to predict and learn how it will perform," he said. "Simulation is the perfect tool for us."

Simulation from Maglev to Hyperloop

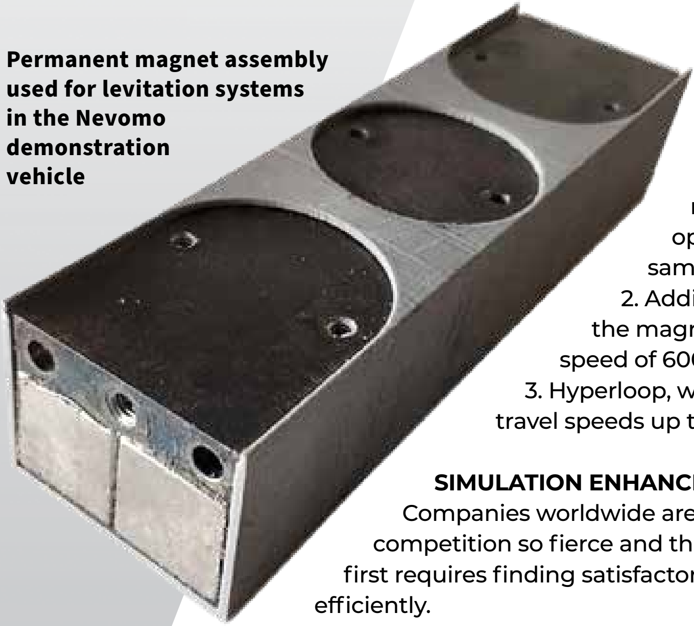
Although travel has been significantly curtailed during the pandemic, it remains a fundamental part of modern life. Whether getting from point A to point B means a quick trip around town or an extended journey across the planet, today's travel experience can be complex and energy-intense. With increasing pressure to lower emissions, figuring out how to make new transportation technology as "green" as possible — while also increasing travel speed and maintaining safety — is a priority.

Among those leading the charge is Polish startup Nevomo. The company, whose founders were finalists in the 2017 SpaceX Hyperloop Pod Competition, is developing a new generation of high-speed railways based on magnetic levitation (called magrail), linear motors and autonomous control systems. Their hyperloop-inspired magrail train will run on existing railway tracks upgraded to accommodate high-speed travel, with no need to build new infrastructure.

Permanent magnet cubes used in levitation systems on the Nevomo demonstration vehicle

HYPERLOOP TECHNOLOGY MEETS THE NEED FOR SPEED

Among other differences, hyperloop rail doesn't run on wheels like a conventional train. Instead, the compartments — called podcars or personal rapid transit (PRT) — are designed to essentially float on something akin to air skis using passive maglev technology to reduce friction. With eventual speeds up to 1,200 kph (745 mph), magrail trains will be faster than airplane travel. Yet, because magrail trains will run on electricity, their carbon footprint is expected to be insignificant.



Permanent magnet assembly used for levitation systems in the Nevomo demonstration vehicle

Nevomo is rolling out its system in three phases. Each new phase promises higher speeds than the previous one:

1. A passive maglev train — or magrail — will operate on upgraded, existing rail lines at speeds up to 550 kph (340 mph). This is about twice as fast as trains operating on conventional rail lines and the same as high-speed trains.
2. Adding special vacuum covers will transform the magrail technology to hyper-rail with a top speed of 600 kph (373 mph).
3. Hyperloop, which will run on a dedicated track, will push travel speeds up to 1,200 kph (745 mph).

SIMULATION ENHANCES MAGRAIL BRAKE PERFORMANCE

Companies worldwide are working on hyperloop vehicles. With competition so fierce and the project so revolutionary, getting to market first requires finding satisfactory solutions to complex issues and doing it efficiently.

Using Ansys simulation in the early design phase enabled Nevomo engineers to quickly understand how passive magnetic levitation, electromagnetic brakes and linear motors will work under various conditions. Ultimately, simulation helped Nevomo avoid errors and achieve a number of design milestones in less time.

For example, simulating the magrail's electromagnetic brakes enhanced the development process by reducing computation time and enabling verification of multiple design variations.

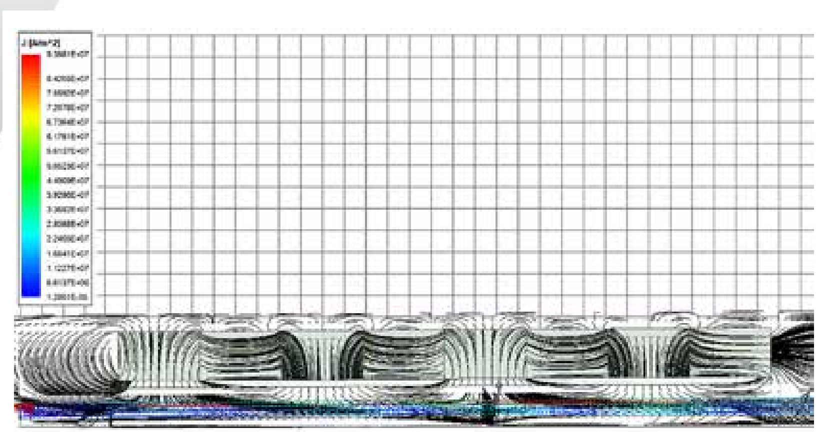
The electromagnetic brakes are based on NdFeB (neodymium-iron-boron, or "neo") permanent magnets — a rare-earth magnet that can meet high-density energy requirements. To optimize the strength of the magnetic field, Nevomo simulated various magnet arrays and magnetization directions. Engineers also used Ansys' distributed solve options (DSO) and high-performance computing (HPC) technology to speed up solution time over hundreds of 3D simulations.

GETTING TO THE FUTURE FIRST

Nevomo's work on magrail technology currently includes designing a permanent magnet linear synchronous motor for contactless propulsion. Simulation helps reduce the number of physical prototypes, saving money as well as time. The company also plans to use Ansys software to analyze antenna design and optimize printed circuit board shielding from electromagnetic radiation.

Working on life-changing technology requires a unique approach and robust tools. With computer simulation, Nevomo is pioneering hyperloop invention and bringing the world into the future, faster.

Symkom, an Ansys Channel Partner in Poland, provides service and support to Nevomo. Symkom provides its customers with computer-aided engineering (CAE) solutions in the areas of fluids, mechanical, electromagnetics and coupled analysis.



A time step from a simulation of the permanent magnet levitation system shows flux lines and current density plots.

Simulating the Hyperloop

A rendering of the Zeleros Hyperloop design

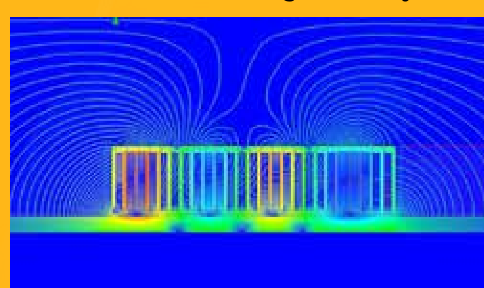
When SpaceX held the first Hyperloop Design Weekend Competition in Texas in January 2016, a team of five students from the Universitat Politècnica de València (UPV) in Spain, calling themselves Hyperloop UPV, won awards for Best Overall Concept Design and Best Propulsion System.

The idea was to use magnetic levitation to give their Hyperloop vehicle a frictionless ride through the tube; the propulsion system was a turbofan on the front of the vehicle that sucks in the air so it wouldn't cause drag. Hyperloop UPV designed this prototype with the help of the Ansys Maxwell and Ansys Fluent software that they obtained as an Ansys sponsored student team.

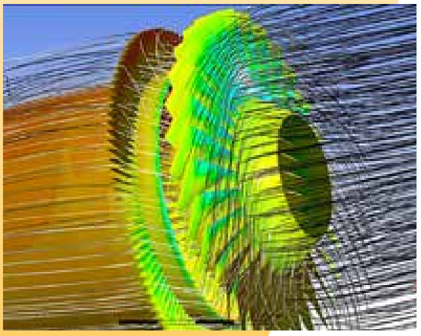
Later in 2016, some members of the team formed Zeleros, a company determined to win the race to bring the first commercial Hyperloop system to market. The Hyperloop is intended to connect cities with a high-speed transit solution consisting of passenger and cargo pods moving through a metal tube at speeds comparable to those of airplanes.

When they formed the company, the person at the university in charge of the Ansys licenses told them they were now eligible for reduced-cost software through the Ansys Startup Program. Zeleros began taking advantage of the program's benefits to use Maxwell to design the magnetic levitation system and Fluent to study the airflow through the turbofan and the rest of the vehicle–tube system.

"In Spain, seed funding is hard to find — you basically have to demonstrate your company's credibility by surviving and making progress for three years in the desert," says Daniel Orient, co-founder and CTO of Zeleros. "At the beginning, we had difficulties finding the money for salaries and laptops. Fortunately, Zeleros successfully overcame these years by raising public



Transient electromagnetic simulation of linear machine



An Ansys Fluent aerodynamic analysis of turbofan engine

and private supports. Thanks to Ansys Startup Program, we were able to navigate this journey with a simulation option that fit our budget, without the need of outsourcing the simulation engineering."

A UNIQUE APPROACH TO THE HYPERLOOP

Orient describes Zeleros' approach to the Hyperloop challenge as "designing a plane without wings to travel through a tube." They are the only company in the Hyperloop race to place all their technology in the vehicle, like the electromagnets for levitation and the turbofan for thrust. This approach will make building the infrastructure — the Hyperloop tube — cheaper and easier to maintain. Other companies are placing the propulsion equipment in the tube instead of in the vehicle.

Also, Zeleros has chosen to have the pressure inside the tube equivalent to the pressure outside a plane flying at an altitude of approximately 15 km. Other designs call for the tube to be at lower pressures, which theoretically would eliminate all the drag because there is no air to deal with. Zeleros chose this intermediate pressure with eventual certification in mind. "By choosing a pressure experienced by airplanes, we know that there are already solutions and standards for their design and certification," Orient says.

SIMULATING MAGNETIC LEVITATION AND TURBOFAN AIRFLOW

For their wingless airplane vehicle design, magnetic levitation replaces the wings to give the pod the lift it needs to move through the tube. It's a tight fit, like a piston in an engine. A combination of permanent magnets and electromagnets located on the topside of the vehicle controls the distance between the top of the vehicle and the tube wall. Zeleros engineers control the distance between the permanent magnet and roof with electromagnets and a gap sensor that continuously measures this distance in a closed-loop control system.

"We use Maxwell to simulate this process because it is an unstable system," Orient says. "If everything in the loop isn't controlled, the permanent magnets can fall down or fly up against the roof." Using Maxwell, they can change the gap distance and the current flowing through the electromagnet and measure the magnetic force. Then they can do experimental runs on a small-scale test model to check Maxwell's results.

"This simulation is easy to do on the magnetic side because the equations are quite thorough and the results match very well with the experimental data," Orient says. "The results you get are very truthful."

The fluid dynamics of the system are much harder to model, according to Orient, because setting up the mass of the vehicle and the boundary conditions adds more variables. "Our main aerodynamic problem is that we have a vehicle that is more or less the same diameter of the tube to cut costs, but this makes it impossible for the air to go around the vehicle because there is no space," Orient says. The Zeleros team uses Fluent to model this complex system, with the turbofan on the front of the vehicle driven by an electric motor swallowing the air to reduce the drag. The air is expelled from the rear of the vehicle. "This process generates the little bit of thrust we need to keep the vehicle moving at the desired speed," he says.

The Zeleros Hyperloop design uses a turbofan on the front of the vehicle to reduce the drag.

THE PROMISE OF SPEEDY, NONPOLLUTING TRAVEL

Because the whole system is driven by electricity, the Hyperloop will produce no pollutants. The availability of rapid ground travel could also reduce the congestion at airports as more people keep flying every year (disregarding 2020 and the drop in travel due to COVID-19). Zeleros predicts having an operational system available by 2027. Certification could take another two to three years, so they are aiming for a commercial launch in 2030. The first team to the finish line could have a major effect on the design of the Hyperloop tube itself.

"Now that the Hyperloop is more visible, we are trying to demonstrate that our concept is feasible and cheap enough to be built," Orient says. "It's a race with different companies working on the same concept with different solutions. Ansys software is helping us in this race."

Transportation Systems Get Smart

INTELLIGENT TRANSPORTATION SYSTEMS (ITS) can already help alleviate traffic congestion, make public transportation more efficient and manage infrastructure use by collecting and sharing traffic and public transport data. In the near future, ITS is expected to be a key component of smart cities by helping people request autonomous vehicles, and then efficiently and safely routing them to their destinations. Together, ITS and autonomous vehicles are expected to improve safety, reduce cybersecurity risks and reduce traffic, which would help improve the environment. To realize that vision, intelligent transportation systems must be thoroughly vetted by simulating the interaction of infrastructure and vehicle sensors under various conditions.

> *“We decided to use Ansys software solutions for this project because of several very important advantages. First, Ansys is undoubtedly one of the world leaders in this area.”*

The Department of Organization and Traffic Safety of the Moscow Automobile and Road Construction Technical University (MADI) was one of the first organizations in Russia to work on intelligent transport systems. It began with a joint project involving the Ministry of Transport of the Russian Federation, MADI, the Russian Association of Motor Insurers (RAMI) and United Telecom. They conducted a study of domestic and foreign traffic enforcement cameras, which made it possible to amend the Administrative Violations Code of the Russian Federation and other bylaws. After that, modern automated traffic control systems appeared, and by 2010 MADI had its own ITS testing ground. In 2014, MADI specialists developed the Russian cooperative intelligent transport systems (C-ITS) to inform drivers of potential roadway problems. They also tested vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and infrastructure-to-vehicle (I2V) communication options at the testing ground. Now, they've introduced simulation to advance their testing.

The scenario of autonomous vehicle lane-change from the third row to the second with a pass of the car, which is changing lane from the first row to the second. The Digital Road Model mobile module monitors lanes near its location to ensure safe maneuvering.

SMART INFRASTRUCTURE SUPPORTS AUTONOMOUS VEHICLES

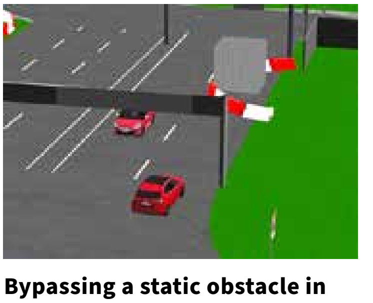
According to MADI experts, the development of a safe unmanned transportation system requires not only appropriate vehicles, but also a suitable road infrastructure. To that end, MADI has developed a Digital Road Model concept, which, together with cooperative and classic ITS, will help ensure traffic safety and increase its efficiency with highly automated vehicles.

The Russian infrastructure for unmanned vehicles is also advancing thanks to the Safe High-Quality Motorways project. The goal of this national project is to improve the state of existing roads and expand ITS implementation, including developing policy papers on the implementation of unmanned vehicles. Within the framework of this project, MADI is developing national standards and regulations for its Digital Road Model, including digital infrastructure requirements to support the movement of highly automated vehicles and data requirements to increase the efficiency of highly automated vehicle navigation via lidar and neural network algorithms. The Digital Road Model will use this data to recognize road markings and signs. In the future, the model will expand to help unmanned vehicles navigate, provide speed limit data and map optimal routes based on traffic loads. The project is slated to be implemented for federal roads between 2025 and 2030.

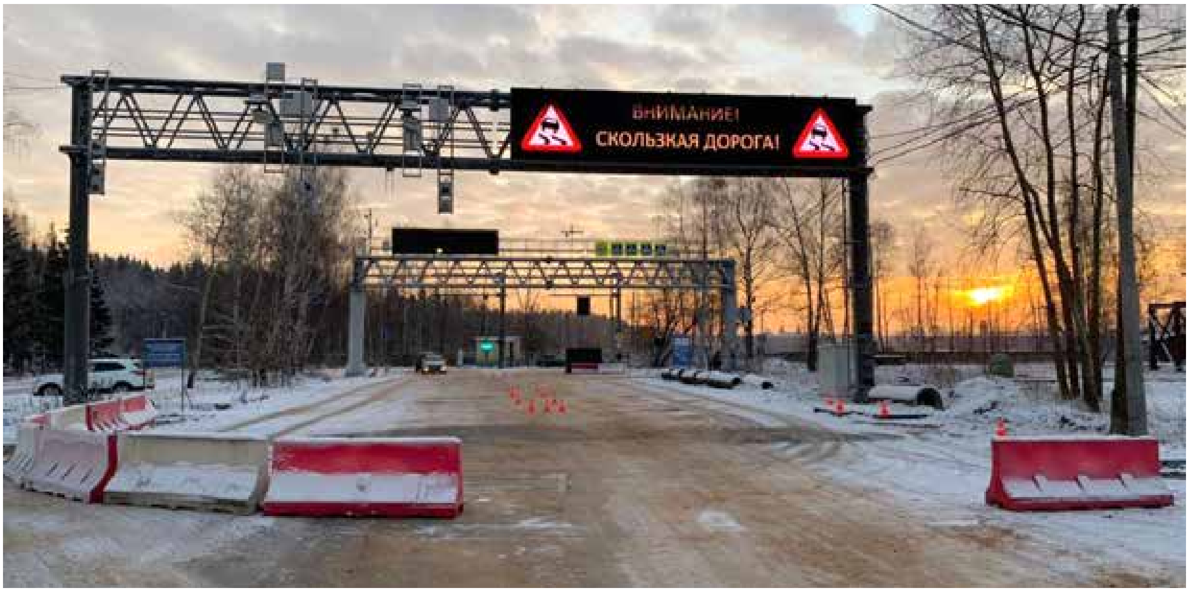
The single-lane crossing scenario. The narrowing is formed from traffic cones. The vehicle must overcome the single-lane siding, passing the vehicle of the opposite direction

SIMULATING INFRASTRUCTURE PROJECTS

MADI, together with its partner FAO ROSDORNII (Russian Road Research Institute), are developing infrastructure projects as part of the development of a Digital Road Model. One project is related to providing additional information for highly automated vehicles. It includes developing a prototype digital model of the MADI Smart Road testing ground. Using Ansys VRXPERIENCE Driving Simulator software, university specialists developed a polygon model that



Bypassing a static obstacle in the opposite lane of traffic. Unmanned vehicle must safely go around the overall obstacle in the traffic lane in the contraflow lane.



General view of MADI Smart Road test ground, where the unmanned vehicle tests are carried out

includes the same parameters as the real road, complete with signs and road markings. A virtual traffic light was developed along with a recommended speed service that allows the vehicle to adjust its speed so it can pass smoothly through green lights. This increases traffic light throughput and saves time while reducing the risk of accidents and congestion.

One of the main tasks of this project is to develop scenarios for the movement of highly automated vehicles in both normal and abnormal conditions, such as construction, bad weather and emergency situations like technical malfunctions or the deterioration of a driver's health. Another task is to develop scenarios in the background to support drivers of highly automated vehicles.

Using the test ground model, MADI specialists are conducting a study to determine the level of accuracy when detecting dynamic objects required for the Digital Road Model so that, when transmitting this information to an unmanned vehicle, it can effectively be used in its control loop. They chose to experiment with seven scenarios in which it was impossible to obtain all the necessary information using the vision sensors of the highly automated vehicle, which could lead to an accident.

Some of the experiments were carried out in the VRXPERIENCE virtual environment, including a scenario in which one unmanned vehicle (or two in some scenarios) does not "see" part of the road due to visual obstacles and must reconstruct it. At the same time, due to lack of information, an emergency situation may arise with other road users, which creates dynamic obstacles. The Digital Road Model must collect information from other sources to detect dynamic obstacles and transmit that data to the highly automated vehicle. This experiment also makes it possible to determine the level of accuracy that is needed for the Digital Road Model to determine the trajectories of obstacles in order to avoid an accident.

MADI specialists used Ansys simulations to set up accident scenarios. Because an accident is a confluence of many circumstances that have to be taken into account, a scenario can be quite complex. The engineers needed to create conditions under which both vehicles could not see each other until they were very close to colliding. The creation of these conditions via simulation reduced the number of physical experiments. The use of Ansys

“Ansys VRXPERIENCE is a very advanced product that allows you to solve most of the challenges of the project in a single system and not have to switch to other solutions when new problems arise.”

VRXPERIENCE allowed the engineers to reduce the time it took to complete their analyses by about 20%.

“We decided to use Ansys software solutions for this project because of several very important advantages. First, Ansys is undoubtedly one of the world leaders in this area,” says Andrey Vorobyov, deputy head of the Organization and Traffic Safety Department at MADI, and Deputy Head of the MADI Competence Center for ITS. “Second, they have high-quality technical support in Russia, provided by CADFEM CIS group, which is especially important when working with complex products. Finally, Ansys VRXPERIENCE is a very advanced product that allows you to solve most of the challenges of the project in a single system and not have to switch to other solutions when new problems arise. Of course, this allows you to save much time, money and other resources, including those needed for training.”

VRXPERIENCE was also used for initial hypothesis testing to eliminate those hypotheses that were not working. For each scenario of the experiment, three hypotheses were considered and the best option was selected.

VIRTUALLY TESTING UNMANNED VEHICLES

The virtual training ground, developed by MADI in VRXPERIENCE, is also used to test the basic functions of an unmanned vehicle before launching.

One such project is based on a Parkon — a car that patrols the Moscow parking space management system. It automatically records the plate numbers of cars parked on its predetermined route and detects violations related to parking rules. To create an unmanned Parkon, a passenger car was automated and given access to public roads. The project was carried out together with MADI partners Moscow Urban Transport Research and Design Institute and RosdorNII. Mostransproekt also created a dispatch system, which helped to determine where the vehicle was located and assess its activity, including the number of parking violations it had detected and how many tickets were issued.

MADI uses Ansys VRXPERIENCE to work out various scenarios for the Parkon system. The results of these studies will form the basis for a software update to Parkon this spring. The first version of the software reacted rather sharply to obstacles while driving. On the one hand, this provided the necessary level of road safety, but, on the other hand, did not correspond to the high level of driver comfort. VRXPERIENCE allowed specialists to simulate various obstacle response algorithms and find the most comfortable option for the driver with the required level of safety.

Thanks to the benefits inherent in simulation, MADI’s virtual training ground continues to quickly advance. The university continues to work with private and public organizations to usher in a safer, cleaner, more convenient transportation system that combines automated vehicles and smart infrastructure.

Kärcher Cleans Up with Ansys Twin Builder

The journey from creative thinking to product realization is paved with good intentions. Many possibilities that look promising at the outset never make it to market. Simulation in both the ideation and iteration stages of product design and development makes getting to "what's next" take less time, effort and expense. When used holistically, simulation enables companies to efficiently bring innovative, well-engineered products to consumers.

By combining Ansys Twin Builder's Modelica capabilities with Ansys Fluent, the Kärcher design team gained a previously unattainable holistic view of an entire product, in this case, an electric floor cleaner.

> **"WITH TWIN BUILDER, KÄRCHER COMPLETED SIMULATIONS ON A SYSTEM LEVEL AT A SIZE AND SCALE THAT WAS PREVIOUSLY INFEASIBLE."**

KÄRCHER, A GERMAN MANUFACTURER of high-pressure cleaning and other equipment, is known worldwide for innovation. Their pioneering products include the first modern pressure washer, first window vacuum cleaner and first fully autonomous vacuum robot. At Kärcher, simulation helps facilitate product realization — that is, the end-to-end process that ensures a product will meet performance and quality objectives. Whether they're developing a new product or enhancing existing equipment, simulation enables product teams to stay on track while generating, selecting, implementing and validating better, more viable ideas in the early development phase.

Being able to virtually compare concepts and understand trade-offs is an essential part of that process. That includes understanding how changes to one component affect not just other components but the system as a whole. But this is something that is often impossible to determine with conventional finite element analysis (FEA) or computational fluid dynamics (CFD) software alone, at least without considerable computational time or cost.

To overcome that barrier, Kärcher engineers used Ansys Twin Builder as the basis for a digital engineering workflow that enabled fast and accurate concept comparisons during optimization of a new device and two existing products: a vacuum cleaner and a battery-powered floor cleaner. Twin Builder is a digital twin platform that combines the power of a multi-domain systems modeler with extensive 0D application-specific libraries, 3D physics solvers and reduced-order model (ROM) capabilities. Ansys Twin Builder enhances the possibilities of digital engineering by making simulation of whole devices feasible. By combining its Modelica capabilities with Ansys Fluent, the Kärcher design team gained a previously unattainable holistic view of an entire product, reduced computation time from days to minutes, and avoided expensive physical prototyping.

Simulation resulted in a lighter and more compact battery pack design, lowering material requirements and costs.

INSIGHT INTO THE ENTIRE SYSTEM, IN MINUTES, NOT DAYS

On the surface, electric cleaning devices may seem simple and the tasks they tackle mundane — mop a grimy floor or vacuum up spilled cereal — but in reality they're extremely sophisticated products. The fluid pumps alone have multiple parts, including a crankshaft, inlet and

"SIMULATING THE BATTERY PACK IN TWIN BUILDER TOOK LESS THAN TWO MINUTES; SIMULATION OF THE ENTIRE CLEANING DEVICE SIMULATION WAS COMPLETED IN FOUR HOURS."

outlet valves, plungers, regulators, and safety devices. Add in the other components — air pumps, electronic terminals and controls, heat exchangers, mechanical parts such as switches, and, often, high-density battery packs — and it's easy to see how complex the design process can be, as well as how the right decisions on the front end can lead to better engineering outcomes and greater consumer satisfaction down the road.

Even optimizing the performance of existing devices is a strenuous process that can go far beyond a tweak here and an adjustment there — especially as new technology becomes available and consumer preferences change. Engineers have to know how existing products work, and not just in the sense of turning a knob to see what happens. Instead, they have to understand the interaction between parts as well as how changing one component can necessitate changing others. Without this information, they may relaunch a product only to discover that nothing has improved.

By simulating the electrochemical-thermal flow of different battery cells under what would be real-life consumer conditions, Kärcher identified a cell type and a battery housing design that would allow them to reduce the number of cells in the battery pack by 20%.

Before Kärcher began using Twin Builder, they simulated each component individually with classic FEA or CFD software. While that helped engineers understand how a part behaved under varying conditions, it didn't provide insight into the system as a whole. Modeling the entire device with individual software was possible but time-consuming — computation could take as long as three days, creating undesirable delays for engineers trying to compare early design phase concepts. Yet if they overlooked this step and didn't simulate the whole device, Kärcher risked getting a product nearly to market before uncovering potential problems that could send engineers back to the virtual drawing board.

Combining the multidisciplinary features of Twin Builder with Fluent provided the proof-of-concept checks Kärcher required. In the case of the vacuum cleaner optimization project, adding Twin Builder to the mix cut computation time from days to minutes. Result accuracy was within 5% to 6% of FEA or CFD alone, a suitable margin during ideation.

SIMULATING A SMALLER BATTERY PACK TO REDUCE WEIGHT AND HEAT

Among Kärcher's product optimization priorities was the development of a new battery pack for a well-established floor cleaner. Kärcher is increasing their presence in consumer markets, and to satisfy the preference for lighter, more flexible products, engineers wanted to downsize the 70-cell battery pack. As part of that mission, they sought to incorporate a new type of battery cell that would produce as much power as the existing pack but with fewer cells.

To enable accuracy and speed, engineers modeled the rechargeable battery pack in Twin Builder and the entire cleaning device in Fluent. Coupling the two enabled engineers to extract key battery pack characteristics from Twin Builder and to increase computational efficiency. In fact, simulating the battery pack in Twin Builder took less than two minutes; simulation of the entire cleaning device simulation was completed in four hours.

Contending with heat buildup is always an issue in battery pack design. Heat stresses batteries, leads to longer loading times and increases the risk of failure, which is particularly unacceptable in consumer products where long battery life equals customer satisfaction.

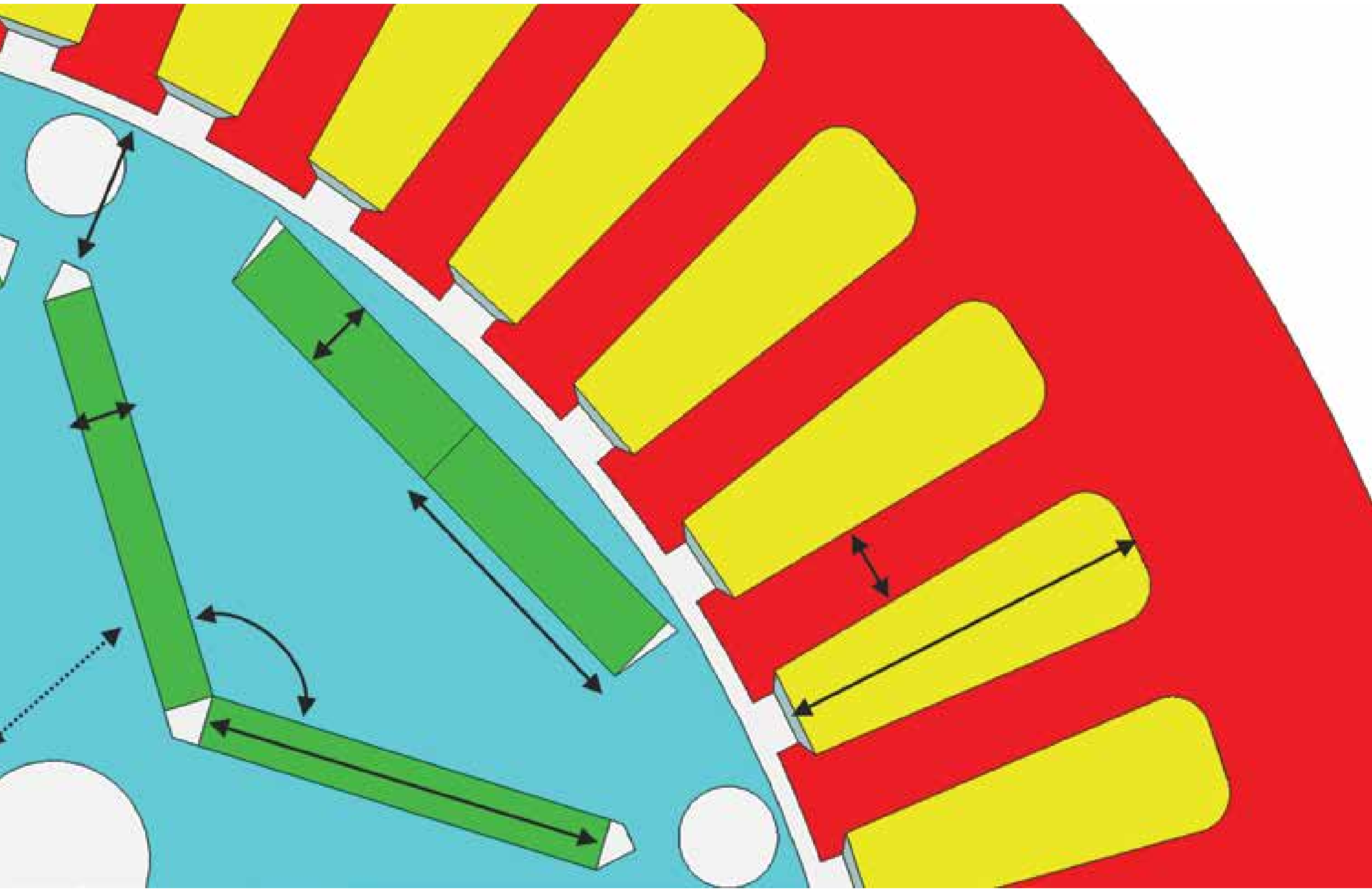
By simulating the electrochemical-thermal flow of different battery cells under what would be real-life consumer conditions, Kärcher identified a cell type and a battery housing design that would allow them to reduce the number of cells in the battery pack by 20%. Not only did this cut heat generation, it also resulted in lighter and more compact designs and lowered material requirements and costs.

Floor cleaner with battery pack

REPLICATING REAL-LIFE OPERATING CONDITIONS

In the end, Kärcher simulated the entire battery pack using Twin Builder and Modelica, which enables component-oriented modeling of complex systems. Engineers also applied Fluent to simulate the airflow inside the entire cleaning device. The two-way coupling of these simulations provided the additional flexibility engineers needed to consider things like different battery cells or battery pack housing materials under real-life installation situations. Because of the computational complexity involved in such detailed system simulations, that would not have been manageable using CFD software alone.

With Twin Builder, Kärcher completed simulations on a system level at a size and scale that was previously infeasible.



Democratization of Simulation Advances Electrification

By **Pierre Millithaler**,
E-machine simulations (FE) and method development,
Schaeffler Automotive Buehl GmbH & Co. KG

What if you deployed a time- and money-saving software application, but people in your company were reluctant to use it because they felt they lacked the necessary expertise?

As technology becomes more complex, this scenario is unfolding in businesses worldwide. In-depth understanding of design simulation software, for example, is often housed in a single department or belongs only to one or two experts, and convincing others to use new platforms can be a tough sell. Even engineers and designers experienced with other sophisticated programs might push back, preferring to work only with the technology they know best.

But it isn't necessary to be an authority on the underlying technology to take advantage of the benefits that simulation software offers. That's what democratization is about: making software accessible in such a way that all users can run it successfully without deep knowledge.

10X MORE SIMULATIONS IN LESS TIME

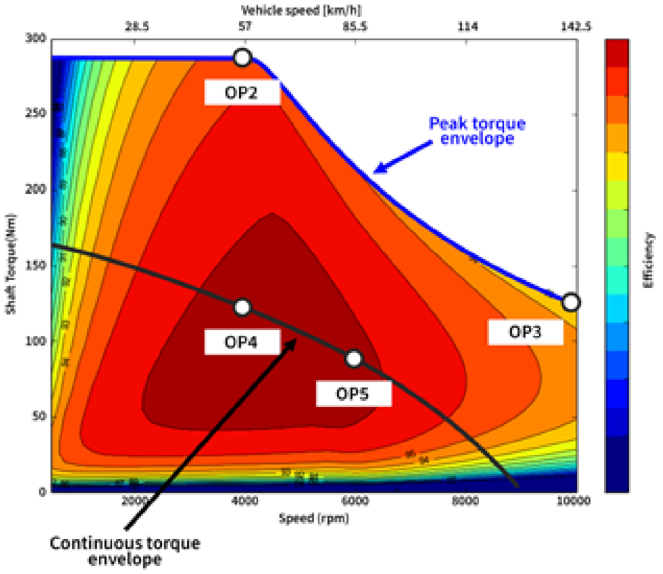
Schaeffler Group designs advanced systems and components for the automotive industry, including powertrains for electric and hybrid cars. A recent democratization effort by the e-machine Engineering Methods & Simulation team — which supports other Schaeffler departments during new tool deployment — centered on creating a computationally efficient workflow that will enable multiphysics, multi-objective design optimization of the electric machine.

Specifically, the group coupled Ansys Motor-CAD, the leading electric motor design software, with Ansys optiSLang, a platform for process integration and variation analysis. The result was a ready-to-use, duty-cycle–based optimization methodology that will help product designers identify the relationships between the e-machine's behavior and specific geometrical parameters under real-world conditions.

Now, Schaeffler designers and engineers enterprise-wide have a better design-to-validation workflow for electric machines that should reduce reliance on expensive physical prototyping. A meta-model enables a substantial increase in the number of optimization iterations that can be performed, in a fraction of the time required when performing simulations on a finite-element model directly. In an era of energy transition where electrification initiatives are on the rise, and demand for powerful, yet affordable, e-machines is growing alongside them, this will enable Schaeffler to satisfy customer demand faster and better than ever.

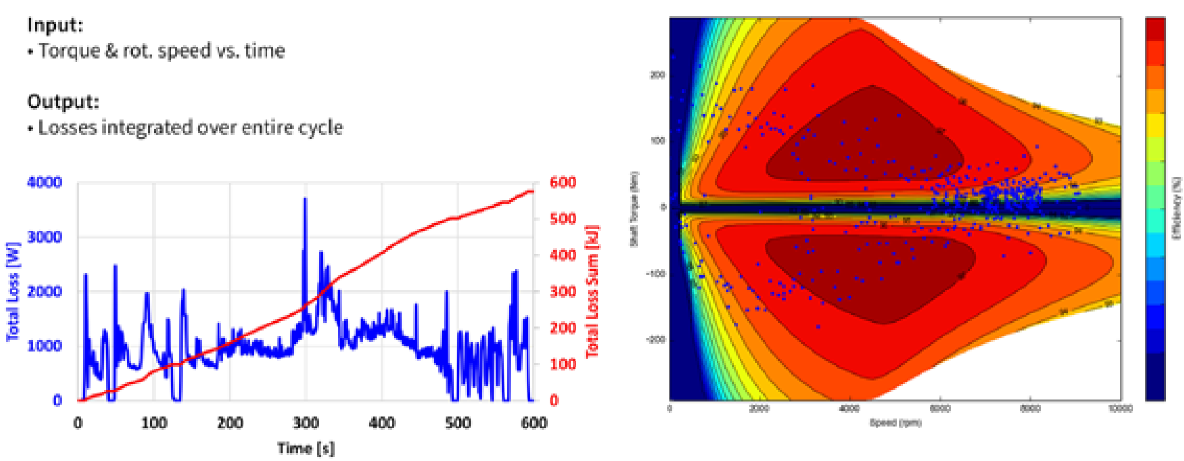
OVERCOMING BARRIERS TO SOFTWARE ADOPTION

Schaeffler helps shape mobility for tomorrow. Their products represent a staggering array of processes and disciplines: different aspects of physics, various thermal states, mechanical engineering and electrical engineering, among many others. With the ability of Ansys Motor-CAD to produce multiphysics simulations across the full-torque operating range, it is easy to see how the software could

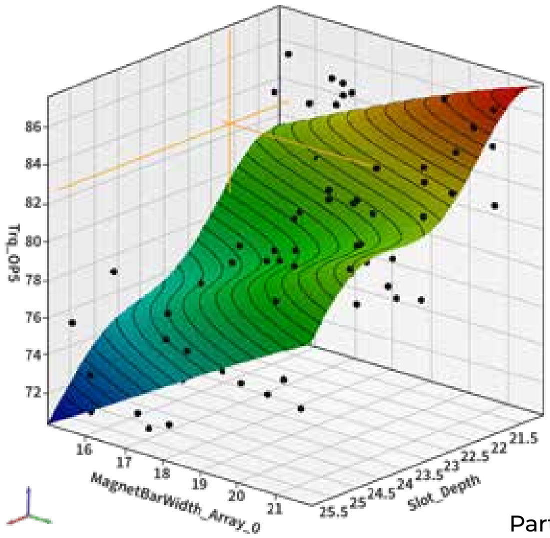


Efficiency map with peak and continuous torque speed requirement

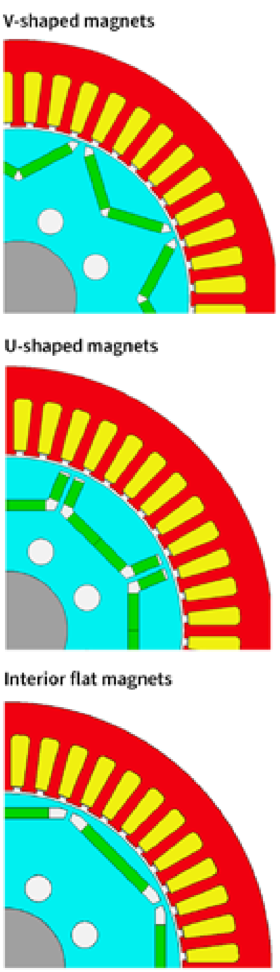
> ***"Schaeffler Group designs advanced systems and components for the automotive industry, including powertrains for electric and hybrid cars."***



Drive cycle efficiency simulation



Meta-model visualization of the relationship between two geometry parameters and the continuous torque



Selection between different rotor concepts for the same requirements, based on the same optimization workflow

fit into the Schaeffler toolkit. In particular, it would allow designers who have expertise in one area — electromagnetics, for example — to performance-map the entire electrical and thermal behavior of electric machine designs without having to acquire additional knowledge.

Among other activities, the Schaeffler simulation department develops standalone tools and workflows that help acquisition teams quickly perform calculations and display specific results. They are also involved in evaluating the potential of existing software and promoting it within the company.

A few years ago, they turned their attention to Ansys Motor-CAD. Since evaluating its potential and promoting its use within the company, the number of users within Schaeffler has been increasing.

Part of Motor-CAD's popularity within the company can be attributed to a meta-model–based approach developed by Schaeffler simulation engineers that coupled Ansys Motor-CAD and Ansys optiSLang to optimize the placement of magnets within an electric drive in the early design phase. Magnets help determine the mechanical power within the drive, so optimizing their volume, shape and other variables serves two purposes. For one, magnets are extremely expensive; using the smallest magnets that meet performance requirements helps reduce overall cost of the electric machine. In addition, geometry optimization helps to minimize performance-altering iron, magnet, and AC or DC winding losses in the electric drive's rotor and stators during specific drive cycles.

EVALUATING 100 DIFFERENT GEOMETRIES

Regardless of the algorithms engineers choose, running an optimization involves multiple iterations, and that can take considerable computational time. It's not unusual for a single finite-element model simulation to take as long as 35 minutes.

To generate results far faster, Schaeffler computed a meta-model in Ansys optiSLang then used the software to also run the optimization. That enabled them to run thousands of optimization iterations within minutes.

Schaeffler simulated 100 different geometries in all, evaluating the effect of each design variable, including magnet thickness, at every operating point. The meta-model also accounted for total loss of energy over a given duty cycle, one of the optimization objectives. Using one of the duty cycles embedded in Ansys Motor-CAD, Schaeffler's simulation engineers were also able to assess integrated heat losses over the entire duty cycle.

THE CONFIDENCE TO DO MORE, INCLUDING SATISFYING CUSTOMERS

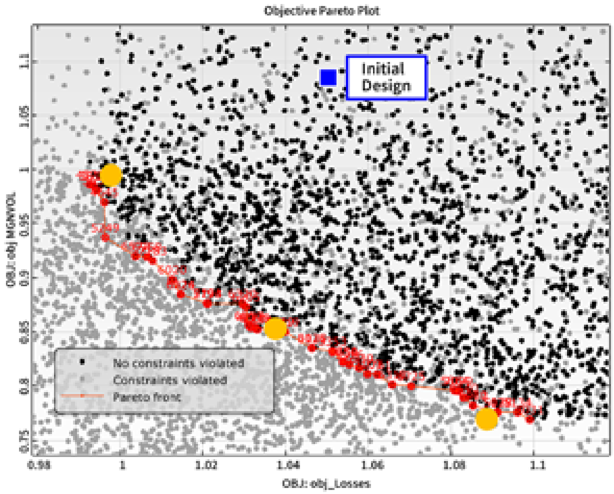
During pre-processing, the goal was to define the relationship between shaft torque and rotor speed as design variables (input values or parameters) changed during different duty cycles and during peak or continuous operation.

Schaeffler then used Ansys Motor-CAD to model changes in torque at defined operating points against changes in various input parameters: Slot depth, magnet thickness and width, bridge thickness, magnet array angle, and pole arc. Using one of the duty cycles embedded in Ansys Motor-CAD, Schaeffler's simulation engineers were also able to assess integrated losses, including those in the form of heat, over the entire duty cycle. Because customers will expect each of the operating points to deliver at least a certain value of torque, the input parameters provided constraints for the optimizer.

At this point, Schaeffler simulations engineers analyzed the relationships between input and output values in Ansys optiSLang. Because the simulation software allowed them to generate meta-models with accuracy greater than 95%, Schaeffler had the confidence to compute all the optimization samples for the required algorithms, and to do it without having to repeat any simulations in Ansys Motor-CAD.

The simulations group also verified the best magnet design to fulfill performance requirements while minimizing sum total losses and magnet volume. The result, a combination of specific magnet dimensions, represented a 23% improvement in magnet volume compared to the initial design.

In the end, Schaeffler's work will translate directly into greater customer satisfaction: When an automotive manufacturer requests optimization of a particular operating parameter, Schaeffler can deliver the most promising concept faster than ever.

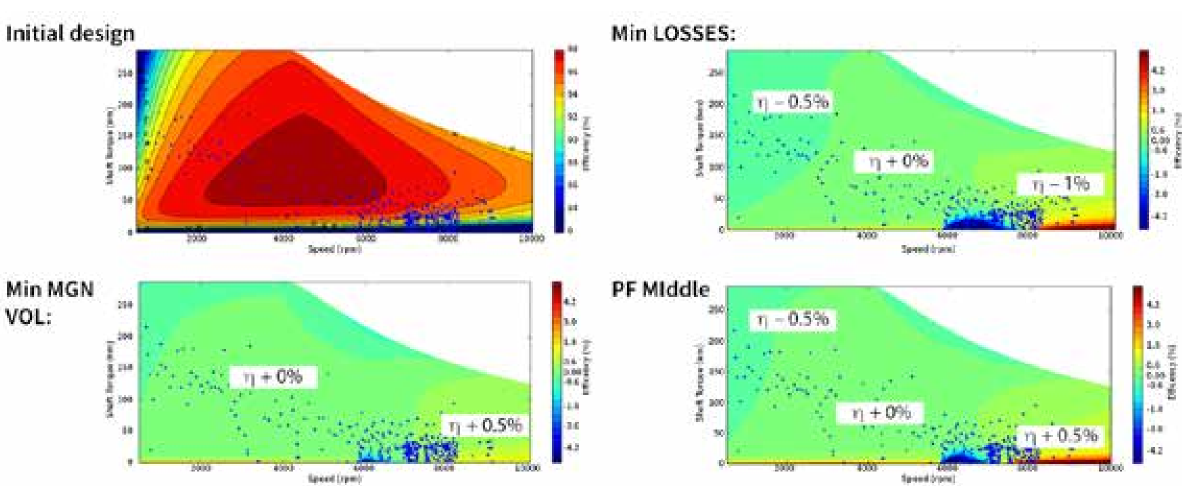


Pareto front, multiple optimal design concepts demonstrating a trade-off between e-machine cost and drive cycle efficiency

STAYING UP TO SPEED

By coupling front-loading methodologies, Schaeffler created an efficient and flexible tool that enables product designers and engineers to use the same optimization workflow for any electric machine concept — and to have results in minutes. Instead of it taking 50 hours to simulate 100 samples using FEA, the meta-model–based optimization can simulate 10,000 samples within minutes.

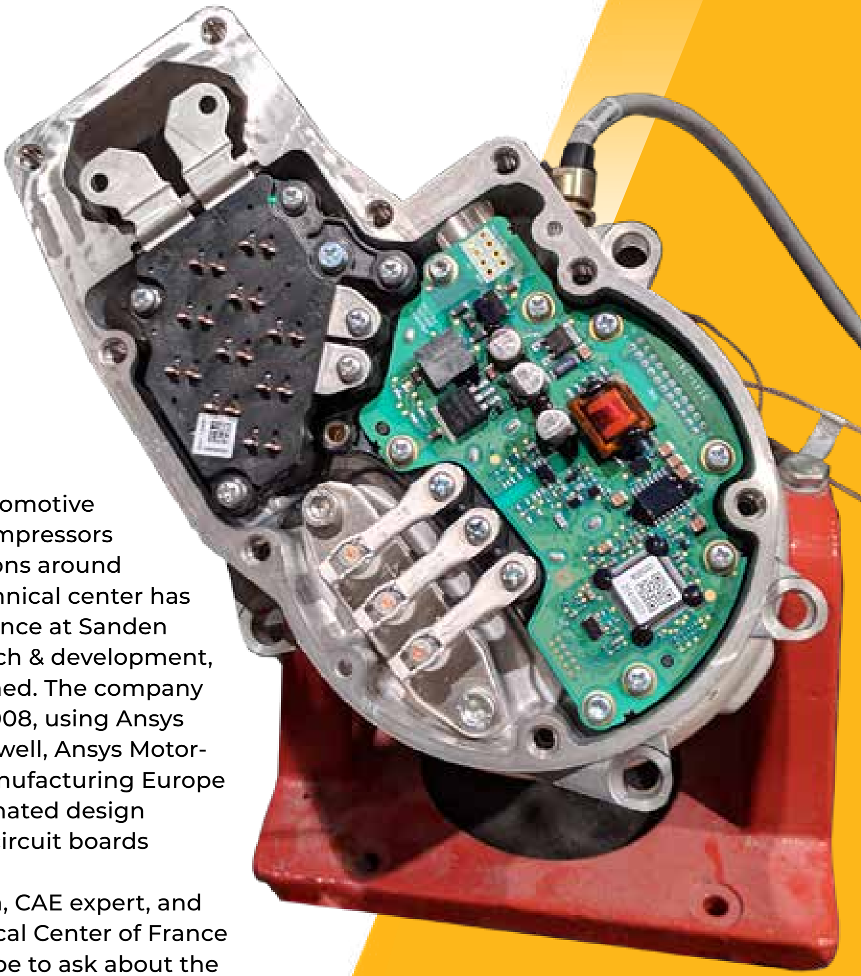
The meta-model also eliminates the usual steep learning curve associated with new software, meaning it is helping Schaeffler engineers and designers be more productive right away — and stay up to speed with their automotive customers.



Comparative efficiency map between different optimal design concepts

Sanden Reduces Model Creation Time by 85%

By **Bruno Gaudin**,
Senior Application Engineer,
Ansys



An electrical compressor PCB assembly mounted on its casing

The Sanden Group is a Tier 1 automotive supplier of air conditioning compressors based in Japan that has locations around the world. The Sanden European technical center has three locations, one of which is in France at Sanden Manufacturing Europe, where research & development, design and test activities are performed. The company has been an Ansys customer since 2008, using Ansys Mechanical, Ansys Fluent, Ansys Maxwell, Ansys Motor-CAD and more. Last year, Sanden Manufacturing Europe decided to test Ansys Sherlock automated design analysis software to analyze printed circuit boards (PCBs) for its electrical compressors.

We caught up with Arnaud Menon, CAE expert, and Jérôme Le Gal, director of the Technical Center of France (TCF) at Sanden Manufacturing Europe to ask about the company's experience with Sherlock and their future plans.

ANSYS ADVANTAGE: How are you using Sherlock?

Sanden: For each new compressor generation, we need to redesign a PCB. So, we start from zero, but we re-use our experience. Sherlock allows us to arrive at a robust design faster, with less trial-and-error iteration.

We analyze the PCB on the electrical compressors. There is one PCB per compressor but sometimes, due to design constraints, we have to split it into two parts. We simulate and, based on the results, we ask for the designers to fix any issue that may be revealed by the simulation analysis, such as adjusting the PCB thickness, attaching a component directly to the housing, changing a component's position, etc. We try to combine everything together: the electronic, mechanical (static and vibrations analysis) and thermal

“The data settings and the meshing job for the simulation is much faster than our previous workflow. We went from a week to a day to generate a first draft.”

requirements. This part of the job is very challenging.

ADVANTAGE: What features made you choose Sherlock?

Sanden: We chose it mainly for its database and the fatigue tools. Until we started using Sherlock, the correlation between tests and simulation was performed, but we did not have any criteria to see if a component would fail or not, so we had to only perform comparative analysis. Now, we can do more precise analysis with real criteria. For example, Sherlock give us the top three most critical components we have to monitor.

The data settings and the meshing job for the simulation is much faster than our previous workflow. We went from a week to a day to generate a first draft. Previously, we had to recreate a material for each component to have the right mass at a good location. Now, with Sherlock it is straightforward. Sherlock also creates a simple and good mesh directly, which was not the case before when we had the computer-aided design (CAD) file. It was more complicated. Sherlock allows us to test more things.

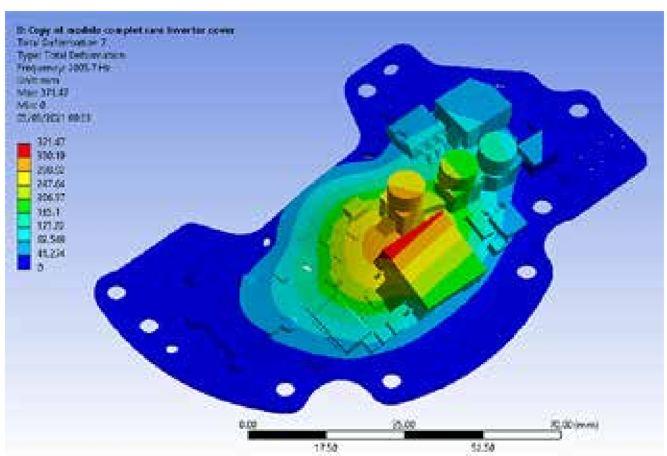
We have not yet tested the thermal aspect. For now, we use Fluent to perform thermal tests. We appreciate that we can perform different vibration analysis (harmonic vibration, power-spectral-density (PSD) analysis, natural frequencies, etc.).

Finally, the direct reading of the ODB++ files allow us to have a direct approach from the ECAD team to the CAD team, avoiding using software to “translate” the ECAD files into CAD files. The visualization of the PCB directly in Sherlock is a strong point. We can see the layers of the components, summaries, etc.

ADVANTAGE: Can you describe your product design and development workflow, and how Sherlock was integrated into it?

Sanden: At the beginning, it was used later in the process. We used Sherlock on products that already existed to make correlations, test Sherlock and have confidence in it. We had PCBs that we could test. This validation was successful.

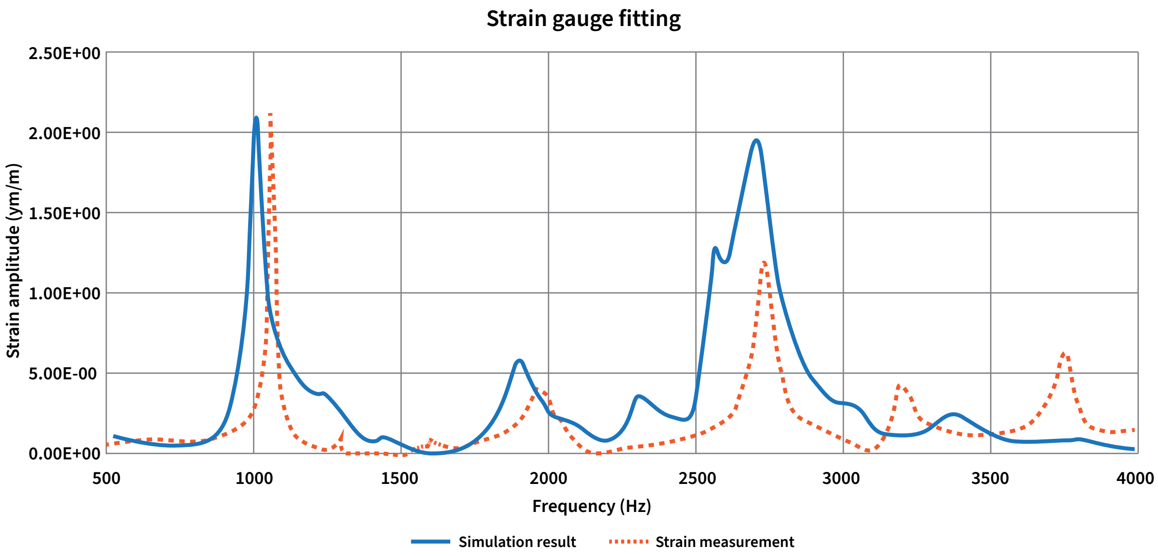
Now, we use it at the beginning of the development. The goal is to avoid future issues before the production of the PCB. On the last project, thanks to Sherlock, we avoided two or three things that would have been annoying for the rest of the project. We removed three vibrating modes from the frequency band associated to our project.



The first eigen-mode of the PCB

ADVANTAGE: How does Sherlock help you address your product design and development challenges?

Sanden: It helps us make the right



Strain gauge amplitude fitting measurement results (dotted red) vs. simulation results (blue)

decision on the validity of the PCBs and how to correct them, improve our product by changing the parameters, and find solutions — even before making a first prototype. It is very easy to iterate on a project, for example, to simulate different scenarios.

ADVANTAGE: Can you provide some concrete examples of benefits Sherlock has provided, such as time or cost savings?

Sanden: For the creation of a simple model, we went from 7 days to 1 day, with an improvement in the quality of the model.

Now, we have criteria. We will refine them, but for a first approach, I use the Sherlock criteria. As a result, we also save time there. It allows us to avoid redesign, and we are more confident in our results and can make decisions more quickly.

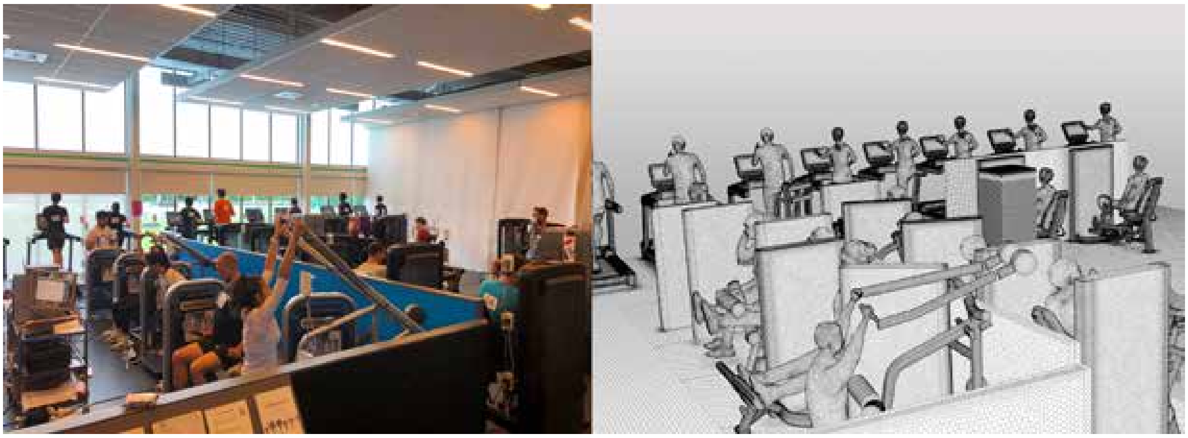
For more information on Sanden Manufacturing Europe, visit sanden-europe.com.

Breathe Easy: Conquering the Coronavirus with CFD

By Ansys Advantage Staff

Fitness centers equipped with insufficient ventilation have been identified by governments around the world as key hotspots for infection during the COVID-19 pandemic. Strenuous exercise causes gym patrons to constantly exhale large amounts of saliva droplets, which creates a particle concentration that is potentially loaded with the virus. As the concentration builds throughout the facility, it creates a substantial risk for those who may ingest virus particles, leading to infection. How can gym owners better protect their patrons? Many governments have delayed the reopening of fitness centers until this question is answered.

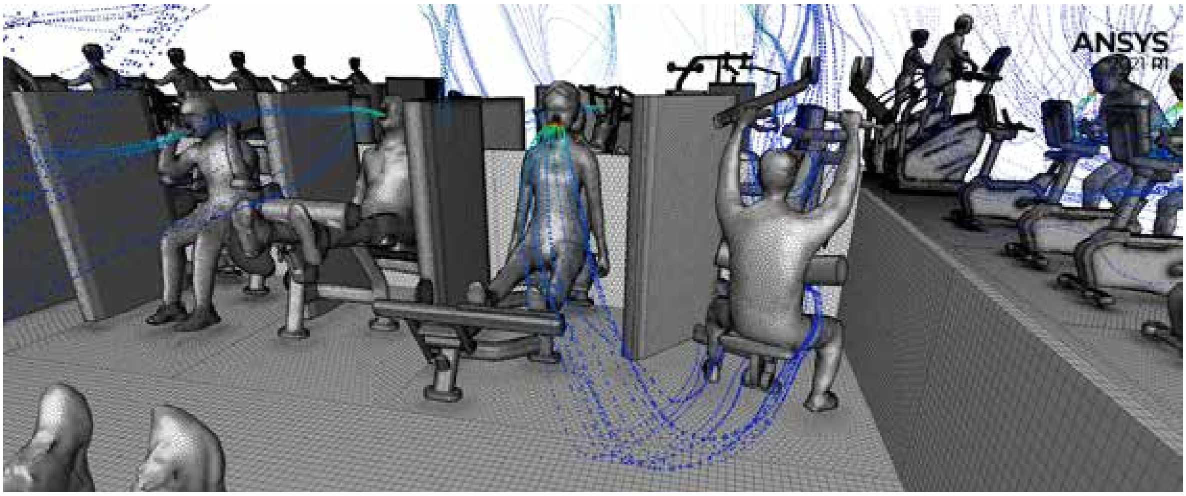
Recently, Sportinnovator in the Netherlands, appointed by the Ministry of Health, Welfare and Sport, took the lead on this critical issue, commissioning Dr. Bert Blocken and his Eindhoven University of Technology research team to examine whether ventilation and air cleaning systems could sufficiently reduce the buildup and inhalation of dangerous microscopic aerosol droplet particle concentrations. When aerosol particles are exhaled, they typically evaporate in a fraction of a second to a few seconds, leaving behind a solid nucleus particle, which the virus can reside on and could remain airborne for several hours, especially for smaller aerosol particles. Invisible to the naked eye, these particles could only be tracked using state-of-the-art computational fluid dynamics (CFD) simulation technology.



Ansys Fluent was used to digitally recreate the Eindhoven University of Technology sports center.

Blocken's team set its sights on learning how to keep aerosol concentrations low enough so that the dose would not grow large enough to cause infection. By combining physical experimentation measurement and Ansys Fluent modeling, the team delivered a comprehensive answer for solving the issue, which would better educate the Dutch government and provide sufficient evidence to the public that properly equipped fitness centers could safely reopen during the pandemic.

The team used Fluent to track the number of particles within the confined space of a Dutch fitness center and learned that the ventilation system, even though it was 4.5 times stronger than the required minimum ventilation rate in the Dutch Building Code, was incapable of preventing the monotonic rise of particle concentrations in the air. This inspired them to find an effective, affordable and energy-efficient solution — advanced air purifying machines — that could work in tandem with the ventilation



Dr. Blocken's team used Fluent to assess the fitness center's airflow and understand how air purifiers and ventilation systems could join forces to help reduce contagion.

system, ingesting the particles to potentially rid the area of contagion and keep patrons safe.

GATHERING THE MEASUREMENT DATA

On July 11, 2020, Blocken's team performed experimental analysis to measure the overall aerosol concentration average of the university sports center at Eindhoven University of Technology.

During the first part of the experiment, athletes rode stationary bicycles, exhaling into a machine that counted the number of different-sized aerosols. In the second part, Blocken's team installed 147 sensors throughout the fitness center that gathered measurement data on 35 people exercising in a series of time slots of 30 minutes, assessing how many droplets patrons exhaled into the air while exercising at different intensities.

Next, the team leveraged the ventilation system and patrons' mouths as boundary conditions and used a light scanner to quickly scan the body geometries of the athletes as they exercised on treadmills and other machines.

The experiments enabled the team to measure the invisible particle droplets and provided the critical data for creating the Fluent simulations, which digitally recreated the fitness center, delivered insights on the fitness center's ventilation effectiveness and the effectiveness of the air cleaners, and illustrated how the particles traveled throughout the space.

USING CFD TO TRACK PARTICLES

To conduct his simulation research, Blocken leveraged his countless hours of earlier COVID-19 modeling studies, where he used Fluent to analyze the airflow and particle droplet dispersion around humans, measuring how they exhaled air and droplets.

Again using Fluent, Blocken's team simulated busy activity at the university sports center for an entire day to understand how a ventilation system or how adding additional equipment like air purifiers could help reduce the particle concentrations.

Fluent was key because, while the number of particles in the center indoor air could be measured during the experiment, their origin remained a mystery. For example, as the 35 gym patrons breathed, their saliva particles were tracked but other particles in the facility were counted in parallel, including particles shed from the patrons' clothing, skin and hair — as well as particles created by the friction within gym machine components. They were challenged by the experimental inability to separate airborne saliva particles from these other particles. Fluent enabled the team to solely highlight the saliva particles. Only saliva particles emerging from the mouth of the 35 patrons were considered in the simulation. Particles in a wide range of sizes were tracked, including those from processes such as deposition and removal by ventilation and air cleaning.

The simulation research kicked off with Blocken's team using Fluent to perform post-processing on the athletes' body scans and carefully applying a computational grid to model airflow around the patrons' bodies. Next, the team tested the different models to arrive at a good convergence on complex geometries — a fairly challenging effort because of the low airflow velocities in the room — and recreate the measurement results.

The team then compared their earlier experimental results with their simulation results, adjusting the simulation parameters until the model results mirrored the team's measurements, accurate to at least 10%. By validating the simulation, the team could then begin to extrapolate and perform parametric analysis by testing a wide range of different CFD modeling scenarios. To accomplish this, they relied on Ansys Cloud and leveraged $250,000 Microsoft Azure cloud credits, generously donated by the White House–led COVID-19 High-Performance Computing Consortium.

Using Fluent, Blocken's team simulated longer exercise durations, different distribution sizes of particles and various types of plug-and-play air cleaning technologies, which ingest the air, remove the saliva particles and recirculate the air back into the fitness center. They also examined how adding more air cleaners and a significantly more powerful ventilation system could impact the particle concentration buildup within the fitness center.

ANALYZING THE RESULTS

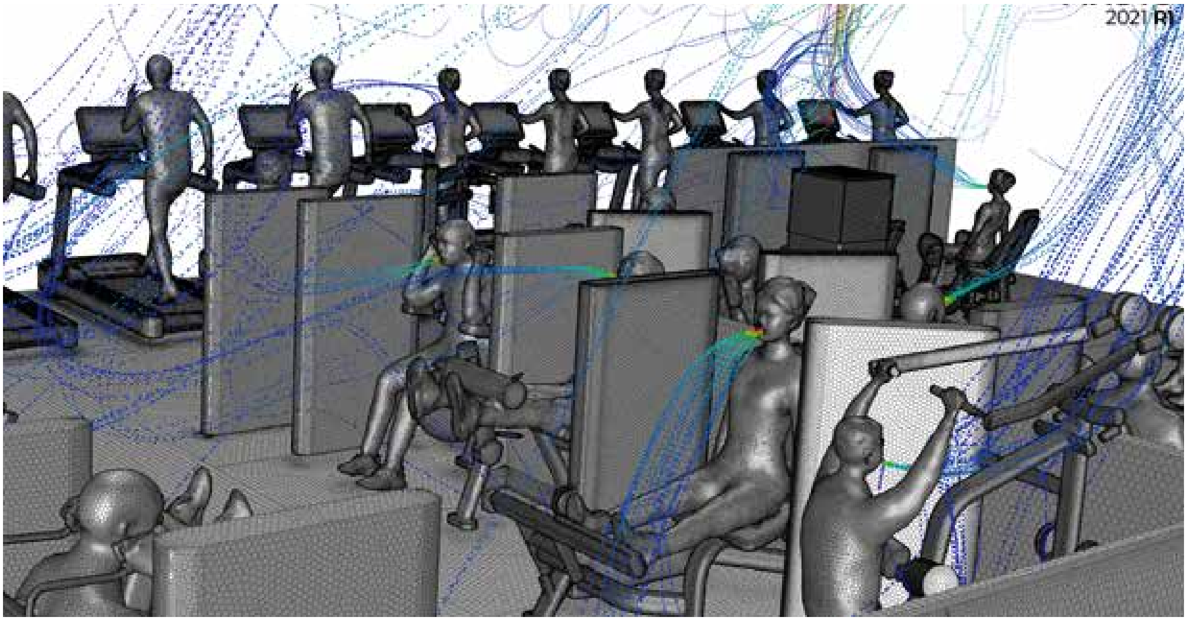
With Fluent and Ansys Cloud, the team discovered that the ventilation system and air cleaners could potentially each introduce oppositely moving indoor airflows that would, to a large degree, cancel each other out, limiting each other's effectiveness. This means that the airflow produced by the ventilation system and the air cleaners must be carefully synchronized to achieve optimum results.

The team's research also concluded that if a fitness center is equipped with a mechanical ventilation system that satisfies the legal minimum requirements but faces aerosol concentrations that are too high, the ventilation system does not need to be updated, which would involve a high cost. By optimizing the number and placement of air purifiers throughout the facility, the aerosol concentration can be effectively reduced — to as much as 90%–95% — delivering the most economical and most efficient means for reducing risk of airborne COVID infection, the flu or any other infectious diseases that might be present.

Without Fluent, the team's workload to complete all gym scenarios would have tremendously increased, stretching the very time-consuming aerosol particle measurement process with volunteer participants tested against COVID-19 to an estimated three years. Using Fluent and the compute power of Ansys Cloud via Microsoft Azure, the team accomplished their CFD research in just three weeks.

Blocken's fitness center study results will help provide governments the proper advice for managing aerosol concentrations — not just in gyms but in countless other applications, spanning global venues such as schools, airplanes, elevators, business offices, movie theaters and more.

Following their success at the Eindhoven University of Technology fitness center, Blocken's team is using Fluent to test upscaled versions of the air cleaning machines' usefulness for large stadiums, such as Holland's Johan Cruyff ArenA, the largest stadium in the country, and the Maaspoort, home of the most successful basketball team in the Netherlands. Deployment of these machines could soon improve public safety at large sporting events around the world.



The team discovered that the ventilation system and air purifiers could work against each other if not synchronized.

The SkyCell 1500 hybrid container in transit.

Simulating Smart Containers Saves Lives

SkyCell saves lives by reducing vaccine shipment loss rate using Ansys simulation to design smart, IoT-enabled air freight containers.

By Ansys Advantage Staff

SkyCell designs, creates and manages smart, durable air freight containers for transporting vaccines across the globe. The containers are constructed with a bespoke material, require no direct human management, control their own temperature and report their location in real time. SkyCell uses Ansys HFSS, Ansys CFD and Ansys Mechanical to simulate a holistic view of Industrial Internet of Things (IIoT) components, air and energy flows, and the structural integrity of the container. Without simulation, it would be impossible for the team to aim for perfection in an industry that needs it, especially when lives are at risk.

MEETING THE CHALLENGES OF SENSITIVE CARGO

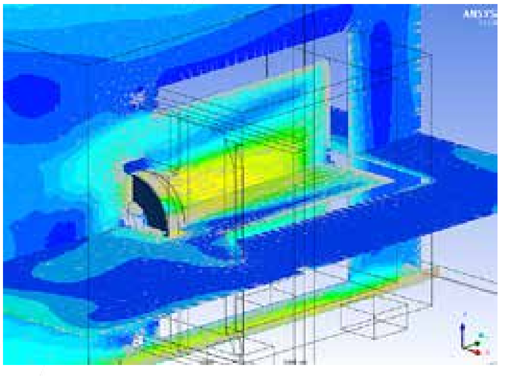
Air freight containers are frequently in grueling conditions: spending hours on hot tarmac runways, subjected to bumpy aircraft landings and trucked via local roads. Vaccines have large molecules and are particularly sensitive to high

"Using Ansys software helps us to reduce the vaccine loss rate during shipping to just 0.1%. When the industry average for air freight containers is between 1% and 10% — and lives are very literally on the line — reducing this by a factor of a hundred has an incredible impact on human lives. Ansys' software allows us to view the world in a more holistic way, designing a product that is far closer to perfection than other platforms can allow."

— **Nico Ros**, CTO, SkyCell

and low temperatures, but temperatures in transit can easily vary from -20°C to +50°C, posing a challenge for logistics firms. On top of this, air freight is an expensive way to move goods, increasing plane traffic and pollution, but it's crucial for vaccines to arrive quickly.

In air freight, it is common for 1% to 10% of a shipment to be lost or damaged, but SkyCell exists to reduce this to just 0.1%.



Enhancing the container internal airflow in a pre-conditioning chamber with 3D CFD simulation in Ansys CFX

"Earlier this year, we had 4,000 coma patients in India waiting for a vaccine from Europe," explains SkyCell CTO Nico Ros. "The pandemic had disrupted the supply chain, so the shipment was stuck in Qatar for five long, hot days. It eventually arrived in Mumbai, in perfect condition, despite the difficult conditions. This is just a regular day for us, and one of many situations that SkyCell was founded to tackle."

Historically, air freight containers have either been active (refrigerant units) or passive (boxes filled with dry ice, for example) but SkyCell uses a hybrid design that doesn't require human interaction or use mechanical components, and can recharge itself when it detects the steady 5°C conditions of a warehouse.

SkyCell's hybrid design is a complex system of interactions. The team previously used separate simulation tools to model all aspects of the containers but knew that the design process could be significantly improved if they could model more holistically.

"We needed a tool that could show us this complexity so that we could not only manage it, but also harness it to work in our favor," says Ros.

ENGINEERING SOLUTIONS TO COMPLEX PROBLEMS

SkyCell worked with CADFEM as a strategic adviser to look at the simulation tools used by neighboring industries like aerospace and, after consideration, selected Ansys. The tools are used to simulate the physical structure, the IoT communications, and the air and temperature flows in and around the container.

"With Ansys, we could stop seeing the containers as refrigerators and start to understand the energy flows more precisely, like seeing the sun as an energy source rather than just thinking about temperature, for example," says Ros. "Our approach is always to aim for perfection first and work backwards to what is possible. In theory, we could have used separate simulation tools for the first 80% of the design,

The SkyCell 1500 hybrid container has an internal temperature range of +2° to +8°C, an external conditions range of –35°C to +65°C, and a storage temperature range of –40°C to +70°C.

The SkyCell 1500 hybrid container in transit.

but we wanted to build the Formula One car of air freight containers — something that will be vitally important when we have a vaccine for COVID-19. We simply couldn't settle for anything less than the best."

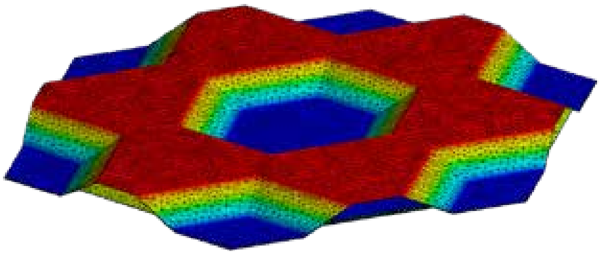
SAVING TIME AND LIVES WITH SIMULATION

Through the SkyCell team's use of Ansys simulation, the vaccine loss rate when using SkyCell containers is currently just 0.1%, compared to the lower end of the industry average 1%.

It takes SkyCell three months to build a physical iteration of a container, but just one week to build it virtually using Ansys software. The relationship between the simulation and the test unit is continually refined.

"Our containers are built from a recyclable, insulated, multilayer, shock-absorbing material," says Ros. "This material absorbs impact and dampens the vibrations from aircraft and trucks, but we had one example where the container frequency wasn't quite optimized. We realized that there was an interaction between the layers of the material itself that we hadn't picked up, but using Ansys we could remodel, correct and optimize this. A less sophisticated simulation tool simply wouldn't have been able to cope with the complexity."

Using Ansys to model the IoT components of the container allows SkyCell to accurately report its temperature and location in real time. This not only helps pharmaceutical companies to track the vaccines, but also to deal with transport regulations quickly because of the comprehensive data log, showing where the containers have been and how their temperatures have changed.

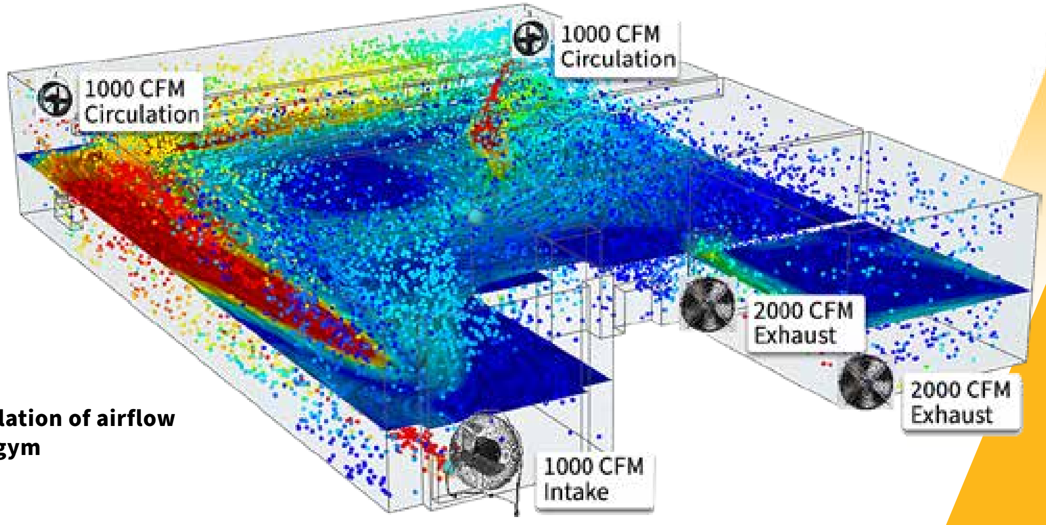


A 3D thermal analysis in Ansys Mechanical showing the sub-model of container insulation with periodic boundary conditions

The system can also provide data on how quickly containers tend to pass through customs, identifying any unnecessarily slow parts of the route. This is vital in helping authorities and logistics firms to optimize their own transport networks and overcome local issues — or to help pharmaceutical companies ship to new areas for the first time, without mishaps.

"Looking to the future, we've estimated that the world will need approximately 160,000 pallets to transport a COVID-19 vaccine once it's developed," says Ros. "This is potentially double the number in existence, although this number will decrease if the system is efficient. Our mission is to help increase this efficiency, and once a COVID vaccine is developed, we'll be proud to do our part."

One Airflow Simulation Can Save a Business



A simulation of airflow in the gym

By Ansys Advantage Staff

When the state of Oregon issued shutdown plans for nonessential businesses because of COVID-19 in the third week of March last year, John Huston, owner of Pacific Crest CrossFit Gym in Portland, was worried that the business might not survive the closure.

"It was terrifying, honestly," he said. "I was afraid that everyone would put their memberships on hold."

While the gym routinely deals with up to four holds at a time for vacations and other reasons, any extensive loss of membership fees from a large number of holds would put the gym in financial danger.

Huston soon learned that the business was more durable and flexible than he originally thought, due to something he already knew: CrossFit gym members don't just come in for a workout and leave; they are a community who counted on working out together several times a week. He was soon to learn more about the range of expertise in this community in the next four months, as the business remained in lockdown.

First of all, the members responded well to his appeal not to put their memberships on hold. Second, physicians who were members of the gym stepped up to offer Huston advice on COVID-19 safety measures. As the gym moved their workouts outside, the physicians helped him to interpret the sometimes confusing and conflicting guidelines that were being issued by various medical groups and government entities. Third, a gym member named Andy Byers worked for Ansys and knew that fluid flow

Pacific Crest CrossFit Gym members worked together to work out during the pandemic.

simulation software could model the flow of air in the gym, helping to ensure that members and staff would be safe when they reopened.

THE FOUR PILLARS OF REOPENING

By following the news and with the help of the CrossFit community, Huston established four pillars that had to be in place for reopening:

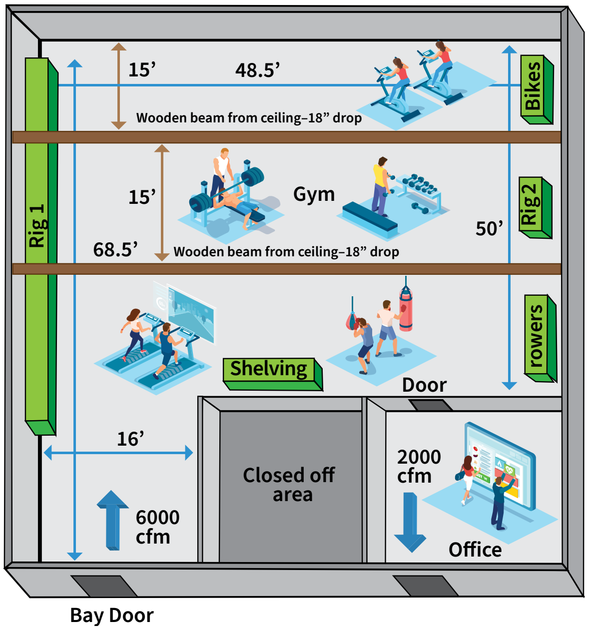
1. Social distancing
2. Hygiene
3. Mask wearing
4. Ventilation

While there was plenty of guidance on the first three, ventilation was more of a challenge. “Honestly, I didn’t even think about ventilation at first,” Huston says, until a member approached him and said she was concerned about being stuck in the back corner of the gym, with little airflow. The potential for air that was just exhaled from other people’s lungs — potentially an aerosol containing COVID-19 virus in droplets — had to be addressed.

Huston’s initial thought was to get a huge fan to move the air around. But his stepbrother, who works in commercial HVAC, said that would just blow the air around randomly and mix it up, not expel it. The answer, he said, was an overpressurization and exhaust model: overpressurize with good air and exhaust bad air. So, they obtained a 6,000 cubic feet per minute (cfm) fan and built a plywood blocker to seal the gym’s bay door. They also installed a 2,000 cfm exhaust fan in the front entrance area and sealed up that doorway.

LOOKING THROUGH “MAGIC GLASSES”

When Pacific Crest CrossFit opened after a four-month lockdown, Huston had all the pillars in place. Being unsure about the 6-foot social distancing rule, he divided the gym into 10-foot by 12-foot rectangles to give everyone more than enough space. The staff cleaned each area with a bleach solution when one member was finished and another needed to use that space. Everyone wore masks, and the ventilation system was up and running.



The gym’s floorplan

When Ansys employee Andy Byers, Strategic Partnership Director/Liaison, returned to the gym and saw everything that had been done, he looked at it through his Ansys-trained eyes.

“When you work for Ansys, you have magic glasses that make you see all the lines of physics — I see airflows moving and electromagnetic waves coming off my phone,” Byers says, jokingly. The ventilation solution he saw wasn’t wrong, but because he is trained to always optimize a solution, he wondered if it could be made even better.

“Given the existing constraints and resources, can we tweak things and optimize the ventilation?” Byers wondered. “Knowing where the equipment and people are in the gym helps, because flow is complex and sometimes it behaves in ways that are not intuitive.”

Byers approached Huston and told him about his expertise: knowledge about airflow simulation and access to Ansys’ design exploration software, Ansys Discovery.

“When Andy approached me about it, I thought: ‘Here’s another shining example of a person in my community who has some expertise in a moment when we really need it,’” Huston says. “I feel really fortunate to have all these people with all these skills and knowledge bases, so when it’s crunch time they are there for you.”

> ***"Knowing where the equipment and people are in the gym helps, because flow is complex and sometimes it behaves in ways that are not intuitive."***

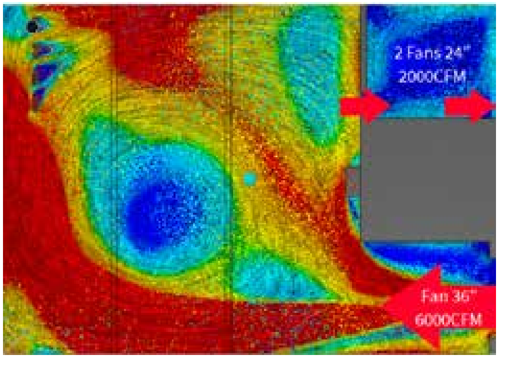
In the spirit of helping his community in a difficult time, Byers offered to run some airflow simulations at no charge to see if there were ways to optimize the ventilation system.

AN AIRFLOW SIMULATION SOLUTION

Byers asked Ethan Rabinowitz, Senior Applications Engineer at Ansys, to run the airflow simulations. He started by obtaining a layout of the gym, which is 48.5 feet by 68.5 feet by 12 feet tall, with an 11-foot-wide bay door and a standard size office door. Fan A was 36 inches square and pulled in 6,000 cfm, while Fan B was 24 inches square and pushed out air at 2,000 cfm. Then he assessed the percentage of blockage to airflow caused by the rigs (0%), bikes and rowers (50%) and shelving (100%).

With these parameters set, Rabinowitz ran a series of computational fluid dynamics (CFD) simulations via Ansys Discovery, exploring various design variables in one-tenth the time of a single traditional analysis. This helped narrow down an optimum design configuration quickly, and then move forward with a more detailed Ansys Fluent analysis.

From the resulting simulation output, Rabinowitz suggested that Huston alter the setup according to two modes:



A simulation of airflow in the gym

MODE 1: During the warmup or weightlifting part of class (lower intensity, less breathing): Turn on 1,000 cfm corner fans and the outer 2,000 cfm fan.

This will naturally pull air in from bay door and push it out through office door at a lower rate that enables the instructor to be heard — i.e., not too noisy.

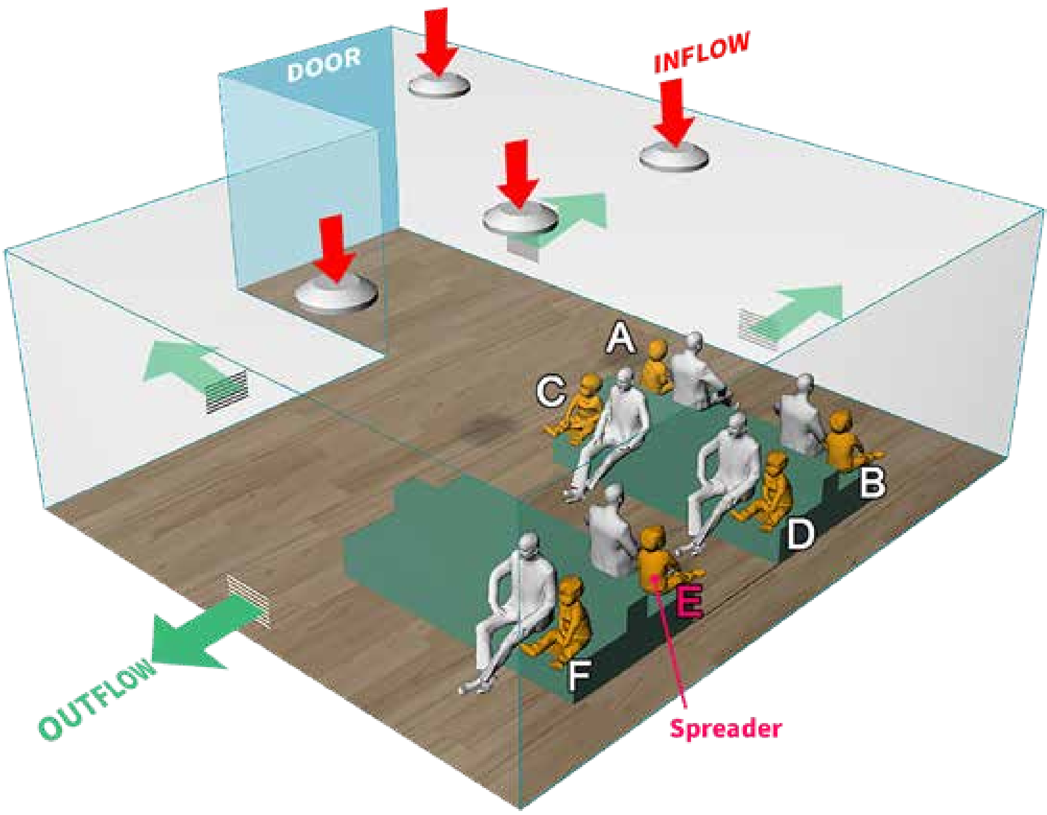
MODE 2: During the high-intensity part of class (workout of the day, or WOD) or between classes to clear out air: Turn on the 6,000 cfm input fan and two 2,000 cfm output fans. This will be noisier, but that's acceptable for the WOD part of class.

Turn off the corner fans. This is counterintuitive, but their angles counteract the natural circulation pattern that you want to establish during this phase.

A SAFER WORKOUT DURING THE PANDEMIC

Huston is working on implementing the changes suggested by Ansys. During the lockdown and throughout the pandemic, he has been driven by a two-part thought process: "We needed to follow the official guidance and regulations that were being issued," he says, "and we had to make our members feel safe."

Optimizing the gym's airflow with Ansys engineering simulations was an extra step toward making the members feel secure that they were working out in the safest possible environment during the pandemic.



How Does HVAC Airflow Influence Coronavirus Transmission?

By **Lorenzo Mazzei**, CFD Consultant, and **Riccardo Da Soghe**, CFD Branch Coordinator
Ergon Research, Florence, Italy

The Vatican State Children's Hospital was keen to minimize the risk of spreading COVID-19 in its waiting and treatment rooms. With the heat of summer approaching, facilities managers needed to know whether to turn on the air conditioning. Which was safer for patients: more airflow in closed rooms or less? Computational fluid dynamics (CFD) consultants at Ergon Research in Florence used Ansys Fluent to answer these questions.

Italy was hit early and hard by the novel coronavirus. By late March of 2020, the country was reporting an average of more than 6,000 new cases per day — a terrifying number at the time. A nationwide lockdown was implemented that month, which succeeded in reducing the number of daily new cases, but much of life in Italy did not regain any semblance of familiarity until May, when restaurants, bars and other gathering places were allowed to open again (though with strict social distancing protocols in place).

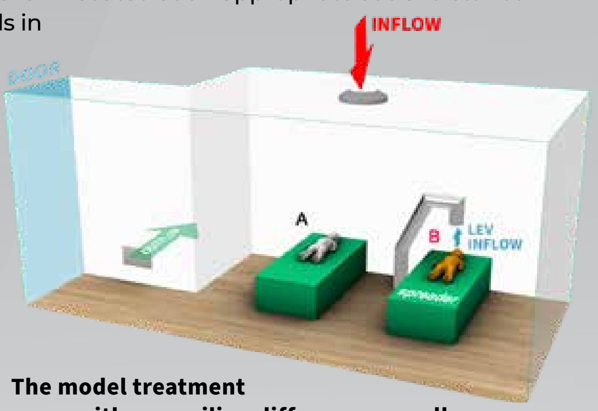
Living in lockdown during an Italian spring is one thing. One could live comfortably with neither the heat nor the air conditioning running. But in summer? Particularly in the south of Italy? Living or working in enclosed spaces without air conditioning could create a secondary health crisis that Italian hospitals very much wanted to avoid.

For administrators at the Vatican State Children's Hospital in Rome (the Ospedale Pediatrico Bambino Gesù, or OPBG, a premier pediatric hospital operating under the administration of the Vatican), this

> **“Ergon Research’s simulations provided the Vatican State Children’s Hospital with the insights that administrators needed as the heat of Rome’s summer approached.”**

issue posed a serious operational question: Would turning on the heating, ventilation and air conditioning (HVAC) system in an enclosed hospital waiting or treatment room increase or decrease the risk of viral transmission to otherwise uninfected individuals? If an unmasked individual with COVID-19 coughed or sneezed — even if seated at an appropriate social distance from someone else — would uninfected individuals in that room be safer if the air were moving or still? Air that was not moving might keep viral droplets from spreading and infecting others. Then again, air that was moving might more rapidly diffuse viral concentrations and help move the droplets out of the room more rapidly.

In April of 2020, Dr. Luca Borro, an employee of the hospital, began asking questions in a Facebook group about using CFD to model a cough or sneeze event and simulating what would happen with the HVAC system running. Though Borro is an expert in 2D and 3D imaging, he was looking for support to deal with specific issues of the CFD modeling. He met Lorenzo Mazzei, a member of the group from Ergon Research, and that chance connection led to a collaboration in which CFD experts from Ergon Research volunteered their time and expertise to help the hospital find preliminary answers to these questions.



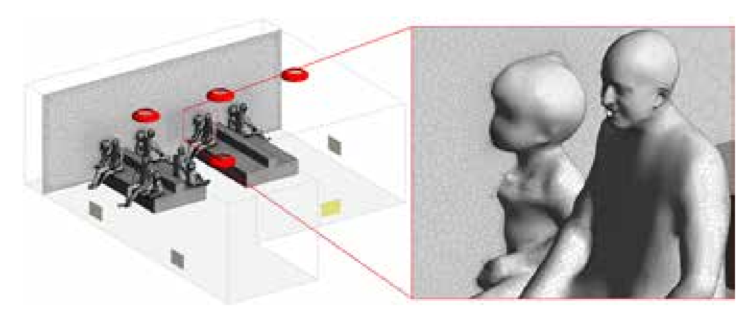
The model treatment room with one ceiling diffuser, one wall vent and an LEV inflow system

DEVELOPING A NEW EVENT MODEL: AN UNMASKED COUGH

Ergon Research began life as a 2008 spinoff of the University of Florence. It provides consultative services in software development, experimental design and CFD, where its experts routinely use Fluent and Ansys CFX to help customers overcome complicated design challenges. Because Ergon Research was familiar with Ansys software and knew they could trust its accuracy, they elected to use Fluent to simulate the airflow.

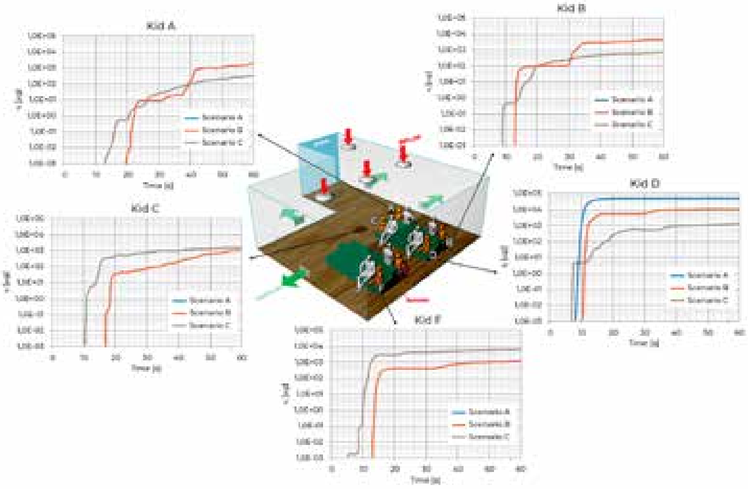
Borro and the team from Ergon Research started by constructing two CAD models — one of a waiting room and one of a treatment room. Into the waiting room model they placed benches for seats as well as a number of seated figures. Because the Vatican State Children’s Hospital is a pediatric hospital, the model included a balance of adult and child figures. The model also grouped the adults and children in pairs — as one might expect to find parents and children paired in a pediatric waiting room — and positioned the pairs, rather than the individuals, at the recommended 6-foot distance from one another. The waiting room model included four air diffusers in the ceiling, which would create a controlled positive airflow into the room when the HVAC system was operating, as well as four wall vents that would exhaust the air from the room. The treatment room model included a single ceiling diffuser, a single wall grate for exhaust and a specialized local exhaust ventilation (LEV) system positioned to draw air into a vent placed directly above the patient’s bed.

In many ways, these CAD models were deliberately simple. The ceiling air diffusers, for example,



The details in the grid were simplified to optimize compute processing and time demands without compromising the quality of the solution.

were generic, circular diffusers that included the deflectors in the simulation so as to solve the internal flow field rather than prescribing it on the boundaries. There were no features on the furniture because Ergon's CFD experts knew that the inclusion of features such as chair arms, legs and backs would not have had a great impact on the informational outcome of the simulations they had planned. Moreover, they would have added considerably to the computational resources and time required to run the simulations. The physical features of the adults and children in the room were likewise simplified — though more detailed than the furniture — for the same reason.



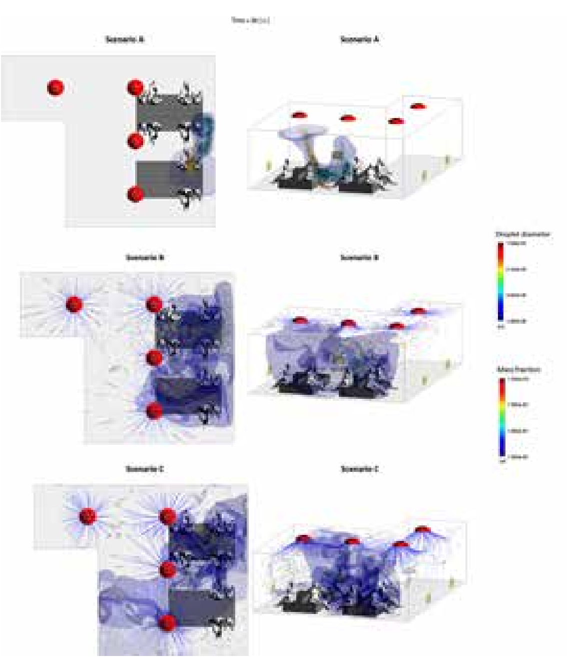
The x-y plots represent the temporal evolution of the index η, which describes the cumulative amount of contaminated air inhaled over time by different individuals in the room. Units are micrograms (µg).

All that was the easy part.

The challenging part involved simulating the behavior of a cough occurring in these model rooms. Though the object libraries in Fluent are quite rich, they do not include pre-build models of a human cough. So, Ergon Research and OPBG created one from scratch. A search of the literature on the dynamics of a cough uncovered a 2018 doctoral dissertation on the numeric characterization of a human cough jet as well as a 1946 paper detailing the distribution of aerosolized droplets in a cough. The 1946 paper identified classes of droplets by diameter (from 3 µm to 750 µm), the respective number of droplets of each size class and the mass flow rate of each class of droplets.

Drawing on their experience in CFD simulations, the team at Ergon Research incorporated these event characteristics — along with droplet characteristics, the interaction of the aerosolized droplets with air molecules, and the buoyancy effects on both liquid particles and air due to gravity — into Fluent. Additionally, they incorporated models representing respiration/inhalation rates for each individual in the room, as well as models representing the mass fraction of the coughed air in the inhaled air (that is, the portion of contaminated particles contained in any inhalation after the cough event itself). The intent was to run coupled Eulerian-Lagrangian simulations to simulate a dispersion and potential for inhalation of aerosolized cough droplets within each of the room models they had built. Many of the key modeling components were already present in Fluent, such as particle injection and tracking, so there was no need to implement missing models. Additionally, Fluent had already been verified and validated against hundreds of papers analyzing Eulerian-Lagrangian simulations. Because Ergon Research wanted to use an event time step of 0.001 seconds and follow the movement of the aerosolized particles for a full 60 seconds, the team reduced complexity of the rooms' CAD models to meshes of just 5M elements, which would conserve compute resources and time without compromising the clarity of the results they sought. They then ran a series of simulation scenarios using the waiting room model:

- Simulation A ran without any HVAC-mediated airflow
- Simulation B included airflow through the diffusers at a flow rate of 2020 m3/hr (the standard flow rate)
- Simulation C included airflow at a flow rate of 4040 m3/hr (double the standard flow rate)

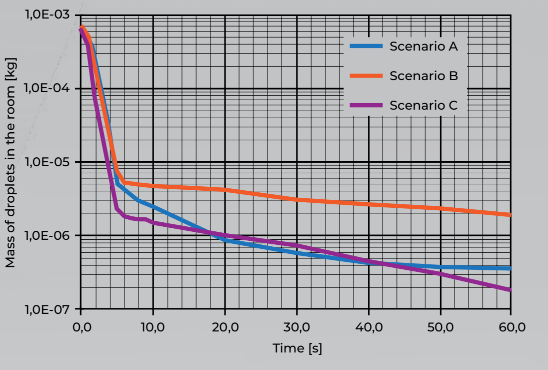


Increasing the flow rate of the HVAC system causes greater dispersal of less concentrated aerosolized droplets (view 2).

Ergon Research ran similar simulations on the model with the LEV system in the treatment rooms (with the LEV inlet vent positioned 43 cm above the spreader patient's mouth and calibrated to exhaust air from the room at a rate of 1080 m3/hr). The solutions were obtained with a pressure-based solver and a semi-implicit method for pressure-linked equations (SIMPLE) algorithm with a second-order scheme for pressure and second-order upwind for all variables (except for turbulence quantities) while time was treated with a bounded second-order implicit scheme.

A TREATMENT PLAN FOR THE HOSPITAL

The preliminary insights that emerged from Ergon Research's simulations in Fluent were consistent, repeatable and somewhat surprising. In all the waiting room simulations, the aerosolized droplets larger than 100 µm tended to gravitate toward the ground (regardless of HVAC flow rate) while the smaller, lighter droplets dispersed through the room in different ways.



Increasing airflow reduces the mass of droplets in the room over time.

- In simulation A, involving no HVAC-mediated airflow, the lighter droplets moved directly toward the person sitting across from the person coughing (the spreader). Only the individual directly across from the spreader appeared to inhale any significant fraction (11%) of contaminated air.
- In simulation B, involving the normal HVAC flow rate of 2020 m3/hr, the lighter droplets expressed from the cough interact with airflow from the diffusers before they come into concentrated contact with the child sitting in front of the spreader and are rapidly dispersed through the room. This reduces the amount of contaminated droplets that the individual sitting directly across from the spreader might have inhaled if there were no airflow in the room (from 11% down to 2.5%), but it also disperses contaminated droplets more widely in the room and creates a slight opportunity for individuals to inhale those droplets. The contaminated droplets constitute 0.5% of the air that individuals farthest from the spreader might inhale.
- In simulation C, in which the HVAC flow rate is doubled to 4040 m3/hr, the enhanced airflow wholly disrupts the aerosol cloud and quickly disperses it throughout the room. While this does expose individuals throughout the room to contaminated droplets, the increased turbulence both dilutes the concentration of contaminated droplets and increases the rate at which the wall vents pull the droplets from the room (at which point they no longer pose a risk to the individuals in the room). Thirty seconds after the cough event, those closest to the spreader are inhaling air that has only a 0.3% concentration of contaminated droplets, and those sitting furthest from the spreader are inhaling air that has only a 0.08% concentration of contaminated droplets.
- The treatment room simulations produced even more dramatic results: When the LEV positioned just above the patient's head was engaged to draw air away from the patient at 1080 m3/hr, all infected droplets were pulled from the room within half a second of the spreader coughing, minimizing the likelihood of anyone in the room becoming infected from the droplets in the cough.

Ergon Research's simulations provided the Vatican State Children's Hospital with the insights that administrators needed as the heat of Rome's summer approached. The outcomes derived through simulations in Fluent suggested not only that they should turn on the HVAC system in the hospital waiting rooms but that they should increase the airflow rate. At the doubled flow rate, air turbulence within the room could reduce the concentration of contaminated particles by 99.6% within seconds, thereby minimizing the likelihood that other patients would become infected from a cough. Similarly, use of an LEV system in a treatment room could minimize risk of exposure almost immediately. Administrators and health care personnel at the hospital would still have to fight an uphill battle against COVID-19, but at least they would not have to worry about complicating matters with a spike in patients suffering from heatstroke while sitting in overheated rooms.

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