SIEMENS

ANNUAL 2023

Engineer Innovation

A Simcenter publication

A hundred years of simulation

2022 was the 100th anniversary of a pivotal moment in engineering, the first practical use of engineering simulation to make real word predictions - in this case weather forecasts by British mathematician Lewis Fry Richardson.

His “computers” - as he called them - were made of flesh and blood rather than copper and silicon. Richardson used seventy-two human computers to make predictions of the weather using a three-hour timestep. It turns out that Richardson’s predictions weren’t actually very good, but in revisiting them, modern mathematicians have suggested a few improvements that would have made his predictions much more accurate. Richardson also designed detailed plans for a real-time-weather-predicting-super-computer, involving 64,000 human clerks in a football stadium-sized auditorium. No need to say that his plan never materialized, and the world would had to wait about another fifty years for digital computers (the type made of copper and silicon) to become powerful enough for the emergence of practical engineering simulation, originally applied to problems in the nuclear, automotive and aerospace industries.

Reading through the pages of this magazine you can see that, another fifty years on, in 2022 engineering simulation and test was used to solve difficult problems in almost every industry. More than that, it is part of the core of those industries, enabling and de-risking innovation that matters. This special print edition of Engineer Innovation includes applications from deep space to the deep ocean, with everything in between.

And while the computers often take the credit we know, like Lewis Fry Richardson knew, that behind every great simulation, there is a great engineer.

Enjoy your read.
Jean-Claude

EI Print Edition

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"
You may have the universe
if I may have Italy."
Giuseppe Verdi

EXPLORE THE POSSIBILITIES

From ICE to Ice Creams

How Internal Combustion Engine (ICE) technology makes better gelato

By Prashanth Shankara

Modena, Emilia Romagna, Italy. Piazza Grande and Duomo Cathedral at sunset.

This story is a surprising marriage of two Italian things that best symbolize heedless pleasure and luxury – supercars and gelato. This is a story of how a small Italian company, well-known for their expertise in super car Internal Combustion (IC) engines, helped an ice-cream manufacturer make better gelato.

Made in Modena, Italy

Our story starts in Modena, the 'City of Engines'. This charming Italian town is also the unofficial 'supercar capital of the world'. Ferrari, Lamborghini, Maserati, Pagani and Bugatti all call Modena home.

It is here, that Giuseppe Calise, a graduate of the nearby University of Modena and Reggio Emilia, established R&D CFD in 2012 with his Professor, Dr. Stefano Fontanesi. Borne out of the University's Internal Combustion Engines (ICE) research group, they do engines well. Really well.

The CFD in their name is a nod to their expertise in computational fluid dynamics (CFD) simulations. R&D CFD works with most of the supercar manufacturers around Modena helping them build better IC engines digitally using CFD simulation.

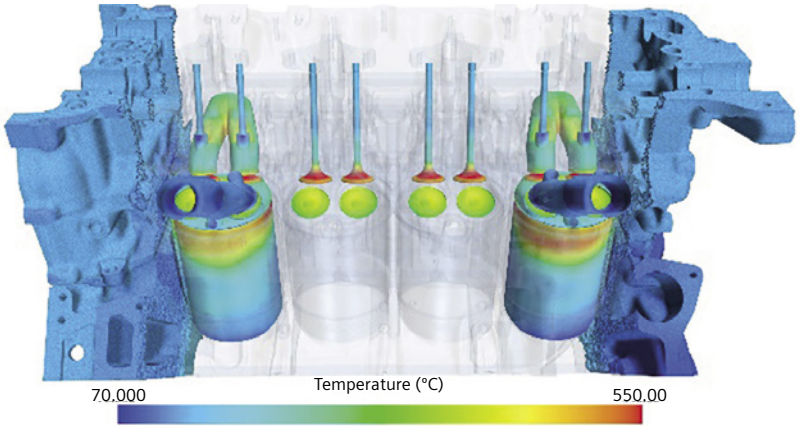
IC engine operation is complex. Combustion of air and fuel, temperatures of 4500 F (2500 C), moving pistons, hundreds of chemical species, and thousands of reactions some of which occur in a billionth of a second. All of this inside a small, dark cylinder, inside a fast supercar. How do you analyze such complexity? How do you find the best engine design?

With CFD, companies like R&D CFD build a digital engine. Every process in and outside the engine is digitally modeled, analyzed and visualized. Add in design optimization and you can evaluate hundreds of scenarios and designs digitally before building anything.

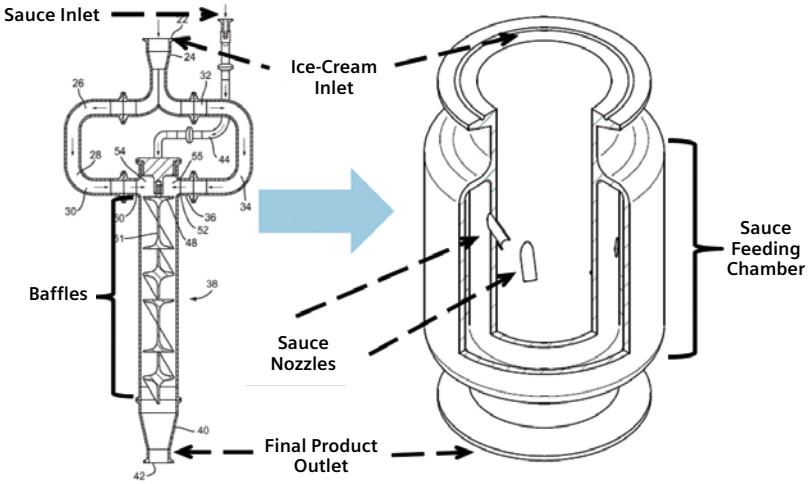
In 2019, their CFD simulation and engineering expertise caught the eye of an unlikely customer: a leading Italian gelato manufacturer.

The variegated gelato

The global ice-cream market is worth $80 billion USD and increasing every year. Nearly 80% of the



Simcenter STAR-CCM+ simulation showing thermal behavior of engine components, courtesy R&D CFD



ice-cream sold is machine-made, either to take home in a box or consume immediately. It's a massive market.

The manufacturer who worked with R&D CFD is famous for their variegated gelato. Excuse the fancy word here! A variegated gelato is merely ice-cream with a sauce swirled into it – chocolate, strawberry, caramel, fruit, peanut butter and more (Now I'm getting hungry).

Chasing the good (looking) gelato

Ice-cream was once a dessert for kings. But thanks to capitalism and mass production, the common man can enjoy one of life's greatest delicacies. Our gelato maker was one such mass producer. Gelato in a box was their specialty. With years of mass-producing experience, the taste of their gelato was world class – creamy, rich and dense.

Good gelato needs to be good-looking. No one likes a dull, rough, garish looking ice cream. Eating ice-cream is an emotional, evocative experience.

In a competitive market, the look and feel of your gelato makes all the difference. The manufacturer's list of requirements for esthetically pleasing variegated gelato was long: soft, smooth, silky, elastic, and of natural color. Improving the look will have a direct impact on sales and customer satisfaction.

"The customer wanted our help to predict how their variegated ice-cream would look at the end of their manufacturing process. People who buy this ice-cream are looking for a certain hand-made feeling. But how do you make it look hand-made in a machine?", says Giuseppe.

A simpler design; a better swirl

The secret lies in the variegator. This machine mixes the ice-cream and the sauce, fed through different pipes. Their current variegator was a static one with no moving parts. But the design was complex. The ice cream and sauce came in contact with screws, baffles and walls. It was hard to control the sauce pattern or mixing. It was exposed to air, a strict no-no for good gelato. The number of parts meant cleaning the variegator thoroughly was difficult to do.

The ice-cream maker found a simpler design. Just two concentric cylinders, one each for the ice-cream and sauce and a nozzle connecting the two. They mix directly in the variegator: no screws; no baffles; or interaction with walls. Just simple, straight mixing. Easy to clean, better to control mixing and a more beautiful sauce swirl into the ice-cream. In theory, the new design was perfect.

Improving the variegator with CFD simulation

Now they needed to make the design better. They needed to predict how the ice-cream would look after manufacturing before being stored in boxes.

This is where R&D CFD's simulation and design optimization experience came in handy. They had Simcenter STAR-CCM+, a CFD Multiphysics software and Simcenter HEEDS, a design optimization software, both tools from Siemens' Simcenter portfolio. For years, they used Simcenter STAR-CCM+ on supercar engines to

Top: Good variegation

Right: poor variegation

Seriously, which one is more appealing?

understand the flow and thermal behavior of engines. Simcenter HEEDS helped them analyze the performance of hundreds of designs and scenarios.

The simulation technology used to design supercar engines was now being applied to gelato making.

"We decided to use our engine simulation tools to improve the variegator design. With digital simulation, we could reduce making prototypes and save time and cost in design. It also helps us analyze hundreds of designs", adds Giuseppe.

2,000 designs; one perfect sauce swirl

"Simulating ice cream and sauce is not so simple as simulating air and water", says Alfonsina Esposito, CFD engineer at R&D CFD. "They are gooey, viscous, elastic fluids. Understanding the rheology and thermal behavior took some time".

Simulating these visco-elastic fluids with CFD is challenging. With Simcenter, they could model such challenging physics, thanks to a Volume of Fluid (VOF) multiphase and rheology model. The software was able to model the ice-cream, sauce, and the interface between the two accurately.

"In the past, we worked with other simulation software where the process was way more difficult. What we enjoy with Simcenter STAR-CCM+ is the variety of physics you can simulate, from engines to ice-creams", adds Alfonsina.

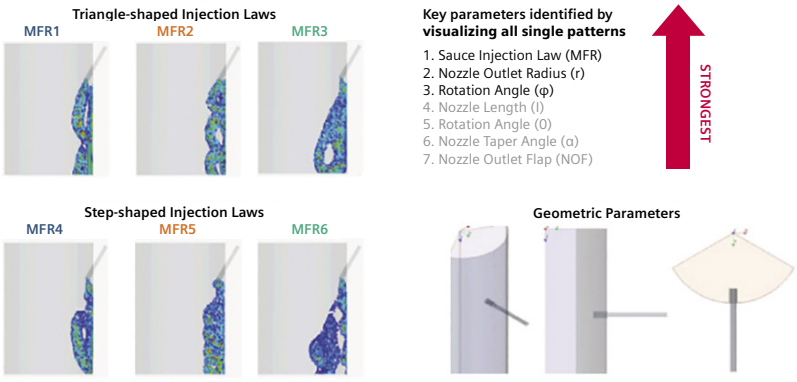
Using Design Manager, a technology within Simcenter, Alfonsina modeled 2,000 different design scenarios changing the nozzle geometry and operational physics laws to inject sauce. The software automatically found the design that produced the best sauce pattern and swirl.

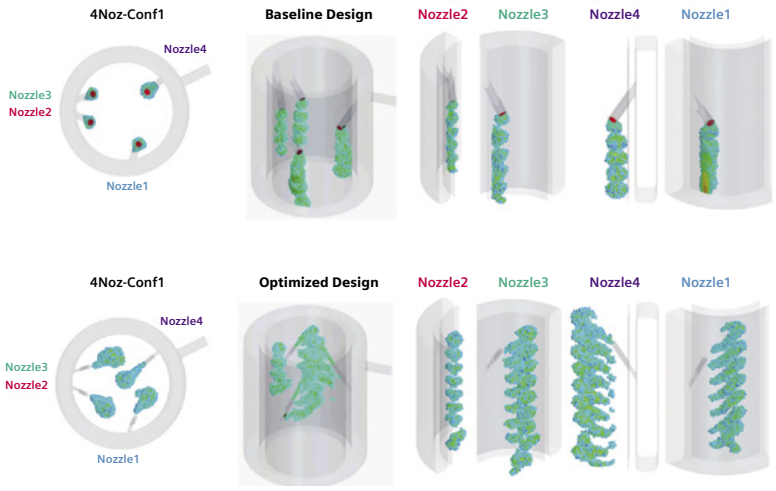
Imagine having to build and test 2,000 different variegators instead!

80 designs; best variegation

For mass production, the variegator needed multiple nozzles for faster operation. All these nozzles need to be fed the same quantity of sauce from the feeding chamber. This way, the ice cream in every box was identical in appearance and texture, ensuring customer satisfaction.

Different nozzle designs to find the design giving the best sauce pattern and swirl





(Top) Baseline design showing poor variegation and irregular sauce pattern from four nozzles (Bottom) Optimized feeding chamber design giving similar swirl pattern and better variegation from all nozzles.

Alfonsina used Simcenter to automatically analyze different geometries of the sauce feeding chamber and the resulting sauce distribution. After analyzing 80 designs, the best feeding chamber design was found. Now all the nozzles receive the same amount of sauce. Mass production of perfect gelato activated!

"It's so fast to do automation and optimization with Simcenter HEEDS or Design Manager", adds Giuseppe.

You can see how the optimized design gives the same, beautiful swirl to the sauce from every nozzle compared to irregular patterns from the initial design.

From ICE to ice-creams

R&D CFD's improved variegator design is now in use in all the manufacturing plants of the customer. As predicted with simulation, the variegation is top-notch.

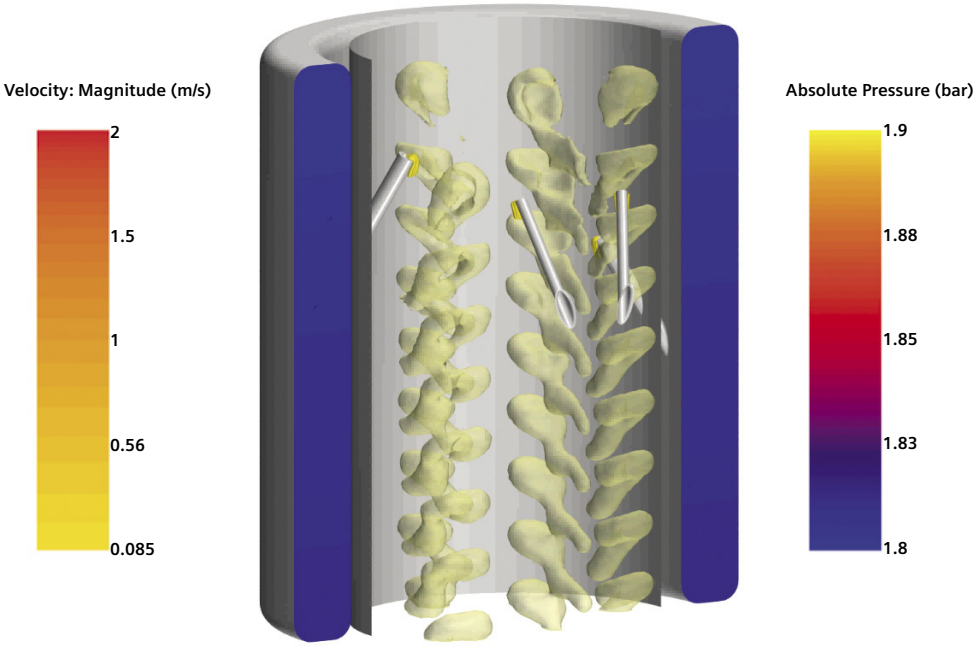
The team at R&D CFD experienced something unique – eat something they helped engineer.

"I've tried the ice-cream and I'm very appreciative of the job done. Looks delicious. Tastes delicious", a smiling Alfonsina reports back.

"We live and breathe internal combustion engines (ICE). We never thought we'd be working on making better gelato", adds Giuseppe. "With Simcenter, we have gone from ICE to ice creams".

Postscript:

- It was a chilly Amsterdam winter when I interviewed Giuseppe and Alfonsina for this story. Throw in our Sicilian cameraman and I felt like an honorary Italian for a good 30 minutes.
- I might have spent a little too much time looking at pictures and videos of ice-cream for this story. The neighborhood ice cream parlors now know me on a first name basis.
- I know you want to try this gelato. Unfortunately, we cannot name the manufacturer. But this is reason enough for you to try all the Italian gelato brands and report back.
- I have successfully managed to write about ice-creams without mentioning that wretched Vanilla Ice song even once (It rhymes with 'Rice Rice Maybe')



Beautiful swirl pattern of sauce from CFD simulations was replicated in the new variegators built by the manufacturer.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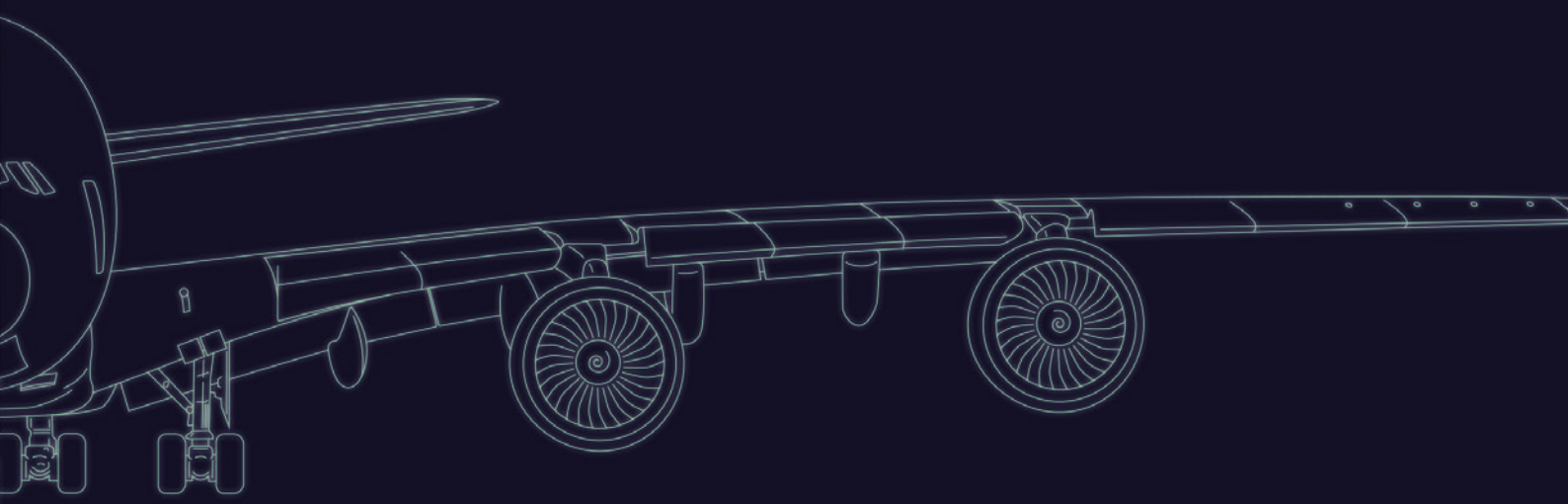
25-07

EXPLORE THE POSSIBILITIES

Why wheels are important on planes

Simcenter enables Safran Landing Systems to avoid technical issues and streamline certification
By Jenn Schlegel



The Wright brothers didn't have wheels on their first plane. So why do we?

Here's some food for thought: early aviation pioneers Wilbur and Orville Wright did not put wheels on their first plane, the 1903 Wright Flyer. The famous 12-second flight that took off on December 17th, 1903 from the beach in Kitty Hawk, North Carolina started by launching the flyer into the air using a rail system. The self-taught engineers didn't use wheels or landing gear because, logically, they were taking off and landing in deep sand. Wheels would be problematic, to say the least.

Constructed with spruce wooden frames, unbleached muslin fabric and honestly heaps of tenacity, sheer grit and dreams, the first Wright brothers' planes were all about getting off the ground and into "piloted" flight. Wheels were either for catapulting the early flyers into the air or for moving the Wright Flyers around on the ground. Only in around 1910 did the Wright brothers' planes, the Military Flyer and the Model AB, feature wheels.

But back to wheels and that 1903 flyer. The 1903 Wright Flyer's wheels were actually attached to the rail system itself. The wheels, which the brothers constructed from recuperated bicycle hubs, were part of the dolly on the launch rail track, not the airplane. The wheels ran on a rail, in reality, an 18-meter wooden track running through the sand that launched the Wright Flyers into "flight". A later model, the 1906 Wright Flyer, had wheels as well, but they were removable and only used to roll the aircraft from one spot to the other. They were removed before taking off on the track.

Landing gear: a long way since Kitty Hawk

Almost 120 years later, we have come a long way since removable landing gear and catapulting flight tracks. Think about this: At Kitty Hawk, the first Wright Flyer weighed only 275 kilograms without the pilot, who by the way, flew in a prone position. Today, a big bird like a fully loaded Airbus A380 weighs in around a whopping 575,000 kilograms. Just think of the loads the landing gear needs to handle when landing something this immense. (And just a side note: the A380 usually has four pilots on board for long flights. Two pilots are required by regulators to fly the plane. Unlike, the Wright brothers, they fly the plane seated, obviously.)

The landing gear on an A380 or similar aircraft – as you can guess – is far from recuperated bicycle hubs and home-made rail systems. A sophisticated hydraulic ecosystem in itself, modern-day landing gear systems features innovations the Wright brothers could barely imagine: decentralized hydraulic generation; integrated modular avionics braking algorithms; high-pressure hydraulics at 5,000 psi; titanium integration and integrated logistics support (ILS) – just to rattle off a bit of LG (landing gear) jargon.

With something as complex and mission-critical as landing gear at stake, entire engineering departments (and companies for that matter) are dedicated to perfecting landing gear design and development. And passionate and innovative engineers (just like the Wright brothers) have dedicated their engineering careers to designing reliable, robust, weight-efficient and environmentally responsible landing gears.

One of those engineers is Jérome Fraval, a French systems modeling and simulation method leader at Safran Landing Systems. For those of you not familiar with landing gear engineering per se, Safran is the world leader in design, development, manufacturing and support of landing gear systems.

Jérome Fraval has been a Simcenter user for years and is one of the pioneers in the field of system simulation and landing gear development. Today, he and his team help Safran provide highly sophisticated landing gear systems to a variety of aircraft programs.

Landing gear is certainly not one-size-fits-all

One of the Safran team's biggest challenges is that requirements vary among customers. And analyzing every single system performance is crucial to perfectly meet the differing expectations of each airframe manufacturer. Safran Landing Systems use two approaches to succeed, in most cases, under tight deadlines. One key to success is the use of simulation and digital twins within the engineering department to virtually anticipate system and component efficiency – long before integration into the final product. The second key to success is to implement standard engineering methodologies and streamline practices to deliver a mature product early in the development cycle.

Safran Landing Systems deploy a common methodology for simulation within internal teams as well as when interacting with customers and suppliers. Very basically, the process starts with developing the landing gear structure, then the wheels and brakes and finally system equipment, such as systems for braking, extension, retraction and steering. Safran Landing Systems designs and manufactures the majority of its key equipment and integrates other small components from hydraulics/electrics component suppliers.

System simulation in model-based systems engineering

Using Simcenter combined with Safran's in-house expertise and experience, acquired over several decades, makes it possible to perform tradeoff studies very early in the pre-design phase of complete systems.

"Today the use of model-based systems engineering is essential in our industry because incomplete knowledge of all the operational cases can lead to an incorrect analysis that originally aims at specifying the component performance, " explains Jérome Fraval, Systems Modeling and Simulation Method Leader at Safran Landing Systems.

He adds, "Virtual integration through the digital twin makes it possible to anticipate the commissioning of our products very early on, even well before the production of the first components, which makes it possible to observe

Wilbur Wright landing an early prototype in 1900. Clearly, landing gear hadn't been invented yet. Image courtesy of the Library of Congress (USA)

sometimes complex physical phenomena and to adjust, if needed, the product design."

System simulation supports the certification process

Virtual analyses with Simcenter enable Safran Landing Systems to support the overall aircraft qualification process and streamline the demanding documentation process. "We have to demonstrate to the authorities that the system model is valid, using the landing gear digital twin," Fraval says. "This is demonstrated through physical correlation with the model that it is valid. The use of Simcenter allows us to support this entire demonstration procedure and complete documentation requirements." Read more about Safran Landing Systems and the Airbus A380.

And from the research side of things...

What is wonderful about Siemens and Simcenter is that for every innovative engineer out in the field, like Jérome Fraval at Safran Landing Systems, there is most likely someone in-house working the research side of things. Senior R&D Manager Yves Lemmens, based at Siemens in Leuven, Belgium, is one of these engineers. Yves Lemmens' research activities focus on analysis methods of structures, mechanisms, and systems for automotive and aerospace applications. One area he works in is... landing gear.

Since the days of wooden frames and muslin wings are long gone in modern-day aviation, a key challenge for aerospace engineers, today, is complexity. Yves Lemmens and his team are working on methodology improvements to manage the complex engineering required to successfully develop future aircraft.

He writes in his blog, "Over the years, scientists and engineers have discovered many paths that can lead to better aircraft. However, highly interconnected system architectures increase the complexity and slow down the pace of innovation. Moreover, multiple dependencies and constraints between components (such as joints and limitations on available space) make the design of mechanical systems even more complex."

Make sure to check out Yves Lemmens' complete blog to explore cutting-edge work, which will certainly impact the aircraft development of the future.

And speaking of future aircraft, things are likely to get even more complex as we enter new frontiers like e-flight and VTOL (vertical take-off and landing) - not to mention supersonic aircraft. The world of landing gears will certainly change again in the not-so-far-away future; Siemens and Simcenter will be there to show the next generation of pioneers the path to safe, secure and super-efficient landing gear.

Sign up for a free webinar about Simcenter solutions for landing gears

Read about GKN Aerospace Fokker Landing Gear

Tune into our podcast series: Talking Aerospace Today.

Sand, grit and perseverance:

Hard work, testing and top-notch troubleshooting got the Wright brothers off the ground

Wilbur Wright landing an early prototype in 1900. Clearly, landing gear hadn't been inve On December 17th, 1903, at precisely 10:35 am, Orville Wright lifted off from the launching rail at Kitty Hawk and flew for 12 seconds at an altitude of 8 feet, landing 120 feet away. The Wright Flyer hit a top speed of 6.8 mph with 34 mph winds. With both brothers piloting, they completed three more flights that day, reaching 852 feet in 59 seconds and a top altitude of 10 feet. Image courtesy of the Library of Congress (USA)

Kitty Hawk is located on the Outer Banks of North Carolina, a series of barrier islands in the Atlantic Ocean. It is the 6th windiest place in the USA. A likely location for the Wright brothers and their first successful airplane flights on December 17, 1903. But what one tends to forget is that this first flight didn't happen overnight. From their beach camp in Kitty Hawk and back home in Dayton, Ohio, the Wright brothers had been experimenting and adapting their flyers for more than four years.

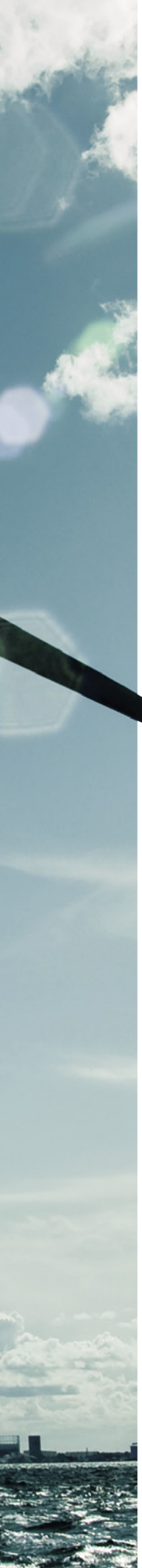
The two brothers, Wilbur and Orville Wright, were self-taught engineers and bicycle shop owners from Dayton, Ohio who were obsessed with the idea of "piloted" flight. They designed and built early prototype gliders that they attempted to fly in 1900 and 1901 in Kitty Hawk. Wilbur Wright eventually glided about 100 meters in 1901, but the brothers knew their early prototype was still unpredictable and some of the data they had gathered seemed to be invalid. Disappointed yet still full of faith, they returned home to Dayton and built a wind tunnel to obtain new data and update the flyer design.

In 1902, they returned to the Kitty Hawk camp and the 1902 Wright Flyer completed 600 glides. The brothers were convinced they had graduated from unpredictable glider to working airplane. The 1903 version would feature breakthrough innovation with a lightweight engine and original propeller design.

The 1903 Wright Flyer was heavier than expected, weighing in at 275 kilograms. This was five times heavier than the 1902 version and the brothers weren't sure the engine would be powerful enough to lift the plane off the ground. This is when they came up with the idea of the launching rail system, which gave the plane enough momentum to take off. (Prior to this, helpers from the Kitty Hawk camp just ran carrying the wings of the much lighter gliders to launch them into the air.)

"We chose Siemens Digital Industries Software as a partner because they have experience working with digital twin technology in other industries and possess a wide branch of software that can support this development,"

Kim Branner, Senior researcher and head of section, DTU Wind Energy department.



GO FASTER

From radical idea to reality: **Leave it to the Danes**

Denmark breaks its own green energy record for the second year in a row and keeps innovating with plans for artificial energy islands and ReliaBlades
By Jenn Schlegel

Last year, Denmark sourced more than half of its electricity from renewable energy. Onshore and offshore wind turbines produced just over 46%, and about 4% of Denmark's renewable energy was solar. 2020 is the second year in a row that this tiny Nordic country exceeded 50% renewal energy usage.

Now, there are a lot of reasons for this green success. First of all, Denmark is a rather windy place so wind energy is going to work. Secondly, they have 8750 kilometers of coastline and ample place to put wind turbines out on offshore wind farms in the North and Baltic Seas. (This way the tiny nation will not be covered in onshore turbines.) And thirdly, the country has a very sustainable mindset and has been committed to wind energy for decades.

True green energy innovators, the Danes built the world's first offshore wind farm in 1991. Today, the country is continually improving wind turbine and offshore technology, including the development of two artificial energy islands in the North and Baltic Seas.

An artificial energy island by 2030

With Europe moving towards renewable energy reliance, increasing offshore wind energy capacity and efficiency has become paramount. As wind energy leaders, the Danish are again at the forefront of technology with their planned energy islands. Acting as energy hubs, these energy islands will be able to pool power from multiple offshore farms and feed the energy directly to several neighboring countries. This shifts the concept of offshore wind farms from unilateral supply to multilateral supply, which is a good thing. At maximum capacity, the islands should be able to power over 10 million homes in several countries and create green hydrogen from sea water to power future shipping, aviation, and industry energy requirements.

Measuring 120,000 square meters in size (that is bigger than 18 standard football fields by the way), the main artificial island, located about 80 kilometers off of Denmark's west coast in the North Sea, will be the largest construction project in Danish history. A second, smaller island has already being planned off Bornholm in the Baltic Sea, to the east of mainland Denmark. This hub

will supply energy to Germany, Belgium and the Netherlands. Both islands will give an enormous boost to the European offshore wind capacity and green energy as a whole.

"This is gigantic," states Prof. Jacob Ostergaard of the Technical University of Denmark. "It's the next big step for the Danish wind turbine industry. We were leading on land, then we took the step offshore and now we are taking the step with energy islands, so it'll keep the Danish industry in a pioneering position."

Improving offshore turbine maintenance and longevity

Energy islands aside, there is a lot more going on behind the scenes in Denmark to keep the Danish wind energy industry on the cutting edge. Another professor at the Technical University of Denmark, Kim Branner, is busy with something really innovative called ReliaBlade.

Offshore turbines are, well, offshore. The good news is that they are not readily visible, not easily heard and can be optimally positioned for the wind. The bad news is that, when something goes wrong, they are hard to get to. Kim Branner and his team recognized a need for a better way to monitor offshore turbines for maintenance purposes. And this is where the ReliaBlade project, a Danish-German joint research project, steps into the picture.

“The ReliaBlade utilizes a comprehensive digital twin to monitor turbines and make wind turbine blades more reliable. That's why it's called ReliaBlade,” says Kim Branner, a senior researcher and head of section at the DTU Wind Energy department. “The focus is to make wind turbine blades more reliable by using a digital twin. That was one of the ideas behind establishing this project.”

Smart turbine maintenance

ReliaBlade wants to ensure that turbine blades last longer without human interaction or other unforeseen problems. By using a digital twin and sensor technologies when building the blades, DTU Wind Energy can develop condition-monitoring systems to observe the blade structure. The system can alert wind turbine owners of potential problems or damage developing in the blade. This allows the wind turbine owner to either change how they operate the turbine or make a repair decision before the issue becomes too critical. For offshore wind farms, this means scheduling the repair when it is easier – say on a summer day – rather than an emergency intervention during a winter storm.

Denmark has committed to an ambitious 70% reduction in 1990 greenhouse gas emissions by 2030, and hopes to become CO_2 neutral by 2050

"With the monitoring systems that can come with a digital twin, you have an opportunity to intervene before it becomes a problem and therefore make these structures more reliable," says Branner.

"We chose Siemens Digital Industries Software as a partner because they have experience working with digital twin technology in other industries and possess a wide branch of software that can support this development," says Branner. "And it's not used so much in the wind energy industry. Some companies have worked with a digital twin for the bearings and gears in the drive train of the turbine, but not for blades. That's unique and of course, an interesting area for us as we work with blades and test blades.

"But it's also a very challenging area because those are some of the most highly loaded structures. It's also a challenge because the goal is it should last 20, 30 years, running on a turbine every day in all kinds of weather. It's a hostile environment out at sea. So it's really challenging to build the systems that are robust and can work in practice."

DTU Wind Energy performed physical testing in Simcenter Testlab software, 1D simulation in Simcenter Amesim software and virtual channels in Simcenter Testlab Neo software.

Ready for the next green energy revolution

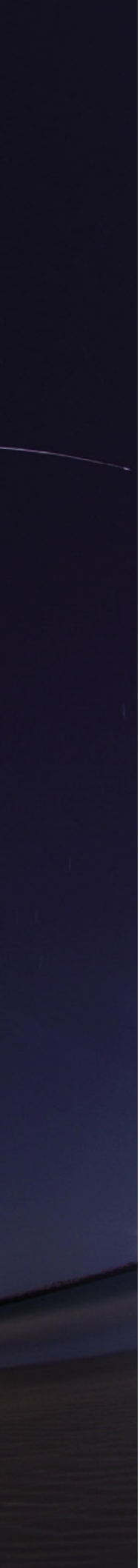
As the Danes start to work on constructing their innovative energy islands out in the North and Baltic Seas, the team behind the ReliaBlade project is taking smart maintenance a step further and showing how advanced digital twin architecture and cutting-edge technology like embedded machine learning methods, automated model updating and vibration-based structural health monitoring can keep the future offshore farms running optimally for decades to come.

Some extra reading about wind energy solutions.

https://www.plm.automation.siemens.com/global/en/our-story/customers/zf-wind-power/67899/

https://blogs.sw.siemens.com/simcenter/not-in-my-backyard-how-annoying-is-wind-turbine-noise/

https://www.plm.automation.siemens.com/global/en/our-story/customers/moventas/17048/



GO FASTER

Shooting for the Stars

Launching Satellites with Simcenter
By Luke Morris

Did you know there are currently almost 2,000 individual satellites in low Earth orbit? And this number is expected to increase exponentially as continued miniaturisation in electronics fuels the growth of the small satellite market over the next decade. By 2030 it's predicted that a further 8,600 small satellites (weighing less than 500kg) will have been launched. This equates to a market worth an estimated $42.8B USD, with about 30% going to launch costs, and growth of 22% CAGR.

But to get a satellite into space you need a rocket. And rockets don't come cheap. So how are companies going to launch their satellites at the right time and place whilst keeping costs under control?

Currently, small satellite companies have to book space on a large rocket, tagging along with a big payload. This causes high lead times of up to two or three years and if the main payload has to change orbit, they may have to find another rocket meaning further delays. All in all, it's a frustrating and inefficient process.

Dedicated launch services for everyone

Reaction Dynamics (RDX) was founded in 2016 by CEO, Bachar Elzein, to address this exact issue. The startup has developed a breakthrough rocket technology that provides the means for an eco-friendly launch solution. Leveraging its breakthrough green hybrid rocket engines, the company's launch technology will pave the way towards clean access to Earth's orbit at a fraction of currently available prices.

Hybrid rocket engines are nothing new – they've been around since the 1930s – but previously they have only been able to run at peak performance for a few seconds. As a result, satellite launch companies have used more complex and more expensive liquid fuelled rocket engines. However, RDX's invention provides better performance over longer duration burn times than any previous hybrid rocket engine – and most importantly, good enough to reach orbit. The propulsion system is much simpler than that of other rocket engines, making manufacturing much cheaper and reliability significantly higher as there are fewer parts that can fail. This also means that vehicle production can be scaled rapidly and, combined with the ease of handling of the propellants, enables a rapid and responsive launch service.

RDX will be manufacturing and operating its own orbital rockets for small satellite launch as a service. Priced at $15,000 USD per kilogram this will compete with other small launch companies as well as some heavy launch companies. The key difference is that RDX provide a dedicated ride at a similar price point to a rideshare on a large rocket. Elzein describes it as "Offering customers a taxi service for the same amount you'd pay for a bus. They can decide exactly when and where their satellites are launched rather than waiting for a

Reaction Dynamics' engine test cell

rocket that happens to be going in the right direction." The simplicity of the design means the rockets can be built and launched very quickly, enabling rapid response times which would be ideal for the reconstitution of damaged or destroyed military assets in space. With RDX's dedicated small satellite service, customers will have full control over the schedule and can have their satellite in orbit within a matter of weeks instead of waiting up to three years to ride along on a bigger rocket. RDX can always find the correct launch point for the required orbit as they have access to spaceports across the world. And for smaller operators who can't afford a dedicated rocket, their service can be sold to launch brokers who will aggregate small satellite payloads.

So how have RDX managed to design their new hybrid rocket engine which is set to revolutionise the satellite launch industry?

Maya HTT guides the way with Simcenter

Elzein and his team knew they would need the most robust simulation tools, combined with high-fidelity analysis, which is why they engaged with Siemens and Maya HTT. Maya HTT is a Siemens Solution Partner, working with companies like RDX to help them realize the full potential of Siemens Digital Industries Software. Maya HTT's expert engineers enable them to make the most of simulation and virtual prototyping to improve performance, quality, and efficiency, whilst reducing overall development costs.

"The quality of the support and the versatility of Siemens' suite of industry software made it a clear winner," says Maxime Goulet-Bourdon, Propulsion Test Lead at RDX. "The integration of so many features within the Simcenter platform means that scaling our simulation capabilities as required becomes efficient and realistic, allowing us to step comfortably into simulations to get the confidence that our designs will respect the applicable norms. Furthermore, the quality of the support received whenever small issues popped up was always great and timely. We know that we can count on the team at Maya HTT to guide and help us through the deployment and adaptation to these new and powerful tools, making us obtain results faster."

Christophe Leclerc, structural design lead at RDX points to CAD integration as a key factor: "For

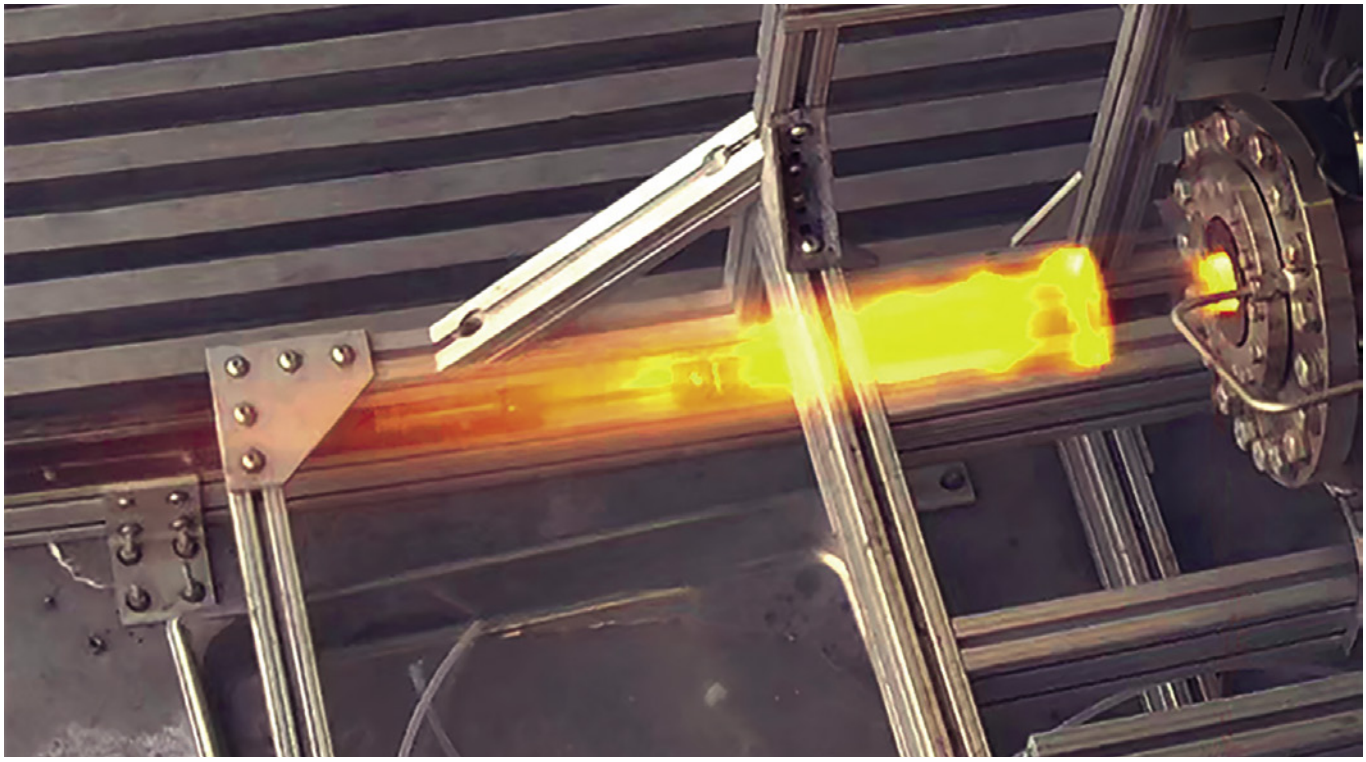
Bachar Elzein, Reaction Dynamics Founder

design and analysis, Simcenter is the best option for us, as it enables seamless transition from CAD to simulation, by streamlining the process of simplifying and cleaning up complex design models to prepare the analysis models. This can help accelerate the design process greatly, during which hundreds of iterations can be necessary. Multiple add-on modules, such as the Laminate Composite module, are also available, enabling us to quickly grow our capabilities when necessary, without having to go through the lengthy process of transitioning toward a new software solution.

Being integrated inside Simcenter, also gives us flexibility in our usage, by enabling the creation of an ecosystem where all of our software needs, from CAD to PLM, and including a wide range of simulation tools, are fulfilled by a single platform. For a startup, this ability of the platform to grow with us is of great importance when choosing the best solution."

Elzein says the development of RDX's revolutionary rocket engines would simply have been more resource intensive without Simcenter and they are continuing to discover more benefits from the software: "After switching to Simcenter for the seamless CAD integration and analysis we've been gradually adding more packages and licenses such as Design Explorer and Simcenter Nastran. Each one reduces both our development time and costs as shorter iterations lead to better products sooner."

RDX will shortly be announcing a demonstration flight using the same rocket engine that will be used to put satellites into orbit. They are then aiming a first orbital commercial launch within the next two years. To find out more, head to https://www.reactiondynamics.space/.



First iteration of the orbital engine tested in early 2021

EXPLORE THE POSSIBILITIES

Heavy Lifting

Taking Heavy Equipment into the Digital Age
By Jane Wade

None of the following statements will come as a surprise for our readers: Worldwide, in some regions rapid, population growth is putting increasing demands on our infrastructure, the infrastructure that delivers our food, transport and power in particular.

The heavy equipment industry faces stringent regulations, that differ country to country, but are primarily concerned with operator safety and minimising environmental impact of activities.

Ever greater exploration of variable environments as we seek to gather more resources, feed, shelter and nurture a growing population globally.

Individually each of these challenges may seem like an insurmountable ask, but collectively they put the industry under tremendous pressure. Does increased digitization and deploying the digital twin offer some solutions?

Recently a group of industry experts from across the Heavy Industry supply chain gathered to talk about the challenges they faced and what role digitization played in their teams' activities and methodologies. Gennaro Monacelli, head of design analysis and simulation at CNH (Case New Holland) Industrial; Yohann Brunel, upstream transmission manager, Poclain Hydraulics; Alastair Hayfield, senior researcher Interact Analysis and Gaetan Bouzard, industry manager, Siemens Digital Industries Software. Against a backdrop of increasing challenges for off-highway vehicle supply chain, new regulations such as ISO (International Standards Organization) regulations and rapidly tightening international emissions standards particularly Stage V for NRRM, increased electrification and lower total cost of ownership how do these businesses approach the future?

Whilst the three challenges are without doubt connected, in this article we try to approach each one to understand the unique drivers and nuanced solutions.

Worldwide population growth

The worldwide population is growing by 1% each year, this puts increasing demands on available land for farming, for building and for the infrastructure such as water and power supplies in addition to the natural materials required to make this possible.

Farming needs to increase productivity to ensure a sustainable food supply, increased urbanization puts demands on the construction and mining industries. The productivity growth required of these industries faces the double threat of a lack of skilled labor, and that available may be either aging or not located at point of need.

Targets

To meet demand, agriculture in 2050 will need to produce almost 50 percent more food, feed and biofuel than it did in 2012. This FAO estimate takes into account recent United Nations (UN) projections indicating that the world's population would reach 9.73 billion in 2050.

Innovation in Heavy Equipment to tackle the challenges because of population growth needs to focus particularly on productivity, also considering the total cost of ownership. It also needs to be smarter, providing solutions to optimize ground exploitation.

More stringent regulations

Operator safety is paramount along with ensuring sustainable practices to support the local and global environment. Heavy Equipment has lagged other areas as it moves to electrification, but the market needs to deliver machines compliant with emissions regulations. Alternative power sources along with all round improved machine operability (considering decreasing skills in workforce) are also key drivers contributing to the increased sustainability required to obtain compliance with stage V emissions regulations.

Operator comfort is also an essential consideration for future machines, often operating in harsh, rugged environments for extended periods, operators should not be subjected to sustained noise of vibration.

Exploration of variable environments

Whilst not entirely new since field conditions have always posed challenges for heavy equipment manufacturers, as ground exploitation is pushed to its limit the variability of such environments also increases. Machines needs to be incredibly versatile, operating under large temperature and humidity variations, often in muddy or dusty environments.

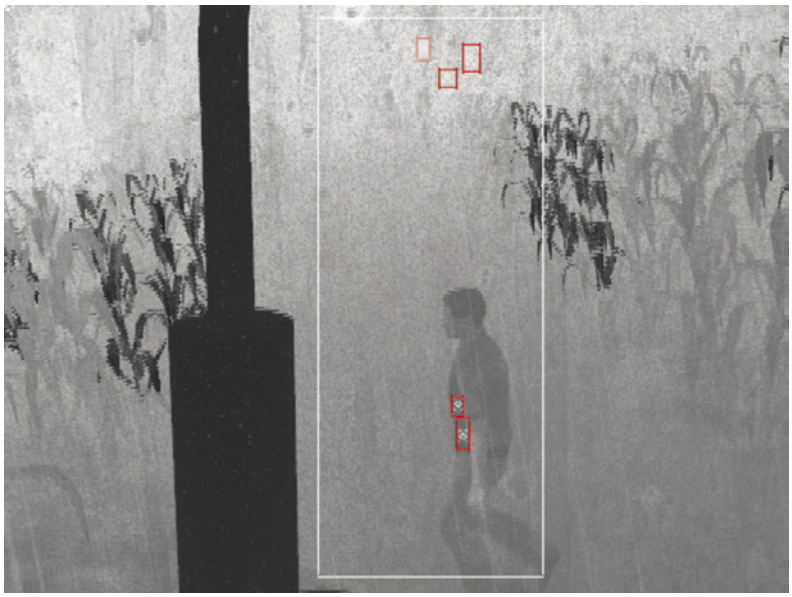
OEMs need to ensure operability and reliability wherever the machine operates, not just on homogenous machines but also on customized machines optimized for a particular use case or operator requirements.

Against this backdrop how do our expert panel ensure their product delivers, wherever they fit in the supply chain?

The time-to-market for manufacturers remains short but the demand for reliability and robustness has increased, Gennaro Monacelli, CNH Industrial, has seen a shift in the mindset of its engineering in response to this:

'If you want to find a solution you go in the field and test. This is no longer acceptable in terms of delivery times. Our industry has a big challenge in front of us.'

Instead, CNH Industrial look to product engineering to do as much virtual testing early in the product development, so when the design phase is released most of the issues have already been checked. Product engineering on this scale is only possible with robust simulation and test operations. It has been a huge shift in philosophy,



> You are bringing in a lot of new engineering requirements and I think a company like Siemens that has those simulation tools and can help partner with companies. They will find their services are in strong demand now because OEM's need that support to help them make that transition."
>
> **Alastair Hayfield**

meaning that when a physical prototype is built efficiency and reliability are already achieved. Not only does this help get a better product to market quicker but less physical prototypes also means a more environmentally aware approach.

Poclain see the benefits of this approach, 'the capability to have a better insight into the products, to improve our learning curve when we have specific dynamics of a specific problem and to better master the performance of a product.' That is the power offered by simulation early in the design cycle.

The skilled labor shortage is not confined to the field, as they break new ground, Yohann Brunel, Upstream Transmission Manager, Poclain Hydraulics:

'The electrification of autonomous vehicles is already challenging everybody. We have innovative technologies to integrate, so we see that utilization and simulation can help us accelerate the learning curve. We are adopting increasingly a system approach, and to be able to spread even more simulation to more people who are non-specialists, we need these kinds of tools.'

The advice from this panel suggests frontloading simulation and virtual testing helps to model many of the engineering complexity early, ensuring few surprizes at the later stages. Using tools that bring powerful physics into the hands of non-specialists at the CAD (Computer Aided Design) stages breaks down some of the silos and enables a more seamless information transition.

Breaking those silos is essential for complex equipment design, by shifting left and improving data and model sharing using tools designed with the user experience paramount. These tools allow non-exploratory experts from the domain to tap into the capabilities of the digital twin. Consider the complexity of electrification, everything is interconnected; the cooling loop, the battery, and the cabin comfort for the operator, the demands are all interdependent and connected. Considering each system in isolation simply will not work.

CNH Industrial have developed this inclusivity even further with immersive technology, in the virtual reality realm. This has enabled them to involve even more knowledge and opinion at the design stage, machine operators and dealers can virtually test the cab before any prototypes are built. It led to some unexpected outcome...including repositioning the water bottle holder.

Achieving a seamless workflow between the engineering disciplines is quite a challenging, as Yohann explains:

"Yes, this is a challenge. The main tool that we use to gather different physics together, different domains, is 1D simulation. We use system simulation to do that. It enables us to cover different physics. It is enabled us to cover different level of details and then the program is to ensure

the numerical continuity between models of each component, simplify the model that we need at system level. For the component level we need fine sense to have connection between the design parameters and the characteristics we need a more physics-based model. A system model we are more interested in the characteristic itself, so we can have a model based on data or something. We must ensure that we have continuity between them to be sure there is no disconnect between the model of the component and the model of the system. This is really a big challenge for us."

How do the experts see the role of testing in the development of Heavy Equipment?

This area threw up two interesting answers, the expected answer was that we do less tests and whilst overall that was the case it was more nuanced.

Poclain changed the way they use tests, they build in elementary tests on components to test the parts they have, confirming or defining the important parameters for the area to be considered. 'We only do necessary tests to validate it and as soon as we have confidence in the model we can iterate and avoid test and fail with real tests on real prototypes.'

CNH has also used simulation to build smarter tests, having started at 5% virtual testing they have now reached 55%, with a target of 80% in five years. A key area for CNH is occupant safety and rollover tests of cabs are essential but also expensive, time-consuming, and potentially wasteful with cabs being destroyed in the process.

'We were about 85% the correlation, but we discovered that correlating exactly, not only simulating, not only the cab, but also the station, the testing ship station and moreover materials, we reached the 95% correlation. This is the target that is important for us, so we do not need to destroy a cab. When we go to the final testing lab, we can just have one shot and do not have any further cycles.'

Smarter testing with simulation has resulted in more effective and quality data acquisition testing, and less destructive testing with the associated environmental and cost benefits.

Drowning in data

Doing more simulation, more virtual testing, more immersive testing, and more physical testing results in more data. Data is also acquired from the field in live operations from sensors on the

equipment. The volume of data can be vast, more is not always better.

CNH are seeking better ways to use this data, to join up a seamless workflow that makes use of available data throughout but does not needlessly collect it.

There is one area where the data from virtual testing has proved invaluable not only in reducing costs but also time to market, homologation and ensuring the many machine variants all meet the required standards and certification. CNH has a close eye on their CO_2 emissions from these tests, 'When we build a prototype, we produce a lot of CO_2 emission and then we destroy it. WE are analyzing this to not only save money but also emissions.'

Alistair Hayfield has seen the data challenge with many clients, 'it's actually pretty costly and difficult to store, warehouse and transmit all of the found data. OEMs need an approach where they are selecting the best or most relevant data to work against you own model.' But used well that data offers many opportunities particularly for automation. Using the data in automation can be key to bringing the machines to market faster, and in a cost-effective way.

Does increased digitization and deploying the digital twin offer some solutions?
The heavy equipment industry is now firmly on the digitization journey, using simulation earlier in design, a greater use of virtual testing and immersive technology along with using more data to gain insight for future improvement.

And whilst all the experts agreed they have not yet reached the destination of the full 'digital twin' they are all benefitting from the increased digitization they can realize from using simulation and test. They are adopting a hybrid approach, shifting from real tests, real prototypes, real field-testing to increasing the role of virtual and immersive. This is a journey that has only just begun but is already taking on those huge challenges that the industry needs to overcome to deliver the world we will be enjoying tomorrow.


LIEBHERR

If I don't use AI, **am I really an engineer?**

Busting the myths of artificial intelligence and machine learning in engineering.
By Christina Kothlow, and Krishna Veeraraghavan

As Artificial Intelligence (AI) has become more ubiquitous in our everyday lives, so too has they hype. There are some pretty scary premonitions about AI too, largely thanks to the science-fiction and dystopian literary genre, but even some of the leading lights in science and technology have some strong opinions.

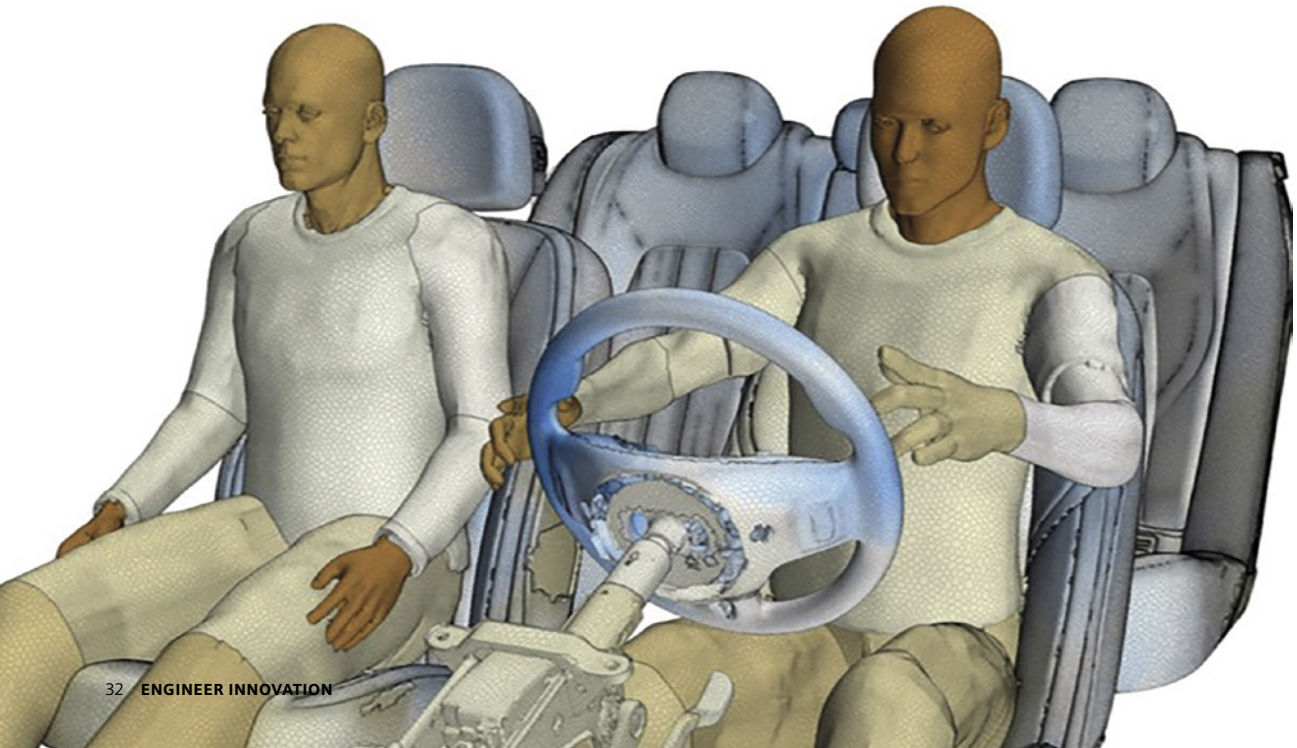
What is AI?

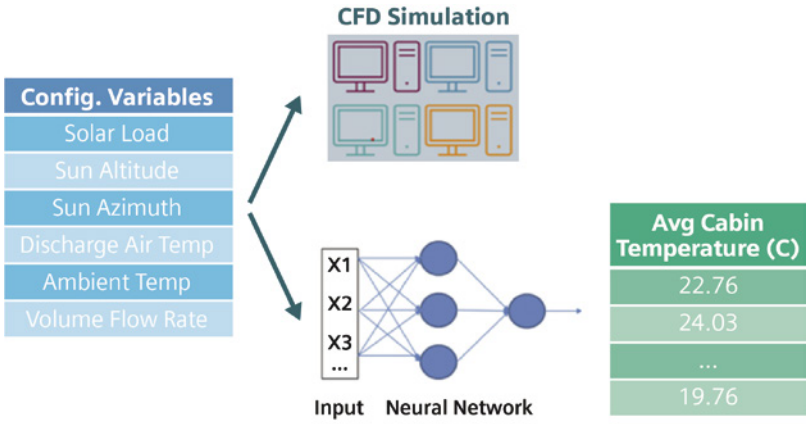
AI is a multidisciplinary topic that enables machines, devices, and computers to think and make decisions in a way that would seem intelligent. AI helps machines and programs make smarter decisions by learning and improving in an iterative process based on the information they collect.

In the future, AI in engineering may focus more on collective intelligence. Engineers and computers working together in feedback loops to identify problems and develop solutions that can make the design process and systems work more efficiently. This would enhance the capabilities and contributions of engineers. This sounds positive, a worthwhile contribution to humanity and real people still central.

Collective intelligence

Collective intelligence somehow seems more sinister, it refers to ways that data and technologies bring people, machines, and





computers together to achieve outcomes that were previously beyond our expectations. Psychologists define collective intelligence as groups whose general ability is to perform well not on a single task, but on a wide range of different tasks. This is possible to achieve by combining human intelligence and machine learning, the ultimate 2+2=5?

Machine learning

Machine Learning (ML) takes us even further into science-fiction territory, a subset of AI, a self-adaptive algorithm that uses statistical algorithms to build and train systems and models. These systems and models can learn and improve without being explicitly programmed to do so and then make predictions or identify hidden patterns in the data. Two types of machine learning widely used are supervised and unsupervised learning. All supervised learning will fall under either regression or classification problem. Input data for both cases can be numerical and categorical.

Deep learning

Deep learning moves us from science-fiction to potential dystopia but is simply a further subset of machine learning. Some of the most frequently used deep learning networks include convolutional neural networks, auto-encoders, transformers, and generative adversarial networks (GAN). Deep learning utilizes hierarchically organized artificial neurons to process data for extracting higher-level features from the raw input and for achieving machine learning objectives. Deep learning is distinguished by its use of many layers of artificial neurons and, consequently, many parameters and hyperparameters. Optimizing hyperparameters can have an impact on the training of machine learning algorithms (a few examples include number of clusters in clustering algorithms, Bayesian optimization, gradient-based optimization, etc.).

Having established some common definitions, we can do some myth busting.

Myth #1: Numerical models are the only solutions available to solve difficult engineering problems. AI is not accurate enough to be a good fit for Computational Fluid Dynamics (CFD) and engineering problems

Reality: Thanks to technological advances, AI/ML solutions now exist that work well on sub-systems with very minimal prediction error. Simcenter Engineering & Consulting Services have worked with customers to use AI/ML in design predictions to minimize CFD simulations with great success and good accuracy.

Myth #2: Data science is easy and there are open-source tools that can be used

Reality: Generic machine learning algorithms cannot handle customer-specific engineering problems. Different applications require different machine learning algorithms and further problem-specific refinement (for example shape detection techniques). Although there are widely available image recognition algorithms, companies must develop an in-house shape detection algorithm to detect various shapes or components of a vehicle.

Myth #3: AI doesn't require people to run it

Reality: The value of AI lies in its ability to augment the capabilities of computer engineers and domain experts. By performing the monotonous and repetitive tasks, it helps engineers focus on solving more complex problems using CFD tools, such as Simcenter, to generate more meaningful simulation data for future predictions. AI is the helping hand, not the hand itself.

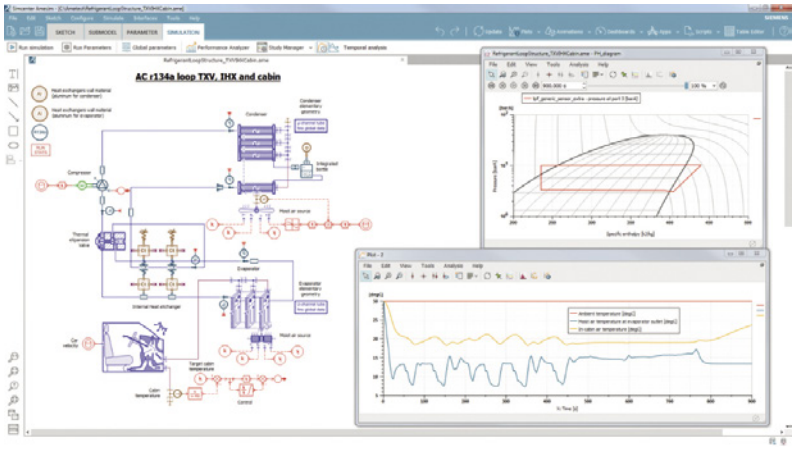
Myth #4: The more data, the better

Reality: AI in CFD needs smart engineering data, such as Key Performance Indicators (KPI), relevant to the problem, to be successful. Simcenter Engineering Services uses feature engineering technologies to achieve data reduction from simulation data to enable AI to deliver high-quality solutions. As with many things more data isn't always better, but relevant data that gives insight is.

AI – more fact than fiction

AI has transformed technologies in every industry. Applying AI to CFD applications can be a strategic asset to companies since it helps to reduce costs and create new differentiated values. AI-driven smart solutions offer substantial benefits to CFD engineers, designers, and analysts:

- Reduce computational, design program, and operational costs by creating more designs per simulation at a faster turnaround time
- Reduce the process and program development turnaround time with ML based surrogate models and smart AI driven workflows to expedite turnaround time
- Enhance the accuracy of simulations by flagging anomalies and providing knowledgebase workflow assistance in the CFD process. This includes CAD, physics modeling, mesh settings, and postprocessing
- Improve product performance and efficiency by creating an ecosystem to simulate, predict, and optimize the product in a seamless way
- Provide knowledgebase workflow assistance in CFD



If AI offers so many advantages for CFD, why aren't all engineers doing it?

Implementing AI, particularly for a niche technology like CFD, can present some operational challenges.

Database management: building and maintaining simulation and design database is a monotonous and expensive process which involves alignment with IT and the various engineering groups. Engineering groups themselves are often disconnected, so the required coordination with an additional department can be a hindrance.

Extracting and then training the data for AI in CFD, there is a lack of required data science skills to extract desired features, build and train the data set for integrating ML techniques with CFD, CAE simulations and for design predictions.

Talent, delivering AI capabilities in CFD designs and simulations requires talent in machine learning, deep learning techniques and CFD skills, and these skills are still largely developmental across the engineering workforce.

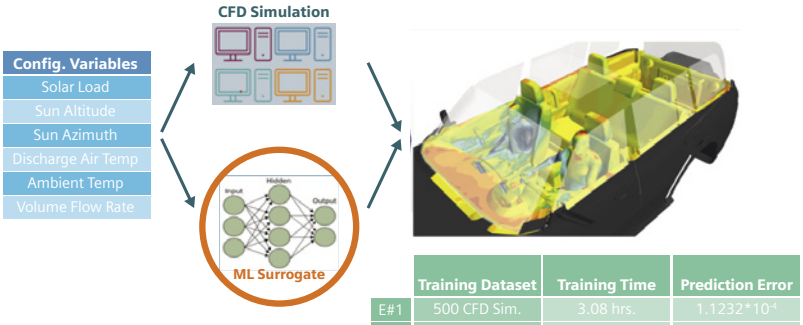
What's the solution?

The Simcenter Engineering Services group at Siemens has developed AI solutions for CFD to solve these and other AI-related problems companies face. These solutions enable companies to:

- Connect CFD with AI and multi field science to assist engineers in multi-physics design exploration studies and AI-enabled control actions to enhance product performance
- Drive innovation in designs and simulations by enhancing their digital twin capabilities, by developing and deploying customizable AI solutions
- Realize successful transformation for AI in designs and simulations by providing domain knowledge, build and train ML models with CFD and multi-science data and provide access to deep learning and ML techniques

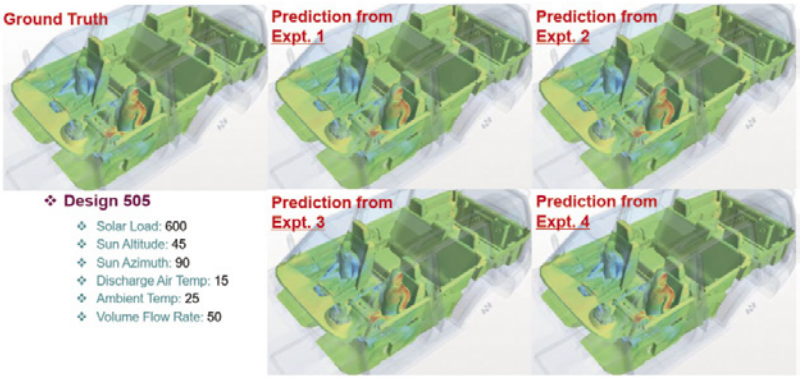
Going beyond CFD

Industrial solutions for AI in simulations have been developed with the Siemens groups including model-based systems engineering, predictive analytics, physical testing, and system simulation engineering. These synergies allow the Simcenter



	Training Dataset	Training Time	Prediction Error
E#1	500 CFD Sim.	3.08 hrs.	$1.1232*10^{-4}$
E#2	1000 CFD Sim.	4.25 hrs.	$6.3939*10^{-5}$
E#3	1500 CFD Sim.	5.40 hrs.	$4.9629*10^{-5}$
E#4	2000 CFD Sim.	6.46 hrs.	$4.8784*10^{-5}$

Source: Siemens Predictive Analytics Group



Engineering Services team to leverage domain expertise and deliver value that goes beyond CFD by focusing on AI/ML and statistical techniques that address customers goals.

If this all sounds theoretical and futuristic, then keep reading.

Real-world applications for AI in CFD

Predict discrete temperature using ML

For engineers responsible for thermal management, regression techniques can be used to develop a prediction algorithm based on input data (such as numerical/categorical) and output data (numerical).

In the above example, the team trained a neural network to predict the average temperature of a vehicle. Completed using 500 random samples from 600 data samples generated by Simcenter for various combinations of operating conditions. The KPI (temperature) was extracted to train the model. Of the 600 samples, the team used 500 for training, and the remaining 100 were used to predict the accuracy of the model. Of 100 data samples, 72 samples had less than 1% prediction error (difference in predicted temperature – actual temperature) and 28 samples had prediction error in the range of 1% to 1.66%. The maximum prediction error in the model was 1.66%, which corresponds to the temperature difference of <5ºC.

Regression techniques can also be integrated with control systems. Using CFD data, engineers can train the regression model, use it to predict values of relevant variables, and then take corrective control actions to achieve the desired target and improve performance (for example, based on the battery range remaining). Additionally, the model can predict the energy load and invoke control actions to adjust the cabin temperature accordingly.

Predict cabin surface temperature using a convolutional neural network

In a similar example, the Predictive Analytics team used data samples to build a convolutional neural network to predict the surface temperature distribution inside a vehicle cabin. In this exercise, a simulation database was generated by running CFD simulations for various operating conditions. While the team tested the application of 500 (Expt.1), 1,000 (Expt.2), 1,500 (Expt.3), and 2,000 (Expt.4) data samples to train the network, the prediction error remained stable. The team tested the accuracy of the neural network prediction with the actual CFD simulation results and found that the results from both techniques matched. We followed the below steps to compute the prediction error:

1. Computed the square error between the true pixel value and the predicted pixel value
2. Normalized it by the true pixel value
3. Computed its average over the entire region.

These tests proved to the team that AI techniques can be used for CFD simulations without compromising accuracy. By applying techniques such as those listed in the examples above, companies can free up their engineers' time and enable them to perform more valuable, complex design and simulation tasks while maintaining accuracy.

Back to the question we posed at the beginning: if I don't use AI, am I really an engineer? The answer today is yes, but in three years maybe not.

Listen to Krishna"s latest podcast

Q&A

INTERVIEW

We spoke to Remi Duquette, Vice President of Innovation and Industrial AI at Maya HTT

We talked about what the training of engineers will look like in the future. How should future engineers be educated? Do we need specialized artificial intelligence or generalized humans?

Well, eventually we're going to talk about the engineer of the future, but I wanted to start off by talking about the engineer of the past. Can you tell us a bit about your background and how you got here?

Well, my background is probably not atypical in terms of engineering. In the 90s I did my engineering degrees and graduated from McGill and University of Toronto, and then went into aerospace engineering. That really was my background. Stayed, of course, for probably about a decade in aerospace engineering, and then moved on to the software engineering world and developed all sorts of funky and fun applications. Now I'm in charge of innovation at Maya HTT, and we develop multiple software solutions for different engineering domains not just space, although we did start in space but we now are developing software for about 12 to 15 different industries with experts in each of them. In the last decade, I really moved on to AI and machine learning as a practice within our company.

And it's changing at a really, really rapid pace, isn't it? Whole swathes of existing skills, like learning to drive, are likely to disappear because they're going to be taken over by AI. Is that what you see is or going to happen?

Well, certainly as you mentioned there, there are some skills that will be made obsolete by some of the new technologies that are emerging. Some are a little bit scary and we'll have to see how they evolve and if it's as rapid as we think it will be, but certainly there will be some rapid change. My nine year old is at a summer camp coding today and it's like, "Well, I didn't have a computer at her age because computers were starting out but not really widespread at the time."

So it's kind of an interesting thought to see, and how rapidly these changes will occur. But yes, I'm certainly bracing for a lot more of those changes and that's why I think the future of engineering is important and a really critical topic to address because the engineers we train today... We can't just overspecialize them on specific technologies as we know those may not be available in five years' time because they keep on changing.

How do you think AI is going to affect future engineers' jobs?

AI is really a technology, a new way of dealing with data and learning from data. Engineers have used data in the past whether it's in controllers, in the manufacturing space, or in operations so it's not really a new topic. It's been made a lot more powerful by the computers that we have and the amount of data we have at our fingertips and are able to process, whether it's from telemetry, real-time telemetry, or additional sources that we can tap into.

I think AI will change engineers in a couple ways. One, in augmenting them and two augmenting their capability. It’s going to change the way that we think of a design cycle in engineering, or product design.

Nowadays, that product sends back telemetry back home, so to speak, and tells you new things in the environment that you may or may not have put into your design in the first place. It brings new ways to think about how to intuitively design and put forward some interesting new ways of coming

If you over-train and overspecialize a little model, well, at some point it just does not generalize very well and it can't adapt very well. It's the same thing for training engineers."

Remi Duquette, Vice president of Innovation and Industrial AI, Maya HTT

up with amazing new products that we couldn't conceive before. That kind of feedback loop that's a lot more rapid and real-time, gives us engineers more tools and interesting information to process.

Do we think that the engineering graduates today are having the correct training to play a part in this future of engineering?
Well, certainly, and I've been in many interesting discussions and conferences with a lot of people that are teaching our engineers. In the past the focus was really more in problem solving skills and I'm going to call them mathematical skills, technical knowledge and logical reasoning and thinking. As, we look to the future, we're at a crossroad where we grapple with generalization versus specialization.

In a way, an analogy to AI. If you over-train and overspecialize a little model, well, at some point it just does not generalize very well and it can't adapt very well. It's the same thing for training engineers.

If I had told you that we would be contemplating self-driving cars 10 years ago, you would've laughed at me but now we're getting closer and closer to that reality and people are not laughing anymore, and they're investing a significant amount to make it happen. That's really, I guess, the point there on specialization versus generalization of engineers. It's definitely moving from pure mathematics to really adaptive skills that will make you a really good engineer that is able to evolve with the pace of technology and adapt with new technologies as new tools.

There is an argument to say that there is a problem with the sort of engineering current software engineers do, in that you spend your whole career trying to drive the software as much as anything else, and not enough time doing real engineering. Assuming that AI is going to free engineers up to do proper engineering, making decisions, giving insight and not just be "mesh monkeys"; Is that how you see the future going?
I definitely see that as a trend, and certainly AI as a technology does bring those insights that kind of bubble to the surface, those insights that may have been hidden in the data or in the software. Instead of having engineers and humans going through and sifting all of this, they can employ the idea of generative AI programs that will give you the best couple of solutions and then you will apply your engineering judgment to pick the right one. I mean, it's still going to be a probability game where AI brings about what's most probable, and people need to think in a different way in those environments. I do see that trend certainly increasing in the future.

And while we will get some brilliant solutions we will also see some completely unfeasible solutions. We still rely on engineers to spot the things that are completely unfeasible.
It's not just unfeasible but dangerous sometimes. You see it in all sorts of things and that's why AI needs to be understood and harnessed in the proper way. AI, again, is purely and simply a new tool in terms of its power. It's been there in terms of algorithms for machine learning and deep learning has been there for over two decades, in which time we've seen it evolve in some brilliant ways, and not so in others. For example if you look at the data used by social media platforms to train chatbots, it may be deemed as unethical in the way that it uses language.

And not forgetting, of course, that human engineers often make bad decisions, and sometimes you're going to need AI to pick up those decisions, as well.

When we talk about the engineers of the future, actually those are the engineers that we're training today because if you graduate next year, basically you're still going to be working in 2060 or maybe even 2070, by which time the world will have changed completely. We have to start teaching these skills, don't we? I guess it happens naturally, but the future starts now.
It does start now, and actually it starts with even us, you and me. I mean, I graduated two decades ago now, but I keep on learning. Every year I make a point of learning, whether it's small or big, a new skill to put in my arsenal of skills. I hate to kind of quote someone like Einstein but once you stop learning, you start dying.

To listen to the full interview, download the Engineer Innovation podcast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EXPLORE THE POSSIBILITIES

Nemo's Garden

Once upon a time, there was a mesmerizing digital twin and a magical underwater garden...
By Jenn Schlegel

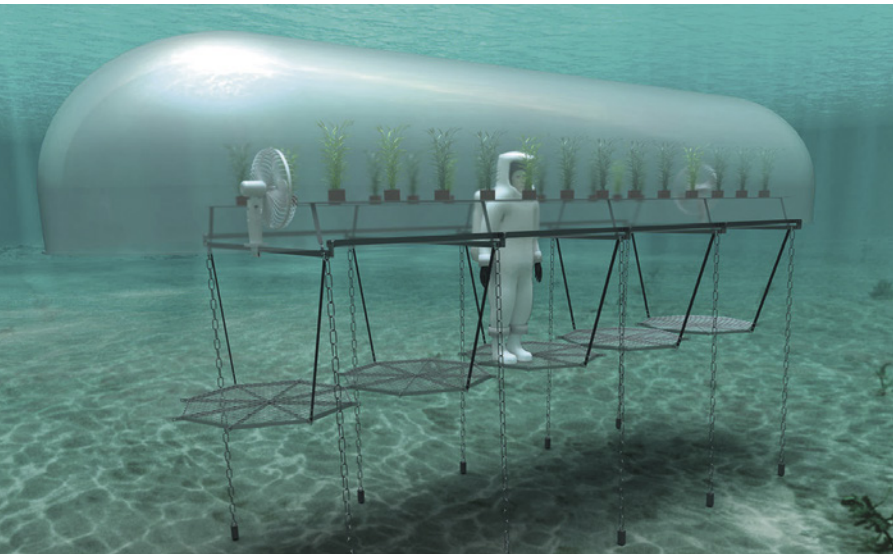
It is not every day that inspiration strikes. So when you happen upon a story like Nemo's Garden and the save-the-planet potential of a simple underwater farm, you can't help but dive right in. Because like many a classic fairy tale, this story shows the magical power of dreaming big.

Today, just off the coast of Noli, Italy (between Genoa, Italy and Nice, France), you will find Nemo's Garden. Visible from the surface, it lies about 40 meters from the local beach at a depth of 6 to 10 meters.

But the real story started in the summer of 2012, when Sergio Gamberini, founder and president of the Italian diving equipment manufacturer, Ocean Reef Group, was vacationing on the Italian Riviera. Between dives, beach strolls and chats with friends about his other passion – gardening, he was struck by the most unusual idea: why not try to grow basil underwater? A couple of phone calls later and some help from his team at Ocean Reef Group, and he was experimenting with creating air-filled transparent biospheres 6 meters below the sea. That summer they successfully grew underwater basil.

10 years later

Today, Nemo's Garden's is a viable underwater greenhouse complex and pressurized underwater research lab. Consisting of 6 acrylic balloon



Built using Siemens NX software, the comprehensive digital twin of Nemo's Garden also includes the inner workings of the biosphere and its environment thanks to integrated Siemens Simcenter software. This advanced simulation can test out detailed case scenarios of any future situation.

structures that hold approximately 2,000 liters of air and float at different depths, these prototype biospheres harness all kinds of positive environmental factors from the ocean: temperature stability; evaporative water generation; CO_2 absorption; an abundance of oxygen; and the ultimate answer to every gardener's bête noire -- natural protection from bugs and pests.

Joined on this magical quest by his son, Luca Gamberini, Sergio Gamberini began to grow Nemo's Garden with a team of like-minded engineers, divers and scientists working to prove the viability of cultivating herbs, fruit and vegetables underwater. The first underwater basil was followed by lettuce in 2014. (The team feasted that summer on biosphere-grown salad topped with pesto made from their own biosphere basil. Already the dream was coming true.) Since then, the team has grown 50 different crops, including a variety of herbs, tomatoes and even strawberries. The team also discovered that plants grown in the biospheres are nutritionally richer than those grown traditionally.

Underwater basil for all

Recent stormy winters and the pandemic did set the project back a bit, but the team persevered. Nemo's Garden definitely worked, and they wanted to take it a step further than beachside Noli, Italy. Could you replicate this idea easily so that others could create and install their own underwater gardens around the planet? Could you increase the growing cycle and therefore grow more food for the global population? Could you make the process smarter and less labor-intensive?

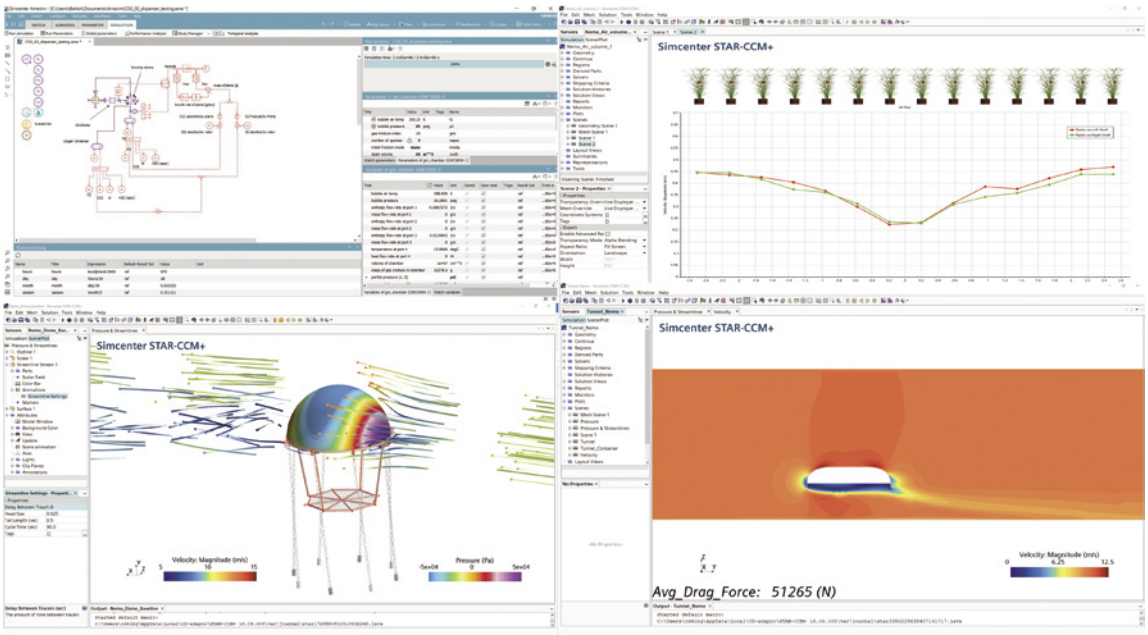
Taking the next step with TekSea and Siemens

Looking for answers to these questions about speeding up innovation and integrating cutting-edge technology, the team reached out to TekSea's Matteo Cavalleroni for insight. After initial discussions, Siemens was invited to join the project, leveraging the Xcelerator software portfolio and services to help Nemo's Garden get to the next stage of development.

"When I first saw the Siemens digital twin technology, I was mesmerized. Nemo's Garden is a one-of-a-kind system and we need to adapt to each environment where it is to be installed. If you can model that environment virtually before you start, you can foresee the challenges and address them in the best way," said Luca Gamberini, co-founder, Nemo's Garden. "We have seen benefits in understanding the flow of water around the shapes of our biospheres. We have a greater understanding of the points of stress on the structure around the biospheres. We also understand how the different interactions of the solar radiation, the temperature and all the physical factors act on the plants. All thanks to the ability of the digital twin to replicate our system."

The mesmerizing digital twin

The virtual aspect of Nemo's Garden starts with a comprehensive digital twin built using Siemens NX™ software. Covering the complete design, it also includes the inner workings of the biosphere and its environment thanks to integrated Siemens Simcenter™ software. An advanced simulation, the Siemens digital twin can test out detailed case scenarios of practically any future situation and location, including the biosphere's growing conditions and the environmental impact on the biosphere itself as well as the surrounding water.



Using the Siemens digital twin, the team is no longer dependent on seasonal trial-and-error, stormy winters or availability of divers and monitoring staff. Adaptations to the biospheres can be tested in the virtual world, enabling the team to refine the entire design and operating conditions at a massively accelerated rate.

Fresh from the farm

Designing and operating the biospheres are just a part of Nemo's Garden. One also needs to keep track of what and how plants are growing, track their progress and conditions and tally up the harvests. For the most part, this job has been quite hands-on, meaning that qualified divers regularly check in on the biospheres and plants; this is complemented by manned onshore monitoring.

Obviously, today's technology can help create a more sustainable and practical business model that does not rely on trained divers collecting data and someone siting behind a monitoring station watching the plants grow, literally. Siemens could lend a hand here as well thanks to its extensive experience in leveraging software and advanced AI technology to automate traditional farming practices.

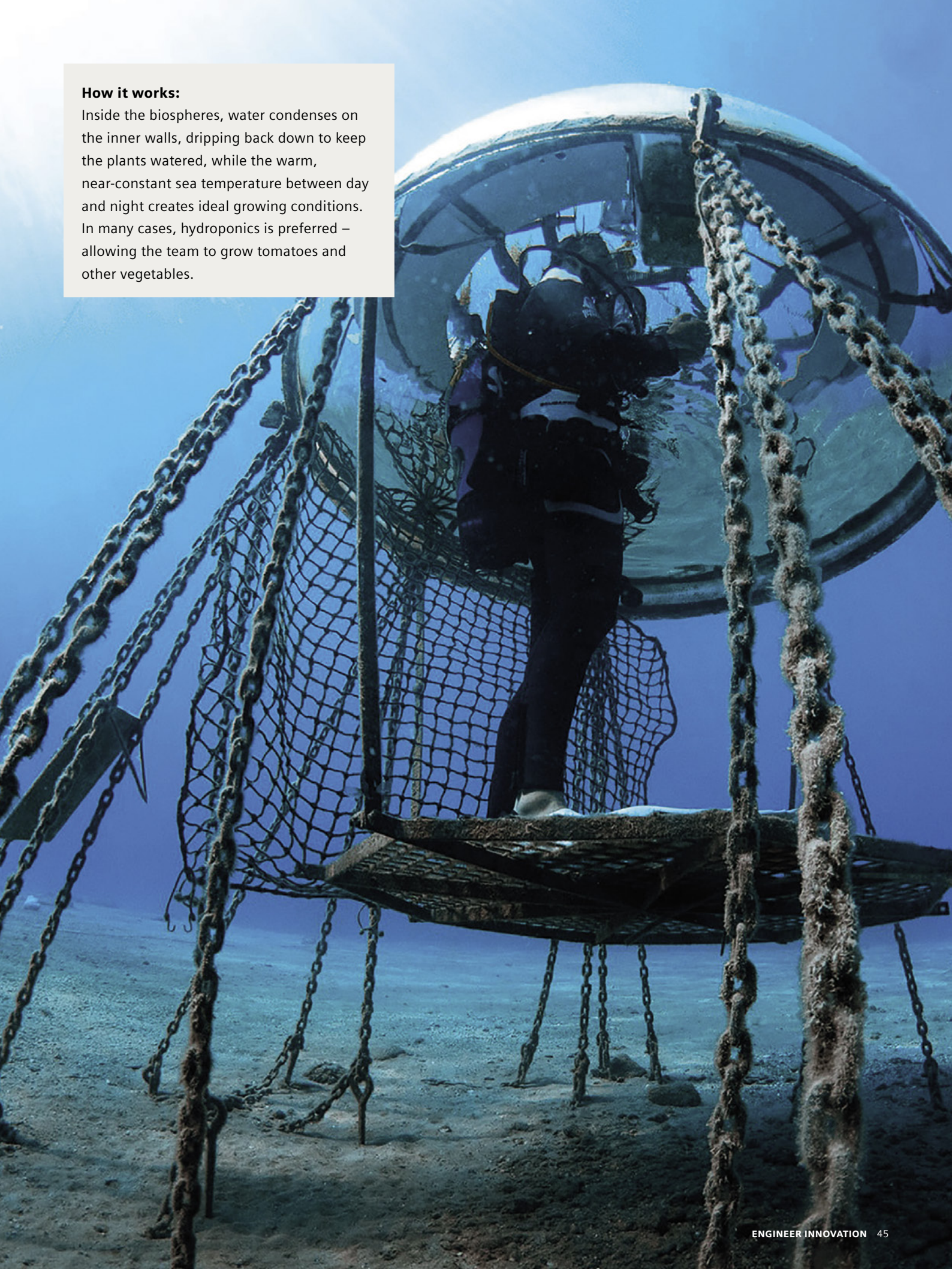
Existing growth-cycle video and archived reference data from traditional farming practices at various growth stages and health conditions was analyzed using the Siemens MindSphere® service. From this, Siemens was able to train a machine-learning algorithm to monitor plant growth as well as the environmental conditions within the biospheres.

Enter the AI farmer

To start, the team will run this algorithm on Siemens Industrial Edge computing devices in each biosphere. With sophisticated data analytics capabilities like these, the team will be able to monitor the plants via a cloud-based dashboard throughout the season from anywhere and in real-time. Next season, the plan is to connect the Siemens Industrial Edge devices to actuators to automatically adjust air circulation, humidity, irrigation and nutrition throughout the whole season. Together with Siemens, Nemo's Garden hopes this will be the foundation for a sustainable, global agricultural service, optimized for subsea operations and locations around the world. And just think, this all started with a dream to grow basil underwater.

The sea space around Nemo's Garden is open to the public. You are welcome to scuba dive or snorkel out to take a peek if you happen to be in the area. There are also guided diving tours available locally.

How it works:
Inside the biospheres, water condenses on the inner walls, dripping back down to keep the plants watered, while the warm, near-constant sea temperature between day and night creates ideal growing conditions. In many cases, hydroponics is preferred – allowing the team to grow tomatoes and other vegetables.



There's a huge amount of work that goes into the design and building of a skyscraper.

Safety is paramount, naturally. Architects must ensure that they can withstand wind, rain, and any other elements thrown at them. Heating and cooling systems must be incorporated into the design, along with staircases and elevators offering easy access and emergency exits.

But have you ever thought about external safety and comfort factors?

At some point, you've probably experienced the 'wind tunnel' effect in the vicinity of tall buildings. This has become more of a problem as cities such as London have seen a rapid growth of skyscrapers in the 21st century. When the 20 Fenchurch Street Building, better known as the Walkie Talkie, was built, there were complaints about the strong gusts at the base of the tower. One person even said they nearly got blown over as they were walking past. And the tallest building in Leeds, 32-storey Bridgwater Place, was responsible for a death in 2011 when strong winds toppled a lorry parked nearby.

So, what is it that causes this phenomenon and what can be done to prevent it?

Downdraught, gusts, and channelling

High winds are created around tall buildings by what's known as the 'downdraught effect'. This occurs when wind hits a building and, with nowhere else to go, is pushed up, down, and around the sides of the structure. The air forced downwards then increases wind speed at street level. Completely square cornered buildings create a further acceleration of wind around the sides that can be dangerous for pedestrians. And several

EXPLORE THE POSSIBILITIES

Windy buildings and **melting cars**

Using simulation to stop skyscrapers affecting the local environment
By Luke Morris

towers standing together cause the air to be squeezed through a narrow space in an effect known as 'channelling' - this is a form of the Venturi effect, named after 18th-19th Century Italian scientist Giovanni Battista Venturi.

The strongest gusts are created when the wall it hits is facing the prevailing wind – in Britain, this is from the southwest. And London is more susceptible to channelling than cities such as New York as much of its layout is based on medieval street patterns. These narrow roads are much more likely to trap the wind than the wider streets of more modern cities. Combine all these factors and you have the potential for the extreme winds capable of blowing vehicles and pedestrians over, leading to injury and even death.

One solution is to build more rounded buildings, such as London's Gherkin. As there is less flat surface the downdraught effect is reduced and there are no sharp corners for the air to accelerate around. But the customers that commission these skyscrapers don't want to be forced into major design decisions like this. Aesthetics are crucial to architects winning projects, so they need to find the right balance between looks and safety.

As concerns over the dangers of wind tunnels have grown, the City of London has introduced stricter rules on new skyscrapers. These require developers of towers more than double the height of surround buildings to carry out both wind tunnel testing and computational fluid dynamics (CFD) assessment. If necessary, experienced wind engineers must be consulted to confirm the findings of the tests and provide assurance that there will be no dangerous effects created.

Wind engineering

In 2019, Joe Osman, Robin Stanfield, and Alex Turpitt founded ArcAero, a specialist wind

engineering consultancy. Having worked together in wind engineering services for over a decade they contributed to projects including the London 2012 Olympic Park, Manhattan Loft Gardens in London, Mercedes Benz Stadium in Atlanta, and London's Gatwick Airport. With their vast experience they wanted to provide building developers with a solution to all their wind engineering challenges.

ArcAero's goal is to enable clients to design and deliver architectural structures that are aesthetically pleasing, comfortable and safe. They knew that wind tunnel testing, whilst essential, is very costly and time consuming so from the start they planned to use more CFD testing.

Having worked in the industry for so long, they were clear on what they needed from a CFD solution. They chose Simcenter STAR-CCM+ due to its capabilities for high fidelity, fast turnaround, and powerful workflow automation. As Joe Osman puts it, "Workflow automation is key for us to create a robust and repeatable process with minimal scope for human error."

To begin the CFD process, the geometry first must be prepared for pre-processing. Due to this coming from clients in a wide range of CAD formats it can take several days or weeks to clean up and repair the data to extract enough detail to model the development and surrounding area. ArcAero uses the built-in surface repair tool in Simcenter STAR-CCM+ to reduce this to a single day or less. It can all be done with just a few clicks, allowing them to focus on the rest of the project whilst the geometry preparation is automated.

And the automation doesn't stop there. ArcAero has developed a process using Java so that all the remaining simulation setups and pre-processing are done automatically, meaning most models are ready to run with 10 minutes once the CAD data has been prepared. "We spend minimal engineering time on the interface," Osman explains. "This allows us to focus on results rather than CFD and the process behind it."

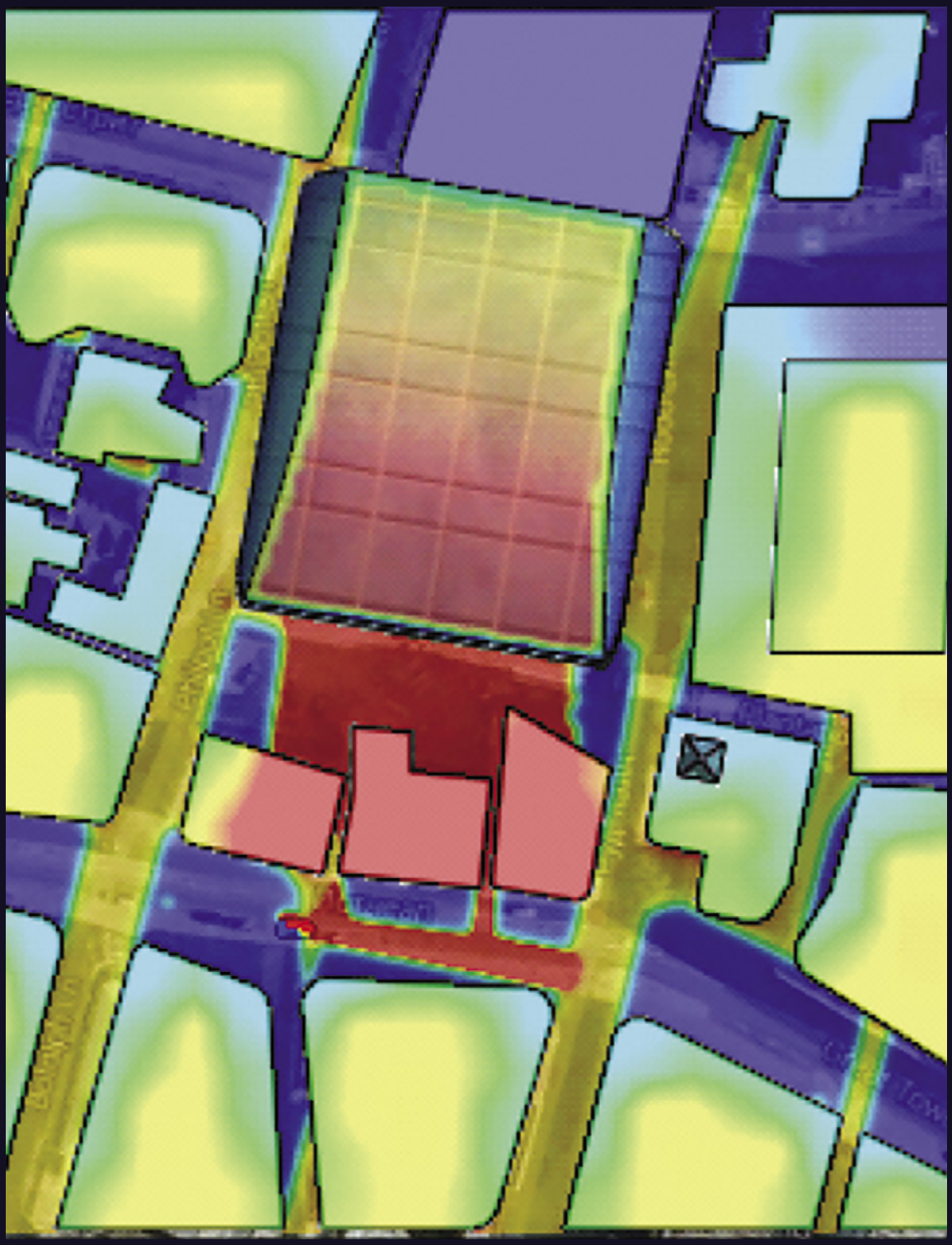
Take Lower Essex Square in Birmingham as an example. A CFD model was built and run quickly using this automated process to predict wind hotspots that were likely to be created. They then verified these finding in the wind tunnel at Imperial College in London, leveraging the CFD simulation to visualise problematic wind patterns and explore design strategies to alleviate the hotspots. Finally, the engineers used their automated process to simulate a number of different design options in succession. These iterations continued until the optimum solution was found and this was then tested in the wind tunnel for final validation.

Power from the Cloud

The only real limit to the speed of the wind engineering process is the available computing power. ArcAero chose to use cloud computing instead of purchasing their own high-performance computer as it gave them the most flexibility whilst maximizing performance and minimizing cost.

"With varying demands in project workloads, cloud computing offers a cost-effective and flexible option in comparison to on-premise hardware," Osman explains. This was another reason for choosing Simcenter STAR-CCM+ as it can be used on the Gompute cloud platform. Osman estimates that this allows them to get results within 30 minutes compared to two days if they were using a local computer. The Gompute platform enables seamless customization and integration of STAR-CCM+ scripts to tie in with the entire automation process. This gives ArcAero a higher level of control and delivers a robust, repeatable process.

Cloud computing is perfect for a growing business like ArcAero as it avoids large capital expenditure on hardware and allows them to flex up or down as required. "Cloud enables our company to handle large fluctuations in capacity as we scale up and pay for what we use, which perfectly suits our highly variable throughput," says Robin Stanfield. He goes on to explain how



Simulation is an essential component of the skyscrapers of the future. The technology available now enables engineers to predict problems early in the design process and work with architects to find the ideal solution.

parallelization and flexible licensing make this the ideal solution. “Cloud hardware allows us to get the most of our licensing costs. We can run virtually unlimited simulations simultaneously. This reduces the turnaround time and allows us to do more thorough exploration of the design space and help our customers to a better solution.”

Protecting against all elements

Wind isn’t the only problem skyscraper developers face.

Did you hear the one about the building that melted cars?

Yep, it was the Walkie Talkie again.

On August 29th, 2013, when the building was nearing completion, Martin Lindsay parked his Jaguar on Eastcheap in the City of London. Two hours later he came back and found part of the car including the wing mirror and badge had melted. On the windscreen was a note from the construction company saying, “your car’s buckled, could you give us a call?” The developers accepted responsibility and paid the repair costs of just under £1000.

But how did this happen?

Dr Svetlana Shtilkind, Dr Andrey Ivanov, and Maxim Popov from Siemens Digital Industries Software used Simcenter FLOEFD to investigate the phenomenon.

They began by creating a full-scale CAD model of the building and surrounding landscape, taking area topology data from Google Maps. The solar radiation parameters (location and time) were specified using Simcenter FLOEFD and automatically included in the simulation.

They estimated the ray-exposed area dynamics as a result of the sun’s position on August 29th and determined that the most heated area at the time of the incident was the section of Eastcheap where the car was parked. The sunlight focus area was then placed in the CAD model and a more exact car position was defined by the focus trajectory analysis.

By defining the relevant areas of the building and the car they were able to simulate the melting that occurred. This showed that the solar influence on the car’s bonnet (hood) and wing mirror peaked at 12:40 at around 1,300 W/m2. This is around 1.5 times higher than the average solar radiation flux value relative to the location, day, and time. The solar influence on the wing mirror lasted just ten minutes, but due to the extreme temperature and the hollow construction with a thin plastic outer shell this was enough for it to melt.

The investigation found that it was in some ways fortunate that the damage was relatively minimal. It compared the results of the reflection from the parabolic glass of the Walkie Talkie with more reflective material. In the case of total or mirror reflection, the Simcenter FLOEFD simulation reported a maximum flux value of 6,000 W/m2. An extreme scenario that would undoubtedly have much more serious consequences.

The future of skyscrapers

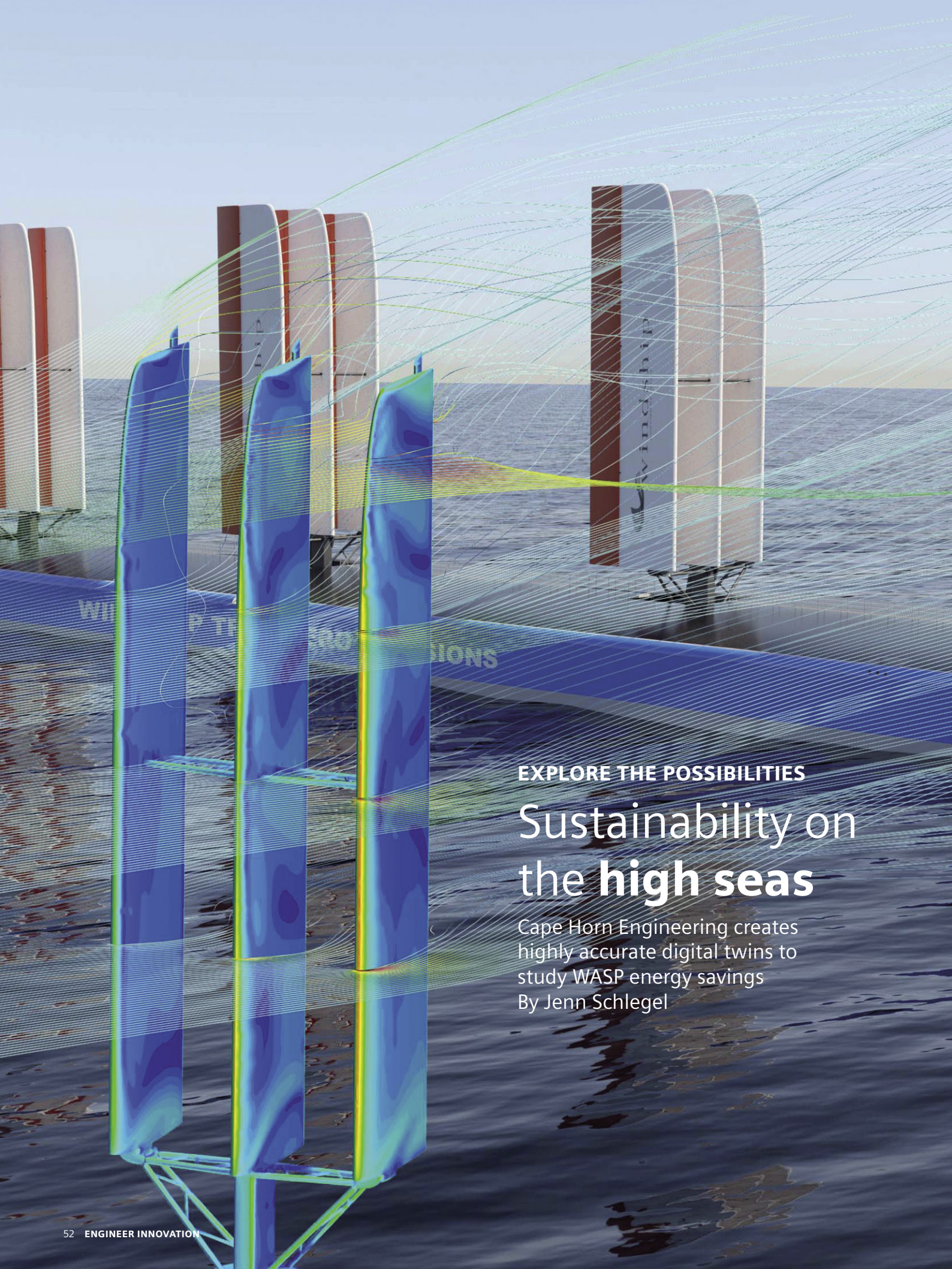
Clearly, skyscrapers aren’t going anywhere. Except up.

Inherent in human nature is the desire to build bigger and better. To push the limits of architectural imagination.

But as larger and more elaborate structures are built, more phenomena caused by the local environment will be uncovered.

With the costs involved in designing and constructing skyscrapers, developers can’t afford the prospect of being forced into an inordinately expensive redesign or even the complete removal of a building.

Simulation is an essential component of the skyscrapers of the future. The technology available now enables engineers to predict problems early in the design process and work with architects to find the ideal solution. Combined with wind tunnel testing to validate simulation results, we can all be assured that as well as looking impressive, modern skyscrapers will pose no danger to people and property in their vicinity.



EXPLORE THE POSSIBILITIES

Sustainability on the **high seas**

Cape Horn Engineering creates highly accurate digital twins to study WASP energy savings

By Jenn Schlegel

The silent green revolution in marine

Sustainability is king across practically every industry today, from automotive, aerospace and energy to consumer goods and food. Although slightly slow to start, the green revolution has taken the greater marine industry by storm. Cargo vessels and cruise ships are being refitted with more sustainable propulsion systems. Next-generation vessel designs are incorporating new wind and solar technology. With new regulations on the horizon, energy efficiency and improved performance are a top priority when it comes to naval architecture and vessel design of all shapes and sizes.

One needs to remember that creating a ship, especially a complex one like Wonder of the Seas, currently the largest cruise ship, is an entirely different ball game than designing a simple four-door family sedan. There could be millions of extremely large and complex parts, components and systems to integrate on something as immense as a cruise ship or specialized marine vessels like an LNG carrier, a polar research vessel or a CTV (crew transfer vessel). Ships run into the hundreds of millions of euros as investments with lifespans of 30-plus years in many cases. When you start to design complex and expensive vessels like these, every cent that you can shave off by enhancing energy efficiency contributes to reducing the overall cost of operation and long-term sustainability of the marine sector – not to mention the overall environmental impact of reduced emissions and global warming.

The brainchild of Dr.-Ing. Rodrigo Azcueta, a naval architect and Computational Fluid Dynamics (CFD) expert, Cape Horn Engineering is a world-renowned CFD consultancy based in Portsmouth, with a serious racing pedigree; heading the CFD technology for four America's Cup Challenges and conducting performance analysis for yachts in the world's most prestigious races including the Volvo Ocean Race, the Vendeé Globe, and the Transat Jacques Vabre.

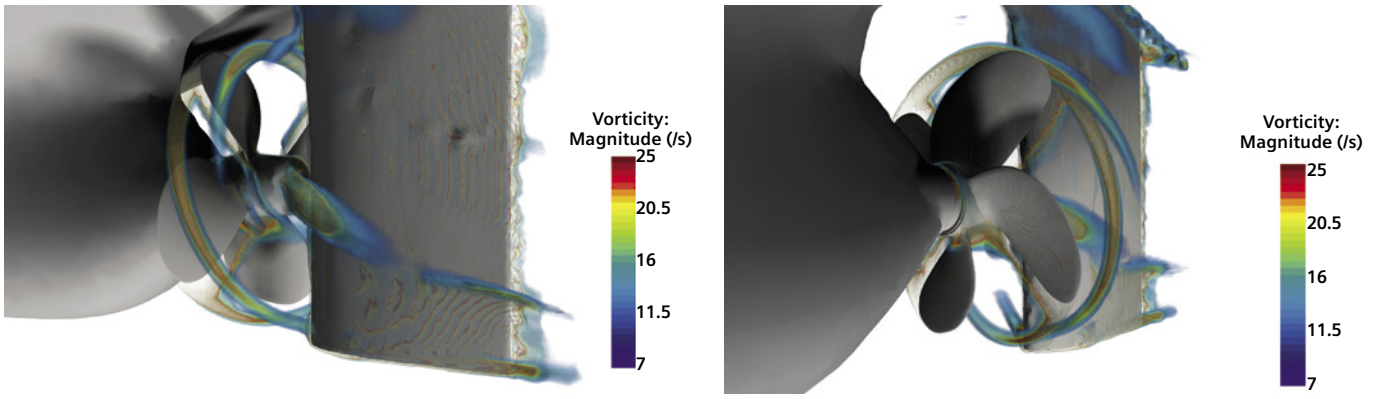
As industry leaders in CFD and marine technology solutions, they specialise in performance prediction of racing yachts, sailing yachts, superyachts, motor boats, commercial ships, renewable energy structures and more.

CFD for a Greener Marine Future

The specialist team at Cape Horn Engineering is dedicated to achieving sustainability throughout the marine sector, helping naval architects around the world successfully reduce emissions, and improve energy efficiency by implementing new, more sustainable energy sources and analysing design options.

One of the key new technologies they use is a simulation process to make sure that a ship design meets or exceeds the upcoming Energy Efficiency Existing Ship Index (EEXI) regulations. The International Maritime Organization (IMO), a specialized United Nations agency, has set a policy framework to reduce carbon intensity by at least 40% by 2030, and a total greenhouse gas emissions by 50% by 2050. The first measures, namely the Carbon Intensity Indicator (CII) and the EEXI come into force on January 1, 2023.

While CII is an operational measure, assessing how efficiently a ship transports its cargo according to real-time fuel consumption, EEXI is a technical measurement that purely considers the vessel's design parameters. It is comparable to the Energy Efficiency Design Index (EEDI) for newbuilds. The EEXI measures the design CO_2 emissions relative to the vessel's size and speed and translates this to emissions per cargo ton per mile. The IMO has set limits regarding the allowable EEXI according to



vessel size and type. Every ship will be required to comply with the EEXI next year.

"Embracing CFD technology gives ship owners a cost-effective means by which they can explore a range of solutions to ensure they are on target to meet the upcoming EEXI regulations. It also provides the ideal environment to test and optimize novel energy saving devices, such as wing sails. There are several possible solutions which must be considered to reduce the environmental impact of the shipping industry, each of which has a very important role to play," explains Dr.-Ing. Rodrigo Azcueta, Managing Director, Cape Horn Engineering.

CFD for a Greener Marine Future

CFD simulation software by Simcenter, can help calculate the EEXI for older vessels by developing speed power curves to update existing documentation. This is a much faster and more efficient method than traditional towing tank testing. Another area where CFD is beneficial, is when engineers need to investigate potential energy efficiency improvements, such as adding Wind Assisted Ship Propulsion (WASP) devices and calculating their impact on the EEXI. To meet the new regulations,several ship owners are considering WASP devices, such as wing sails, suction sails and Flettner rotors...to name a few.

"WASP devices can potentially cut fuel costs by 10 to 30 percent, but they are highly complaex systems to model. Both the hydrodynamic and aerodynamic effects need to be modelled simultaneously in a single simulation. We have developed a simulation workflow to directly compare WASP device efficiency and determine potential savings. Wind conditions above the water surface are modelled with an accurate wind profile taking into account the atmospheric boundary layer wind gradient," explains Dr.-Ing. Azcueta.

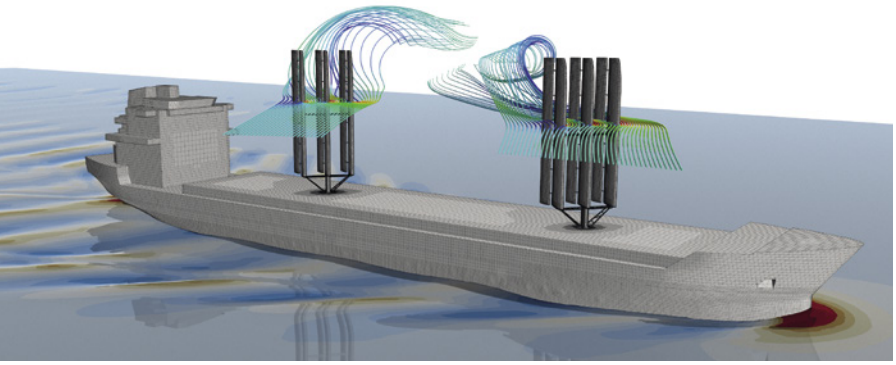
Comparing WASP technology with digital twins

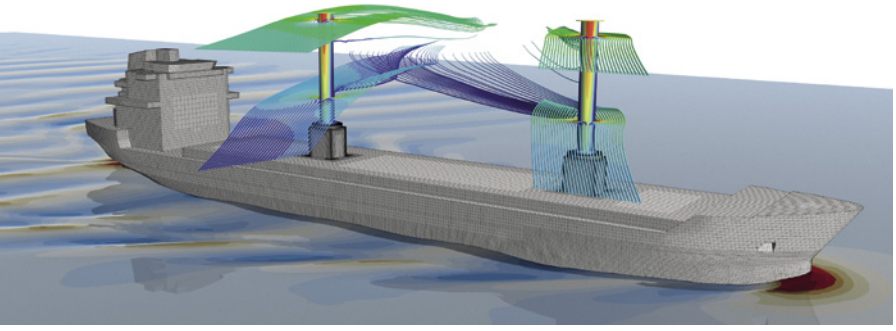
With simulation technology, naval architects and engineers can investigate the performance of different WASP options virtually, to make the most effective choice according to the vessel's requirements.

Of course, result accuracy is always important, which is why engineers need to be sure to quantify and understand the simulated CFD results via a solid verification and validation process. Today, with increased computer power and more accurate software and processes, digitalized versions of vessels are reflecting real-world performance quite accurately. This is what is referred to as a digital twin.

To showcase this solution, Cape Horn Engineering developed a case example comparing two WASP configurations on a 138m general cargo vessel, the MV Regal. Benchmark data was readily available for the MV Regal, making it an obvious choice for verification and validation of the process.

The first option examined consisted of two three-wing-three-flap wing sails mounted on the deck.





The second option replaced the two wing sails with two similar-sized Flettner rotors.

“We didn’t aim to compare the WASP technology itself, but rather demonstrate our simulation set-up as a feasible way to compare different types of WASP devices with a highly accurate all-in-one, 6 degrees-of-freedom hydrodynamic and aerodynamic simulation, based on Simcenter software,” explains Dr.-Ing. Azcueta. “Even unoptimized, there was a 14 and 24% power reduction thanks to the WASP devices. This tool can clearly help ship owners make an informed decision when it comes to retrofitting their vessels for energy savings.”

Enter Artificial Intelligence

Modelling wing sails under realistic conditions can be accurately done, but it still takes super-computer capacity to run these types of simulations, especially when optimization loops are included. In an ideal world, the simulation runs for a study like this could hit the hundreds or even thousands of computed simulations. To address this issue, Cape Horn Engineering is working together with several companies and universities to train AI models to use reduced order modeling and design neural networks to compute the aerodynamic forces in seconds rather than hours.

“Incorporating AI into the picture opens vast possibilities to optimize the wing sail design and develop intelligent control systems to ensure the largest possible reduction in emissions,” adds Dr.-Ing. Azcueta.

He concludes, "Our niche area of CFD expertise has so much potential to offer greener shipping solutions. It is not often that your interests align in such a way, so it is an exceptional and exciting opportunity for everyone involved. Collectively we can make a difference on a global scale."

About Cape Horn Engineering

Cape Horn Engineering is a UK based company, best-in-class independent CFD (Computational Fluid Dynamics) consultancy with clients all over the world. Industry leaders in CFD and marine technology solutions, specialising in performance prediction of racing yachts, sailing yachts, superyachts, motor boats, commercial ships, renewable energy structures and more.

CFD technology is a crucial support for naval architects, yacht designers and design engineers to optimise designs for critical elements such as weight saving, performance predictions, reducing emissions and design optimisation.

Using their extensive experience, they offer unique solutions and insight into how this revolutionary technology can assist designers to improve performance and efficiency, leading to considerable fuel and emission reductions.

https://www.cape-horn-eng.com

MODEL THE COMPLEXITY

Step by step

Helping stroke patients regain mobility
By Kate Foster

"It just an average day," Anna recalls. "The usual ups and downs at work, a gym class, then a glass of wine with a friend on the way home, nothing extraordinary." But it was just as Anna had curled up on the couch to scroll through her social media feeds and catch up on her messages that she realized that the day had been anything but ordinary for family friend, Peter. "There it was: a group chat message saying that Peter had suffered a stroke that morning and was in hospital. I automatically thought of the last time I saw him at a get-together, just a week ago; he was tending to the barbecue and telling us about his upcoming ski trip. I was just shocked. It was hard to imagine him as a stroke patient."

Anna's reaction highlights the intrinsic nature of such medical events. They are so sudden, so quick, so seemingly indiscriminate. Strokes, or cerebrovascular accidents (to use medical terminology), are life-changing moments that strike the patient down, often out of the blue. Recovery is a long process. For many sufferers, this involves relearning even the most taken-for-granted actions, like walking and talking.

A growing challenge

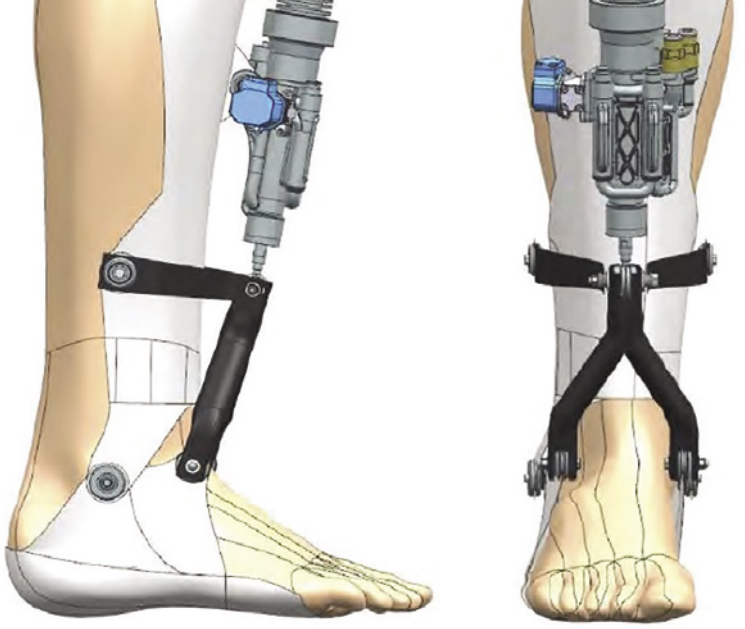
It's a story that, across the world, is all too common. The World Health Organization (WHO) estimates that 15 million people per year suffer a stroke[1]. Often, a stroke results in brain damage due to the sudden reduction in blood flow to the brain cells. It is estimated that, after three months, 20 percent of people who lost mobility as a result of a stroke remain wheelchair bound, while approximately seventy percent of sufferers walk at reduced velocity[2]. In many cases, patients undergo a lengthy and gruelling period of rehabilitation in order to re-establish the muscle strength, balance and range of mobility that they lost.

The reality is that stroke rates are increasing. According to a 2020 research report[3], the number of people living with stroke is estimated to increase by 27 percent between 2017 and 2047 in the European Union, mainly because of population ageing and improved survival rates. And given the prevalence of neurological and physiological damage following a stroke, the need for effective rehabilitation methods is acute.

Explainer: What happens during cerebrovascular accidents?

Put simply, a stroke is an attack on the brain; when the blood supply to part of the brain is cut off, it causes damage to brain cells and results in impaired neurological and physiological functioning. This can present as paralysis down one side of the body (hemiplegia), muscle weakness and imbalance, speech problems and changes in sensation.

Source: Stroke Association, https://www.stroke.org.uk/effects-of-stroke/physical-effects-of-stroke



But for stroke patients like Anna's friend Peter, there is some positive news. Modern rehabilitation methods are embracing not only proven repetitive, task-specific approaches, but also cutting-edge technologies that are enabling people to walk again and re-establish their independence and quality of life more quickly. Much research is being done in this area and the technological advancements that are emerging in this space are encouraging. One such field is that of robotic exoskeletons, wearable mechanized devices that assist gait rehabilitation by amplifying and assisting natural motion.

Wear and walk

Many stroke patients are already benefitting from robotic exoskeletons, which offer numerous benefits along the road to regaining mobility. They allow for more effective physiotherapy sessions, greater patient comfort, and can even provide quantitative information about the patient's recovery such as velocity, smoothness and range of motion[4]. Various clinical studies have suggested that the use of exoskeletons in rehabilitation therapy can offer greater biomedical benefits than more traditional, passive orthoses such as braces and supports.

But while this burgeoning field of biotechnology is rapidly gathering pace, robotic exoskeleton design is still in its infancy, with many practical challenges like mass and size to overcome.

So, how are engineering teams around the world working to advance exoskeleton designs and take this life-changing technology forward?

Innovating the exoskeleton

When mechanical engineer Emmanuel Viennet was starting out in his career, medical science couldn't have been further from his mind. He spent three years as a simulation engineer in the field of vehicle transmission systems, before coming to specialize in hydraulics. These days, he is a professor of mechanical engineering at Switzerland's HEIA-FR university and, through his work in fluid power technology and system simulation, is helping advance stroke rehabilitation technologies like exoskeletons in novel ways.

"Our current project focuses on the development of a hydraulic actuator for an ankle exoskeleton that would be used by stroke patients in rehabilitation settings," he explains. The project—named Talaris after the winged sandals of Hermes, the Greek messenger god— investigates harnessing fluid power technology, which uses the natural flow of pressurized fluid as an energy supply to a hydraulic system as a means of powering the lower-limb device. This represents a departure from common exoskeleton designs relying on electric motors which can be noisy, heavy and bulky for the wearer[5].

The design challenge for Viennet and his team was to build a demonstrator of the innovative hydraulic-powered concept—but within the limitations of the university department's finite financial resources. The nature of the concept also posed tough questions around testing. Viennet says his team generated around a dozen viable a priori variants by combining different hydraulic architectures, distribution principles, actuator types and energy storage components. But with the means to only build and test a maximum of two solutions, how would his team choose between pump-controlled or valve-controlled distribution, or decide on the best kind cylinder type?

This was where Viennet's background as a simulation engineer came into play and resulted in him introducing Siemens Simcenter to this ground-breaking project. Using Simcenter Amesim, a powerful software for modelling and analysis of multi-domain systems, the Talaris team

was able to evaluate their potential designs with ease in numerical simulations and preliminary tests, then make decisions with confidence.

"Thanks to Simcenter Amesim, we could narrow down our initial design ideas and thoroughly investigate our two final design candidates." Emmanuel Viennet, HEIA-FR University

Testing the possibilities

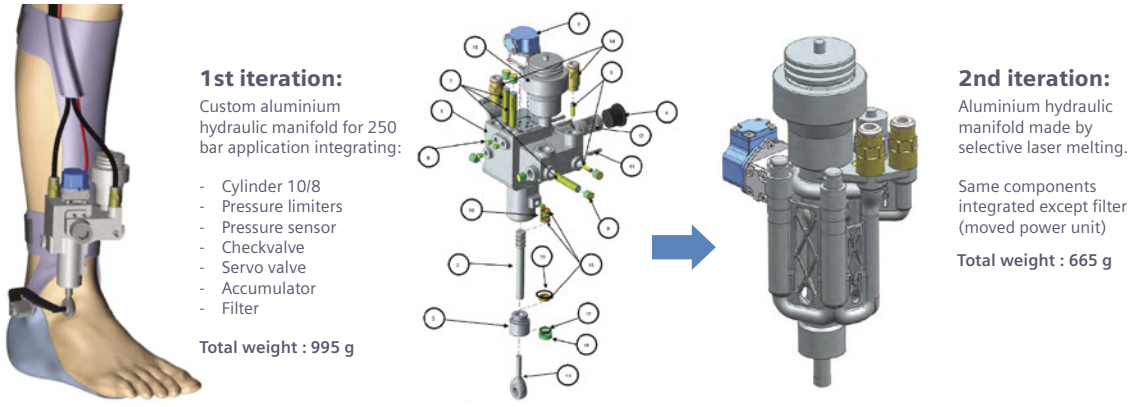
The winning design featured a servo-hydraulic actuation rather than an electro-hydraulic solution, after Simcenter Amesim helped the team identify the option for best dynamic performance based on an ankle exoskeleton to support an 80kg patient when walking at a normal speed requiring the whole system to have a bandwidth of at least 8 hertz (Hz).

"Without simulation, we would have used more classical tools like spreadsheet, which would have limited ourselves to steady state analysis. On the other hand, we would have built more prototypes to reach the same level of system understanding," Viennet says.

"Simcenter Amesim helps us by serving as a virtual test platform where design space can be narrowed down in a systematic and efficient way. In a less expected way, it also helps in providing a technology-neutral platform that can be leveraged by users to dive into domains they are unfamiliar with," adds Viennet.

This opens the door to teams with diverse skillsets and domain expertise coming together to innovate, experiment and create. The low-risk environment simulation provides means that imaginations can be stretched to their fullest—and the potential outcomes are limitless.

In the world of stroke rehabilitation, exoskeletons are undoubtedly changing the game by harnessing technology and engineering excellence to help patients walk again while reducing the burden of lengthier recoveries for healthcare institutions. A recent review of exoskeleton technology[6] published in the Journal of Neuro-Engineering and Rehabilitation, however, saw the authors point out that wearable robotic exoskeletons—a relatively nascent approach to rehabilitation since their first use in 1994—still have some way to go in terms of optimal design. Based on a review of exoskeletons currently in use in rehabilitation setting, the report is a reminder that wearer comfort, complexity of fitting and operation and the device's ability to mimic natural gait are areas of design that must be improved in the future. As Emmanuel Viennet's work at HEIA-FR University illustrates, simulation has a central role to play in realizing those improvements.



First concept for integration of the actuator on an exoskeleton stricture and design iterations

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GO FASTER

The future of road transport

How simulation is powering innovation
By Luke Morris

Modern transportation has changed the world. By drastically cutting journey times countries, continents, and indeed the whole globe have become much smaller. People and goods can travel further and faster, opening up new economic possibilities for everyone.

But the adoption of the internal combustion engine as the preferred method of powering transport for the best part of a century has come at a significant cost. Of the 50 billion tonnes of CO_2 emitted globally each year, 8 billion comes from transport alone. Road passenger and freight vehicles account for around 75% of this figure.

Switching to electric propulsion is an obvious way to significantly reduce this impact. According to the latest Mobility Consumer Index, more than 50% planning to buy a car will choose either a fully electric, plug-in hybrid, or hybrid vehicle.

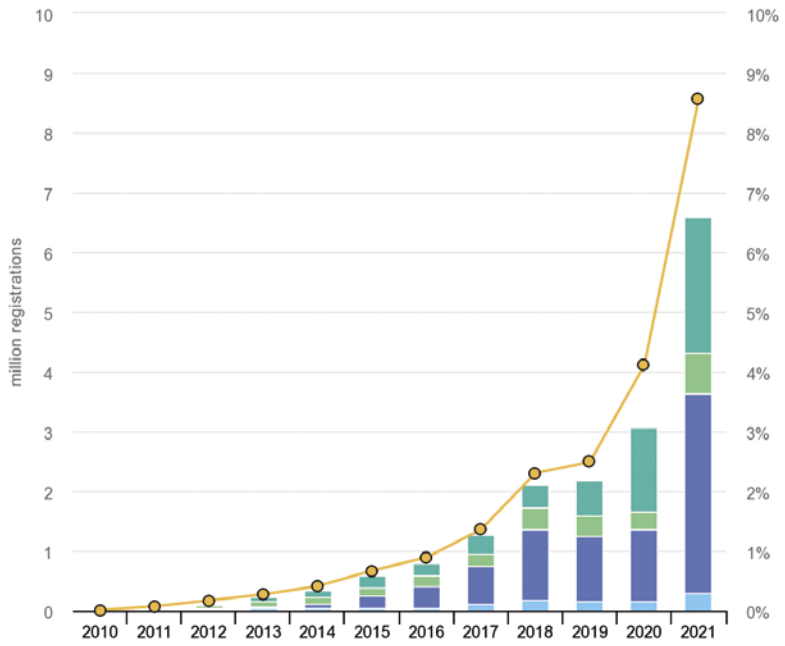
Something must change, and fast. If emission reduction targets are to be met and a climate catastrophe avoided, the automotive industry must accelerate the transition from internal combustion propulsion to electric propulsion. As Bill Gates recently said, "We need to be adopting electric vehicles as fast as we bought clothes dryers and colour TVs when those became available."

This is far easier said than done, however. Manufacturers need to produce vehicles that customers want and offer them at a competitive price. For a company like General Motors (GM) which has over 100 years of experience with brands such as Chevrolet, Buick, GMC, and Cadillac, a new approach to development is needed to produce the environmentally friendly and economically viable vehicles of the future.

Of course, it's not possible to make an immediate and complete switch to producing electric vehicles. GM needs to follow a carefully planned transition, which means developing internal combustion engines, hybrid drive units, and electric drive units at the same time.

This means an increased number of complicated, separate development threads. Finding ways to reduce the cost of each thread and speed up development time is critical to a successful transition and the continued profitability of the company.

Michael J Grimmer is Technical Fellow in the Propulsion System Global Noise and Vibration department at GM. He explained how his team has adopted simulation to meet these challenges, facilitate innovation, and help the company stay ahead in an increasingly competitive market.



Driving quality forward

Whichever type of vehicle is being developed, driveline quality is key to performance, comfort, and fuel economy. To optimise it, engineers need to fully understand the energy efficiency on the drive quality and seat acceleration experienced by the driver and passengers.

Building physical prototypes to carry out these tests is an expensive and time-consuming process. To overcome this, GM has used Simcenter Amesim to build comprehensive digital twins of each vehicle they develop. This allows them to perform many more what-if analyses than previously, so that when they do build a physical prototype it is much closer to the ideal solution.

Grimmer cites driveline noise and vibration reduction as an example. Previously, they had to design and build prototypes of components such as isolators and perform physical tests to understand their impact. This would typically take several months and cost up to $50,000. With Simcenter Amesim, GM engineers can create these isolators virtually using model-based systems engineering (MBSE) techniques and carry out the testing in the simulation environment. All in a matter of days at a significantly reduced cost.

Encouraging innovation

Simulation has also delivered a huge boost to innovation for GM. When physical prototypes are needed to prove concepts, risk must be minimized to avoid wasting critical development time and money. Engineering experience, best practice, and analysing results from existing similar products can only do so much, and this limits the opportunity for innovation.

By introducing simulation, engineers can experiment with their designs and test many more concepts in a much-reduced timeframe. Grimmer says, “We can do concept selection based on simulation of how products will perform. This greatly expedites the number of options we can consider and the correctness of the ones that we choose.”

Ultimately, accurate simulation is enabling innovations in vehicle design that would never previously have the chance to be fully explored and realised.

Improved methodology

With the adoption of Simcenter, GM has established new simulation-based standard work practices that improve their overall development processes. In the case of driveline noise and vibration, this means better optimisation and balance of all elements. They have used simulation to establish best practices that also take into account the energy and fuel economy requirements of each vehicle. The capability to simulate so many different designs and scenarios allows engineers to develop solutions that achieve the optimum balance across these different performance areas that previously wasn’t possible.

The Simcenter portfolio also enables better cooperation between teams and suppliers as models can be easily shared, as Grimmer explains:

“The Simcenter Amesim models that we build are easy to operate by others and can be integrated into the rest of the system and with the controls. Another user from a different engineering team can receive the subsystem model from us or even from a supplier as a black box and integrate it in their workflows quite effectively.”

Technology that evolves with the industry

As vehicle technology, and electric technology in particular, continues to evolve at a rapid pace, simulation must evolve too to keep up and

maintain its usefulness. To ensure the software is always at the cutting edge of simulation, Simcenter Engineering and Consulting services work closely with companies such as GM to understand the challenges they face and inform the future direction of products like Simcenter Amesim.

Grimmer says his GM engineers will work with the product development team on new or improved features that will enhance their experience and add functionality.

"Modelling torsional isolators within the transmission involve arc springs that have unique physics and Simcenter Amesim has an out-of-the-box sub model for modelling those physics, which was improved to achieve much quicker and accurate simulation," he says. "Another example is what's called a viscoelastic spring and its interface was improved for a more intuitive version based on our needs. That was extraordinary product support. We're very pleased with the product support we get with Simcenter Amesim."

Transition of practices as well as products

Physical testing is still a crucial component of the overall development process to ensure optimum quality in new vehicles. But clearly the more testing that can be replaced with simulation, the better, cheaper, and faster development will be.

To advance this transition, GM exports simulation data from Simcenter Amesim into Simcenter Testlab to compare simulation results directly with test data. This enables validation of their virtual models and gives increased confidence in using more simulation in the future.

Grimmer firmly believes that simulation accelerates product performance prediction, allowing teams to make well-informed decisions in earlier development stages. As simulation improves it's becoming possible to not only model and simulate a broader range of product designs, but also production, manufacturing variation, and what-if analyses.

So, the key to reducing road transport's impact on the environment is not one transition but two. For GM and other manufacturers to carry out a successful transition to more environmentally friendly vehicles and stay competitive they need the support of a technology transition: the introduction and increase of the use of simulation to enhance their development processes, foster innovation, and reduce costs and time to market.

STAY INTEGRATED

Letting electricity do the **heavy lifting**

Reducing heavy equipment power consumption and improving performance with simulation

By Luke Morris

When it comes to heavy equipment, safety is absolutely vital. As is performance, efficiency, and emissions control.

Construction sites are potentially dangerous places that need to stick to tight schedules and budgets. So, they only want to use the safest, most reliable, and most economical equipment.

A common piece of heavy equipment seen across construction sites is the scissor lift used both indoors and outdoors to provide an elevated platform for workers. It needs to be able to cope with all sorts of terrain – muddy, uneven, sloped – without risking user safety or compromising performance.

Historically, these lifts have been powered by internal combustion engines that can meet the demands and pressures that they are expected to deal with. However, as construction sites strive to be more environmentally friendly and stricter regulations are imposed by local authorities, demand has grown for alternative solutions powered by cleaner energy.

Enter Pulseo by Haulotte, a range of next-generation, all-terrain electric scissor lifts.

But switching from a thermal engine to an electric motor without losing any performance is no easy task. It requires so much more than simply swapping power units. Transitioning from thermal to electric demands analysis of the entire equipment architecture to optimize it for a completely different power system.

And Haulotte didn't want to produce an electric lift that was merely as good as older models. They wanted it to be even better.

To meet this challenge, Haulotte turned to simulation to help them design and develop the ultimate electric scissor lift. We recently spoke to Arnaud Chaigne, head of the Simulation and Digital Validation Division at Haulotte to find out why simulation was the solution and what the end results were.

Understanding the old to optimize the new

To define the optimal system architecture for the electric lift, Chaigne's team had to ensure the battery was sized correctly. As power requirements fluctuate during operation, there's always a risk of oversizing to ensure the machine can cope during moments of peak power demand, but this would compromise on overall performance.

Simcenter 3D Motion allowed for the modelling of the forces in the hydraulic actuators that raise the

platform. By taking into account kinematics, mass distribution, friction, and dynamic effects, engineers got full insight into the pressure level details and the energy that the actuators need to do their job. This showed Chaigne and his team that the peaks in demand occurred at the very beginning of elevation when the lift started to rise.

"We started by modelling the existing thermal system in order to identify the most energy consuming parts (energy-loss mapping). By doing this, we were able to define a new architecture more suited to an all-electric machine where all energy consumption counts," Chaigne explains. "In order to optimize the battery size, we had to develop control laws to smooth out the power peaks while offering a similar lifting time. This resulted in a constant power level during the entire elevation movement."

Using Simcenter Amesim, they then studied a multitude of design possibilities and predicted the machine performance of each one.

"Simulation allowed us to assess the feasibility of different innovation scenarios, taking into account the impact on various systems, like hydraulics, electrics and controls, as well as machine stability and operator safety."

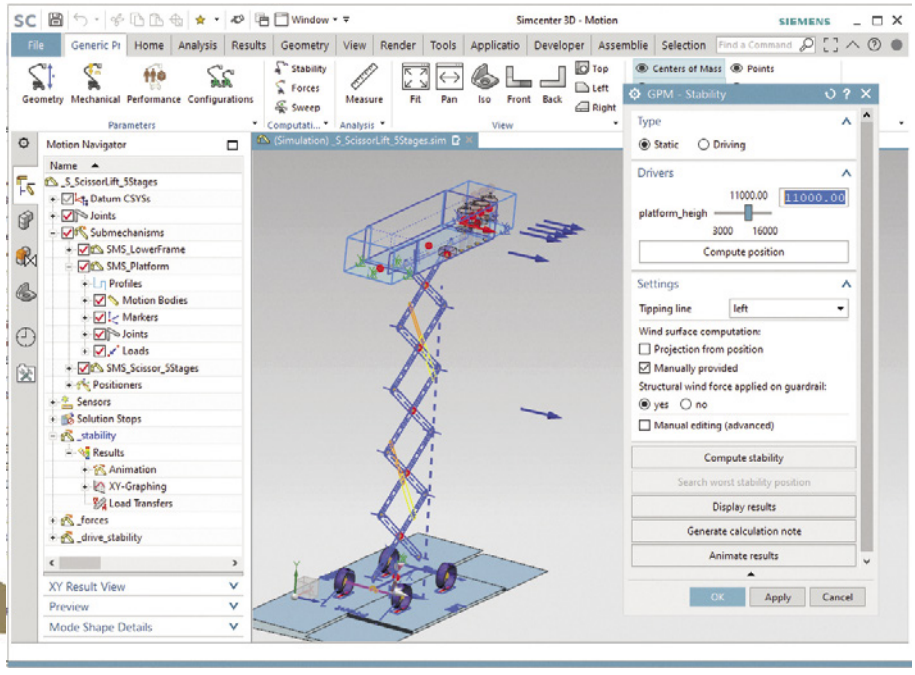
Keep it steady

Simcenter 3D Motion was also used to ensure the stability of the lifting mechanism both during transit and in operation. Regulations are in place to guarantee worker safety on and around elevating lifts. These stipulate that not only must they be stable when workers are on the platform, but also when the equipment is being moved into position.

The Haulotte engineers needed to anticipate all possible scenarios by studying the behaviour of the scissor lift – in particular that of the oscillating axle. Chaigne says that Simcenter 3D Motion was the perfect tool for this. "We used Simcenter dynamic multibody simulation to size the scissor lifts to ensure stability. This made it possible to find the best compromise between performance and machine weight and save time during development."

Co-simulation delivers the best results

Co-simulation is a technique where global simulation of a coupled system can be achieved by composing the simulations of its parts. Simcenter's wide portfolio of software enables



co-simulation by allowing for the easy exchange of information between each tool.

For the Pulseo range, Haulotte engineers used Simcenter 3D for structure and stability analysis and Simcenter Amesim for energy analysis and battery sizing. “Firstly, the two software programs operate simultaneously and exchange information to converge toward a common solution,” Chaigne explains. “We also use Simcenter 3D Motion to generate force tables according to the cylinder position. This information is then transferred to and used in Simcenter Amesim.”

Chaigne notes that analysing the pressure balance in the hydraulic actuators and the resulting stress distribution is key to improving performance. “Co-simulation allows us to analyse the stresses under normal conditions and during failures. We can see how the load transfers take place and the impact on hydraulic cylinder pressure.”

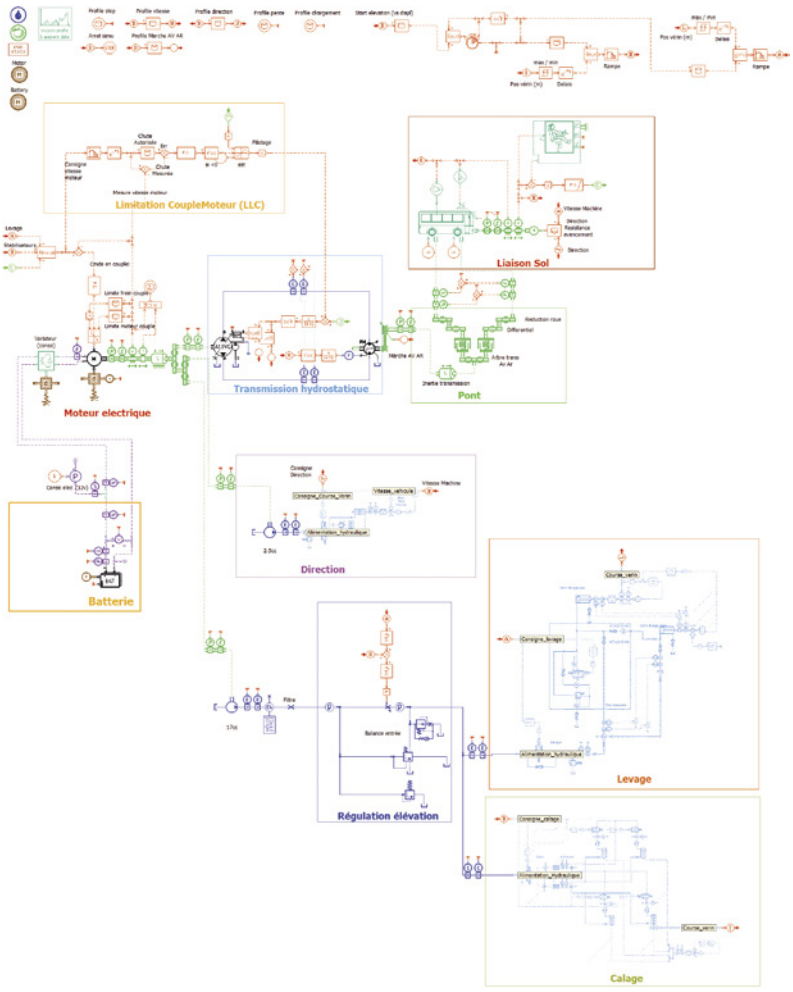
Democratizing simulation

In the past, use of simulation models has been restricted to specialists due to their complexity and the need for a full understanding of the tools involved. This has slowed down development as teams have had to wait for these specialists to process information at key stages of projects.

But this is changing thanks to what has become known as the ‘democratisation’ of simulation

“As a simulation expert, I am responsible for making sure our simulation tools are accessible,” says Chaigne. “The customisation possibilities in Simcenter 3D via NX Open have made it possible to integrate our business rules and regulatory norms to speed up the calculation process and reduce the risk of error.”

In the case of stability analyses, the team must work to standard norms which vary between regions. Each will have different requirements for environmental, operator impact, and equipment handling factors. To improve and speed up the analysis process, Haulotte has developed a customised process-oriented workflow tool using



the NX Open software automation module for Simcenter 3D. In short, this allows them to automate data entry taking into account the various norms of different regions. Chaigne explains, “During post-processing, it provides clear-cut stability information. This enables non specialists to use more complex Simcenter 3D Motion models.”

Lower costs, improved performance

The success of simulation has meant that Haulotte has been able to save both time and money by reducing the amount of physical testing required. Chaigne notes that the test phase remains essential but is much more streamlined thanks to Simcenter. “Simulation helps us identify the most critical cases in terms of stability, evaluating parameters like machine position, loads and forces.”

And when testing does highlight issues, simulation provides a deeper insight into the cause and helps to find the solution. “To reproduce the performance accurately, you have to model different physical phenomena. This includes identifying influential parameters and evaluating alternatives immediately. Working like this, we can reach the prototyping phase with a more mature, even definitive architecture.”

But what about the performance of the final product? Let’s compare past with present.

The older internal combustion powered lift had a 23kW thermal engine, maximum working drive height of 12m, and a loading capacity of 500kg.

Haulotte’s Pulseo lifts are powered by a 12kW electric motor. The working drive height has increased 25% to 15m and the loading capacity has increased by 50% to 750kg.

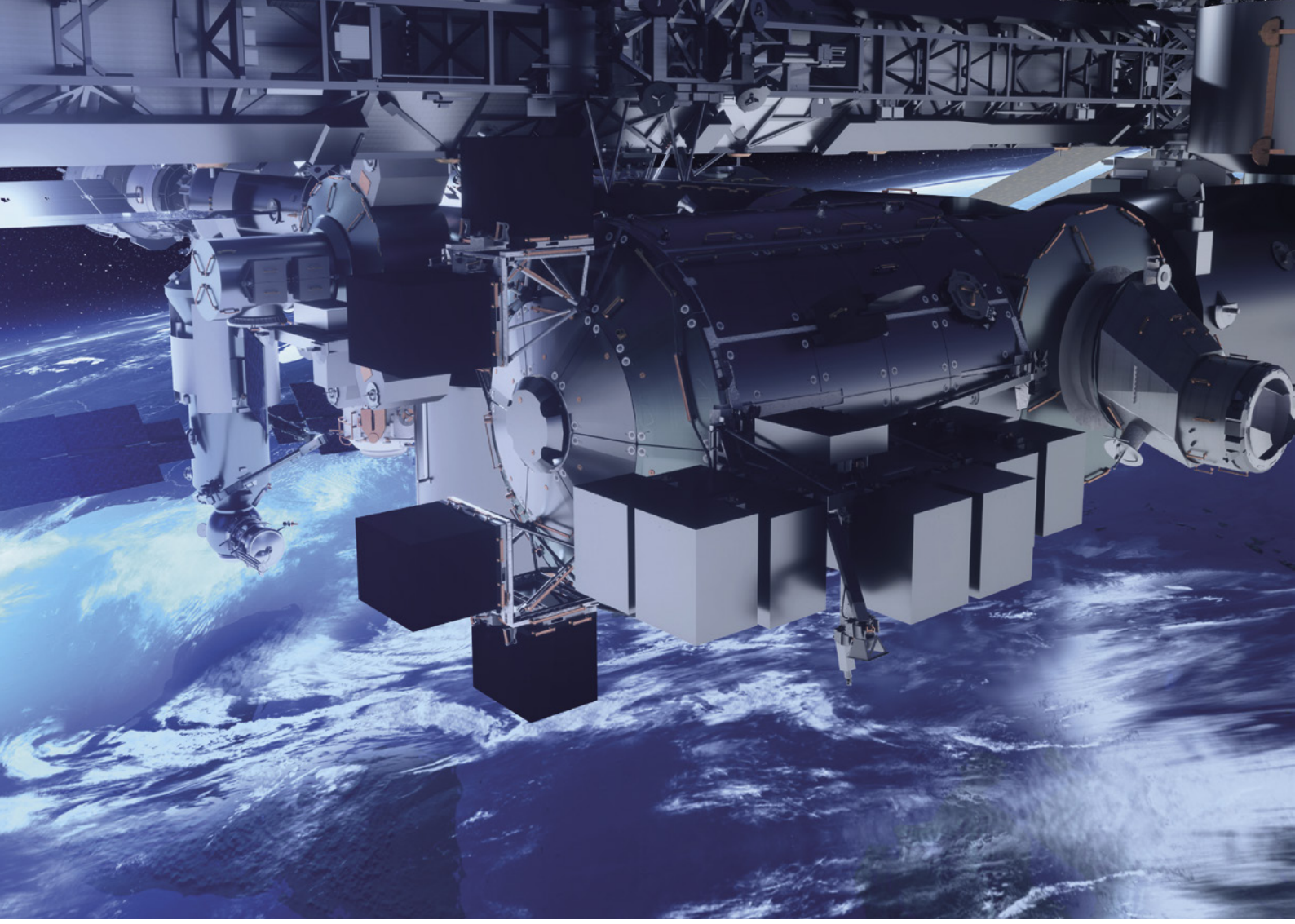
That’s a huge performance increase and an equally huge reduction in power. Of course, the new scissor lifts comply with all the operational stability safety standards across different regions. And thanks to being electric, they’re pollution-free and much quieter, enabling them to meet any noise and carbon emission regulations.

So, if you were thinking that some heavy equipment requires too much power to switch to electric energy, think again. Harness the power of simulation and you’ll start to see things very differently.

STAY INTEGRATED

Straddling the **Kármán line**

Getting results both inside and outside Earth's atmosphere
By Luke Morris



The Kármán line, named after Hungarian American engineer and physicist, Theodore von Kármán, is the boundary between Earth's atmosphere and outer space. Broadly, most experts say that space starts at the point where orbital dynamic forces become more important than aerodynamic forces so designing structures or aircraft to be used on our side of the line typically requires different types of testing and analysis to those on the outside. But it's still possible to use the expertise of the same engineers on both sides if you have the right tools for the job.

Expanding the International Space Station

The Bartolomeo platform, produced by Airbus, is the newest payload hosting platform designed to explore the potential commercial use of the International Space Station(ISS). When it came to the critical and complex testing phase of the project, Airbus turned to DLR for help.

The Institute of Aeroelasticity, based in Göttingen, is part of Germany's space agency, Deutsches Zentrum für Luft- und Raumfahr (DLR). It is a leading research centre that focuses on structural dynamics, unsteady aerodynamics, and dynamic loads. Traditionally, it has worked on aircraft, including ground vibration testing (GVT), multi-axis vibration excitation, and test rigs for wind tunnels, but more recently has evolved to include modal survey tests (MST) for the space industry.

DLR used the 192-channel Simcenter SCADAS Mobile hardware equipment for a modal survey test to update the finite element simulation model

of the Bartolomeo platform. This was crucial to the project as it allowed for the simulation and prediction of aspects such as how the platform would couple with the ISS. Reliability and accuracy were vital as in space the tiniest miscalculations can have serious consequences. Simcenter SCADAS Mobile enabled the capture of accurate experimental data to validate and improve the fidelity of the FE model by measuring 192 signals simultaneously.

Having recently switched from Simcenter SCADAS 3 to Simcenter SCADAS Mobile this was DLR's first major application of the new system, but as Julian Sinske, Structural Dynamics Testing Lead, says, they had no doubts in its capabilities. "In our experience, Simcenter SCADAS has always been issue-free and reliable, so we were extremely confident in the updated system."

Fully customizable

Sinske says that Simcenter SCADAS Mobile provides extra flexibility for handling not only MST, but different types of tests such as GVT thanks to the versatility of the data acquisition system. He also points out the advantages of using it alongside another tool from the Simcenter portfolio: "Simcenter Testlab is well-suited to large-scale tests like this one, particularly with the flexibility to customize what it offers."

This customization allowed DLR to run its own algorithms alongside Siemens' PolyMax algorithm to satisfy their specific testing needs. DLR engineers also customized the user interface and projected the results onto the wall of the laboratory so that everyone could track test progress. This all led to significantly quicker results than comparable testing scenarios, with the first measurements available less than an hour after setup.

Delivering results fast

The complete test results were delivered in less than four days – unprecedented based on previous projects. The structural dynamic data set produced by DLR enabled Airbus to determine the appropriate modal model, identify nonlinearities, and update the finite element model.

"Airbus had very high expectations," Sinske says, "which thanks to having the right tools available to us, we were able to meet. The entire test went according to plan. We needed to work as fast as possible to swiftly deliver the data that was required. Simcenter SCADAS Mobile and Simcenter Testlab helped us achieve this."

The future has just begun

Now they've done it once, the engineers from DLR's Institute of Aeroelasticity will be able to do it again and again. They've created a replicable testing approach that can be used in either aviation or space. "We use the same hardware and software for both GVT and MST and we have a plan in place," says Simske.

But they're not standing still and basking in their achievements. DLR is already hard at work developing new testing methods and technologies for the future, including the use of automation and artificial intelligence.

So, whichever side of the Kármán line a project is focused on, DLR now has a blueprint for fast, effective, and reliable testing. And it's all thanks to the agility of Simcenter SCADAS Mobile and the flexibility of Simcenter Testlab.

> Airbus had very high expectations, which thanks to having the right tools available to us, we were able to meet.

Julian Sinske,
Structural Dynamics Testing Lead

GO FASTER

Scuderia AlphaTauri

Scuderia AlphaTauri creates a top performing F1 car


PHATAURI

Using NX, Simcenter and Fibersim to create the ideal chassis and seat for F1 drivers.

The rise of Scuderia AlphaTauri

On February 23, 2022, the world got a taste of the new Formula One (F1) cars as they completed their pre-season test days in Barcelona. This was followed by testing days in Bahrain in early March 2022, where the drivers focused on getting comfortable driving the new cars before the race season began on March 21, 2022.

During the test days and the first few races, two young Scuderia AlphaTauri drivers, Pierre Gasly and Yuki Tsunoda, worked with the Scuderia AlphaTauri engineers to discover how the new car performed and fix the mistakes that occurred with the new design.

"There are new things to discover with this car every time we go out on the track so we have to make the most of each session and learn as much as we can before the first race here," says Pierre Gasly, trackside during the test days in Bahrain in March 2022. "The feeling was unique. I was excited to discover these new cars and see how they felt on the track."

That feel-on-the-track performance enhancer

In F1 racing, the driver and the car become one. This feel on the track comes from the part of the car that normally doesn't get to be in the spotlight, the driver's seat.

"The chassis is one of the most sophisticated parts of the car for safety and performance reasons. You need to start working on that part immediately even if you don't have all of the information," says Raffaele Boschetti, head of information technology (IT) and innovation for Scuderia AlphaTauri. "Before partnering with Siemens, we spent three months producing a good chassis. With Siemens software, we did this in one month. This saved us a lot of time and gave us many advantages."

Aside from the chassis, the seat is important for driver safety and overall driver performance. Overall seat design is strictly regulated by F1 safety and crash test rules. If something goes wrong,

drivers need to be able to exit the car quickly and safely. The safety marshal and medical teams need to be able to extract injured drivers from a crash effectively. Boschetti is quick to point out that there is much more to the seat in an F1 car than just safety.

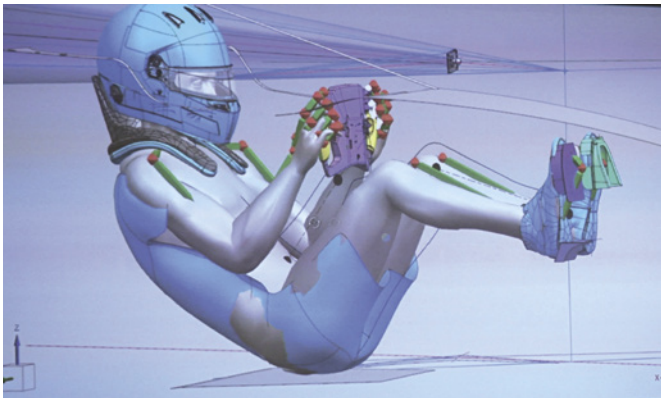
"The seat is a part of the car that delivers performance. The driver feels all of the vibrations, accelerations and handling through the seat. On the track, we can modify the car settings to improve the car based on the driver's needs," says Boschetti. "In Formula One, you have a couple of tests in February or March. In this situation, the software and platforms Siemens provided us were vital to building the seat."

One size does not fit all

Not every F1 seat is the same. Composite design engineers will tell you that half of the challenge isn't the seat but how to fit the driver in the car.

"It is like a tailored suit. You have to look at things in terms of helmet position, back position and you have to be as low as possible," says Francesco Dario Picierro, senior composite design engineer for Scuderia AlphaTauri.

To ensure these critical performance aspects were correct, Picierro and his colleagues developed a unique seat-designing process. To start, they designed a slightly larger seat than necessary and then heated a batch of special resin and took a physical mold of the driver's body in the ideal position. From the resin mold, they used NX™ software to create a complete scan to design the seat. NX, the Fibersim™ portfolio and Simcenter™ software are part of the Xcelerator portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software.



"The process might seem simple, but thanks to Siemens' products it becomes smarter," adds Picierro.

Using digitalization for F1 success

With the complete design and chassis change in the 2022 model, the team had to simulate every detail in computer-aided design (CAD) from overall visibility to how the driver would fit into the chassis design.

Getting the driver to squeeze in, reach the pedals and obviously see – while considering the helmet, safety regulations and the new chassis and car design – is an engineering feat in itself. The team knows that digitalization is the only way to succeed in F1 these days. Using Siemens' digitalization tools removed most of the grunt work from the design, engineering and production cycles.

"Using NX helped us with our digitalization efforts. For example, we can replicate the exact handwork on the steering wheel or the visibility using the driver's camera. We can also scale the digital mannequin according to the measurements of the driver," says Picierro.

Racing against the clock

While the composite design engineers are custom fitting the driver to the seat (a process that can happen several times per season based on the

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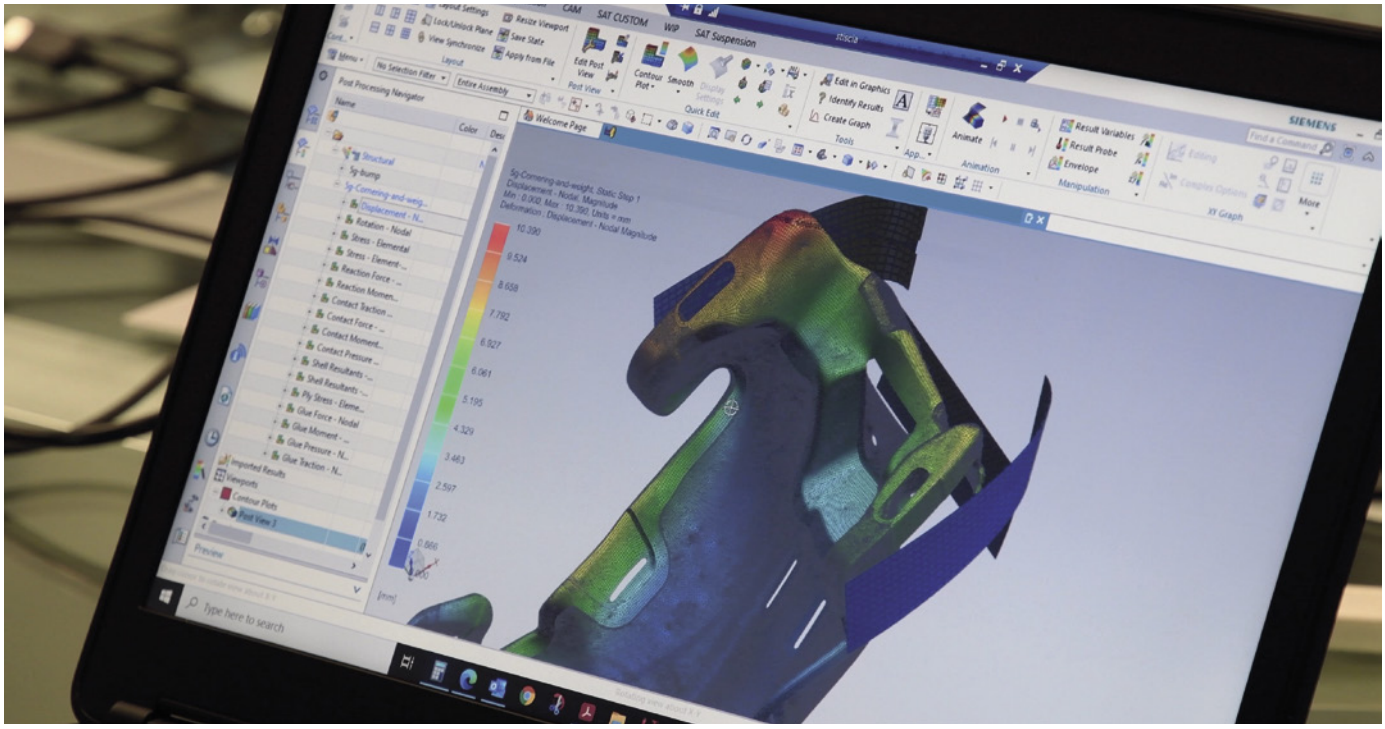
> **Raffaele Boschetti**
> Head of IT and Innovation, Scuderia AlphaTauri



needs of individual drivers) other members of the Scuderia AlphaTauri engineering team are optimizing the new car design for driver performance in time for race day.

Aside from the tight deadline, the other challenge for every F1 engineer is weight. F1 engineering teams struggled to make the minimum driver plus car weight of 795 kilograms (kg), especially with the new safety regulations and ground effect pull. At the last minute, the teams reached a compromise to increase the weight to 798 kg.

"Of course it's always difficult. It's a completely new regulation. These cars are complicated and it is difficult to design everything to meet the weight limit requirements. As we can see, nearly all of the teams are overweight. We also have to consider costs. It is expensive to reduce weight. Considering the cost cap, our teams were able to come to a compromise," says Franz Tost, team leader for Scuderia AlphaTauri.

One platform and a secret to success

As Tost explained, balancing design parameters is always a challenge for engineering teams. Using the same digital platform and software suite to examine the real behavior of the car helps the team make the right decisions for the races.

"Our job is to evaluate the strength and stiffness of the part. The driver's seat needs to be strong enough to support the acceleration loads and stiff enough to make a proper interaction between the driver, the chassis and the rest of the car," says Giuseppe Stiscia, a chassis group leader and structural engineer for Scuderia AlphaTauri. "We use Siemens Simcenter to generate the finite element model and generate the load model conditions." Simcenter clearly shows the standard stiffness values of the structure via a color strip. Each color represents a state of stress or displacement of the part.

"Structural engineers use this information to understand the real behavior of the structure. Our goal is to make the part as strong and stiff as possible, but we need to optimize the weight first. He adds, "Simcenter helps us calculate the part faster and use the same platform for everyone involved in the project."

Development time is gold

Andrea Rizzo, a research and development (R&D) digital layup group engineer, uses this same platform with his colleagues. They use Fibersim tools to finish the actual part.

"We use Fibersim to achieve a perfect connection between the FEA results and the real lamination,"

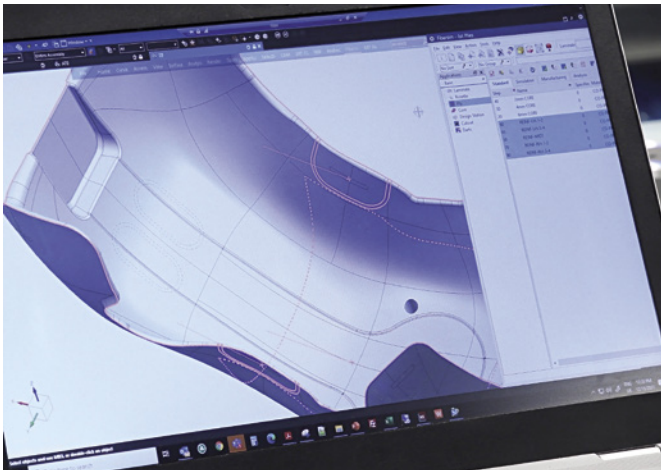
says Rizzo. “With this material, you need to cut a shape in the ply to be laminated on the mold. Any extra or unnecessary material applied to the mold is an additional cost. We try to laminate with as little material as possible to save time and money.”

The Scuderia AlphaTauri engineering team also uses Fibersim to maintain the consistency of the customized parts. Unlike commercial vehicles, F1 cars contain many handmade carbon fiber parts created by carefully layering composite plies inside the laminate. Each part has unique structural characteristics. Although the team wouldn’t say for competitive reasons, one can guess that spare parts and replacement parts are created on an as needed basis.

“Each carbon part is a laminate, so we need to make sure the first one is the same as the last one. This is why we use Fibersim. We save time during the production process with this comprehensive simulation. We can prepare plies to be the same for all laminations.

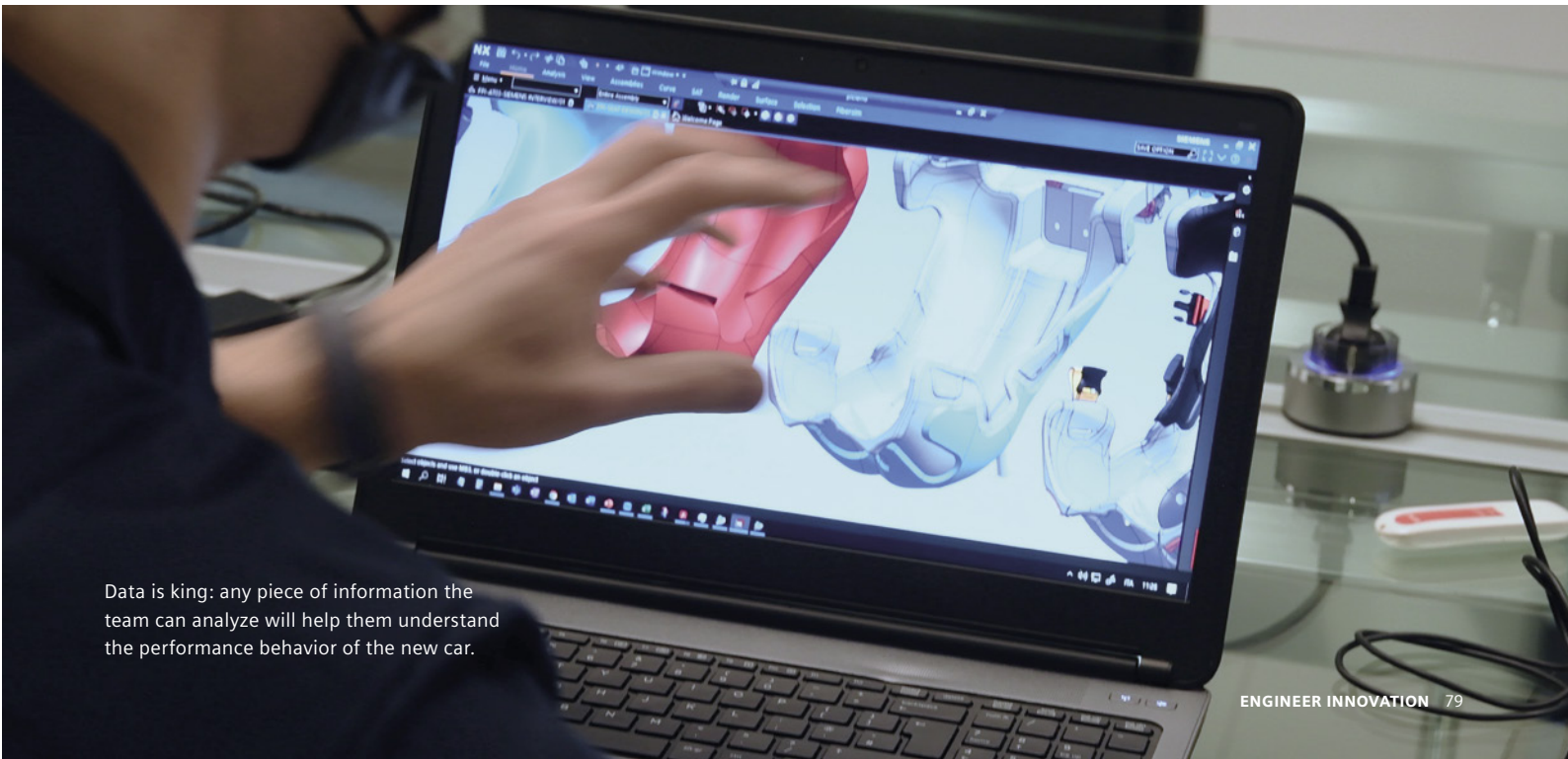
“With Fibersim, we know what is happening in the component. We know the quality standard of the plies. We follow every single ply during the process. We can prevent problems before they happen because we ‘live’ in the same platform from NX to Simcenter to Fibersim. And more importantly, we save time,” says Rizzo.

“The problem with F1 especially – but even for standard cars – is that you need to produce the

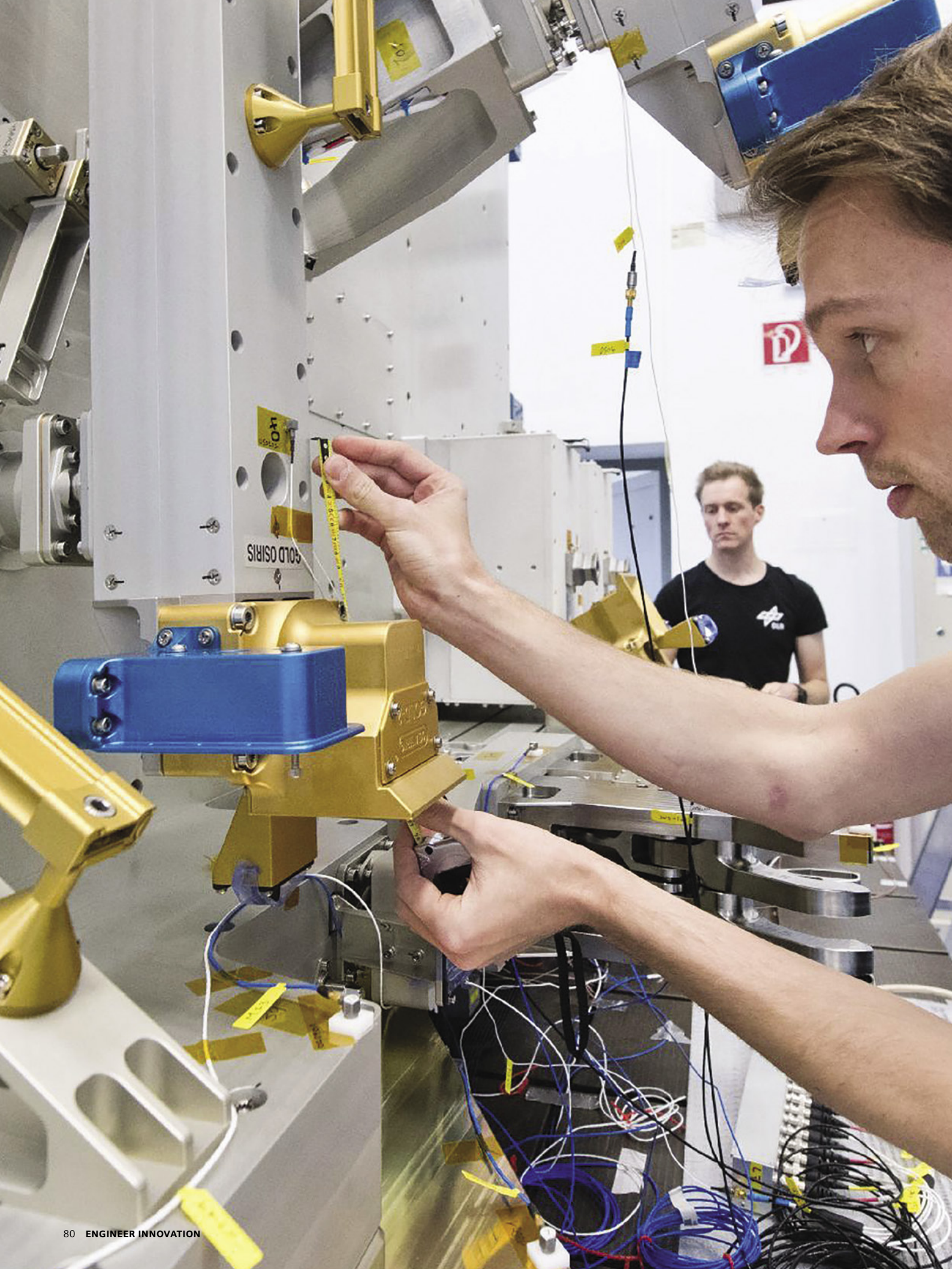


same part with the same quality at the same time. If you use the same suite that calculates everything for you from the CAD part to the production line, then you end up with a quality part that will deliver performance on the track. That’s the goal,” says Boschetti.

Thanks to Siemens Xcelerator tools like NX, Simcenter and Fibersim, the team can customize each seat to the driver using layers of composite plies to create a hyper-lightweight laminate that performs well to achieve safety and design specifications for the new Scuderia AlphaTauri cars. This provides Gasly and Tsunoda with the ideal connection to the car they need to perform well. Thanks to some superb engineering from the team in Faenza, Italy, and help from the Siemens Xcelerator portfolio, the Scuderia AlphaTauri team is more than ready for the upcoming F1 season.



Data is king: any piece of information the team can analyze will help them understand the performance behavior of the new car.


GOLD OSIRIS

GO FASTER

DLR

Blasting into space by completing a modal survey test in less than four days

DLR uses Simcenter Testlab and Simcenter SCADAS Mobile to validate finite element model together with AIRBUS Defence & Space in near real time.

Moving to the space sector

Deutsches Zentrum für Luft- und Raumfahrt (DLR) is the German space agency and runs the government's national program. By driving scientific excellence and harnessing technological expertise in its work, DLR aims to enhance the commercialization and competitiveness of Germany's space industry.

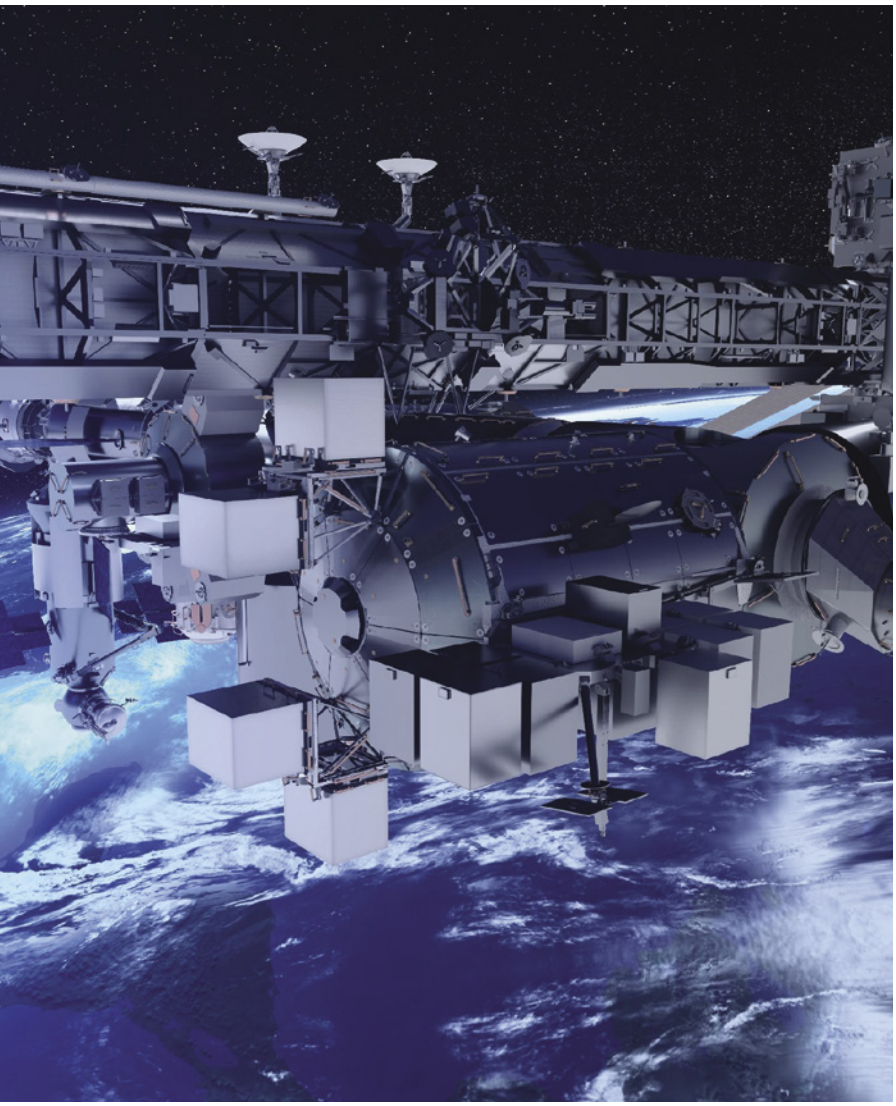
DLR's Institute of Aeroelasticity is a leading research institute that regularly performs specialist structural dynamic experiments and testing for third parties, such as aerospace entities. Based in Göttingen, Germany, the institute has traditionally focused on aviation testing, with expertise in, and facilities for ground vibration testing (GVT), multi-axis vibration excitation, unsteady signals measurement and test rigs for wind tunnels. More recently, the institute has evolved to also conduct activities such as modal survey tests (MST) for the space industry.

"We are well placed to apply our broad experience and proven testing methods we use to study aircraft and perform rapid, reliable and cost-effective testing within the space sector," explains Julian Sinske, DLR's structural dynamics testing lead.

For DLR, the ability to generate accurate test results within short timeframes is essential for the high-quality analysis and modeling the institute prides itself on delivering. To that end, DLR has used Siemens Digital Industries Software's testing solutions for several years. "We are now very familiar with Siemens testing products and enjoy significant benefits from the opportunity to integrate them with in-house techniques and algorithms," says Sinske.

Taking up space

A good example of this is the Bartolomeo project for Airbus Defense & Space, which explores the potential commercial use of the International Space Station (ISS). In the test, DLR used the 192-channel Simcenter™ SCADAS™ Mobile hardware, which is part of the Xcelerator portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software, as the critical measurement equipment for a modal survey test that was meant to update the finite element (FE) simulation model of the Bartolomeo satellite. This enabled the team to simulate and predict aspects that could only be done using simulation and analysis, such as how the platform would couple with the launcher. Therefore, reliability was key.



To do this, DLR needed to capture accurate experimental data to validate or improve the fidelity of the FE model. The Simcenter SCADAS Mobile setup featured two mainframes and was able to measure 192 signals simultaneously. Having switched from Simcenter SCADAS 3 to Simcenter SCADAS Mobile in the past year, this was DLR's first major industrial test using the powerful yet compact and flexible hardware.

"In our experience, Simcenter SCADAS has always been issue-free and reliable, so we were extremely confident in the updated system," Sinske confirms. Transitioning to Simcenter SCADAS Mobile provides extra flexibility for handling different types of tests. The data acquisition system is versatile and can be used for modal survey tests, GVT tests or others without any issues.

Flexibility and speed

According to Sinske, the open architecture of Simcenter also came into play when configuring test data with Simcenter Testlab™ software.

"Simcenter Testlab is well-suited to large-scale tests like this one, particularly with the flexibility to customize what it offers," says Sinske. For example, alongside Siemens' PolyMax algorithm running in the background, DLR was able to plug its own algorithms into Simcenter Testlab to adapt it to specific test needs. The DLR team also customized the user interface (UI) and projected the results onto the wall of the laboratory in for a good overview of the test progress. With the first measurements available in less than an hour after installation, the overall setup brought significantly quicker test results than comparable testing scenarios.

Overall, the test, which was completed in less than four days, delivered quality, reliable results at unprecedented speed. The resulting structural dynamic data set enabled Airbus to determine the appropriate modal model, identify nonlinearities and update the finite element model (FEM). In fact, AIRBUS Defence & Space was able to begin updating the model while the measurements were still running. "Airbus had very high expectations, which thanks to having the right tools available to us, we were able to meet," Sinske points out. "We could actually analyze around 80 percent of the data for the final test report immediately.

"The entire test went according to plan. We needed to work as fast as possible to swiftly deliver the data that was required. Simcenter SCADAS Mobile and Simcenter Testlab helped us achieve this."

On course for future success

By applying tested methodologies and trusted tools to its testing capabilities, DLR's Institute of Aeroelasticity has created a replicable testing approach that allows it to segue easily from aviation to space. "We use the same hardware and software for both GVT and MST and we have a plan in place," says Sinske. "Projects like this give us added confidence in how we work and the tools we're using."

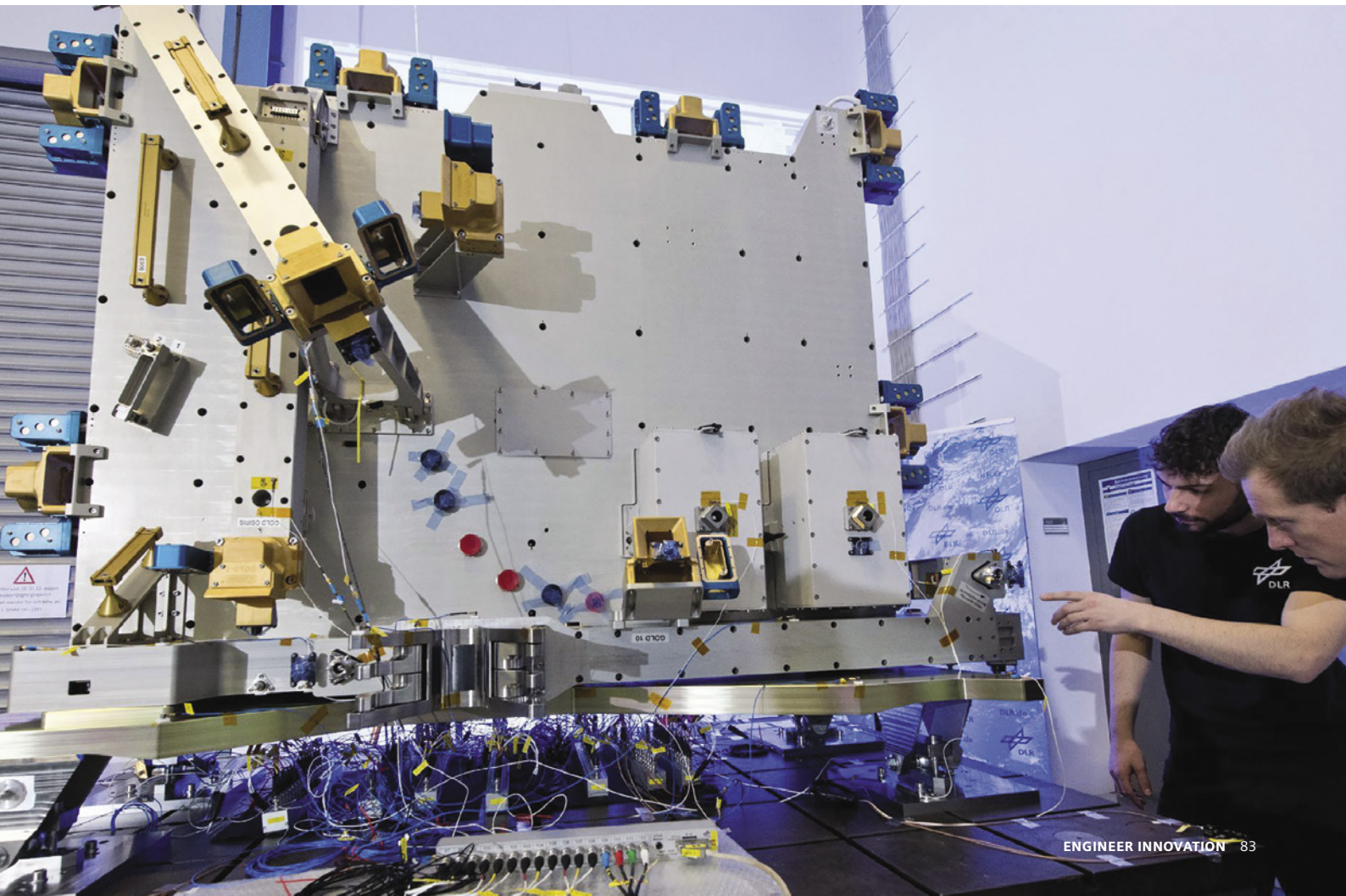
Now the team is building on this momentum to introduce new test methods and technologies for the future, including those incorporating artificial intelligence (AI) and automation.

By leveraging the agility of Simcenter SCADAS Mobile and the flexibility of Simcenter Testlab, DLR has successfully created a blueprint for fast, effective and reliable testing in the aerospace field – for structures on either side of the Kármán line, the boundary between Earth's atmosphere and outer space.

"I hope there will be many more projects like this," says Sinske. "We had a solid process, good planning and strong testing tools at our fingertips, which meant fewer mistakes and quick results."

> "We are now very familiar with Siemens testing products and enjoy significant benefits from the opportunity to integrate them with in-house techniques and algorithms."

Julian Sinske
Structural Dynamics Testing Lead, DLR



GA-ASI reduces detailed structural design time by 25 percent by using Siemens' CAD tool suite.

Pioneering the path for remotely piloted aircraft

Pioneers of remotely piloted aircraft, General Atomics Aeronautical Systems, Inc. (GA-ASI) was established 30 years ago and is headquartered in San Diego, California. The company is known for its Predator series of aircraft and specializes in research and technology development for unmanned systems. GA-ASI unmanned aircraft and sensor systems are designed and engineered for long-endurance.

Dee Wilson, vice president of engineering at GA-ASI describes the company as "a vertically integrated aerospace company." GA-ASI designs and manufactures 90 percent of the components that go into an aircraft, from structures, avionics, power plants, to all mechanical systems. Their engineering team is responsible for running the gamut of disciplines to develop the aircraft and related systems such as ground control stations, payloads and support equipment. Along with building unmanned aircraft, the company also manufactures and tests them at their factory and flight test facilities.

GA-ASI needed to increase collaboration among their engineering teams, move faster, perform

GO FASTER

General Atomics Aeronautical Systems, Inc.

Accelerating aircraft design using tool integration and automation

more detailed analyses earlier in the design phase and reduce the late discovery of design issues. They began the search for computer-aided design (CAD) and computer-aided engineering (CAE) tools they could integrate in a more seamless way, working from a single source of engineering truth data. This led them to select the CAD package from Siemens Digital Industries Software. The solution enabled them to create an aircraft design framework where CAD and CAE tools were automated and connected by a digital thread.

Making the jump to Siemens' tool suite

GA-ASI's engineering team was looking to accelerate their design process using advanced model-based design capabilities that could digitally and directly flow into the manufacturing process. This would eliminate time consuming manual steps, especially related to composite airframe structures.

The engineering team was relying on manual model creation and disjointed CAD and analysis models, while executing repetitive tasks. GA-ASI's processes were also based on individual discipline evaluations and they were not taking advantage of a digitally integrated, multidisciplinary environment. If their engineers could spend less time building and managing the mechanics of the models (for example pre- and post-processing, meshing and other discipline-unique preparation activities), they would be able to focus on

interpreting data, iterating creative solutions, solving design problems and performing design analysis.

After looking at several tools, GA-ASI selected Siemens' CAD tool suite, which includes NX™ software and Simcenter™ 3D software and the Fibersim™ portfolio. By using these solutions, they were able to reduce the number of hours it took them to perform detailed structural design and create the technical data package required for manufacturing by 25 percent. From that point, they decided that all new start programs would start with NX as the baseline CAD program.

Freeing up engineers' time

Upon implementing these solutions, Siemens provided the company with training tutorials, Q&A sessions, onsite technical experts and a dedicated support engineer to answer any questions. "Overall, transitioning to Siemens' software was a nice user experience," states Phu Nguyen, engineer in the airframe design group at GA-ASI. NX and Simcenter are part of the Xcelerator portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software.

Initially GA-ASI had several talks with their subject matter experts (SMEs) to pinpoint where they could reduce design time and bottlenecks. It was important to understand how the SMEs were consuming the CAD data to identify which processes could be automated.

GA-ASI ran some pilot programs where they used the advanced tools and computing power to enable their engineers to spend most of their day making analysis decisions as opposed to setting up models and analysis tools. For example, they ran an effort using NX CAD Software, NX Open, Simcenter, as well as Teamcenter® software to perform a tail configuration trade study and preliminary design. The team could feed all the other models with a maximum amount of reuse and total linkage between them. "Siemens' tools did all the work for us in creating the models and only required minor tweaking from the SME in those design disciplines," states Nguyen. "This proved the engineers could start doing design and analysis in a matter of minutes."

The engineering team found that the high surface quality was one of the most important features in Siemens' tool suite because it affects all other disciplines downstream. This includes computational fluid dynamics (CFD) and meshing, which require clean surfaces. The high surface quality prevents the end users from having to spend time fixing the geometry. With these solutions, GA-ASI could perform higher fidelity physics-based analysis earlier in the design cycle, minimizing the labor involved in model building, model updating and post-processing.

Performing deeper exploration of designs

By using Siemens' CAD software to perform the tail configuration trade study, GA-ASI reduced labor hours by 90 percent. "We did several

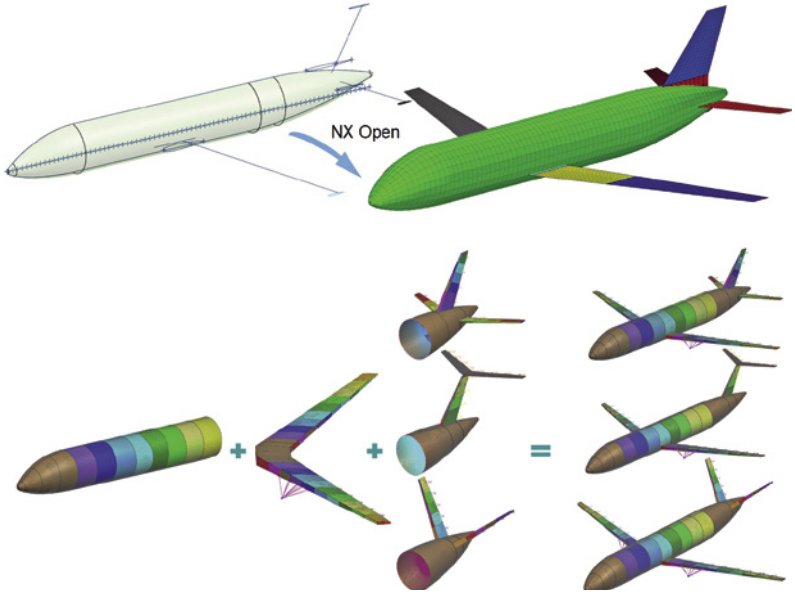
iterations of that to get a preliminary tail design," claims Wilson. "We were on the order of 1000 plus hours and brought that down to about 100 hours by using this new construct."

GA-ASI found that the entire process of going from CAD to a stress analysis model was easy. "We no longer have to export the STEP file and export the mass and stiffness matrices. It is all in this integrated environment," claims Nguyen.

"With Simcenter 3D, we could write several NX Open codes to enable us to rapidly build the model, especially with hundreds or thousands of fasteners that we have to idealize," continues Nguyen. "Making this an automatic process in Simcenter 3D really helped us." The central design data and geometry source enabled the team to achieve efficient data sharing, better collaboration and model-based definition.

The open environment enables the team to perform deeper exploration of their designs, produce new capabilities and reduce late discoveries of defects due to unmodeled physics. "The open, flexible environment was the reason the engineering team was successful; this is what our solution made possible," states Nguyen. "When we ran trials and training, I received feedback that the software was very intuitive and easy to learn," continues Wilson.

Additionally, the team appreciated the support they received from Siemens experts. "The



customer support and responsiveness we get from Siemens is like no other vendor I have worked with before." Wilson continues, "we really appreciate everything Siemens has done to help us get to this point and evaluate their tools. The system is also extremely responsive when we find issues that we need customized or fixed to work for our setup. The engagements Siemens has with the aerospace and defense industry are top notch," states Wilson. "They really work with the industry as a partner on developing these tools. It enabled us to make this leap."

Achieving higher levels of design maturity earlier on

The next effort GA-ASI is embarking on is converting their previous processes to an integrated design environment. Teamcenter will be a significant a part of this solution. "We are at the beginning of this and right now we have various independently manually created models starting with CAD, then all the other disciplines work from that but manually create their own model," states Wilson. "We find engineers spend the majority of their day doing manual conversion pre- and post-processing of those models' setup and we want to use the advanced tools in the Siemens' suite."

GA-ASI's goal is to use this integrated design environment with these key pieces and continue to add to it, to achieve a higher level of design maturity earlier in the program phase and then enable the engineers to iterate more, perform design analysis and solve design problems. They intend to use Teamcenter to help them manage that data.

STAY INTEGRATED

Heraeus Noblelight

Accelerating turnaround of CFD simulations

Figure 2. The positioning and setup of IR emitters is key to manufacturing high quality products in the automotive industry.

Heraeus Noblelight reduces simulation run time by using Siemens' on-demand cloud services.

Heraeus Noblelight GmbH has been developing specialty light sources since the invention of the quartz glass lamp in 1904. Light, whether ultraviolet (UV), infrared (IR) or middle wave range, is at the heart of everything they do. Located in Germany, the company has harnessed the power of light to solve a wide range of challenges in the manufacturing and process industries. They also design and manufacture consumer products like the Soluva® air purifier, for removing airborne viruses including the Coronavirus disease of 2019 (COVID-19) from healthcare settings, public transport and classrooms.

Engineering simulation is not only used during the product development phase, but also to understand the best way to deploy products in the field. "We use CFD simulation to help our customers understand their processes and where to locate our UV or IR emitters to make them most effective," explains Dörte Eggers, simulation engineer at Heraeus Noblelight. Eggers continues, "sometimes a customer already has a process in operation that is not working optimally, so we also use simulation to troubleshoot and find ways to improve it."

Modeling the complexity with CFD

Heraeus Noblelight products cater to a wide range of industrial processes, from curing paints and adhesives using precision IR emitters, to water and air disinfection equipment using ultraviolet C (UV-C). A range of modeling techniques are

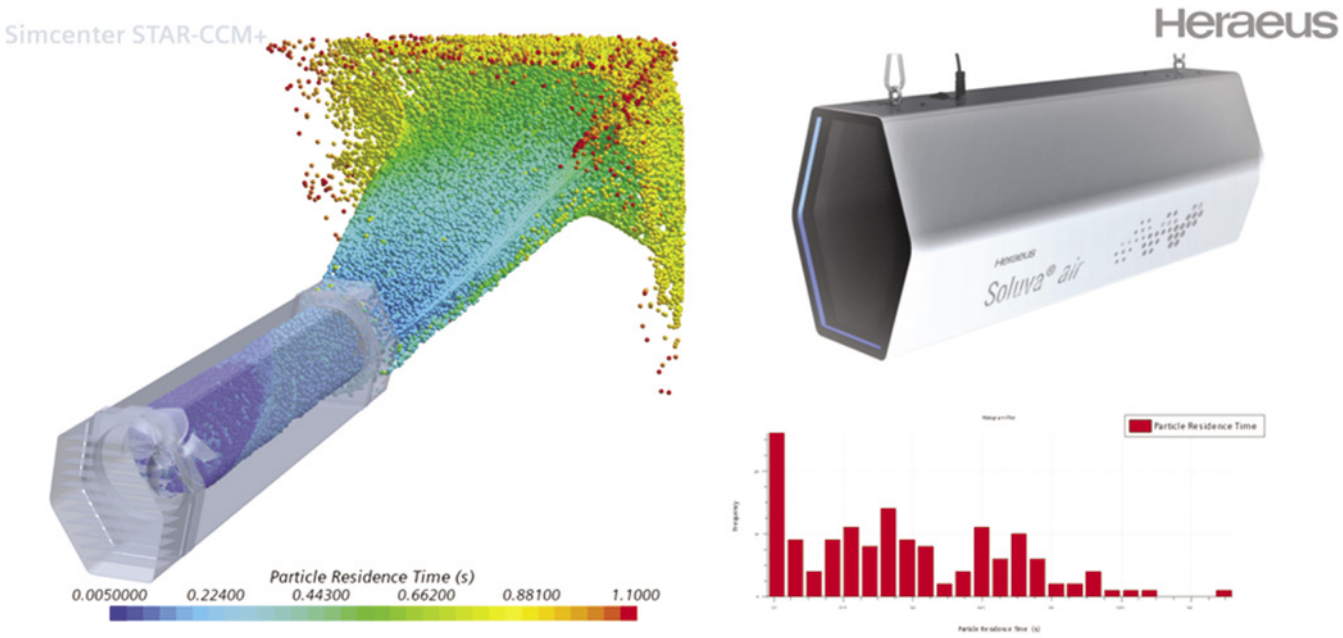


Figure 1. Particle tracking analysis calculating residence time of air in the Soluva air purifier – a device for removing airborne viruses from public spaces.

required to capture the prevalent physics regimes in each case.

"We selected Simcenter STAR-CCM+ for CFD analysis because it delivers a wide range of physics modeling options in a flexible and easy-to-use package," says Dr. Larisa von Riewel, computer-aided engineering (CAE) group leader. "Our core workload is thermal management simulation. However, we often need to include additional physics like multiphase flow and particle tracking."

Seeing the invisible

Since many of their products operate outside of the visible light spectrum, computational fluid dynamics (CFD) simulation is a valuable tool for verifying specific applications, tailored to each customer's process. Therefore, CFD has become a routine part of the sales process and requires a rapid turnaround of simulation work. This provides confidence that the construction team will deliver a high performing product and add significant value for customers.

As well as making invisible light visible, using CFD analysis makes the unmeasurable measurable. "In some cases, running physical trials is very expensive and sometimes impossible," states von Riewel. "Taking our IR emitters as an example, simulation is essential as it enables us to estimate parameters we cannot physically measure. Understanding this behavior is critical for achieving the functionality and lifespan we need from the devices."

Communicating the insights gained from simulation to a range of stakeholders is also an important part of the process. "Every new release of the software has additional post-processing features and we find these very useful to present simulation data to customers in the context of their equipment and processes," says von Riewel.

Going faster with Simcenter Cloud HPC

Today, most CFD simulation at Heraeus Noblelight is done in-house using a large on-premise workstation. However, during busy periods, the team needs to tap into additional resources by outsourcing simulation work. The need to scale up and down quickly makes it difficult to manage licensing costs to cover short periods of use and to ensure that resources are used efficiently.

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>
> **Dr. Larisa von Riewel**
> Computer-Aided Engineering Group Leader, Heraeus Noblelight

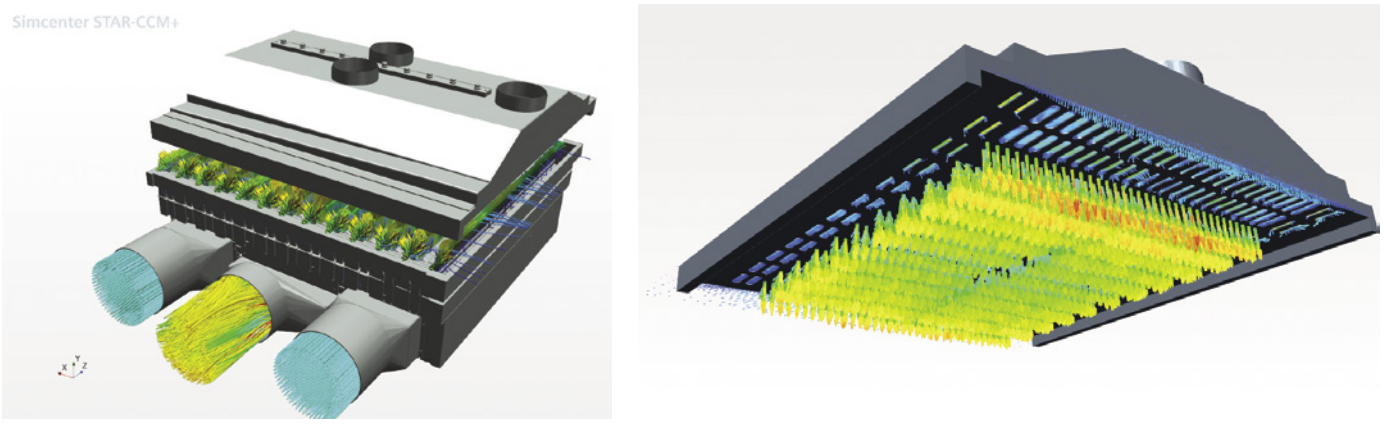


Figure 3. Heraeus Noblelight Infradry Combi used for drying inks on paper. CFD is used to make sure the IR emitter is kept cool and to enable homogenous heating and drying.

Over the past few months, Heraeus Noblelight has been an early-access user of Simcenter ™ Cloud HPC software, a new hybrid software as a service (SaaS) product, which enables simulation runs to be launched on cloud infrastructure directly from Simcenter STAR-CCM+ ™ software. These are part of the Xcelerator portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software. By purchasing hardware and software in the same transaction and paying only for what is used, Heraeus Noblelight sees potential to gain more efficiency by being able to instantly access high performance computing (HPC) resources from anywhere, at any time.

Accessible

"When we are working with remote simulation teams, we often find we do not have HPC resources where we need them to be," continues von Riewel. "Therefore, Simcenter Cloud HPC would enable us to speed up collaborative projects. We also would not need to worry about license costs going to waste if a project finishes sooner than expected." Using the cloud means the HPC resources are readily accessible by all team members. "I would say the interface is user friendly and intuitive, with several options for monitoring the runs," continues von Riewel. "Transferring the simulation files was fast and straightforward."

For von Riewel and Eggers, simulation is a small part of their working day. Therefore, they are not able to devote as much time as they would like to researching and testing new models and features. Therefore, they rely on the expertise of the Simcenter customer support team and their dedicated support engineer (DSE). "We are always under time pressure. When we face new challenges, we prefer to go to our DSE who explains relevant new features and how they will benefit us. This is a great time saver," von Riewel explains.

Flexible and scalable

As well as facilitating collaboration with remote teams, Eggers also sees potential to leverage cloud resources to run more ambitious simulations or broaden the scope of projects while still meeting tight deadlines. "In some cases, we need to run bigger models to capture more detail or run more

> "In some cases, we need to run bigger models to capture more detail or run more simulations in the same amount of time. Simcenter Cloud HPC gives us that flexibility."
>
> **Dr. Larisa von Riewel**
> Computer-Aided Engineering Group Leader, Heraeus Noblelight

simulations in the same amount of time. Simcenter Cloud HPC gives us that flexibility."

Secure

Heraeus Noblelight frequently works on projects involving customer proprietary processes and technologies, so data privacy and security are critical for their business. "When we sign agreements with customers, there are usually terms restricting how and where we store and work on their data," explains von Riewel. "Of course, all stakeholders need to be sure their data is safe. I expect attitudes will gradually change as the world adapts to this new way of working."

Simcenter Cloud HPC is built on Amazon Web Services (AWS) cloud infrastructure and follows best practices developed by AWS and Siemens for developing and operating multi-tenanted SaaS applications. Users have complete control over data sovereignty and retention and the product will also go through the International Organization for Standardization (ISO) 27001 and System and Organization Controls 2 (SOC2) Type 1 certification.

"I am confident that Siemens is diligent in maintaining the necessary policies and certifications to satisfy us and, importantly, our customers," von Riewel concludes.

Looking to the future

When asked about how running CFD simulations in the cloud might impact their work in the future, Heraeus Noblelight sees flexibility and accessibility as key benefits. "Since the pandemic, there has been a large shift toward remote work, which means there are not always people available to access workstations in the office when something goes wrong," says von Riewel. "Being able to work on projects from anywhere in the world is a dream and I feel this is the way humanity should go."

Von Riewel also sees the ability to scale up and down instantly as a future competitive advantage. "The world continues to develop and everything is increasing in complexity. Models are becoming more accurate and we need to capture more physical realism. You can guarantee we will frequently require more powerful HPC resources in the future. Simcenter Cloud HPC offers that agility, which translates to a more competitive offering for our customers."


The Hyundai sound
adds another dimension
to the brand's personality.

STAY INTEGRATED

Hyundai

Using an enhanced sound concept as a brand differentiator for electric vehicles

Hyundai uses Simcenter active sound design solution to align the acoustic experience with its brand strategy and style.

Creating a new customer experience

In developing its electric vehicle (EV) brands – Hyundai, Kia and Genesis – the Hyundai Motor Group (Hyundai) recognized the critical role acoustics play in shaping the driving experience. What's more, the company saw new possibilities for using sound to enhance the customer experience and distinguish the brand.

To pursue this opportunity, Hyundai developed a new approach to the use of active sound design (ASD), aiming to create an acoustic signature that while allowing for personalization by the customer, binds together the emotional and technical aspects of each vehicle brand.

"One of our primary goals using ASD was to create a new customer experience," says Dr. Dong Chul Park, research fellow and head of the sound design research lab at Hyundai. "To take a holistic approach and create an acoustic identity for our vehicles – sound that manifests and expresses the unique character of each brand."

In addition, the Hyundai sound design development team takes into account a further variation – the differences in acoustic perception and expectation across the globe. Each region and culture, and even each generation, has different preferences and anticipation of how a vehicle should sound.

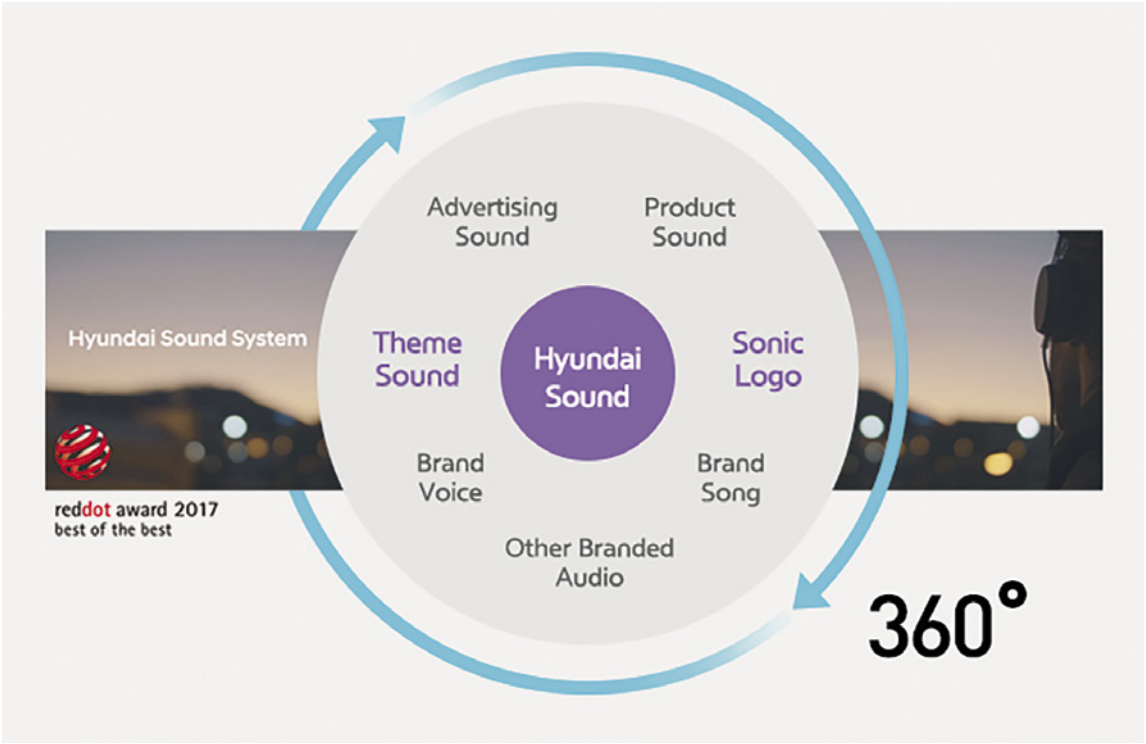
Although ASD can be used to mask unwanted sounds/noises that are audible in the interior of the vehicle, it is not effective for masking subpar NVH performance. Consequently, Hyundai NVH engineers use Simcenter™ software solutions to address these concerns and design a car with the optimal NVH performance. Simcenter is part of the Xcelerator™ portfolio, the comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software.

New possibilities with active sound design

The use of ASD in the automotive industry is not new. Many manufacturers, including Hyundai, have used acoustic enhancement and noise control technologies to modify the sound from the smaller, quieter, engine systems developed to reduce environmental impact.

In the case of internal combustion engine (ICE) vehicles, active sound design, which is delivered through the car's sound system and adapted to current driving conditions, is used to manage and enhance the existing engine sound to make it more appealing to the customer. However, in EVs, which emit little powertrain sound in comparison to ICE vehicles, there is the freedom to create almost anything.

Active sound design in EV opens the door to new, almost unlimited opportunities to develop



outstanding acoustic experiences and adds a new branding dimension – sound. It is an opportunity to create something entirely new.

A holistic approach to create acoustic identity

In order to create a sound that people will relate to Hyundai brands, the active sound design development team works closely with the brand marketing teams.

The teams take a holistic approach to sound design, working to ensure that all the various acoustics in a vehicle are attuned and work together – even down to the welcome/goodbye message on entering or leaving the vehicle.

Park explains, "Our strategy and primary mission is to design sound that reflects and completes the brand identity of each of our vehicles; that appeals to the emotions and aspirations of our customers and becomes, in short, a kind of 'sonic logo,' an expression of the brand in sound."

Enabling acoustic personalization

Nevertheless, the Hyundai team recognized that while the vehicle sound should have a distinctive character, in the digital age it should be able to be personalized for the customer.

It would not do to offer their vehicles with the acoustic equivalent of "any color so long as it's black."

To resolve this issue, the Hyundai engineers created a clearly identifiable sound design strategy for each brand. But within the design, the customer can make adjustments; for example, alter the low, medium and high frequency acoustics or the response of acceleration pedal to meet their preferences.

This can range, for example, from combustion engine-inspired sound to a more futuristic sound. "We provide three sound concepts with each brand identity," explains Park, "so we can give customers the ability to choose the style of sound they want, but without losing the character of the brand."

Developing a car with superb NVH performance as a base

However, developing the acoustic identity for the brand is only part of the journey. Even though the motor of an EV is quiet compared to an ICE vehicle, there are many other sounds to contend with when the vehicle is in motion – commonly summarized as noise, vibration and harshness (NVH).

"The sound design research lab and the NVH engineers interested in composing sound find it easy to use Simcenter and combine the sound with brand philosophy and vehicle behavior."

Dr. Dong Chul Park
Research Fellow and Head of the Sound Design Research Lab, Hyundai Motor Group

NVH encompasses aerodynamic sound, such as wind; mechanical sounds, road noise, noise from the brakes and electrical sounds, such as electrical actuators or the traction motor in electric vehicles.

Without the masking effect of the dominant combustion engine sound in electric vehicles, other noise sources require even more engineering effort than before for NVH engineers.

A crucial starting point is engineering a car without ASD with good NVH performance: although ASD can be used to mask unwanted sounds/noises that are audible in the cabin, it would not be effective using it to mask weak NVH performance.

For this reason, Hyundai NVH engineers use Simcenter software solutions on a daily basis to address these issues and design a car with the best possible NVH performance.

In this case, the role of the ASD can still be to mask some of the remaining existing sources of noise, but also to create a sound concept that works brilliantly in real driving conditions.

Harmonizing the sound concept in real-life conditions

Something that sounds great in the studio does not necessarily sound great in the vehicle. In the end, the sound needs to work on the physical vehicle with its existing NVH and driving performance.

You cannot work individually on each factor to develop the acoustic experience. It's a case of bringing everything together – the existing vehicle NVH, driving performance and the ASD sounds – and ensuring they all work well together. Close collaboration between the NVH, powertrain calibration and ASD development teams is required to achieve this goal.

With EVs, the ability to link these three capabilities is no longer a nice-to-have. It's a must-have. Active sound design is not a standalone field: It is closely linked to driving performance, which in turn has a huge impact on the performance of the vehicle.

"Unlike many suppliers who focus on implementing sound logic in the controller, the

Siemens team is knowledgeable about EVs and understands how to enhance sound in that context," comments Park."

Linking ASD with NVH simulation and driving performance simulation

The Simcenter active sound design solution not only allows the designer to create the desired sounds from scratch in the studio, but also to test and tune those sounds on the vehicle prototype or simulator. With this, the designed ASD models can be further tuned and optimized in real-life conditions. As a final step, the created sound models are deployed on the selected tier-1 audio controller.

Siemens' Simcenter Testlab™ Sound Designer software provides the capability to work on every one of the three stages, leading to higher efficiency. "The sound design research lab and the NVH engineers interested in composing sound find it easy to use Simcenter and combine the sound with brand philosophy and vehicle behavior," reports Park.

Simcenter solutions can also be used to make a critical contribution by linking ASD with NVH simulation and driving performance simulation. These are key reasons why the Hyundai sound designers continue to work with Simcenter, building on a relationship of more than 10 years.

Combining art and engineering

Many sound design solutions exist to compose sounds for the music industry. However, designing ASD for cars requires the marriage of sound composition with vehicle engineering.

At Hyundai the lab uses Simcenter Testlab Sound Designer for data-driven composing to craft the sound design. The input comes from the vehicle – vehicle speed, motor speed, powertrain load or throttle – and from that component the sound engineer generates a new sound.

For EVs, the team has adopted a new data-driven approach, called the granular synthesis method, which they apply using Simcenter Testlab Sound Designer. This starts with a recorded or composed sound sample matching the required driving emotion for a specific vehicle. Short sections of the sample, called grains, are synthesized one at a time and varied in position, pitch and duration as a function of the vehicle's dynamic driving parameters. This methodology maximizes the creativity of the designed sounds while taking into account its use in the vehicle.

Developing in-house skills

Given the new, extended possibilities of acoustic design in electric vehicles, and its potential for enhancing brand identity, Hyundai regards it as essential to maintain and develop sound engineering skills in-house.

Therefore, the company has taken the strategic decision to keep active sound design skills in-house and focus on skills development – and not to spend valuable resources building its own tools. For this, Hyundai has chosen a strong partnership with Siemens.

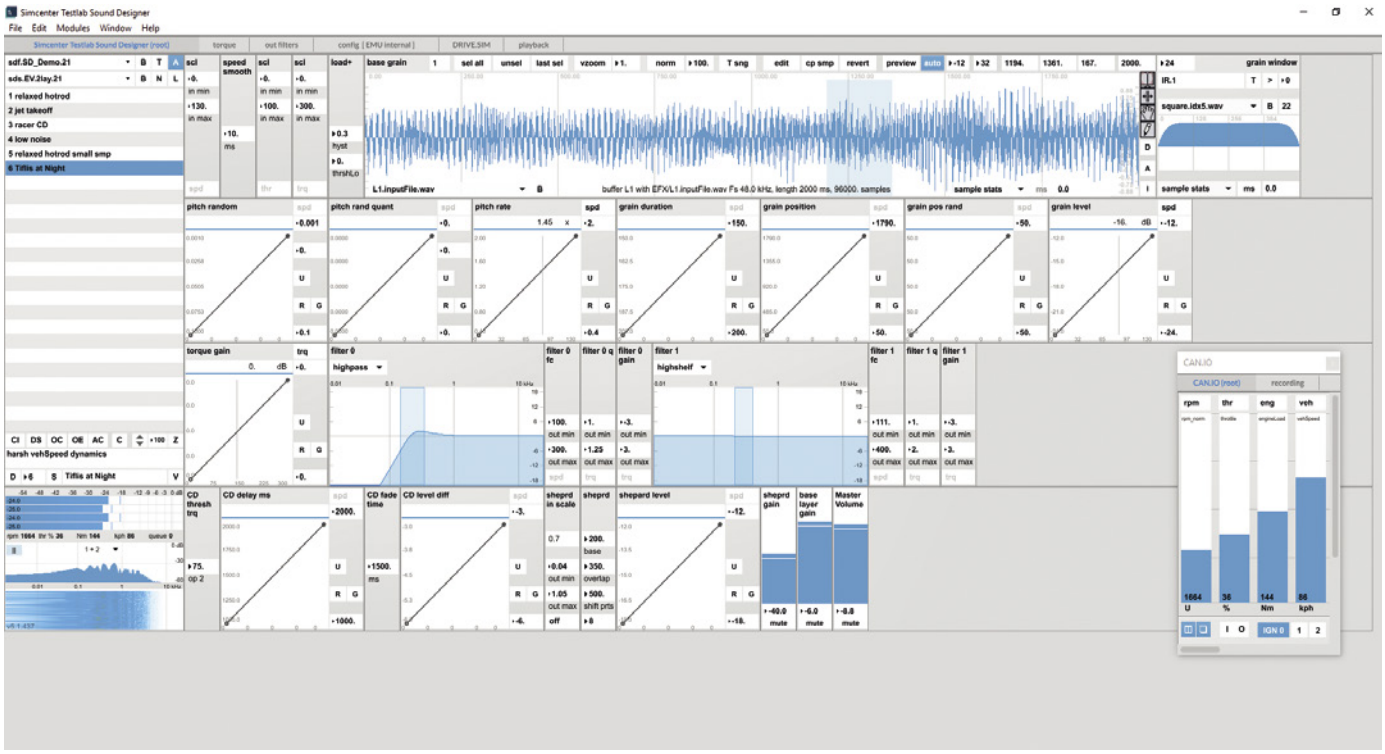
Front-loading sound design without vehicle prototypes

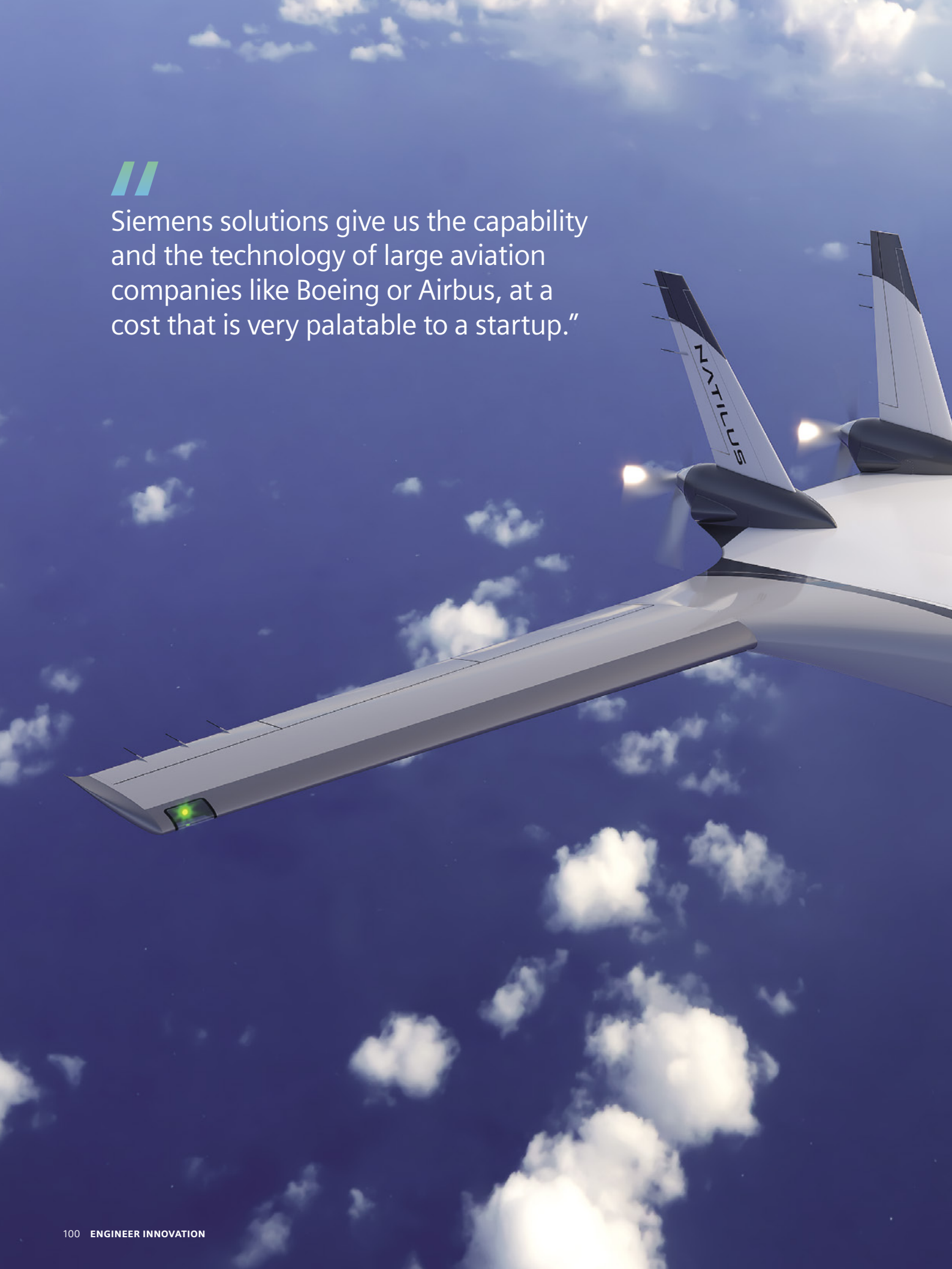
The Hyundai development team is now using Simcenter Testlab Sound Designer to design, validate and tune the acoustic concept of a vehicle before the prototype is built, thereby accelerating development of new vehicles.

First, the EV models are tuned on NVH simulators. The lab can also create or simulate driving profiles with a 1D simulation program that captures all the driveline complexity and even the controls of the vehicle. These drive profiles can then be applied to the active sound design models to link the created sound with how the vehicle drives.

Increasingly, Hyundai is looking toward tightly integrating these building blocks, which is exactly where Siemens can help. The aim is to reach the position where the design models, in conjunction with the simulator, enable creation of a comprehensive digital twin that can precisely simulate the driving experience in all its aspects.

Finally, the lab is looking to the future and getting ready for autonomous vehicles. Here sound will have the additional, critical function of relaying safety and relaxation messages to the driver/passenger.





"Siemens solutions give us the capability and the technology of large aviation companies like Boeing or Airbus, at a cost that is very palatable to a startup."

EXPLORE THE POSSIBILITIES

Natilus

Reducing the cost of airfreight with innovative designs

Siemens solutions help startup company develop airplanes that can reduce the cost of airfreight by 50 to 60 percent.

Reducing the cost of air freight

Natilus is a California-based startup working on creating remotely controlled drone aircraft. The company's goal is to reduce the cost of airfreight by more than 50 percent through thoughtful design and a smarter use of space. The small and growing team of extremely passionate engineers is working on re-thinking the next generation of freight aircraft. The team includes builders and designers who have worked on more than 25 aircraft programs in general, commercial and military aviation.

"We believe that reducing the cost of airfreight by 50 percent or more will bring fresher produce into our stores, enable cross-border e-commerce to flourish and enable low infrastructure regions to develop," says Aleksey Matyushev, CEO and founder of Natilus. "To make that happen, we need a new type of vehicle and a different way of thinking."

"The problem we're trying to solve is that air freight is too expensive, but timely, and ocean freight is a commodity, but it's very untimely," Matyushev explains. "To give you a perspective, to bring goods via ocean from Asia to the United States can take up to a month, but it's very inexpensive. Air freight costs ten times as much but can be done in two to three days. Our solution is to bridge the gap and capture the timeliness of airfreight, but at a reduction in cost of 50 to 60 percent to get closer to the commodity pricing of ocean freight. When the industry goes green, whether through hydrogen fuels or electrification, specifically for the weight classes of our planes, air freight will be a commodity. Ocean freight could almost disappear – an interesting future that we think about every day."

Finding traction in the air cargo industry

Natilus already has more than $6 billion in initial orders from major airlines and customers all over the world, with an order book of more than 400 airplanes. "From a business perspective, our solution has really found traction," says Matyushev. "Cargo airlines have small operating margins, three to four percent, and can turn a profit in a good year. If they replace their fleets of

Boeing and Airbus planes with our solutions, that margin could go to 33 percent, which is an astronomical change for bottom-line performance."

Natilus solutions also address another industry challenge – the worldwide shortage of well-trained pilots. Passenger traffic is predicted to double by 2035, and pilots in the freight world are expected to help fill that gap. With remote piloting capabilities, Natilus solutions will enable a single pilot to command three aircraft at once. "One of our requirements is that there will be no pilots in the cockpit," says Matyushev. "We're helping to fill that void."

Natilus is currently developing three products, all with carbon-fiber composite airframes. The first is a 19,000-pound aircraft with a 90-foot wingspan, slated to begin production late in 2021. The second is a 60-ton aircraft, similar in size to a Boeing 767, targeted for domestic service in the U.S. but also capable of serving Europe and Asia. The flagship product is a 700-ton competitor to the Boeing 777 with 10 percent larger wingspan, capable of trans-Pacific flight.

Natilus' blended-wing body configuration is a first for cargo aircraft. "From a freight perspective, it makes a lot sense," Matyushev explains. "It has 50 percent more volume internally, so it doubles the amount of revenue cargo per flight. With conventional designs you start to run out volume before you maximize the takeoff weight of the airplane."

Advanced engineering tools for a bold vision

To develop its products, Natilus uses NX™ software for computer-aided design, part of the Xcelerator™ portfolio of integrated solutions and services from Siemens Digital Industries Software.

Natilus had worked earlier with a popular mainstream CAD package that was attractively priced (always a consideration for startups) but lacked powerful surfacing, large assembly design and other capabilities needed for large aircraft development. That software proved incapable of evolving designs to the degree needed for suppliers to manufacture the production prototype. "We started to get into more complex surfacing, specifically with our blended-wing body design with a lot of curvatures and intricacies in the surfaces, and we could not get through the problems using the other software," Matyushev explains.

Siemens NX (and its predecessor, Unigraphics) has a long history as a workhorse in the aerospace industry that factored into Natilus' selection of a higher-performance CAD solution. "Two of our three co-founders were really influenced by NX when we were in industry," Matyushev relates. "We looked at other solutions, but NX is an incredible tool for us."

Another factor in the decision for Siemens solutions is a Siemens program for qualified startup companies that offers discounted pricing. The program recognizes the unique challenges of startups and helps entrepreneurs grow their business to full potential using cost-effective and high value-added software.

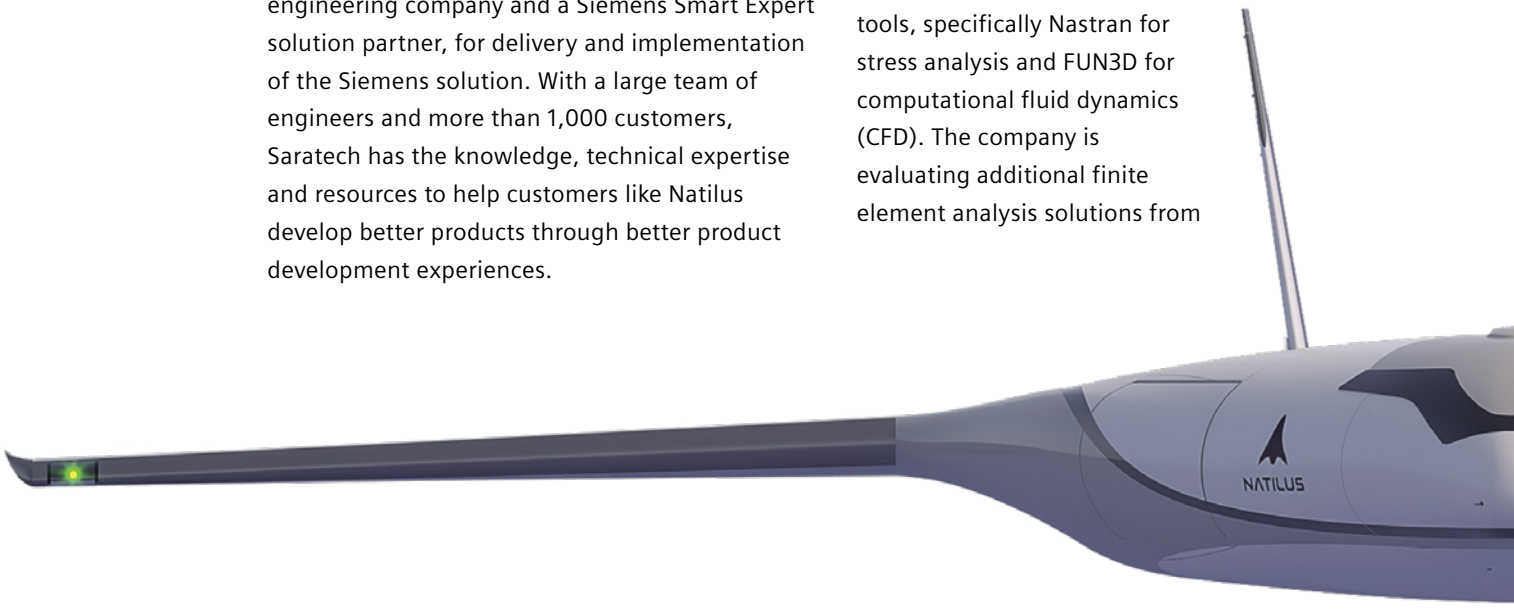
Assistance from an expert partner

Natilus is working with Saratech Inc., an engineering company and a Siemens Smart Expert solution partner, for delivery and implementation of the Siemens solution. With a large team of engineers and more than 1,000 customers, Saratech has the knowledge, technical expertise and resources to help customers like Natilus develop better products through better product development experiences.

Collaboration and data management

Natilus is also working to implement Teamcenter™ software to provide collaboration and data management tools for its rapidly growing development team. For the next phase of development, Natilus also plans to use the Fibersim™ portfolio of software for composites engineering. "The airplane is in the detailed design stage – the bones of the airplane have been laid in but there is currently no core in terms of carbon fiber," says Matyushev. "Fibersim will be part of our daily workflow as we set up the plane for manufacturing, moving from a solid model to foam cores with ply schedules. The airframe structure is one of the longest lead time items and our big push over the next six months."

The Natilus team is currently using NASA-developed digital simulation tools, specifically Nastran for stress analysis and FUN3D for computational fluid dynamics (CFD). The company is evaluating additional finite element analysis solutions from



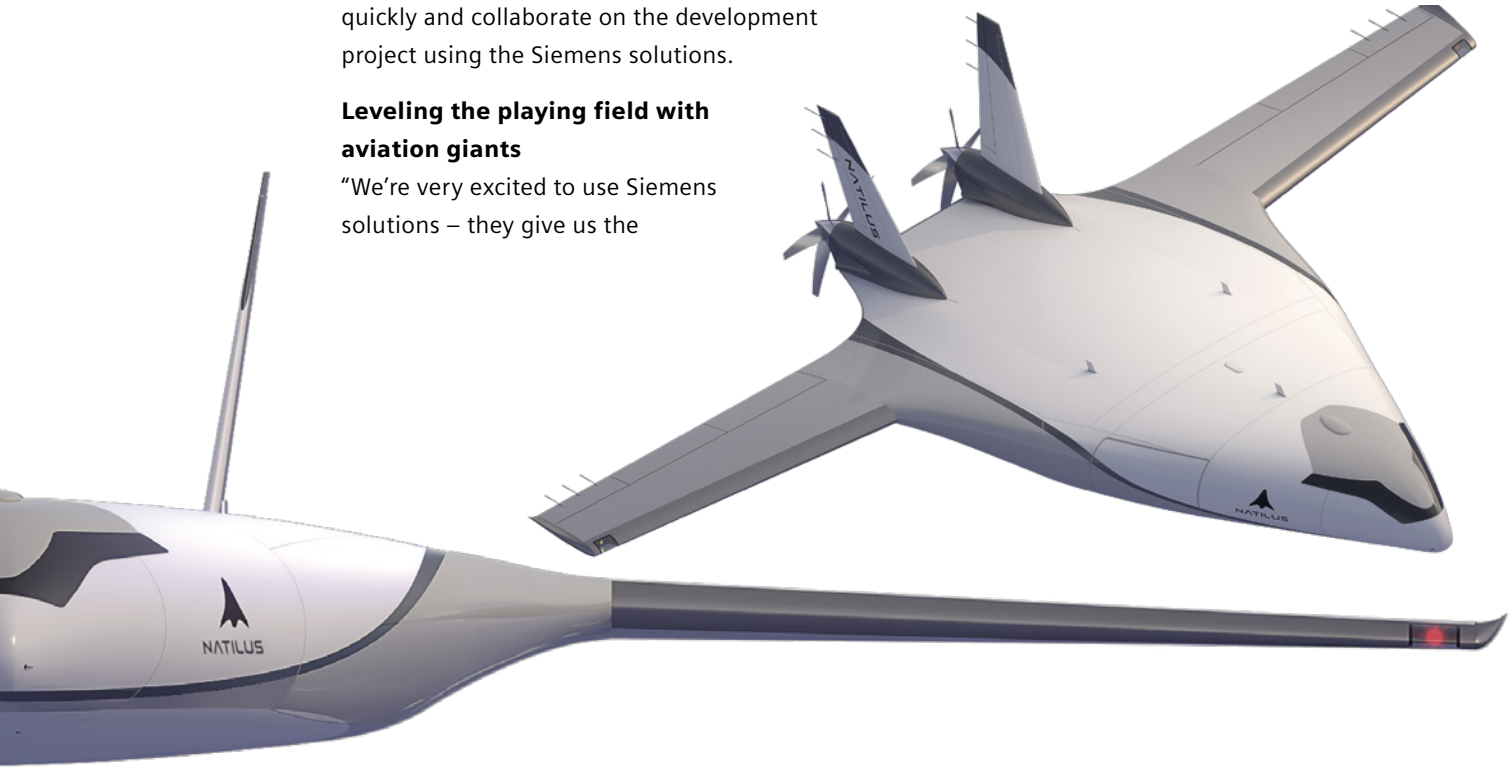
Siemens' Simcenter™ portfolio of simulation software for stress analysis.

Expanding the team

Currently, Natilus is expanding its development team, with a target of doubling headcount very quickly. The company is seeking dynamics engineers, composites experts, and electronics and propulsion engineers. "We're looking for 'the right stuff,'" Matyushev says. "We want people who are extremely passionate about aviation, people who have been in industry, like to work with their hands and are multidisciplinary. They will be stepping into an environment that works very fast." The expanded team will be onboarded quickly and collaborate on the development project using the Siemens solutions.

Leveling the playing field with aviation giants

"We're very excited to use Siemens solutions – they give us the capability and the technology of large aviation companies like Boeing or Airbus, at a cost that is very palatable to a startup," says Matyushev. "We can operate in an engineering environment that is on the same level as the big giants, essentially leveling the field with them. Siemens is almost a one-stop shop for core tools and technologies that work within the same environment, and that will help us get to where we need to go with our products to deliver solutions to our customers."



GO FASTER

Princess Yachts

Reducing the time necessary to hone acoustic performance for luxury vessels

Princess Yachts uses five main engine manufacturers. All these engine options add their distinctive sound signature to the yacht. This potentially creates dozens of test configurations.

Princess Yachts uses Simcenter to leverage NVH technology that is tough, versatile and dependable.

Prioritizing NVH

Commonly scrutinized in the automotive market, acoustic performance has become a significant differentiator when it comes to considering a new purchase in all kinds of industries, including the luxury yacht market. That being said, the luxury yacht market is still one of customization and artisanal craftsmanship. Every Princess yacht is unique and this makes noise, harshness and vibration (NHV) engineering and perfecting the overall acoustic performance, both inside and outside, a tremendous challenge. This is where Michal Tomaszczyk, an NVH engineer at Princess Yachts, comes in. Tomaszczyk started to work on NVH thanks to the TRANQuil project, a 3-year research project with Princess Yachts, The University of Southampton and TBG Solutions, which focused on innovation, like an active noise control system, to overcome noise and vibration issues caused by secondary generators on yachts.

"Princess Yachts is my first great engineering challenge," says Tomaszczyk. "Right after university, I was given the task to investigate and integrate NVH tools and processes into our production process. We are very fortunate at Princess Yachts because we have great people with vast experience constructing luxury yachts so they are more than capable of building the best product using best practices and years of artisanal experience and specialty skills. However, there really wasn't too much NVH data to start from."

One size doesn't fit all

Practically every Princess yacht is handcrafted to the customer's exact specifications and this creates a plethora of unique NVH challenges. But like other industries, yacht construction is undergoing a revolution in design as well as production. Besides streamlining the simulation and design process and coordinating with

> In my opinion, our new testing process based on Simcenter testing solutions has dramatically changed how we work."
>
> **Michal Tomaszczyk**
> NVH Engineer, Princess Yachts

suppliers, the Princess Yachts team needs to account for different engine options, interior elements and an entire realm of new materials, including cutting-edge composites. "Not so long ago we dispatched a Princess 35-meter that had been highly specified," explains Tomaszczyk. "The boat has dark furniture, lots of chandeliers and special features. It is beautiful, but every boat is decorated individually. We handle a variety of special requests and customized elements. You can imagine what this does to our testing process.

"We use five main engine manufacturers: Volvo, Cummins, MAN, MTU and Caterpillar. All these engine options add their own signature to the yacht, which is custom built. So there are a lot of variables to test. It is important to prevent the noise and vibration from influencing the hull of the yacht itself, and in turn, the yachting experience. This is our main job.

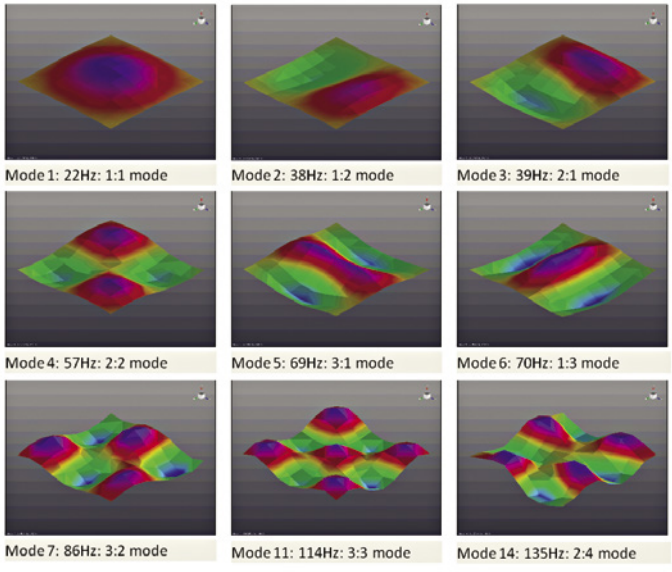
"Princess Yachts invested very heavily in development last year. Projects like TRANQuil allowed us to choose partners that would really push our capabilities forward and not just provide the equipment. We needed an NVH strategic plan as well as an NVH quality plan. Today, we have this and the constant support from the Siemens Digital Industries Software team in the U.K."

Acoustic testing for plywood and composites

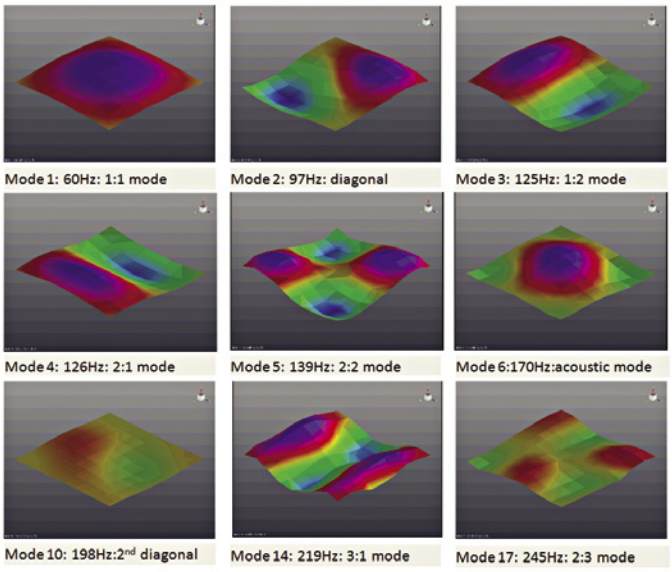
One of the new areas that Princess Yachts works on is looking at how sound energy radiates through plywood and composite panels that are used in the bulkhead. The idea is to study the sound fields and display panel attenuation easily. A dedicated testing facility has been built in one of the factory units in Plymouth, United Kingdom (U.K.). This is practical, but also means that background noise needs to be taken into consideration when measuring the sound field.

"You could call my testing environment rather unique," says Tomaszczyk. "The process of building a yacht is still very hands-on. As an engineer, you have to be on the floor and right in the process. You can imagine there is a lot of noise. People are sanding wood, hammering and sawing. With all

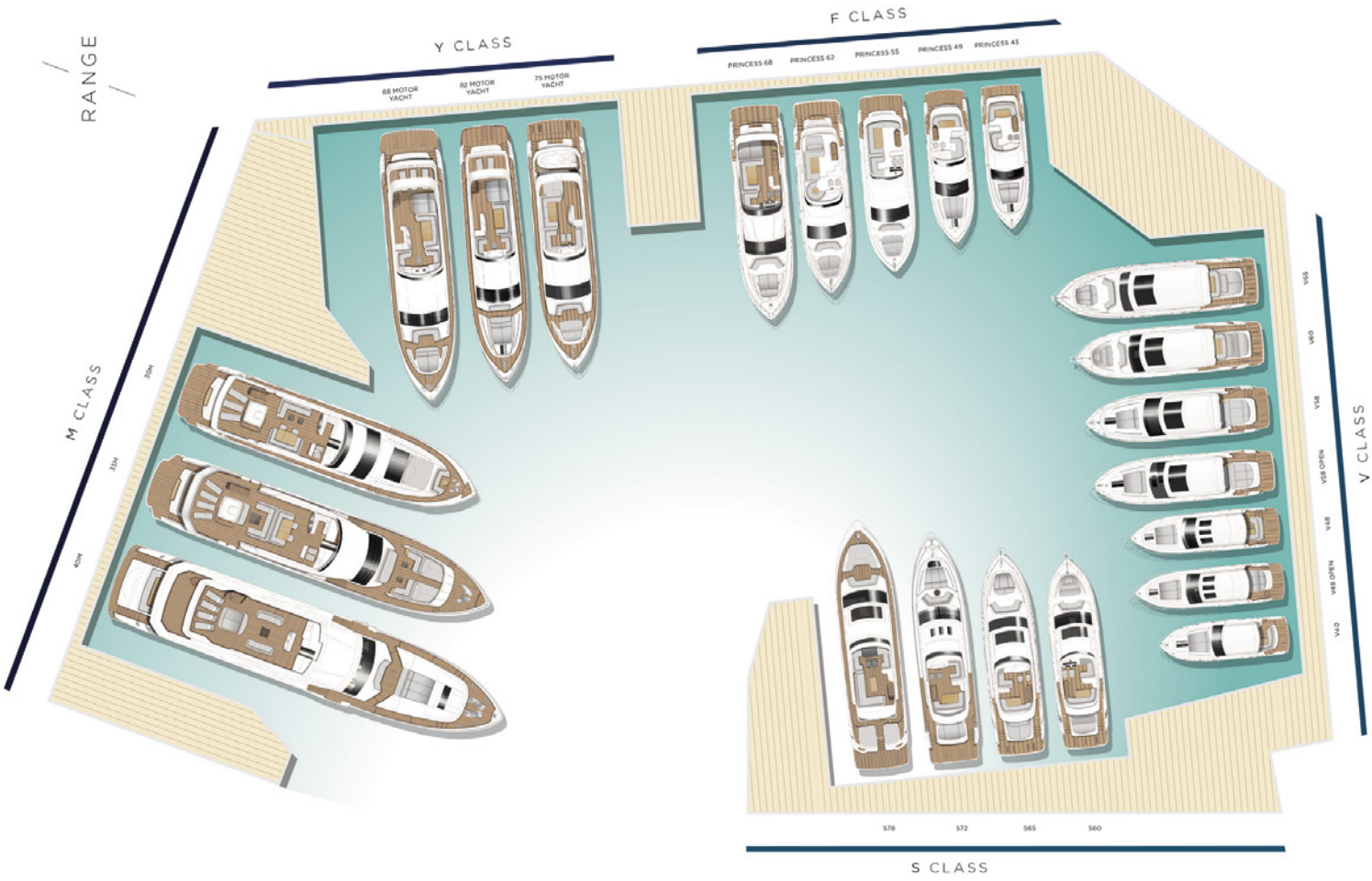
Modal characterization of plywood panel



Modal characterization of plywood panel



One new NVH area that Princess Yachts works on is comparing how sound energy radiates through plywood and composite panels that are used in the bulkhead. The company built a dedicated testing facility to acquire data and study the sound fields to compare and display panel attenuation more easily.



this action, we have to think about clever ways to get things tested. One example is that we use sound-directional techniques, which makes our testing insusceptible to background noise."

For panel testing, Tomaszczyk sets up a typical test using microphones, an intensity probe to find the transmission loss and the Simcenter™ SCADAS™ Recorder hardware 16-channel data acquisition solution, which can be used remotely thanks to its flash drive and internal battery. "Testing a panel like this is especially interesting on the supply side to confirm performance before we put it on the yacht," says Tomaszczyk. "We use Simcenter Testlab software and Simcenter SCADAS hardware. They work flawlessly and are very robust solutions."

The ever-important sea trial

Every Princess yacht must undergo strict, multiple sea trials prior to delivery. During the trials, Tomaszczyk works onboard taking measurements as the yacht is put through its paces to guarantee excellent performance.

"There are many data acquisition systems available on the market, but we have a saying at Princess Yachts, 'Good is not good enough,'" says Tomaszczyk. "We not only wanted a good and effective testing solution; we wanted the best. A single NVH test on a multimillion-pound M Class yacht takes a minimum of seven hours. You can imagine it is very important to have a testing system that is tough, versatile and highly dependable. You have to work fast and you don't want to repeat the measurements."

Simcenter SCADAS Recorder is an excellent tool for sea trials. Not only does it meet the stringent military standard (MIL-STD) 810F specifications, which means it can easily handle rough sea conditions, it can also record data on the fly without a personal computer (PC) connection. The Simcenter Testlab™ Scope App is well suited to mobile use on the tablet for quick measurements and can be used in addition to Global Positioning System (GPS) functionality, which is a great way to track speed versus turning angles and other maneuvers at sea.

"On the sea I instrument the entire yacht with sensors, paying special attention to the engines, gearboxes and mufflers," says Tomaszczyk. "We measure the vibrations and look at various correlations like the helm and the rotating machinery. We also conduct acoustic measurements in critical areas, like the master bedroom and staterooms, to make sure the yachting experience is exceptional and that disturbing noise is minimal. As far as I know, no other yacht manufacturer has such a comprehensive NVH program."

The one-man test department

In addition to Simcenter SCADAS, Tomaszczyk appreciates automation features, like the Simcenter Testlab software advanced signature testing worksheet. This worksheet provides a set of standard analysis tools to quickly identify the source of noise and vibration issues related to rotating machinery, hydrodynamic effects or other auxiliary systems on the yacht. "Our entire production process is centralized in Teamcenter, which makes it easily accessible for everyone involved in design, development, construction and delivery of the yacht," says Tomaszczyk. "Having the Simcenter testing solution aligned with the entire process will help minimize the 'monkey jobs,' so to speak. It leaves much more time for larger scale test campaigns.

"To give an example, the NVH report for the Princess 40-meter is more than 40 pages. There is quite a lot of data to manage and the reporting capabilities in Simcenter Testlab really help to automate this process. This wasn't possible before."

Simcenter and Teamcenter are part of the Siemens Xcelerator portfolio, the comprehensive and integrated portfolio of software, hardware and services.

The Simcenter advantage

In the future, the team is looking at integrating more of the Simcenter portfolio. "We really feel that having the Simcenter simulation capabilities and a digital twin will benefit us in the near future," says Tomaszczyk. "This will bring more transparency to the overall engineering process so that the data acquired during testing can help improve the simulation of future yacht designs.

"In my opinion, our new testing process based on Simcenter testing solutions has dramatically changed how we work. First of all, we are able to communicate effectively with other NVH engineers on the supply side. We can interpret the specs and apply measurement techniques to set NVH targets. This is a huge market advantage because each and every one of the approximately 250 yachts we create annually must be of the highest possible quality.

"As market leaders our main challenge is to stay ahead of the competition. Our customers are starting to appreciate the distinctive NVH qualities of Princess yachts. As an NVH engineer, this makes my day."

We use Simcenter Testlab software and Simcenter SCADAS hardware. They work flawlessly and are very robust solutions."

Michal Tomaszczyk
NVH Engineer, Princess Yachts

STAY INTEGRATED

US Sailing

Fine-tuning sailing performance with Siemens solutions

Photo Credit: Sailing Energy

Photo Credit:
Allison Chenard,
US Sailing Team

NX and Simcenter STAR-CCM+ help US Sailing Team understand hydrodynamics of Olympic sailing.

Competing in the Olympic games

As the national governing body for sailing, the United States Sailing Association (US Sailing) is responsible for selecting and supporting the members of Team USA, many or all of whom are drawn from the US Sailing Team, the annually-selected national team that competes at events around the world throughout the four-year Olympic cycle. The team of athletes recently completed the Tokyo 2020 Olympics, held in the summer of 2021 in ten classes of competition.

Through US Sailing and its sponsors, athletes on the Olympic path receive financial, logistical, coaching, technical, fitness, marketing and communications support. Siemens became a sponsor of US Sailing in 2019, providing advanced-capability technologies for modeling and simulation that help the team understand and optimize the tuning and setup of Olympic sailing boats. The solutions include NX™ software for computer-aided design (CAD) and Simcenter™ STAR-CCM+™ software for computational fluid dynamics (CFD), both from the Xcelerator™ portfolio of integrated solutions and services from Siemens Digital Industries Software.

"I have been using Simcenter STAR-CCM+ software since around 2007," says Riley Schutt, head of technology at US Olympic Sailing. Schutt holds a Ph.D. degree in aerospace engineering and fluid dynamics and has extensive experience with America's Cup racing teams. "I joined US Sailing in 2017. I wanted to develop in-house engineering, modeling and simulation capabilities to help win sailboat races – that's what motivates me."

Schutt is a full-time employee of US Sailing, and works with preferred contractors, interns and volunteer engineers on specific projects. "Our sailors' primary role is to sail boats, but several have engineering backgrounds and we give them access to the Siemens tools," Schutt explains.

Self-paced training builds proficiency quickly

For a team that includes volunteers, contract engineers and sailors, US Sailing relies on Siemens'

Photo Credit:
Allison Chenard,
US Sailing Team

Xcelerator Academy, an e-learning portal with rich self-paced training tools, to quickly build proficiency in the use of Siemens solutions. "For our workflow and team structure, Xcelerator Academy has been a great resource to get up to speed with the tools quickly and make contributions to our projects," Schutt says.

NX for computer-aided design

US Sailing is on a long-term quest to build digital twin models for all its Olympic racing classes. "Earlier this year we started using NX as our main CAD tool," Schutt says. "For a couple of the classes we have CAD models that are a combination of models that we have built in NX and models imported from other sources."

The design capabilities of NX support US Sailing's focus on better performance. Advanced surface design capabilities enable rapid modeling of complex geometries such as compound-curve hull shapes. With reverse engineering tools, the team can leverage scanned data to quickly model components. With NX additive manufacturing, US Sailing can rapidly design and produce components like mounting brackets using in-house 3D printers or carbon fiber additive machines.

Adding numbers to feelings with CFD

All 10 of the Olympic sailing classes are regulated by class rules that keep the manufactured equipment virtually identical and closely constrain engineering optimization efforts. "We don't have much leeway to redesign the boat," Schutt explains. "Our goals are to understand the pre-designed Olympic equipment. There is some room to optimize parts in some of the classes, but we are largely using the Siemens portfolio as an educational tool for sailors and coaches to help them understand the details of different boat parts and setups. They are all world-class expert sailors, and most of the time their feelings about what works well are true, but understanding the fluid flow physics adds numbers to their feelings which goes a long way as an aid to training. It gives our sailors confidence that the homework has been done."

Photo Credit:
Allison Chenard,
US Sailing Team

Photo Credit:
Sailing Energy

> For our workflow and team structure, Xcelerator Academy has been a great resource to point them toward, to get up to speed quickly and make contributions to our projects."

Riley Schutt
Head of Technology, US Olympic Sailing, US Sailing

As a long-term user of Simcenter STAR-CCM+, Schutt affirms the software's advantage over other CFD codes. "I have used it, and so have many others, in racing sailboat simulations," Schutt says. "It has a proven track record. It has advanced meshing and can simulate structural deflection and transitions – you can do it all in STAR-CCM+ and don't have to use other software. We can be confident that we're getting the right answers."

Fine-tuning boat setup

The Nacra 17 is a performance catamaran used as the Olympic multihull equipment since the 2016 Olympics. For the Tokyo games, the Nacra 17 was converted to a sailing hydrofoil, making it a very dynamic platform. "There is a lot that goes into boat setup with the Nacra," Schutt explains. "It has four different hydrofoils in the water that the boat flies on when sailing, and there are many ways that you can set the angles on those hydrofoils to affect your speed. STAR-CCM+ CFD simulation enables us to identify the drag and lift forces on the individual components and get a much more detailed picture of how changes can make a difference."

High-performance computing in the cloud

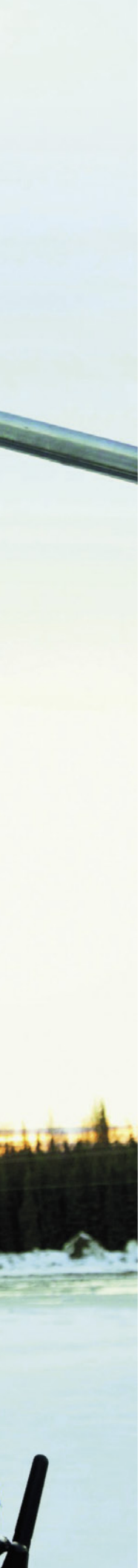
Another US Sailing sponsor is Nimbix, a provider of on-demand high-performance computing (HPC) in the cloud. "We entered into our agreements with Siemens and Nimbix at about the same time because we knew we needed both the software and the hardware for bigger CFD simulations," says Schutt. "Most of the people on the US Sailing Team work remotely, so having an on-premise cluster was never going to be an option for us. Cloud HPC is designed to be remote – I can access from my home, from a regatta, or while we're training. It abstracts away the IT overhead and makes it possible for a small engineering team to harness that power. We would be running much smaller simulations if we were using in-house hardware."

Looking to the future

The Tokyo Games introduced the first hydrofoiling boat in Olympic competition. "In 2024, we'll have five hydrofoiling classes," Schutt says. "It's something that the Olympic world needs to understand better, which makes it interesting. We're scratching the surface of where we want to be in 2024. The more data and insights we can give to our coaches and sailors, the faster they will go."

Photo Credit: Allison Chenard, US Sailing Team


RICK



MODEL THE COMPLEXITY

Wild Well Control

Using computational fluid dynamics simulation to preserve lives and assets

Wild Well Control relies on Simcenter STAR-CCM+ to prepare for and control well blowouts and fires.

Saving lives with simulation

In the midst of the Persian Gulf War, retreating Iraqi military forces set fire to over 700 Kuwaiti oil wells. The fires were started in early 1991, and it took over 10 months for multiple expert companies to extinguish all fires. The first well fires were controlled in April 1991, and the last well was capped in early November 1991. Workers of the U.S.-based company Wild Well Control (WWC) actively contributed to constrain the human, material and environmental damages.

Founded in 1975, WWC is the world's leading provider of onshore and offshore well control emergency response, pressure control, relief well planning, engineering and training services. If a well blowout occurs, WWC is called to the rescue. Workers intervene equipped with metal hard hats, fireproof overalls and engineering simulation models! Taking an engineering approach to well control has always been at the heart of the WWC ideology.

Safety is a major concern for the oil and gas industry. At every step of the oil and gas supply chain, it remains essential to safeguard lives, protect the costly assets in and around the wellbore and preserve the environment. WWC engineers rely on the advanced computational fluid dynamics (CFD) technology of Simcenter STAR-CCM+™ software to understand and predict phenomena such as fire propagation, heat radiation or gas dispersion. Simcenter STAR-CCM+ is a part of the Siemens Xcelerator portfolio, the comprehensive and integrated portfolio of software, hardware and services.

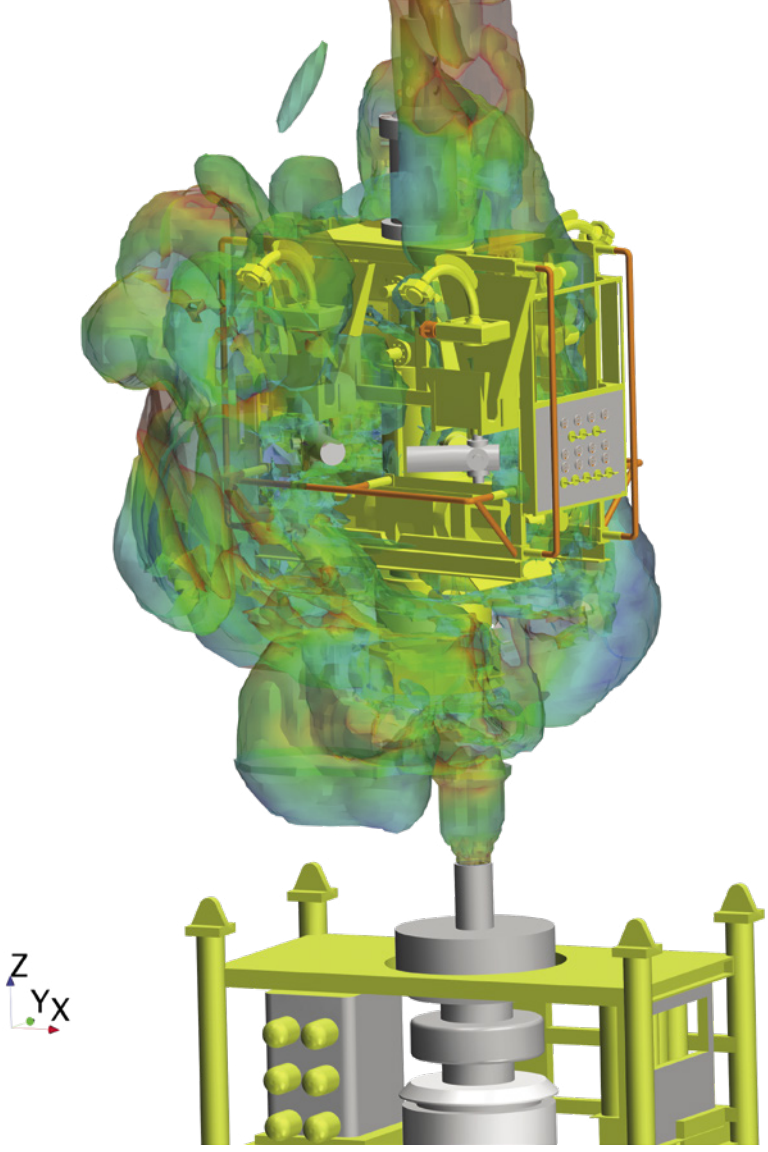
Modern simulation techniques prove to be an effective way to inform well control decisions and response operations and prevent further incidents and minimize risk. The applications include well control engineering (such as blowout rate, kick tolerance and dynamic kill simulation), subsea plume and gas dispersion modeling to understand where hydrocarbons go in the event of a blowout, radiant heat modeling of a fire, erosion modeling and thermal and structural analysis.

Depending on the issue at stake, WWC uses various simulation techniques to assess and mitigate risks and hazards: well control simulations, CFD modeling of the subsea plume, gas dispersion or erosion or structural analysis. WWC helps its clients understand the physical phenomena occurring in an incident, calculate and assess the risks and the lessons learned so they can ensure a rapid and effective response.

Limiting the effects of leaking hydrocarbons

CFD simulation is particularly helpful when well control events occur below the sea surface. WWC engineers use software such as Simcenter STAR-CCM+ to simulate the transit of hydrocarbons from the seabed to the sea surface.

"One of the most important aspects for us is understanding and predicting the fate of the hydrocarbons from a subsea blowout," explains Alistair Gill, general manager of engineering services at Wild Well Control. "With that knowledge we can plan to respond safely to the well control incident, save time and money and reduce the environmental impact. Therefore, we



need an accurate subsea plume model to understand where flammable hydrocarbons may arrive on the surface."

In addition to studying subsea plume formation, WWC engineers rely on CFD simulation to compute the hydrodynamic forces impacting a capping stack used to control the well event.

"One of our methods for controlling a well blowout subsea is to use a capping stack," says Gill. "It is lowered down through the water column onto the wellhead. We need to anticipate if installing the capping stack onto the well subsea is feasible or is going to present a greater challenge than normal. In a well blowout, a high-velocity jet of hydrocarbons surges from the wellhead. Using Simcenter STAR-CCM+, we assess whether the hydrodynamic forces caused by the well flow could potentially prevent the capping stack from landing; and, if so, what additional steps need to be incorporated into our capping plan."

Simulating heat radiation on land

WWC also uses simulation for land-based events. Gill says, "In case of a land well, there is the significant risk of fire and this complicates response efforts." It is particularly important when multiple wells are located close to the site of a blowout. "Sometimes there are several wells close to each other, so if you have a well-control event on one of those wellheads and it catches fire, the situation can quicky escalate," says Gill. "We also use Simcenter STAR-CCM+ to simulate the dispersion and combustion of the hydrocarbons to predict the radiant heat from the fire and understand how that may impact on the surrounding infrastructure and personnel."

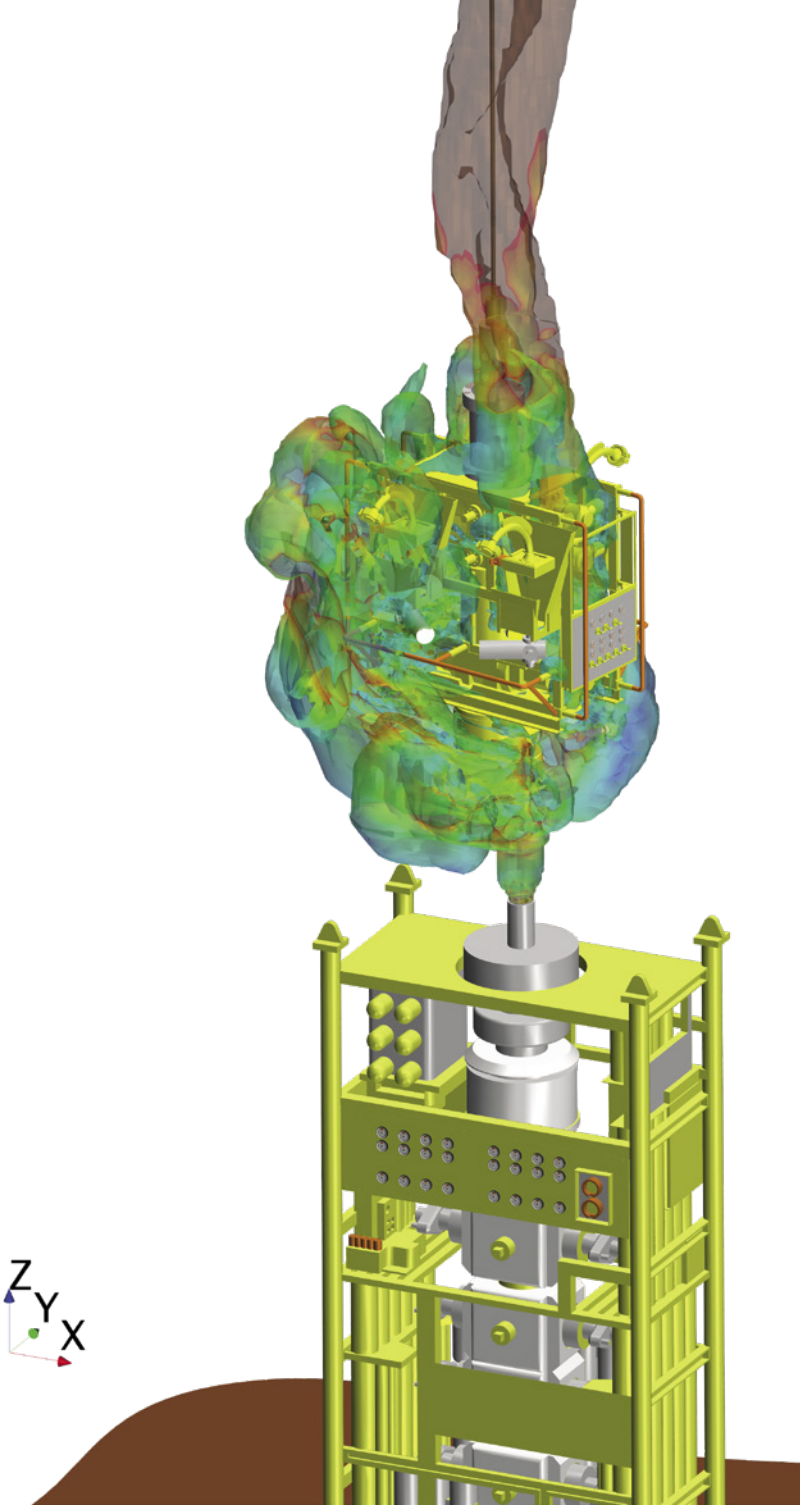
WWC also employs simulation to propose preventive measures. The company helps its clients understand potential risks and how to reduce them.

"When hydrocarbon gas is released offshore, there is not only a real danger it could catch fire or be toxic for the people in the vicinity," says Gill. "It is also important to know or at least to predict where and how much gas will surface if a release takes place subsea. Using Simcenter STAR-CCM+ for simulation, the engineers can improve decision-making and improve outcomes. Simulation also helps us to reconstruct an incident and understand how it came about. If we can find the cause and learn from it, we hopefully can prevent it in the future."

Validating simulation models with realistic experiments

Naturally, applying CFD simulation to understand and predict events is only valid if models are trustworthy. Model validation is essential to gain full confidence in the results, especially when it comes to such a nonlinear subject as fluid dynamics. WWC is part of the Subsea Underwater RElease (SURE) joint industry project (JIP). In this project, WWC collaborates with Sintef, a major research center in Norway and a number of major international oil and gas operators. As part of the JIP, various experiments were performed to validate and develop trustworthy CFD models.

"One of the projects where we try to optimize the simulation of leaking gas has been running for several years in multiple phases," explains Gill.



"The first phase took place in a water tank about 20 feet deep in a lab. The next phase took place in the inshore waters of Trondheim Fjord, Norway. In depths of about 100 feet, compressed air was released and phenomena such as the size, the velocity and the density of the gas bubbles was monitored." The data captured was used to validate and improve the CFD prediction.

In the next step of the project, natural gas was released in 1,200 feet of water. In that way, engineers can get closer to the conditions of a well control event and adapt the simulation. "By carrying out experiments like this, we can better understand the physics involved and improve the CFD simulation," states Gill. "The physics involved are complex and the experiments confirmed that when used correctly CFD codes such as Simcenter STAR-CCM+ CFD give us realistic answers."

Predicting time-to-failure of components

Another application of CFD simulation in support of incident prevention is time-to-failure prediction. WWC's engineers use Simcenter STAR-CCM+ to understand and quantify the impact of sand erosion on the production equipment and predict wear on wall material and components. The objective is to maximize the operational life of production equipment. The CFD simulation is particularly helpful for understanding how sand loading affects parts with complex geometry. It also helps predict changes in the wall profile of pipes. The deforming mesh capability in Simcenter STAR-CCM+ eases the highly nonlinear analysis, adapting to the changing profile of a pipe wall eroded by solid particulates.

Metal hard hats, fireproof overalls and simulation

As surprising as it may sound, simulation is an essential tool to plan for and control fire and blowouts. It helps the engineers accurately understand the physical phenomena of gas dispersion and heat radiation to provide the appropriate emergency response and prevent further incidents. It is also essential to define and apply preventive measures that contribute to a better and safer world.

"We find that simulation is an excellent tool for understanding what we should be doing, what effect this action is going to have, what the hazards are and most importantly, to make sure we are not putting anyone in harm's way," says Gill. "We will continue to rely on well control operations teams with metal hard hats and fireproof overalls in the future. But by using reliable simulation techniques, we're ensuring that we protect lives, assets and the environment to the best of our ability and can resolve an emergency as quickly and as safely as possible."

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