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Making it real!



Emerging from the electrifying atmosphere of the Siemens Realize Live Conferences, I want to bring you a glimpse of engineering innovation at its peak. There, I engaged with exceptional minds propelling the frontiers of possibility through simulations, tests and groundbreaking ideas.

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A standout in this edition: MxD's article, "Breathing Life into the Digital Twin." They birthed an executable digital twin of a ventilator, revealing its potential to support the breathing needs of two patients in extreme conditions.

Immerse in Trek's saga, using Simcenter to silence the Trek Fuel Exe e-bike, the market's quietest. Traverse the realms of motor modeling, where Simcenter empowers skyTran's 100mph autonomous monorail and aids Vuyk Engineering in designing ship apertures unlocking new depths of marine exploration.

Siemens Energy's feat beckons: 99% reduction in turbine blade simulation time, revolutionizing ultra-low-emission gas turbines.

This is the embodiment of engineering innovation – where imagination shapes certainty. Embark on this odyssey, absorb the stories, embrace the spirit of sustainable innovation and make it real!

Savor the journey,
Jean-Claude



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EXPLORE THE POSSIBILITIES

The subjective world of e-acoustics

How Trek Bicycle put sound quality on the e-bike metric map.
By Jenn Schlegel



“The most significant bike launched this decade” and Popular Science’s “100 Greatest Innovations 2022”...the accolades just keep on rolling in for the Trek Fuel EXe.

It is the perfect autumn day. The leaves are just starting to turn. Summer is still in the air as the sun burns through the green-yellow canopy. The chirp of the chickadees. The crunch of pine needles on an empty trail. You’re off for a ride to remember. Without a care in the world...Just you, Mother Nature and your new electric bike – a Trek Fuel EXe.

Being a born-and-bred Wisconsinite, we’ve had Trek bikes in the family garage since the early days of the company in the 1980s. I have fond memories of tooling around the University Wisconsin-Madison on a much beloved black Trek – almost like a precursor to their now famous Electra Townie®. However, let’s put my nostalgic love of the brand aside and look ahead to the world of e-bikes.

One thing that I’m pretty sure about is that the sound of an e-bike is not 100% silent.

This statement comes from my eclectic experiences with first-generation EVs, e-vacuums and robotic lawnmowers. It is true – you don’t

hear the dBs of a combustion engine or the hum of a small motor anymore – but whatever you electrify, you tend to hear an intriguing selection of rattles, hums, whirs, whistles, clicks and the occasional buzz.

Experts are quick to point out that quite a few of these sounds always existed – it is just the fact that you hear them better without the decibels of a combustion engine covering them up. Others admit that quite a few of these new sounds come from electric drivetrains and e-motors. But argue what you want, electrification and electric motors do bring their own soundscape to the bigger picture.

Electrification does not magically equal silence

Let’s turn back the clock to the late 1990s and the early days of modern EVs. Acoustics specialists and NVH guys were scratching their heads about what to do when you don’t hear the growl of a combustion engine anymore. Do you replace it with artificial sound? Were all those strange sounds driving customers away? Were they genuinely annoying? Or was it just a small group complaining? And more importantly, what about pedestrian safety?

Fast-forward two decades and the EV sector seems to have acoustics under its thumb. EVs today are

required to have a PWS or pedestrian warning system or AVAS (acoustic vehicle warning systems). In most cases, this is an external soundscape to signal to pedestrians that an EV is moving in the area.

Of course, certain automotive brands have embraced the world of EV acoustics to their advantage. The booming EV market features everything from exclusive interior soundscapes from award-winning composers to luxury soundscapes to enhance that “silent” EV driving experience to individually-tuned soundscapes to match your personal preferences and driving style. It seems that today, the EV community has its head around the very subjective world of e-acoustics and, some might argue, have taken a serious slice of profit pie as well.

All that being said, it is still early days for e-bikes and acoustics which is where we start our story.

Now, purists will claim that an e-bike comes with a variety of inherent mechanical sounds – pleasant or unpleasant. And, well, it is just a bike – so why bother with e-acoustics at all? This wasn’t the thinking at Trek, the award-winning bike company from Waterloo, Wisconsin (USA) with innovation embedded in their DNA.

Trek Bicycle is one of those small-town dream-big global success stories. Started in 1976 in a red barn, a typical sight in any small rural Wisconsin town, Trek is synonymous with high-quality, high-tech innovation and top-biking performances – no matter if you are riding a Trek Electra cruiser

to the beach or happen to be Mads Pedersen with your own custom-built Tour de France Madone SLR.

Putting sound quality on the e-bike metric map

Knowing it was a hot topic in the industry, the R&D team at Trek decided to put sound quality on the e-bike metric map with the launch of its new award-winning Fuel EXe in July 2022.

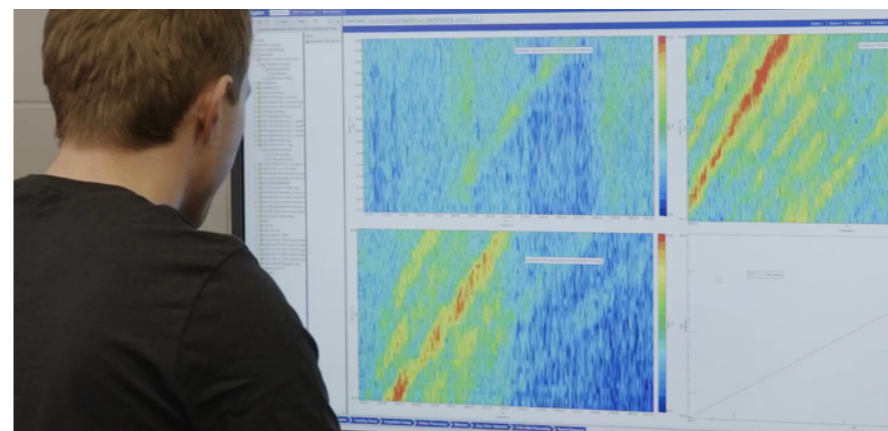
“As Trek’s acoustics testing and analysis expert, which was not only a new role for me but a new type of role for the bike industry, we aimed to take Trek’s acoustics competency to the next level while applying new test and analysis methods to the Fuel EXe development cycle,” explains Paul Harder, principal research and development (R&D) engineer within the Trek Performance Research Group at Trek. “It was quite the endeavor with a lot of firsts happening at the same time.”

The R&D engineers in Trek’s Performance Research Group tend to stay on the experimentation and simulation side of things, testing new prototype ideas and conducting experiments to seek out new knowledge in bike physics and human performance. This quest for new knowledge landed the team in the sound quality realm.

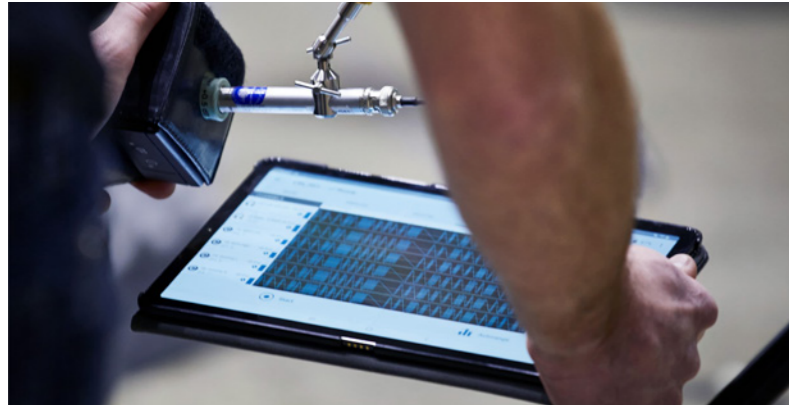
“Over the years, the industry has made a lot of progress to make e-bike motor and battery systems smaller, lighter, more integrated and more ‘natural’ to pedal,” says Harder. “But the inherent noise of electric motor and gearbox systems often remained a common downside. With the Fuel EXe, we had a unique opportunity to improve that last piece of the puzzle and make an e-bike that really has no downsides.”

Inspired by EVs

The team looked to the electric vehicle (EV) industry for inspiration. They realized that, like the early days of automotive EVs, the world of e-bike acoustics presented opportunities. The Trek team took acoustics full circle when investigating the options for the Fuel EXe in terms of the sound experience and unpleasant sounds. This included looking at industry-first acoustic metrics for the e-bike sector, like tonality and the articulation index.



Trek Bicycle continues to innovate with the Fuel EXe bike, a pioneering line released in July 2022.



The team at Trek counted on Simcenter Testlab to help define what 'sounded really good' meant from an acoustics testing and engineering standpoint.

"Since I almost always ride with other people, any noise that distracts from the ability to converse bothers me. This relates to the articulation index," adds Harder. "Using tonality as our key metric for unpleasantness came from quite a bit of exploration and research into the many sound quality metrics that are commonly applied to electric motors."

Integrating sound science with advanced engineering

Harder and the MTB engineering team at Trek knew the acoustic experience for the Fuel EXe depended heavily on the e-motor. The team was working with TQ's HPR120 motor, which is a powerful but fairly loud motor. The team was looking for a smaller, quieter version of the motor. They found that TQ's harmonic pin ring technology with minimum moving parts and unique gear meshing could play a role in making a new, quieter motor.

"We have an exclusive partnership with our e-motor OEM, TQ, so that means we can effectively collaborate when creating specs and testing our e-motors," says Harder. This collaboration resulted in the HPR50 e-motor that's in the Fuel EXe and Domane+.

Making a great first impression

After the usual back and forth between Trek and TQ, the prototypes with the HPR50 were ready to hit the test trails. The Trek test riders thought the prototypes with the HPR50 e-motor sounded really good. This was great news, but Harder knew they would have more work to do.

"Our team had developed solid acoustics test and analysis capabilities, but we still needed to figure out how to quantify what 'sounded really good' meant in the context of an e-bike," explains Harder. "We had acoustics as a key goal for the new TQ motor and we used the analysis to quantify that, understand it and track it as we decided between the many prototype iterations throughout the development process."

From subjective opinions to objective measurements

The team started by measuring loudness and found out that Fuel EXe was nearly two times quieter than other e-bikes but the test riders subjectively thought this understated how much better it sounded.

"At this point, we realized just how important sound quality is to the e-bike experience and how important tonality as a key metric is for quantifying the pleasantness of electric motor noise," says Harder. "We knew we had to get a little bit smarter about how we quantified these sound descriptions. So, we moved to the sound quality aspect, which has a ton of options. We looked closely at the EV acoustic space where we knew that tonality was a best practice."

Executing the test on the trail and the sound studio

After the initial test rides, the team needed more concrete acoustic data to work with. They headed to the sound studio at the Trek factory headquarters in Waterloo, Wisconsin, which is where Trek's private mountain bike trails are located, to run more exploratory acoustic analyses. This included sound power and sound quality metrics such as loudness, tonality and articulation index using Simcenter testing solutions, like the portable, Simcenter™ SCADAS™ XS hardware and Simcenter™ Testlab™ Neo software, the next-generation software platform for multidisciplinary test-based performance engineering.

"Using Simcenter SCADAS XS to perform field testing is pretty easy because it fits in a bike jersey pocket, integrates seamlessly with the binaural headset and can be controlled wirelessly with the



Simcenter Testlab Scope App on a tablet outside," adds Harder. "During the trail tests, we also used a GPS and action camera to visualize the data in Simcenter Testlab Neo."

The lab test setup included the Simcenter SCADAS XS, professional microphones, an acoustically-isolated stationary trainer set to 300W total resistance and, of course, the Trek Fuel EXe adjusted to maximum assist mode. The Trek team used Simcenter Testlab Neo according to the ECMA-74:2019 standard to calculate tonality.

"After researching various sound quality metrics, it became clear that tonality was the most representative of what our riders were hearing," says Harder. "Thanks to using Simcenter Testlab, we could easily explore other relevant metrics like prominence ratio and articulation index. Nothing is worse than coding an algorithm by hand for a couple of days only to realize it's not a useful metric for this test."

Harder and team provided feedback throughout the prototyping process and ended up creating an advanced set of methods to diagnose and improve e-bike motor acoustics. As a final step, they verified the field and lab results on the final production motor for two days in an anechoic chamber. The

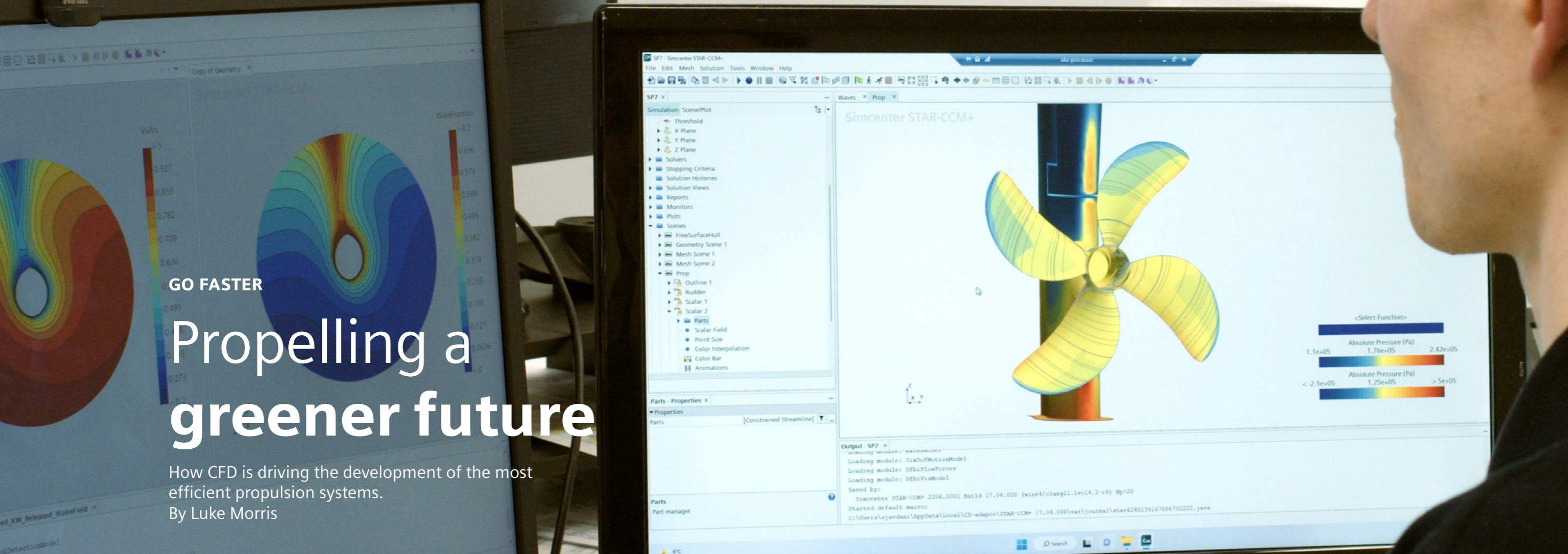
final results proved that using Simcenter helped them design the Fuel EXe to sound five times more pleasant and nearly two times quieter than other popular e-mountain bikes.

The future of e-bike acoustics

As the HPR50 and Fuel EXe rolled into production, the Trek Performance Research Group realized that they were working on cutting-edge e-bike acoustics.

"Quantifying human sound perception is extremely complicated," says Harder. "Using Simcenter SCADAS XS and Simcenter Testlab Neo software let me focus less on how to get correct answers and more on what those answers were teaching me. The ability to quickly test different metrics and interactively visualize, filter and playback data led to much quicker and more confident insights than we couldn't have gotten otherwise." Harder says, "The really exciting thing is that we can now leverage these tools and acoustic knowledge in even earlier stages of future e-motor and e-bike R&D projects."

Thanks to Paul Harder and the R&D team at Trek, you will be able to enjoy a whole new realm of forest sounds (and silence) on your morning trail rides for years to come.



GO FASTER

Propelling a greener future

How CFD is driving the development of the most efficient propulsion systems.
By Luke Morris

Oceans cover more than 70% of the Earth.

So, it's not surprising that 80% of global trade goods are transported by sea.

Add passenger ships to those large carriers and tankers and you have approximately 100,000 vessels in the entire world.

We typically think of cars and planes in relation to pollution, but these ships can also be incredibly damaging to the environment. The marine industry is estimated to contribute 2-3% of global greenhouse gas emissions, 5% of nitrogen oxides (NOx) and 4-9% of sulfur oxides (SOx). (Source: Statista)

As a result, the maritime industry is urgently prioritizing the enhancement of sustainability practices to prepare for impending stringent

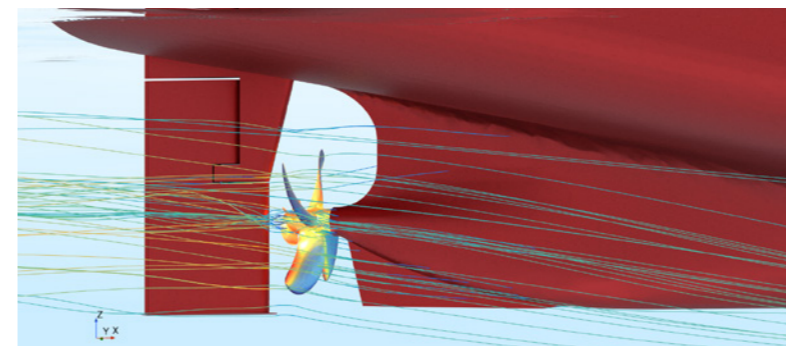
regulations. According to the International Maritime Organization, optimizing the propulsion system can improve a ship's efficiency by as much as 10%. This would lead to a significant reduction in harmful emissions.

Saving the oceans with simulation

"If you want to save the planet, save the oceans," says Saeed Javdani, Innovation and Technology Manager at [Teignbridge Propellers International](#), which has almost 50 years of experience in designing propellers and shaftlines.

But this isn't straightforward, as ships can harm the environment in different ways. First, the type and amount of fuel used contributes to carbon emissions. Second, noise pollution can do serious damage to marine life and biology.

To become a world-leading and reliable supplier of high-performance propulsion systems, Teignbridge uses both [Siemens Digital Industries Software](#) [Simcenter™ STAR-CCM+™](#) software and



[HEEDS™](#) software to optimize propeller designs and make them as efficient and environmentally friendly as possible.

Working with [Siemens Digital Industries Software](#) solution partner, [Maya HTT](#), Teignbridge has carried out fast and accurate CFD simulations in [Simcenter STAR-CCM+](#) that allow design engineers to understand the interaction between propulsion systems and the high-velocity water flowing across their surfaces. They can predict performance,

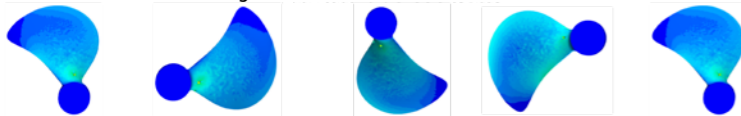
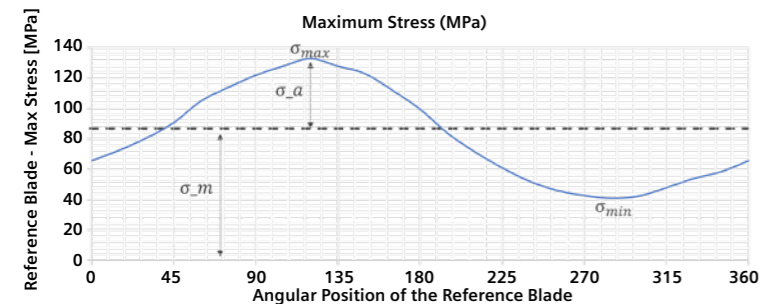
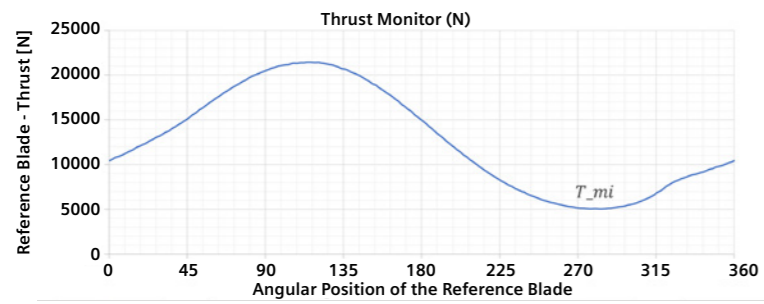
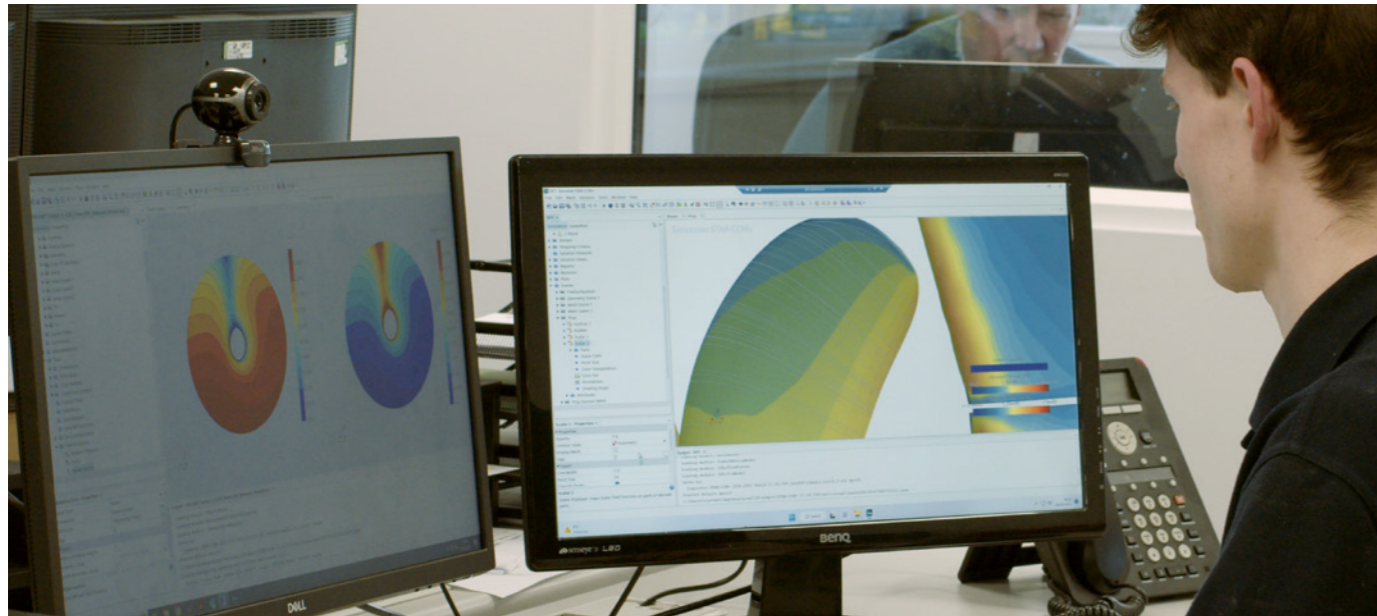
durability, and generated noise, then modify designs to optimize each aspect.

And all this can be done with simulation before any physical components even get wet.

"In the past we used to just consider one or two design points," explains Javdani. "But now with [Simcenter STAR-CCM+](#) we can predict how the vessel will perform at different speeds and in different sea conditions. Simulation makes it possible to explore many more iterations in less time so that we can then come up with the optimal design."

Small changes deliver big results

Tiny alterations in propulsion system design can make huge differences. Even in an 8-meter propeller, a design adaptation of just 1 millimeter can have a noticeable performance impact. So, simulation is key to analyzing design changes and predicting the effect they will have.



In one instance, Javdani's team identified cavitation – a phenomenon where vapor bubbles in a fluid grow and collapse due to local pressure fluctuations – as being caused by areas of low pressure on the leading edge of a rudder. By redesigning the rudder and aligning its leading edge to the downstream rotational flow from the propeller, the cavitation and noise were significantly reduced. And the vessel's top speed was increased by approximately 7%.

In another situation, a customer needed to reduce radiated noise levels by 10 decibels to minimize environmental impact. By exploring hundreds of potential design iterations, Teignbridge was able to achieve a 15-decibel reduction.

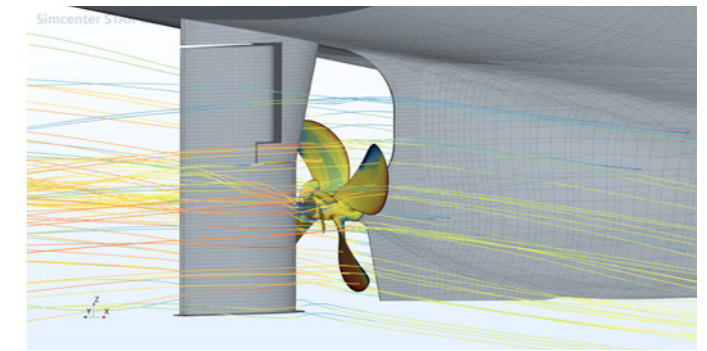
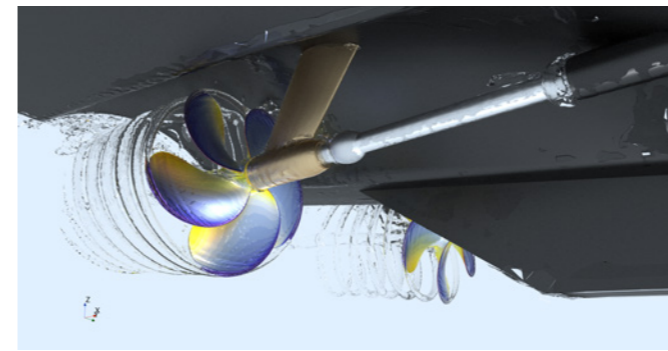
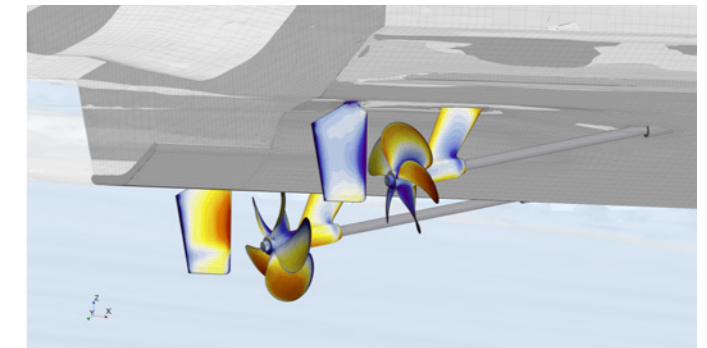
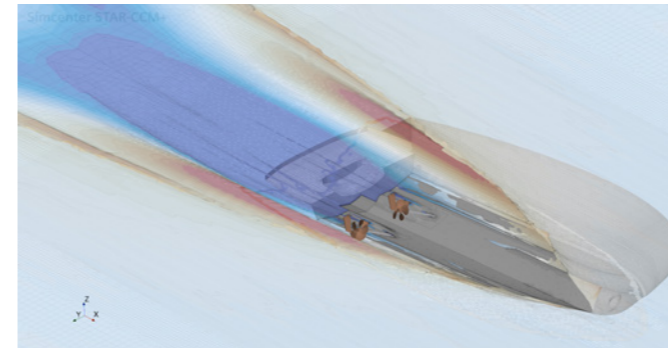
The secret to this is the automation capabilities of HEEDS. "We can test up to 500 iterations in just 48 hours," says Javdani. "Without HEEDS it's simply not possible. It would take far too long and wouldn't be cost-effective."

Closer collaboration

Simulation has also been vital to satisfying classification societies and providing extra reassurance to customers.

"Simcenter STAR-CCM+ enables us to show authorities that new designs will meet their standards before they are even built," says Javdani. "We can show that new components will perform within the safety factor required under dynamic loading."

Group Managing Director, Mark Phare, explains that simulation has been essential to Teignbridge's progress. "Naval architects expect propulsion designers to have CFD capabilities and to offer an analysis of the underwater equipment at the design stage. Many of our customers use Simcenter STAR-CCM+ which means we can easily share data and talk the same language when evaluating new projects."



Becoming the best

Phare's vision for the future of Teignbridge is straightforward but challenging: "We want to be the world-leading designer and manufacturer of propulsion equipment."

And there's no doubt that simulation will play a key role in making that a reality.

"Simcenter STAR-CCM+ has enriched the scope of work and sparked a great deal of innovation at Teignbridge," says Javdani. "It helps us to better understand exactly what customers need, and helps us solve problems they didn't even know they had. We can now design and supply products that we weren't able to previously, opening up new markets and establishing ourselves as the go-to company within the industry."





MODEL THE COMPLEXITY

A decades-long partnership in marine **simulation and testing innovation**

By Jenn Schlegel

CETENA, Simcenter and the University of Genoa join forces to create a marine engineering ecosystem to meet current industry challenges

Unlike the automotive industry or even aviation, the marine industry, for the most part, faces an extreme challenge when it comes to manufacturing: every ship is unique. Although segments of the industry -- such as "smaller" luxury yachts and various sport boat segments -- do production-line type of assembly, for the most part, big players like Fincantieri, the largest cruise ship builder in the world, make bespoke or practically bespoke vessels*. The product line includes everything from aircraft carriers and military frigates to mega-yachts and ultra-luxury cruise ships that resemble small villages.

It is probably a huge understatement to say that from an engineering standpoint, there are a lot of angles to cover when building a ship like the MSC Explora 1 or Seven Seas Grandeur. Just the size and complexity of projects like these can be mind-boggling from an outsider's perspective. Of course, you have classic naval architect topics like ship design and hull integration, which people might argue is the easy part these days. And then you have the more advanced topics like structural dynamics, vibro-acoustics, overall performance issues, fuel efficiency and new propulsion methods, optimization, and sea trials and

certification. This is where the real engineering expertise takes center stage. And thanks to a strong partnership between CETENA, Siemens and the University of Genoa, the marine engineering ecosystem around Genoa, Italy is certainly thriving.

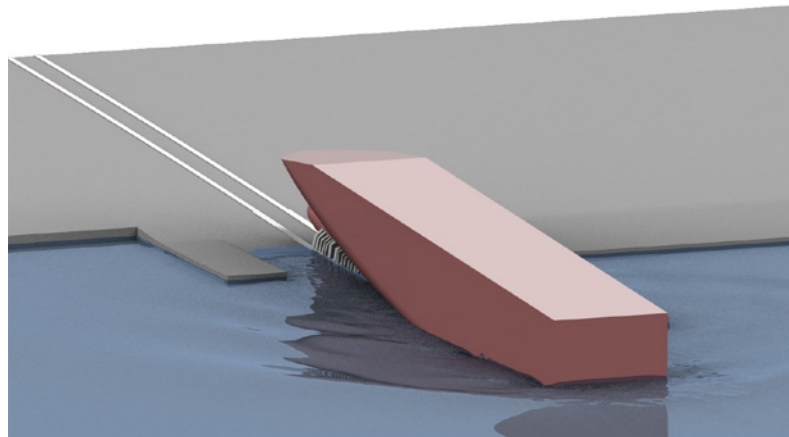
CFD simulation and the marine industry

Ask anyone for the reference CFD software in the marine industry and there is a good shot that the response will be Simcenter™ STAR-CCM+™ software. This is pretty much the case as well for Dr. Davide Grassi, Senior Naval Architect at CETENA.

"Although we tend to use Simcenter STAR-CCM+ as our reference software for most hydro-dynamic issues, we also use our own tools and tools from open-source environments." He adds, "Simcenter STAR-CCM+ is our starting point when we have a new project because we need to leverage the technical support that the software offers. This was certainly the case with our ship launch project."

Several years ago, Dr. Grassi and his team tackled an "overlooked" issue in naval architecture simulation: full-scale vessel launching. Especially since the size and cost of both military and commercial vessels have dramatically increased, guaranteeing a safe launch of the final, completed product has become mission critical.

"What you don't want happening is that shipyards use old launch equipment or outdated launch practices when putting these new bigger and



taller vessels in the water. There are all types of areas where things could go wrong: the vessel might slide too far and hit the dock, or go too deep and hit the bottom. Then there are the influences of free surface effects on structural stability, or the effect of the hull's drag resistance and waves from the vessel upon first contact," explains Grassi.

To prevent these events, the team decided to create a full physics-based digital twin of the actual launch vessel, slipway and launch process for Fincantieri. Throughout the development process, the team counted on Simcenter

Engineering and Consulting Services to help refine the tool and iron out trickier aspects of the numerical model. With the comprehensive digital twin, they could check the effects of various design decisions well in advance and verify the launch process, correct for potential issues and guarantee the safety of the vessel upon launch.

"Using the Simcenter simulation tool, we can gain valuable insight into future ship launches for our clients and analyze the effect that different design solutions will have," says Grassi.

Concludes Grassi, "Simcenter STAR-CCM+ is a high-fidelity tool. And we can say this with confidence since we have had the chance to compare our simulated results with actual data. We have found a very minor difference of 1%. We trust this solution based on Simcenter STAR-CCM+ to simulate very risky applications, like vessel launches."

Cutting-edge research and a simulator for the Italian marine industry ecosystem

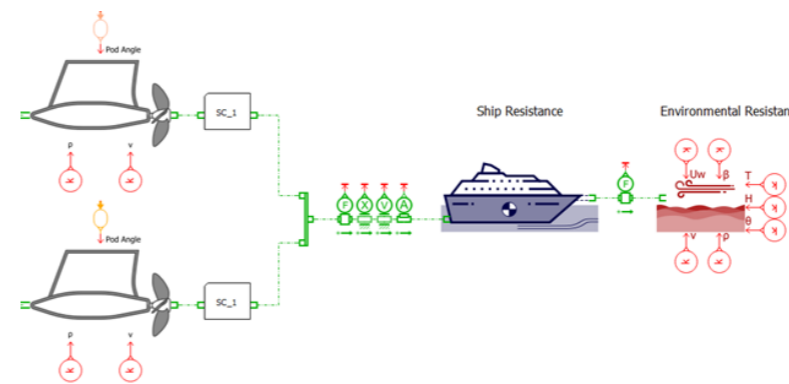
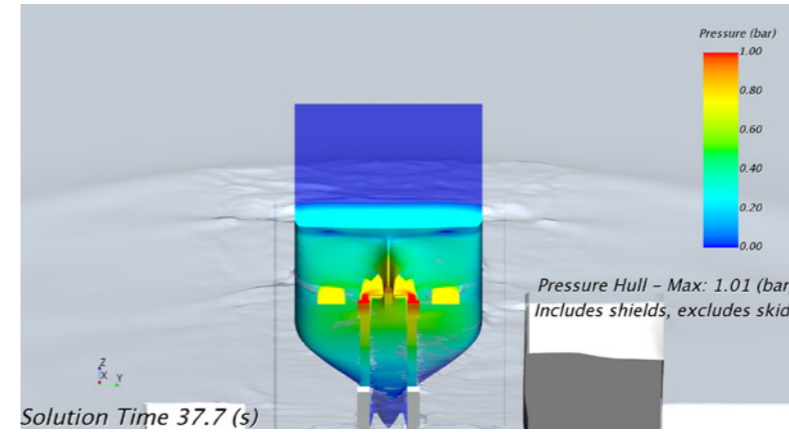
More recently, the CETENA team has turned to other parts of the Simcenter advanced engineering portfolio to solve common marine engineering issues. A recent research project is a true example of the strength the Italian marine industry ecosystem and the growing partnership between the University of Genova, Siemens and CETENA.

The project was to create a dynamic model or simulator of a cruise ship in one degree of freedom in Simcenter Amesim. The final Simcenter Amesim simulator would be used as a virtual benchmark to test control logic for electric propulsion plans for difficult maneuvers like crash stops.

"The crash stop maneuver is used to prevent collisions. The ship is going ahead at full speed and you need to stop and reverse the thrust. It's a very challenging maneuver that could be dangerous or damaging if not properly managed by the ship's control system," explains Martelli.

A Simcenter simulator for electric propulsion control logic

The best option to avoid risks is obviously to try out the control system on the vessel virtually. For his thesis project, one of Prof. Martelli's masters



students, who had never used Simcenter™ Amesim™ software before, developed a reliable model of the vessel to test the electric propulsion control data using benchmark data from CETENA.

"Just to let you know, he had never opened the software previously. And within a couple of months, he was able to develop a simulator. A very good one," adds Martelli.

The Simcenter Amesim simulator was almost an exact match to industry experimental data, which meant that it could be reliably used to test control logic on a variety of maneuvers.

"When we started to test various control logic options during maneuvers on the Simcenter Amesim simulator, I was happy with the results," explains Martelli. "The software was quite intuitive to use – especially if you have a good background in simulation and are willing to learn new stuff."

The importance of upstream simulator work

Guglielmo Sommariva, a marine engineer at CETENA and thesis project supervisor, acted as an industry mentor during the thesis project. He was quick to point out the importance of upstream simulator work in the overall development of electrified vessels.

"The crash stop maneuver is very hard to simulate because it depends on automated parameters that are not known early in the design process. In most cases, designers don't have a clear idea about the automation plan. Often, they make a prediction using basic information like correlating the ship's mass, the velocity, the propulsion plans and the time necessary to stop the ship completely."

"Especially with new propulsion systems, this is guesswork; it doesn't take into consideration the control logic or other outside factors like wave or wind forces. We clearly needed a more accurate simulator upfront in the design process and we were able to create one in Simcenter Amesim," states Sommariva. "And it helped that Simcenter Amesim, with its validated libraries, makes it easy for the user to change parameters quickly, try out lots of different scenarios and visualize the results in very little time."

Advanced safety simulations with Simcenter Flomaster

One of the newer members of the team who is working on some of those advanced and complicated simulations is Andrea Gambino, a Mechanical Engineer at CETENA. Gambino and his colleagues have worked on a variety of simulation projects including sea-keeping analysis, ballistic impact analysis, shock and response spectrum analysis, and one-dimensional fluid dynamic analysis, where he used Simcenter Flomaster for several system-level simulation projects.

One project involved an important aspect of cruise ship safety, a topic close to the heart of all at CETENA. Gambino used Simcenter™ Flomaster™ software to evaluate the hydrodynamic pressure of the water entering the nozzles of the automatic sprinklers on board a cruise ship.

"Simulating this system is very important because these nozzles need to work properly with minimum water pressure. So you need to check and evaluate that the entire system on the ship is going to work properly," explains Gambino. "After this first project, we used our simulation model together with the engineers at Fincantieri to model the complete onboard firefighting system."

He is quick to point out the obvious advantages of simulating fire sprinkler systems.



"If you don't use simulation for projects like these, the only other possible approach is physically testing and troubleshooting the system. This obviously isn't very practical, although at Fincantieri, we do perform actual onboard system testing as required by international safety standards. It is nice to know that with the Simcenter Flomaster simulation, everything will go according to plan for the real live test."

"Simcenter Flomaster matches very well with common theoretical formulas related to one-dimensional dynamics and it solves accurately non-linear issues. I have to say it is a perfect match." He adds, "If I had to create all the mathematics and an object-oriented programming approach like this, it would take me an entire year to write a decent simulation program to test the sprinklers virtually."

Sea trials: A costly but mission-critical exercise

And speaking of real live tests, the pinnacle of thousands of hours of design, development and advanced engineering, integration and cabin design and performance simulation – all comes down the sea trial.

For those unfamiliar with term, a sea trial is a series of mandatory performance and safety tests performed at sea by the shipbuilder prior to certification and delivery to the shipowner. Naval insiders like to call it a shakedown cruise because the main purpose is to push the vessel to its performance limits. Depending on sea conditions, this can cause quite a bit of vibrations on board. At times, fittings and fixtures loosen and "shakedown".

A sea trial can be as simple as taking a small luxury speed boat out with an NVH expert, a laptop running Simcenter™ Testlab™ software hooked up to trusty and tough Simcenter™ SCADAS™ data acquisition hardware and experienced captain for those tricky maneuver's. A few hours on the high seas and you'll have the job done. On the other side of the spectrum, a sea trial on a mega-cruise ship like the MSC Explora or Seven Seas Grandeur can take about a week, running the cruise ship over 2500 kilometers and take a full crew and testing staff of 500 people to complete.

One can imagine that a sea trial carries a high but vital price tag. A sea trial operation needs to be as efficient as possible.

"Even as we are moving more and more towards digital simulations, physical testing with models in a towing tank or the full vessel during sea trials aren't going away," explains Codda.

"You must remember that sea trials are more, let's say, contractually related. So it's the owner who wants to see and touch and verify that the ship complies with the contracted performance characteristics. Sea trials are not the best way to validate numerical models because the environment is not controllable, it is not predictable." He quips, "The only thing predictable about a sea trial is that it means spending a lot of money."

Today, sea trials are used on all types of ships – from your standard sport boats to massive cruise ships and military vessels. Taking hours or weeks (even months for certain types of military ships), the crew familiarizes itself with the ship and confirms everything from basic seaworthiness and maneuverability to performance metrics like fuel efficiency, emissions, noise and vibration limitations, maximum speeds and a variety of safety features.

A testing center of excellence

One of the experts at CETENA involved in testing is Federico Gaggero, a long-time Simcenter Testlab and Simcenter SCADAS user. Their main test center is located right in Fincantieri's Riva Trigoso

shipyard, slightly south of Genoa. It is one of the company's most important test centers specializing in military and civil certification and shock testing. It is the unique location in Europe for MIL S 901 D shock certification, which is required for most shipboard machinery, equipment, systems, and structures. The test center is equipped with a NavSea-accredited medium-weight shock machine, one of two in Europe.

The testing team at CETENA has used Simcenter testing solutions since 2005 and the team continues to use the software and hardware for a variety of testing scenarios ranging from acceleration measurements during shock tests, to sea trial data acquisition to onboard acoustic testing. They are especially fond of the Siemens token system, which offers full flexibility when it comes to using the software for different applications.

"This token system lets us turn off and turn on certain modules in Simcenter Testlab. It gives us incredible flexibility when using our Simcenter testing systems. We can increase the number of tests and offer our clients a wider range of tests."

"99% of our work is performed with just a couple of our Simcenter testing tools. We can trust the results. We have very good support from Simcenter experts from the Torino office as well as





online help,” says Federico Gaggero. “It does happen that we need some guidance during a test and the Simcenter technical support team is always there to help solve the problems so we can continue the test – even when we are at sea on a sea trial or completing a real challenging test request for a customer. This is much better than turning the boat around, going back to port and starting over or saying that we can’t do it. The entire Simcenter testing solution and technical support team is just excellent.”

Simulated performance indicators spell success

Matteo Codda is quick to point out that everything on both the simulation and testing sides is correlated so that the final sea trial is success.

“Sometimes simulation is used, let’s say, to extrapolate sea trial results because the ship is still under construction or is not complete. This can be seen as ‘performance indicators’, for example, to see how the vessel should perform during a maneuver like the crash stop test.”

“We look at everything in the finest detail -- from supplier requirements for materials installed on board to final systems performance according to vessel certification, shipowner requirements, and military standards.”

Continues Codda, “From my point of view, it is very important that we have the opportunity to validate our simulation and numerical models with experimental measurements and testing. This is still a vital step. In the marine industry, it is quite unusual that both the simulation and test experts work closely together in the same company. We have this luxury since we are the research center for Fincantieri. We have direct access to the ships, the test data and the validated simulations. This is not always the case throughout the marine industry.”

Codda concludes, “In the last decade, our role at CETENA has become ‘the selectors’ of the best technologies and mathematical models developed in the professional and academic community. We have to select and adapt available tools for the Fincantieri technical office. In some cases, we develop advanced design tools and models from existing software that the design office uses by themselves, such as the Simcenter Flomaster fire system model. In other cases, we develop more complex numerical procedures such, for example, the launching simulation. Simulation work like this is so complex and so computationally demanding that CETENA is still the best place to perform it.”



EXPLORE THE POSSIBILITIES

The future of engineering

Stay ahead of the curve with the EI podcast
By Luke Morris

How do you keep up to date with the latest developments in engineering?

Obviously, you're already reading Engineer Innovation, which is a great way to discover how cutting-edge technology is being used to solve engineering problems and break boundaries. But did you know about the [Engineer Innovation podcast](#)?

It's a show by engineers for engineers who want to know about the most exciting emerging technologies and how they will change the face of engineering. In each episode, Stephen Ferguson and Chad Ghalamzan interview different experts who bring their own knowledge and thoughts on what the future holds.

Series 2 has recently launched and has already had some fantastic guests. Here are just a few highlights of the series so far:



Exploring massive engineering data analytics

30 years ago, the human race had created a total of 15.6 exabytes of digital data. Now, we create that much data every 15 days.

Mind-boggling when you think about it.

Of course, storage has evolved rapidly in the last 3 decades to make this possible, but if we can't efficiently make use of all this data then what is the point in keeping it?

[Ian McGann](#), Siemens Digital Industries Software Director of Innovation, explains how machine learning algorithms can help engineers leverage data science to make better decisions and learn from not only their own experiences but also those of the wider engineering community.



Rethinking fuel for industrial thermal systems

As well as striving for technological progress, it's essential to improve sustainability. Many manufacturing processes rely on extreme heat, but we need to transition from fossil fuels to protect our planet.

After all, what's the use of exciting new products if our habitat becomes too hostile to enjoy them?

[Eric Duplain](#), Numerical Simulation Specialist, and [Guy de Carufel](#), Director of Engineering and Operations, from BMA Inc discuss the challenges of reducing carbon emissions and the fuels that are most likely to become the future of industrial thermal systems.

Engineer Innovation Podcast

Experiencing the Digital Twin in the Industrial Universe
with Virginie Maillard



Digital twin models in the industrial metaverse

You've most likely heard about the digital twin, but what about the industrial metaverse?

Think of it as a virtual mirror of real machines, factories, buildings, cities, grids and transportation systems. Only here, problems can be analyzed and fixed without impacting the people who depend on them. Or even discovered and prevented before they become reality.

[Virginie Maillard](#), Head of Global Research in Simulation and Digital Twin at Siemens, explains why the industrial metaverse is so important for our future and why digital twin models are a key part of it.

Engineer Innovation Podcast

Adapting to a New Era of AI
with Justin Hodges and Remi Duquette



Adapting to a new era of AI

ChatGPT has propelled it into the spotlight, but artificial intelligence has been around for longer than many people realize.

Until recently, AI has been the preserve of specialists, but the latest advances have made it more accessible to engineers than ever before. And that is only going to continue to increase in the future.

[Justin Hodges](#), Senior AI/ML Technical Specialist in Product Management at Siemens Digital Industries Software, and [Remi Duquette](#), Vice-President of Innovation and Industrial AI at Maya HTT, discuss how artificial intelligence can boost innovation and whether engineers should be concerned about it replacing them.

Engineer Innovation Podcast

The Truth about AI in Engineering
with Jousef Murad



The truth about AI in engineering

With AI being such a hot topic, we needed more than one episode to explore it.

As well as being an engineering AI expert at Monolith, [Jousef Murad](#) is a social media influencer on a mission to help students and professionals increase their experience through his content.

He gives his views on what AI can do now and how it will shape the future of engineering. He also explains why it isn't a "magic pill" and how you can get started with artificial intelligence and machine learning today.

Get listening today

This is only a snippet of the wealth of information available on the Engineer Innovation podcast. And with new episodes released every two weeks you can be sure we'll be covering all the important topics that are influencing the future of engineering.

If you're not keeping up, you'll be left behind!

So, subscribe today wherever you get your podcasts to ensure that you get the latest episodes as soon as they're available. And if you're enjoying the content, please leave a review and tell your friends and colleagues so everyone can benefit from the valuable insights shared by our expert guests.



GO FASTER

The most comfortable ride on the road

How integration of virtual simulation and physical test are helping Hyundai Motor Group to optimize their NVH performance.

By Luke Morris

For most modern road users, comfort is a key factor when it comes to choosing a vehicle.

With speeds limited by both traffic and regulations, different cars will get you to your destination in a similar amount of time. And the vast majority of vehicles are built to the highest safety standards to ensure you arrive unharmed.

Getting you there in the most comfortable way is the biggest differentiator a manufacturer can make.

So, what makes a vehicle comfortable?

An ergonomically designed seat? Sure. But it's about much more than that.

Rattling body work, whistling winds, the sound of the tires on the road surface. All of these can add up to an unpleasant, uncomfortable experience.

Now, with the rise of electric vehicles, road noise is even more of an issue as it is no longer masked by an internal combustion engine.

Manufacturers need to adopt new design technologies to improve NVH performance and stand out in a crowded marketplace.

Integrating test and simulation model

To help realize its goal of becoming the number one electric vehicle manufacturer in the world, Hyundai Motor Group (HMG) has transitioned to an integrated modular architecture (IMA) strategy. This allows for the same part to be used in multiple vehicle models, thus reducing overall development costs. While HMG is adopting this new approach for all vehicles, it's particularly useful for electric vehicles as batteries can be developed to attach flexibly to any automotive model.

Knowing that virtual development would be vital for the accuracy and speed of the new process,

HMG senior research engineer, Sangyoung Park from the driving comfort virtual development team, formed a strategic partnership with Simcenter™ Engineering and Consulting services to aid them in getting the most value from products within the Siemens Xcelerator portfolio.

"Three years ago, we set out on a mission to define the test engineer's role for the virtual development environment," explains Park. "We began by focusing on developing test models that would be compatible with our simulation models. However, I faced significant obstacles when attempting to create perfectly compatible test



models, so we turned to Simcenter Engineering and Consulting Services for help.”

“We selected Simcenter Engineering Services because we knew they could help us transform our vision into an actionable, realistic roadmap for implementation,” says Park. “They have developed proven methodologies and experience for integrating hardware and software to achieve balance between practical application and technology advancement.”

Authoring system models experimentally

A key aspect of reducing road noise is understanding the invariant loads from a vehicle’s tires. Together with Simcenter engineers, the HMG team applied component-based transfer path analysis (TPA) at the wheel level to determine these blocked forces which are invariant to the receiving structure.

They also used Simcenter Virtual Prototype Assembly (VPA) to combine the invariant loads with virtual vehicle assembly variants and predict the resulting road noise performance.



They also used frequency-based substructuring (FBS) decoupling to accurately represent the subsystem in its realistic operational boundary conditions and identify unknown components’ frequency response functions (FRFs).

This led to the building of a customized bench to accurately and repeatedly test the suspension and further optimize the design – a world-first in FBS-based assembly analysis.

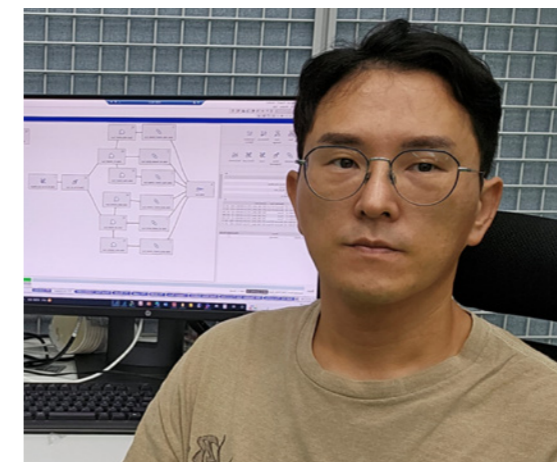
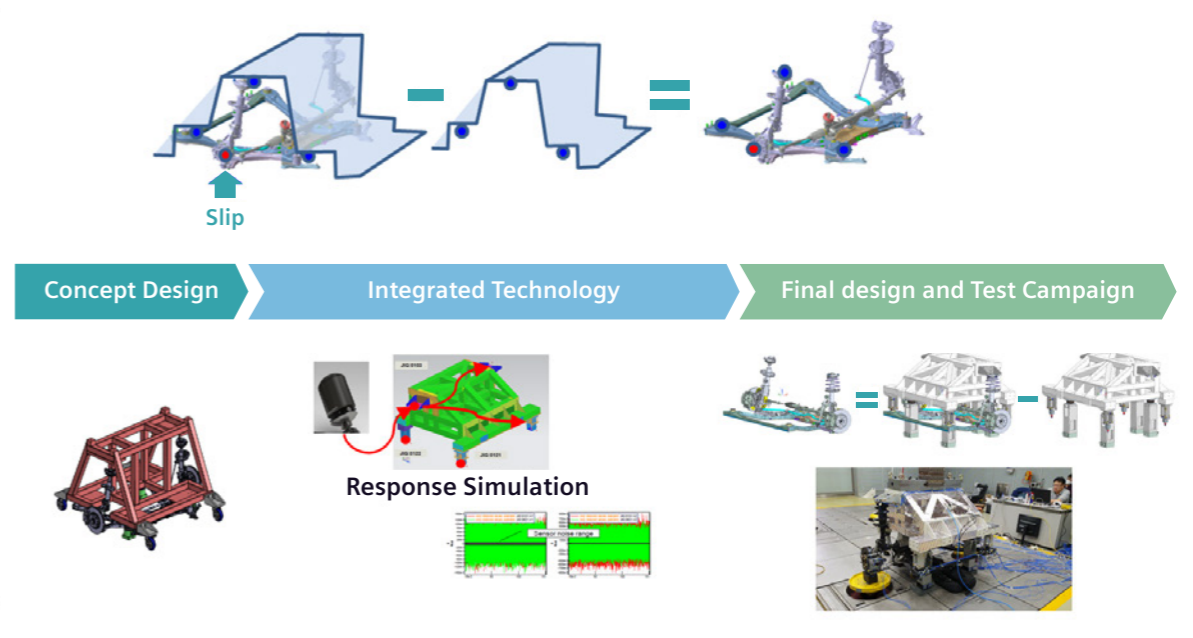
“When I suggested our idea for acquiring a suspension model, I wasn’t sure it was achievable,” says Park. “However, Siemens integrated hardware, software, and component based TPA testing enabled us to design a very challenging jig flawlessly. Additionally, various techniques learned from other test campaigns were used to successfully make on-the-fly changes. The progress we’ve made is encouraging and will help us prepare future models to evaluate performance at the early stages of development.”

Assembling test and simulation models for NVH performance prediction

The next stage was to build a virtual vehicle assembly based on the test and simulation models such as tire, suspension, bush or body. This allows for NVH performance to be predicted as reliably as possible and enables much faster design optimization in the the early stages of vehicle development.

Subjective evaluation in the early stages

The work doesn’t stop here.



The partnership is now focused on customizing Simcenter VPA to meet HMG’s specific needs. Ultimately, they are able to listen to the sound of a vehicle in development before a physical prototype has even been built. Simcenter™ Testlab™ NVH simulator will combine road noise with other

noises such as wind, tires, and powertrain to make performance prediction even more accurate and allow for earlier design changes.

HMG’s engineers are in no doubt as to the benefits the partnership will bring as they continue to strive to design the most comfortable vehicles on the market.

“The outcome of our research with Simcenter Engineering Services is that we can now use objective and subjective evaluation platform integrating both simulation and test models virtually for developing our vehicle architecture NVH performance,” says Park. “Virtual development using integration of simulation and test models is increasing cooperation with foreign offices such as HMETC and tire suppliers to make HMG vehicles more comfortable and enjoyable to drive.”

“The outcome of our research with Simcenter Engineering Services is that we can now use objective and subjective evaluation platform integrating both simulation and test models virtually for developing our vehicle architecture NVH performance.”



Using HEEDS doesn't necessarily save time, It's the quality of the engineering and final design that results in big-picture savings such as less fuel consumption, lighter overall design and better structural performance."

Erwin Put, Operational Director, Vuyk Engineering Rotterdam

MODEL THE COMPLEXITY

Vuyk Engineering Rotterdam

Optimizing moon pool design and performance with advanced simulation engineering

By Jenn Schlegel

What the heck is a moon pool and why does it matter?

It is not every day that you get to talk about designing better-performing moon pools. And probably the first question that comes to mind is: **What the heck is a moon pool?** Well, simply stated, it is a hole in the hull of a ship to access the water and ocean floor underneath.

Moon pools are typically found in high-tech fall-pipe and drilling vessels, diving support boats and scientific research ships. Essentially, any type of boat that has to release something safely and correctly from bottom of the hull needs a well-designed moon pool. This could be something as simple as a cable or as heavy as a piece of steel pipeline or as mission critical as a submarine full of marine scientists.

A top-performing moon pool takes the heavy lifting out of advanced geotechnical projects. With a drill tower and moon pool, drilling vessels can perform drilling and subsea well services directly from the bottom of the vessel. For fall-pipe vessels like the Simon Stevin (pictured), the moon pool provides a way to deposit rock via a long pipe directly on the seabed, which is useful for activities such as land reclamation, port

infrastructure work and ocean foundation reinforcement for offshore wind farms.

From a scientific side of things, moon pools can help research teams access hard-to-reach places in the ocean, like parts of the frozen Arctic, safely and securely launching submarines and other scientific equipment. They can also enable teams to work directly inside the vessel and not outside in the harsh sea-faring elements.

In a nutshell, the real engineering question at hand is: how do you design a good hole in a boat? One that can improve performance and save on fuel consumption -- which is positive news for budget-savvy owners as well as the environment.

How to design a good moon pool?

This was exactly the question on the minds of the engineers at Vuyk Engineering Rotterdam working on the design of the Simon Stevin. A moon pool can obviously cause some performance and safety issues, ie. you don't just cut a hole in the vessel in any old place. Optimizing a moon pool design means finding the right balance between hundreds of possibilities including customer specifications, cost options and various performance factors.

"Our customers set the technical specifications," says Erwin Put, operational director, Vuyk Engineering Rotterdam. "We work within these boundaries according to a specific budget and timeline. It is our goal to come up with the best possible solution within those boundaries. The



marine industry is still an extremely customer-centric and customized industry. You have to understand the huge amount of capital invested in a single vessel project. The customer has a wish-list when it comes to performance. By the time we come into the picture, our time and budget is limited.”

Since moon pools are usually bespoke, one-off designs, they can differ greatly from vessel to vessel. Moon pools can typically cause issues, like unwanted water flows, increased resistance, increased fuel consumption and additional turbulence. To engineer a moon pool properly you have to cover a lot of angles, therefore experts tend to use CFD and optimization tools to get to the right result.

Enter the CFD engineers

Back to the engineers at Vuyk Engineering Rotterdam and the Simon Stevin. One engineer in this story had already worked on optimizing a specific moon pool design for a drilling vessel using Simcenter™ STAR-CCM+™ software for the CFD work. After completing five simulation studies, he managed to take the resistance level of the moon pool on the vessel’s hull down by 2.4%. But looking at the big design picture, one of his

colleagues realized that with the right tool they could do more. He was thinking about HEEDS™ software.

HEEDS is a design space exploration software package that can interface with all types of CAD and commercial CAE packages as well as in-house and customized tools. It takes a big picture overview of the engineering work and various software packages and tools involved and optimizes the overall design and engineering process. In other words, it can up an engineering game from very good to great – no matter what tools or solutions are used.

From good to great engineering

Knowing that there was room for improvement, the team at Vuyk used HEEDS to investigate further. Running a design exploration loop revealed better design options, trimming the overall resistance by more than 1% from the previous resistance level.

Decreasing resistance by more than 3% can mean a lot for any huge vessel – especially ones with moon pools. It translates into an immense fuel savings and overall annual cost reduction. Not to mention the environment impact of not burning all that fossil fuel.

“Using HEEDS doesn’t necessarily save time,” says Put. “It’s the quality of the engineering and final design that results in big-picture savings such as less fuel consumption, lighter overall design and better structural performance.”

Quality engineering provides a competitive advantage

Time and budget issues will always be there, but using quality optimization techniques like HEEDS means that Vuyk isn’t competing on price or an hourly rate; they are competing on the quality of the engineering they deliver and the time it takes them to do it.

“Working with HEEDS requires a different mindset as an engineer,” says Put. “You need a big picture view as an engineer. You need to think about the whole design and where it would work best to apply certain improvements.”

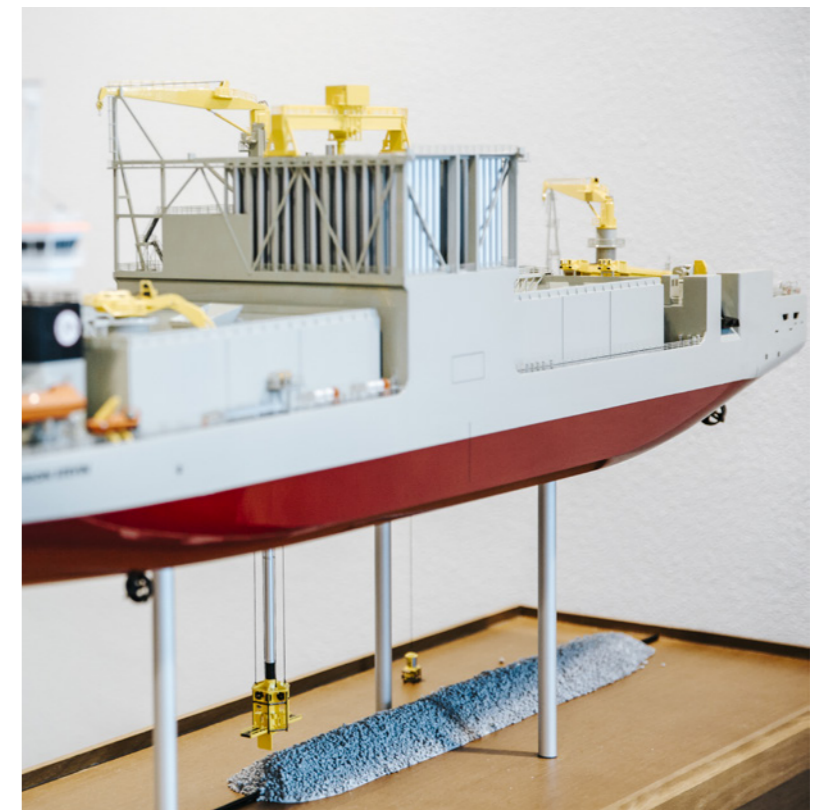
Today, this mindset has clearly paid off. The Simon Stevin, which has been active since 2010, continues a wealth of tough projects including hauling and installing protective layers of foundation rocks for the German North Sea wind farms and contributing to a more sustainable future for everyone.

In the case of research vessels, a moon pool allows technicians and researchers to lower scientific equipment and even submarines directly into the ocean.

For complex drilling vessels and fall-pipe vessels like the Simon Stevin, a moon pool takes the heavy lifting out of advanced geotechnical projects. With a drill tower and moon pool, these vessels can perform drilling and subsea well services directly from the bottom of the vessel.

For fall-pipe vessels like the Simon Stevin, the moon pool provides a way to deposit rock via a long pipe directly on the seabed, which is useful for activities such reinforcing the ocean foundation for offshore wind farms.

A moon pool is certainly not the first thing that springs to mind when you talk about naval architecture and marine engineering. But then you aren’t designing almost 200-meter-long deep-water mining and fall vessels like the Simon Stevin every day.





MODEL THE COMPLEXITY

The future of **mass transit?**

skyTran, a NASA Space Act company, brings us closer to the dream of fast, convenient travel around cities without congestion or noise.

By Anna Wood

skyTran is using Simcenter™ MAGNET™ software to develop a revolutionary transport system. The technology is in its infancy but confidence in the modeling is speeding up its development.

skyTran's design for city transport

Maglev trains have already set world speed records; a Japanese bullet train achieved a record 375 mph in 2015.

Although they are hugely expensive to design and build, the benefits are enormous. Maglev-based transport is attractive because it achieves speeds comparable to aircrafts but does not use any fossil fuel. skyTran's design has an added benefit in that its vehicles hang from an overhead rail that rests on pylons, removing the need to acquire large continuous strips of urban real-estate. Numerous Maglevs exist globally but they tend to focus on hub-to-hub travel, such as city-to-city or airport-to-city. skyTran's lower-cost infrastructure and unique switching technology could change this and the way we travel in cities.

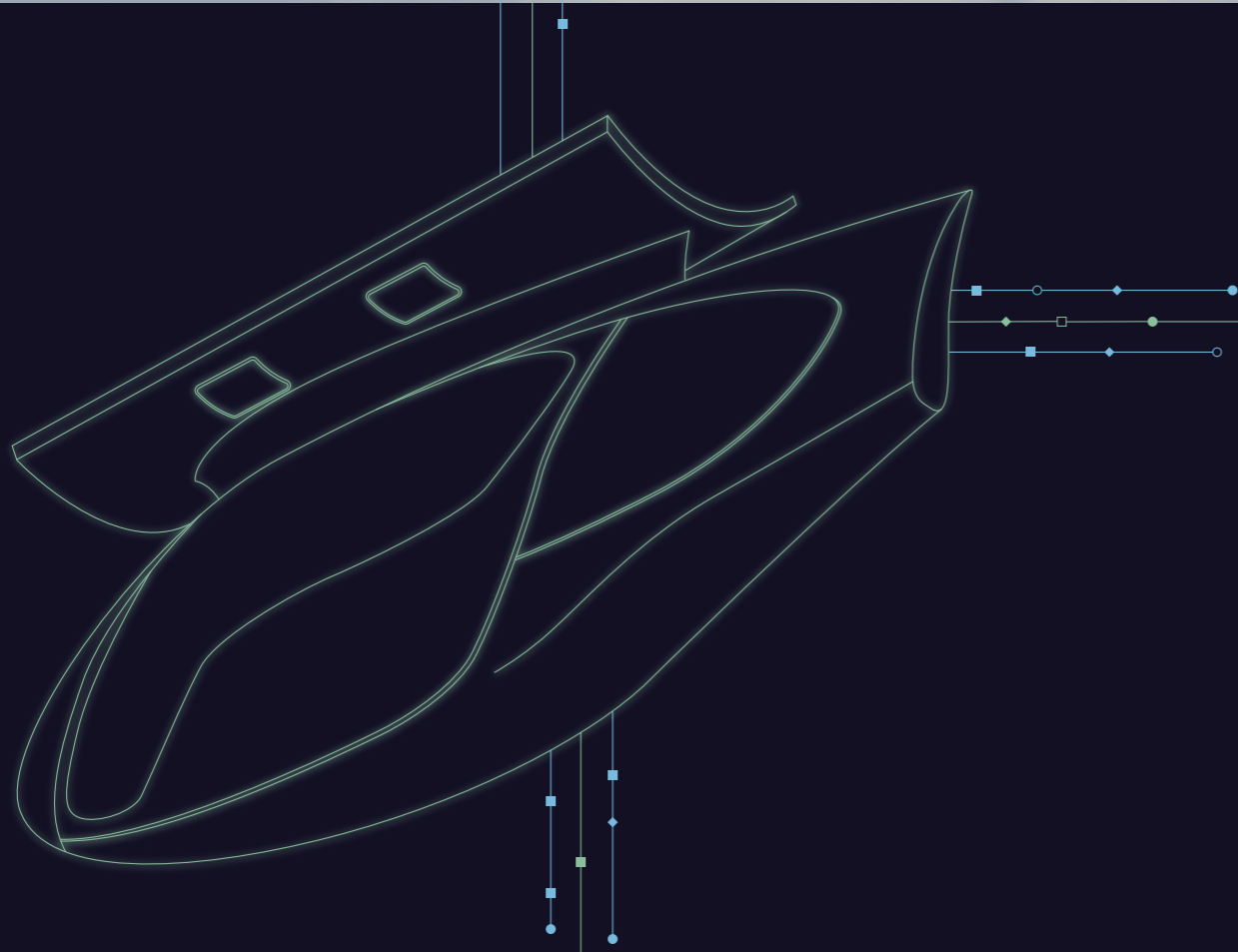
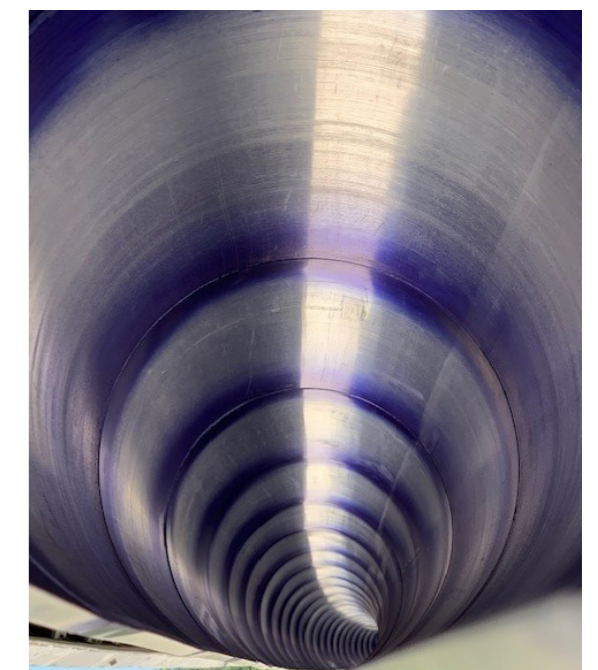
The new design could free our cities from cars, pollution and congested streets with a personal rapid transit system that glides above the urban landscape. Passengers would travel directly to their destinations at speeds of up to 100 mph in pod-shaped vehicles suspended from an overhead rail. skyTran is a NASA Space Act company that received a grant from the Research and Innovation

Technology Institution of the US Department of Transportation.

skyTran's vehicles will operate autonomously with proprietary switching technology that enables each one to navigate to its destination. The prototype for this utopian transport system brings us closer to the dream of fast, convenient travel around our cities without any congestion or noise.

A breakthrough in maglev technology

skyTran uses a particular variant of Maglev technology called electrodynamic suspension that works by magnetic levitation combined with a propulsion system. The propulsion system comprises a drive motor with a magnetic rotor and an aluminum stator. This operates together with





the levitation system which is driven by the interaction between the steel guideways and the electromagnets in the vehicle.

There is a need to understand how the high transit speeds of the vehicles will affect the magnetic forces. This part of the project is pushing the limits of current modeling techniques.

A full-scale rig is used to test the concept but each test takes a lot of time to set up and is expensive in terms of materials and resources. It is particularly costly to test how the vehicles will operate at full speed, so simulation is playing an important role. It is speeding up the development work and reducing the number of physical prototypes by around 90%.

skyTran recruited Iana Volvach, a specialist in Finite Element Analysis and expert in the modeling of electromagnetic devices and spintronics, the physics of nano-magnetic materials. Volvach set to work to build simulation models for the levitation and propulsion systems and soon made progress. "When we use Simcenter MAGNET we quadruple the rate at which we develop, test and manufacture new parts", she explains.

Volvach imported CAD models of the hardware into Simcenter MAGNET and built a model of the

electromagnetic devices in the maglev mass transit system. She used this to tackle one of the most fundamental aspects of skyTran's maglev system – the phenomenon of eddy currents.

The disadvantage of eddy currents

Eddy currents are initiated by a magnet passing a steel rail. In maglev vehicles, eddy currents induce electromagnetic drag and reduce the attraction force between the magnet and the rail. As a result, an increase in speed decreases the attraction force and increases the drag force. Both effects are undesirable and are a key focus of skyTran's research and development.

Volvach knew that if the cores of the steel rail were formed from laminated steel layers it would increase the resistance of the steel rail to the circulating eddy currents. This is because the stacking of steel layers and insulation makes each lamination become a separate electrical conductor but allows the magnetic flux to pass through. Therefore, the design of the laminations for the steel rails would become a pivotal area of research for the new system. skyTran needed to know how to design the lamination, which materials to use and how to model the motion to see if the design was correct.

Volvach created Simcenter models to measure the eddy currents, first with solid steel and then with laminated steel to determine the best design to limit the eddy currents that occur at high speeds. She added a rigorous validation process to be sure that she could have confidence in her models.

It took a lot of work to optimize the design for the laminated steel and it was particularly difficult to determine how many layers would be required. Volvach needed to determine the smallest number of steel plates that would suppress the eddy currents within the company's specification.

Strange results and a pleasant surprise

Volvach could model the laminated steel rails with layers of insulation between the steel plates, so she assumed she had an exact representation of her physical tests, however the simulations were revealing an anomaly. The results did not match her physical tests. It was not clear if this was due to an unknown property of the lamination or an error.

At this point Siemens Digital Industries Software provided some help. They have a knowledge base article on anisotropy and the Simcenter MAGNET perfect electric insulator (PEI) boundary condition to approximate the thin layers of insulation between steel laminations and a Siemens support engineer suggested a few adjustments to the simulations.

Volvach had been modeling steel plates of 10, 20, and 30 mm thickness with thin areas between the layers. She did not know that the mesh is stretched in the spaces between the layers, and that this adds inaccuracy.

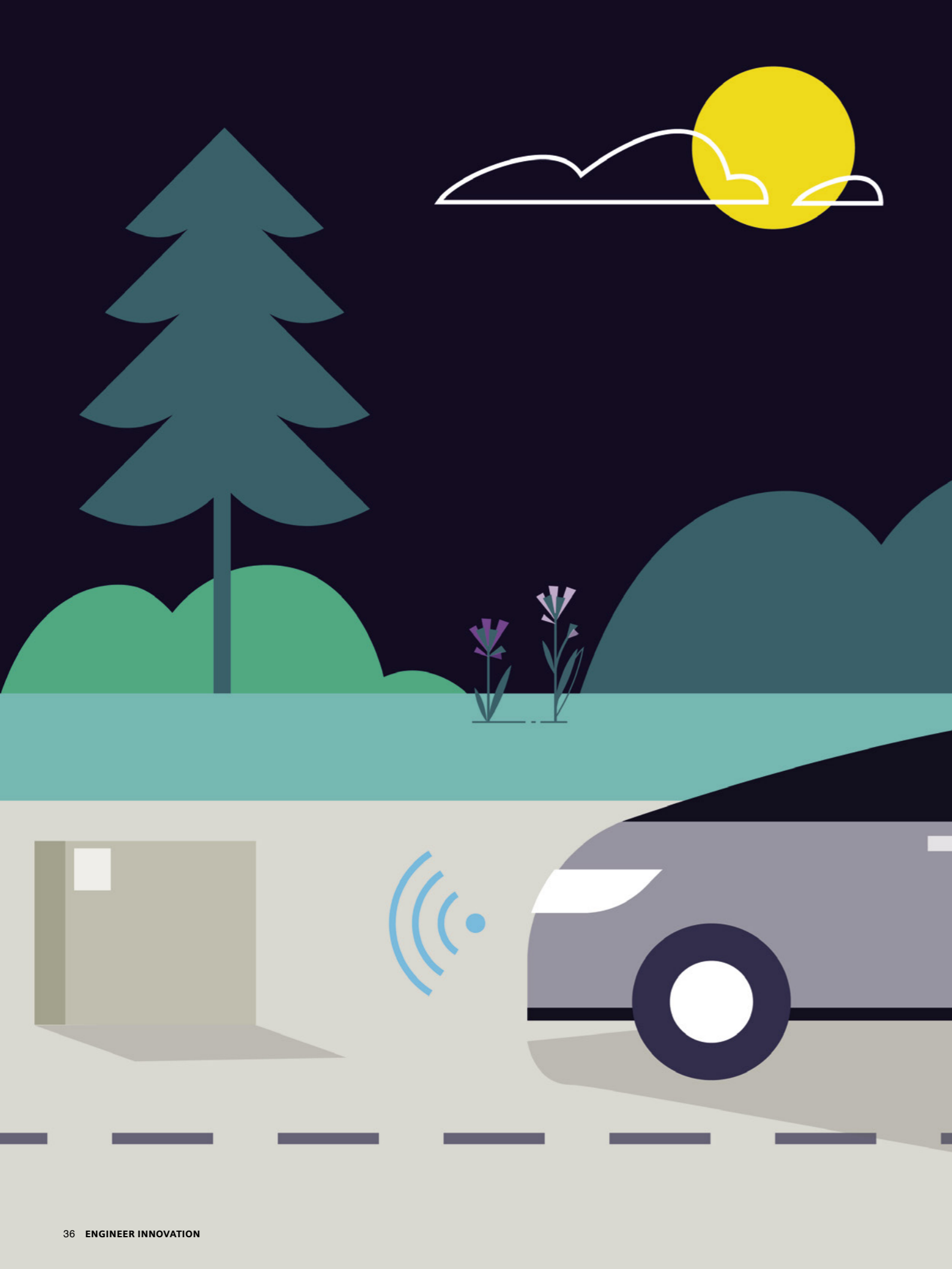
Volvach measured the lift and drag forces in relation to travel speed and different air gaps, coil currents and steel material parameters. The results confirmed that the lift force and drag force are both related to these variables and revealed the optimum number of layers to use. The results were a little surprising. She says:

"The particularly interesting thing we found is that we didn't need nearly as many laminations as we expected, which made our final design much simpler."

Volvach is confident that her model accurately predicts the behavior of the maglev system. The simulation results correspond closely to the results from the physical tests with the difference between Simcenter MAGNET and the real-world experiments ranging between 5% and 10%. Volvach is pleased with the outcome:

"Given that the materials always vary and that there are errors due to physical measurements, and that the model is simplified to make modeling easier, we were very happy to have a difference averaging 7% between the physical test and the simulation."





STAY INTEGRATED

Enhancing autonomous driving with MBSE

How MobileDrive is leveraging the power of model-based systems engineering to build the advanced driver assistance systems of the future

By Luke Morris

Did you know that the global autonomous vehicle (AV) market is predicted to be worth nearly \$400 billion by 2025?

That's not to say that all these vehicles will be driving themselves by then. However, many already have some of the simpler forms of autonomy, such as adaptive cruise control and lane centering assistance. As the market grows, manufacturers are looking to better incorporate advanced driver assistance systems (ADAS) into their vehicles.

FIH Mobile, a subsidiary of Foxconn, built its name in the mobile and wireless communication and consumer electronics markets. In 2021, on seeing the increased demand for autonomous vehicles, they partnered with Stellantis, a leading global automotive manufacturer, to form [MobileDrive](#).

As well as using its existing skills and experience to develop infotainment systems for vehicles, MobileDrive wanted to build its own ADAS to meet the growing demands of the AV market.

A new approach

MobileDrive identified that a model-based systems engineering (MBSE) approach would be key to realizing its ADAS ambitions. This would allow them to capture data from the requirements stage through to development and testing to ensure systems were fully optimized and that they could deliver products of the highest quality.

To facilitate the adoption of MBSE, MobileDrive enlisted Simcenter's expertise. Together, they agreed to focus on six ADAS features: lane keeping assistance (LKA), emergency lane keeping (ELK), lane following control (LFC), auto lane change (ALC), evasive steering assistance (ESA) and autonomous emergency steering (AES).



“Simcenter™ Engineering services gave us a good understanding of the basics, including how to deliver on requirements and how to build the initial architecture,” says Winston Hsu, MobileDrive CTO. “They also helped us to understand best practices for writing and managing use test cases to guide software development.”

Advancing with Siemens Xcelerator

The teams used a range of products from the Siemens Xcelerator platform to meet their goals including Simcenter™ Amesim™ software, Simcenter™ Prescan™ software and application lifecycle management tool, Polarion.

Once market studies had been carried out to define the system requirements and build the models, Simcenter Amesim and Simcenter Prescan were used to define the environment for different driving scenarios. This incorporated various virtual ADAS sensors such as cameras and short- and long-range radar. The features were then tested in a closed-loop framework between the different

software platforms. This digital twin allowed engineers to identify performance issues and address them as early as possible in the development cycle.

Real-time collaboration

Using Polarion, the teams stored all levels of requirements such as use cases, customer needs, OEM needs, and system, software, functional safety, and failure mode requirements. These were used to develop software architecture and software feature requirement specifications that were implemented with Simulink model-in-the-loop testing. Polarion provided the results in a dashboard with real-time metrics on the pass/fail criteria and key performance indicators.

By hosting Polarion on a cloud platform, engineers from both MobileDrive and Simcenter Engineering and Consulting Services team could easily access the software from anywhere and collaborate efficiently and effectively.

Crucially, Polarion’s ability to maintain and capture verification testing allowed MobileDrive to ensure it was compliant with Automotive SPICE and ISO 26262 regulations.

“The MBSE approach provided by Simcenter Engineering and Consultancy Services was extremely successful,” says Burt Chen, MobileDrive project manager. “The functionalities all worked as promised and this gave us the confidence to deliver high-quality software to our OEM.”

Ready to drive forward into the future

As part of the project, the team from Simcenter Engineering and Consulting Services conducted multiple hands-on workshops to train the MobileDrive team in using the new MBSE framework and ensured that everything built in Polarion was integrated into their own development and production environments.

“Simcenter Engineering Services provided us with industry best practices for developing and using MBSE,” says Chen. “We now have a full

understanding of how to accelerate our algorithm and verification activities for product development. Using Polarion also showed us how we can be more compliant and structured in order to meet functional safety standards, such as ISO 26262.”

By using a digital twin, MobileDrive has been able to verify ADAS software features much earlier in the development cycle than if they had to wait for hardware-in-the-loop testing. Ultimately, this implementation of MBSE has resulted in a significant reduction of the time to market of the ADAS product before any physical prototypes were even built.

“MobileDrive’s goal is to be the leading provider of ADAS engine control units,” says Hsu. “Thanks to our partnership with Simcenter Engineering Services, we anticipate that we will be able to bring these to market in a much more streamlined, efficient manner.”





EXPLORE THE POSSIBILITIES

Keeping a new turbine design turning

Siemens Energy uses Simcenter to reduce simulation time from 235 minutes to just 2 minutes. That's over 99% reduction per simulation
By Richard Williams

Developing a new gas power turbine is a challenging task. Rotors spin at thousands of revolutions a minute, which means if you haven't got everything right, your new design could quite literally shake itself apart.

So when it came to developing a new lightweight and efficient power turbine for a new industrial gas turbine aimed at improving emissions and creating a greener solution, engineers needed a way of simulating the dynamics of the rotor.

Bringing down emissions

Siemens Energy is on a drive toward greener power. The group is not only helping its customers meet their growing energy demands but also it is coming up with solutions that can help protect the climate. The company has developed a range of ways to accelerate decarbonization, new methods to help its customers transition toward renewable energy, and has also helped bring down the emissions of components that use more traditional fuels.

Slimming down

As part of this drive toward greener power, Dr. Zhiqiang (David) Meng, technical specialist, and Richard Bluck, head of the compressor rotor group at Siemens Energy, came up with a new gas power turbine concept featuring a lighter structure with more efficient low-blockage struts. Because, when it comes to saving energy, reducing weight is

everything. However, in the world of rotors and turbines, that does bring up a whole host of challenges.

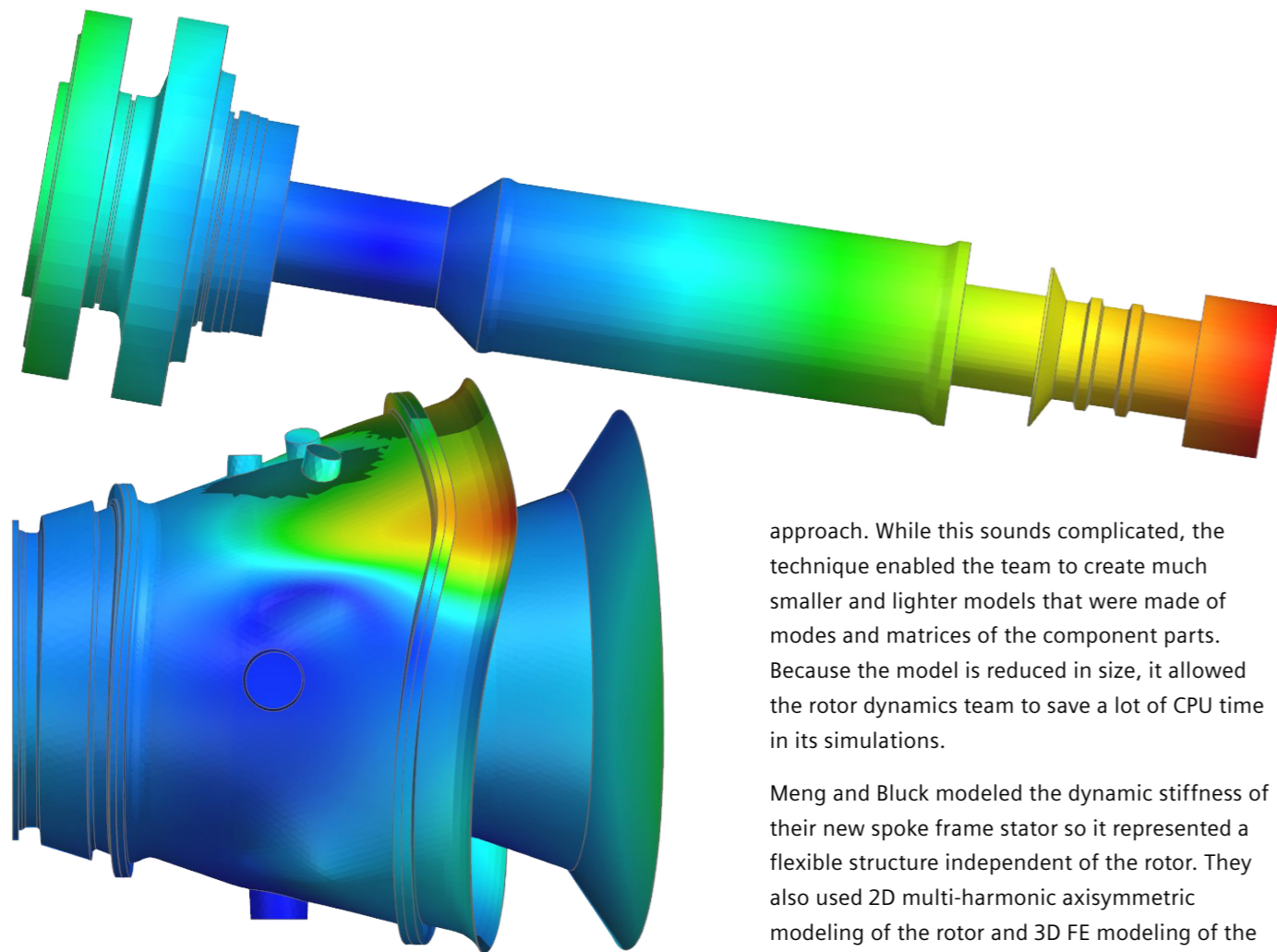
A slimmer and lighter design was key to improving the aerodynamic performance and cost of the new turbine, but a lighter design meant a more flexible structure, which can play havoc with the rotor dynamic behavior if the vibrations are not studied upfront.

Proof of concept

Meng and Bluck needed to carry out detailed simulations to prove the operational safety and efficiency of their new design and to show that the new concept had maintained the operational margin of critical speeds and stability. Not least because the new turbine had to comply with American Petroleum Institute (API) standards.

Traditionally, Siemens Energy used numerous simulation tools, but they faced the issue of the rotor dynamics being only one part of the overall system of the turbine. It had to be integrated with all the other elements to ensure it ran as expected when the complete model was assembled. The challenge Siemens Energy found, was that different departments were using different simulation tools, so integrating the separate models took time and made it difficult to reach the optimum design within a reasonable period.

Things had to change. This time, Meng and Bluck decided to use Simcenter™ 3D Rotor Dynamics software, part of the Siemens Xcelerator business platform of software, hardware and services. Simcenter 3D allowed Siemens Energy to share



models with other teams and make design changes more rapidly while completing the overall product based on precise simulation. It could also support all the necessary calculations.

Simulating success

A heavy, thick stator design of traditional gas turbines provide structural support and constant stiffness but moving to a lighter, more flexible concept meant Meng and Bluck needed to know if the materials would flex. Since, if the materials flexed, they would have to consider problems associated with resonance frequencies. Different materials and designs have different resonances therefore a change in either or both can be detrimental to the stability of the final product. To ensure the turbine is functioning perfectly, Meng and Bluck had to identify the rotational speeds at which resonance occurs to avoid or limit resonance as much as possible.

Simcenter 3D enabled Meng and Bluck to use a component mode synthesis (CMS) super-element

approach. While this sounds complicated, the technique enabled the team to create much smaller and lighter models that were made of modes and matrices of the component parts. Because the model is reduced in size, it allowed the rotor dynamics team to save a lot of CPU time in its simulations.

Meng and Bluck modeled the dynamic stiffness of their new spoke frame stator so it represented a flexible structure independent of the rotor. They also used 2D multi-harmonic axisymmetric modeling of the rotor and 3D FE modeling of the stator to create a complete model of both parts. The pair were also able to identify resonance frequencies and simulate amplitude vibrations.

Teamwork

Siemens Energy did not take on this project alone. The support provided to Meng and Bluck kept the project on the right track. While the team had to learn Simcenter 3D they were not only provided all the tutorials they needed but also engineers from Siemens Digital Industries Software were accessible, and the design team were quickly able to fully understand the capabilities of Simcenter 3D Rotor Dynamics and prepare highly accurate simulations.

“Siemens Digital Industries Software support was fantastic throughout the project,” said Bluck. “Not only did they help us get started with a new product, but they provided expertise whenever we needed it.”

A 99% CPU reduction

The results for this project are quite staggering. Meng and Bluck say the use of the super-element

model meant that each simulation could be completed in just two minutes compared to 235 minutes when it was not used - a reduction of more than 99% in computation time, and that is per simulation. Additionally, the rotor dynamic analysis of the combined rotor and stator model showed that with the lighter and slimmer spoke frame, the power turbine still met all API requirements while delivering both cost and performance benefits.

Timely turbine

The adoption of Simcenter 3D led to the successful verification of a more efficient gas power turbine design much faster than would have been previously possible. Not only were Meng and Bluck able to make new and better calculations, but it also enhanced collaboration across teams as they were able to seamlessly share models with other departments, streamlining the process of integrating the new stator support structure design with the complete power turbine.

“Using Simcenter 3D Rotor Dynamics made it much easier to share models with other teams,” explained Meng. “We were able to make design changes much quicker and finish the overall product based on accurate simulation.”

Rotating future

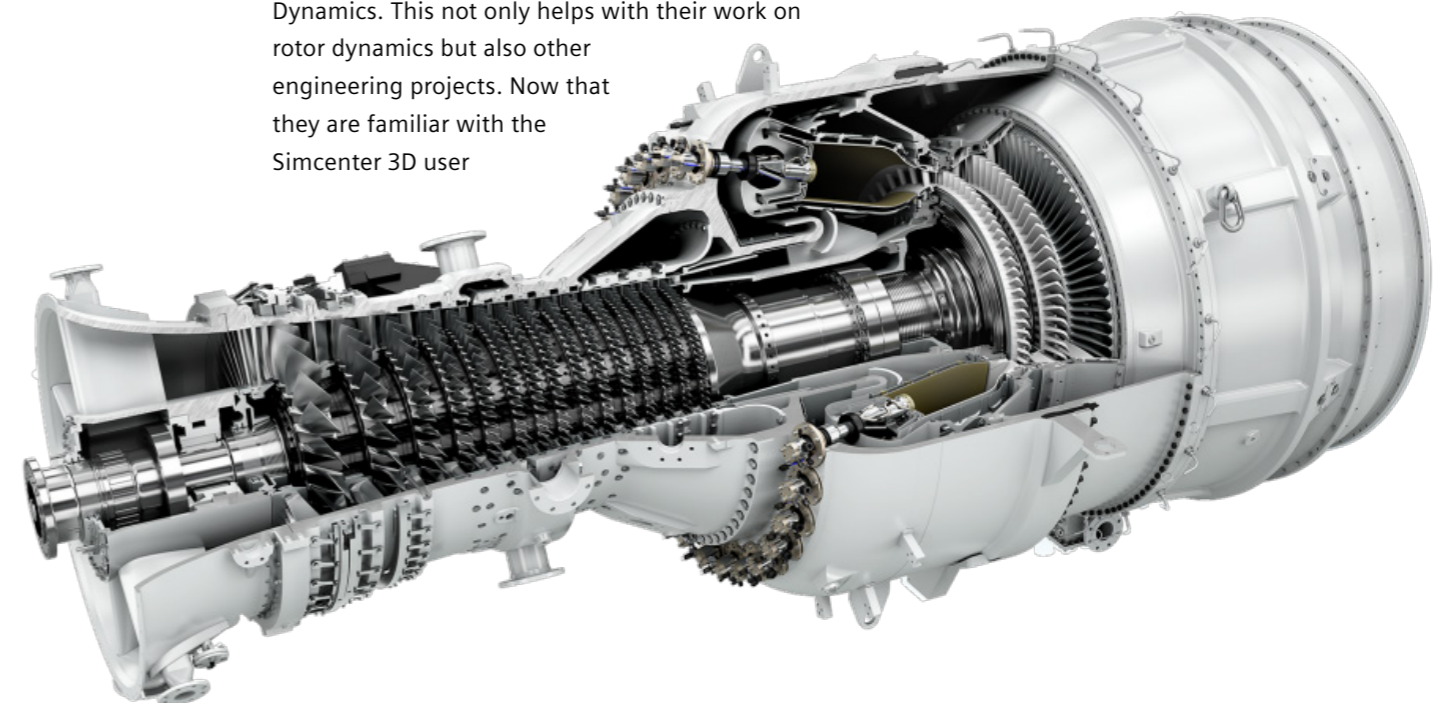
As part of the project, 20 engineers at Siemens Energy have been trained in Simcenter 3D Rotor Dynamics. This not only helps with their work on rotor dynamics but also other engineering projects. Now that they are familiar with the Simcenter 3D user

environment they can more easily transfer their skills to other Simcenter 3D packages that are used throughout the organization.

Introducing multiple engineering teams to Simcenter 3D is also advantageous to the rotor dynamics team since they can now call on colleagues to help meet tight deadlines. Previously, it would have taken too long for them to get up to speed on the simulation solution to make it worthwhile. Now as more engineers become familiar with Simcenter 3D, they don't need to learn a new package because the overall environment is the same. They only need to learn the functionality that is specific to rotor dynamics, which can be picked up much more quickly.

Tomorrow's benefits

As Siemens Energy increases its use of Simcenter 3D, the company will continue to realize more benefits as it develops a more dynamic and agile team. The company expects to benefit from the increased ability of engineers to collaborate more easily, enabling them to seamlessly shift between projects. Ultimately, using Simcenter 3D will help deliver even better products faster, enabling customers to meet their efficiency and decarbonization targets sooner.



Q&A



INTERVIEW

Breathing life into the digital twin

Daniel Reed from MxD talks to us about advancing technology with the digital twin.

By Luke Morris

MxD is a not-for-profit public private partnership that matches \$1 of federal investment with \$1 of private industry investment. Its aim is to advance digital manufacturing technology for the entire manufacturing sector across the USA.

We spoke to Technical Program Manager, Daniel Reed, about how MxD helps businesses and how they built a digital twin that's revolutionizing the production and use of medical devices.

Can you tell us a bit about what you do at MxD?

Our focus is around digital manufacturing, cybersecurity and the digital thread. Today I'm in our 22,000 square foot **future factory** space in Chicago. Here, our members bring some of their most advanced technologies to showcase it and teach others about it.

We also have a lot of the projects that MxD scopes, funds and executes on the factory floor. We have a real variety here – everything from demonstrators for educating the public about manufacturing, to our advanced wireless testbed where companies can test their products on every kind of wireless protocol available.

We host events here too, so it's a truly multifunctional space.

It's certainly very different from a traditional factory, isn't it?

Absolutely. The old image of a factory is a dirty, dangerous place, but this is far from that. It's bright, gleaming and shiny. Modern factories are very advanced and combine both physical manufacturing technology and digital data technology. Collecting and understanding data about their operations is what's going to give manufacturers a competitive advantage. It's used to drive insights and decision-making and enhance automation. That's not about replacing humans but automating the more dangerous or dirty jobs so people can focus on more important activities and improve overall efficiency.

So, how do you go about helping businesses collect operational data?

Most factories have been around for decades and it's not feasible to buy all new digitally enabled equipment. So, we show companies how to attach something as simple as sensors to their legacy equipment without making any direct changes to processes.

For instance, we pointed a webcam at an analog dial gauge and used visual recognition and Python code to translate the image into a digital reading of the dial that is recorded.

Another example is a Bridgeport milling center that we've added sensors to, allowing us to track the status – is it on or off? Is it cutting? Is it waiting? Is it spinning but not cutting?

By capturing this data, a manufacturer can gain a lot of insight into machine usage. This drives

decisions such as whether it should be upgraded, replaced or even removed if it's not being used often.

OK, let's talk about digital twin models. First of all, what's your definition of a digital twin?

I think of a digital twin as a simulation that's enhanced with the data from the real world – in this case, from those sensors that we just talked about. Without that data, you can't perfectly simulate the real world. The digital twin improves simulation by capturing data from the real physical system and learning what normal operation looks like. You can then use that enhanced model to understand all kinds of different things with simulations.

Normal operating conditions change throughout the life of a product, so you can use a digital twin to see how it will behave in different scenarios. If you decide you want to use it for something slightly different, you can test the viability first. Which brings us nicely onto our Lungs in the Loop demo.

Yes, we're excited to learn about this! How did the project come about?

In the early days of the COVID-19 pandemic, there were huge numbers of patients showing up to hospitals with respiratory issues. The nation's stock of ventilators was much lower than required, but these are complicated medical devices – you can't just quickly produce thousands of new ones.

The existing ventilators weren't approved for use by more than one patient on each, but doctors were having to make difficult decisions when

patient numbers were at their highest. As they'd never been used like this before it was impossible to say when it was or wasn't safe to have two patients attached to the same ventilator.

We partnered with Siemens to take a holistic look at the product design of a ventilator. We built a digital twin of the machine operating with both one and two patients attached. We then ran simulations to show which scenarios were safe and which weren't. We then detected anomalies that were occurring and identified potential patient deterioration in certain situations. Ultimately, this enabled us to prototype a redesigned, improved ventilator in a much quicker timeframe.

[Watch video now](#)

What does this digital twin look like?

It's essentially a one-dimensional simulation of the ventilator operation and how gas flows through it. We took the operating conditions of the system and then put sensors in the operating line at critical points to see how much air or breath was flowing in real time. So, by using data from the real physical product and then simulating airflow, we were able to see how it performed based on its expected operation conditions.

We call this a live twin as it's running in real time along with the digital twin. For the physical system we used lung simulators to simulate the patients' breathing. We had a device that introduced a small leak into the line so we could confirm this was detected and an alarm was triggered.



"We partnered with Siemens to take a holistic look at the product design of a ventilator. We built a digital twin of the machine operating with both one and two patients attached. We then ran simulations to show which scenarios were safe and which weren't."

Daniel Reed



Our simulations showed that for two patients to be ventilated on the same machine, they must be in similar lung condition. Their lungs must be able to take in air at the same pressure. With the physical system we simulated one patient getting sicker and not getting enough air, but the ventilator didn't understand this as it wasn't designed to work that way. However, the digital twin understands it as it's learned over time what normal operating conditions look like. It could then produce an alarm saying that you may need to move one of the patients.

Presumably, the more operational data you gather, the better insights you get?

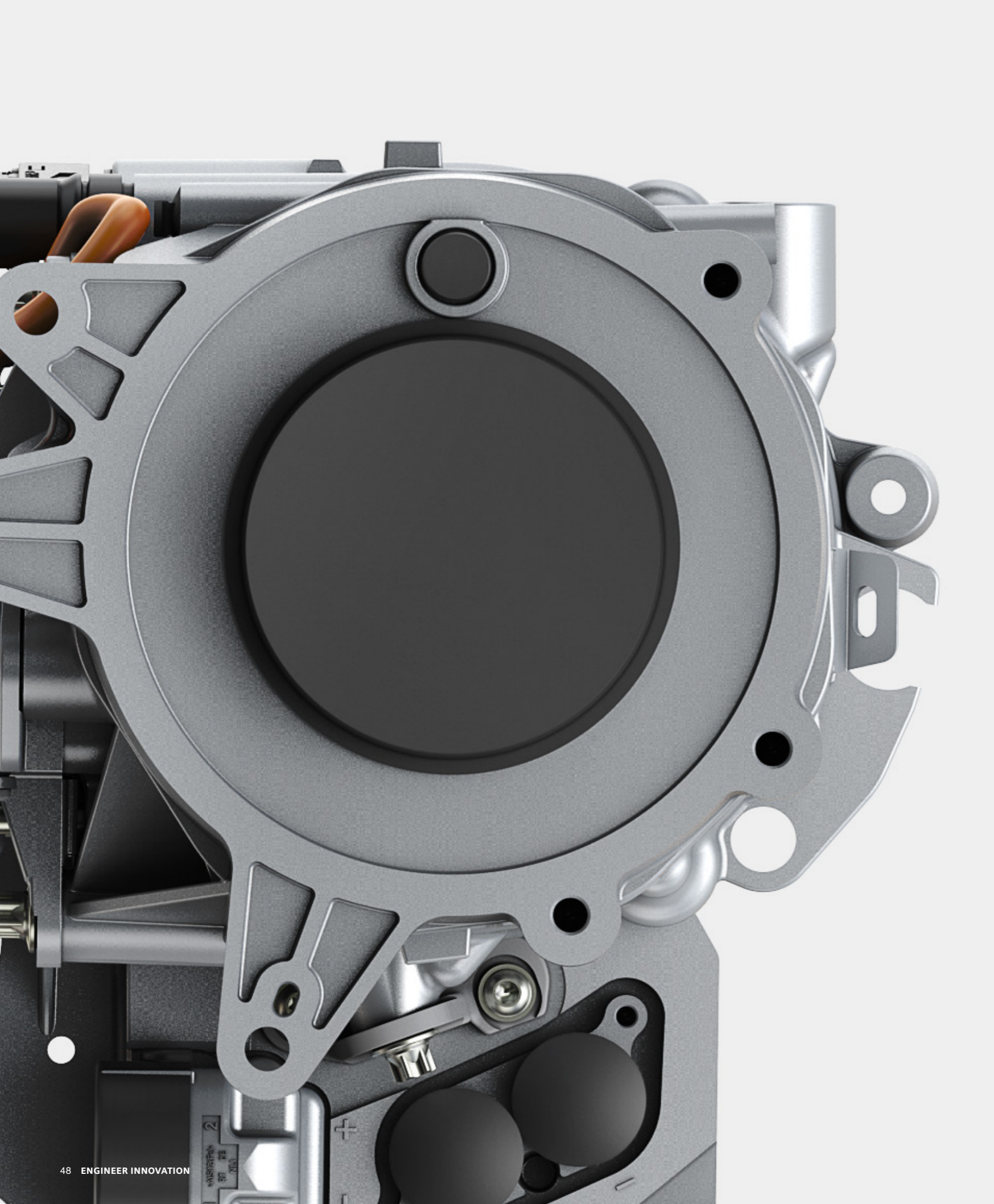
Yes, if you deploy the digital twin across an entire fleet then you can collect even more data to help with predictive maintenance, you can then spot the signs that a machine is approaching breakdown and intervene before it affects performance. Designers can learn from the data too by seeing how it operates in different conditions and take all the learnings to apply to future designs.

This is very sensitive data though, as it's real people's health information. We need to extract the value from it without risking patient privacy. That's why cybersecurity is a key part of what we do too.

Thanks for sharing your experiences with us, it's really interesting to learn about the work MxD is doing. Finally, what are your thoughts on the future of the digital twin?

Simulation technology is evolving fast. Previously, we needed dedicated computing resources but now you can run simulations on a laptop or even a cell phone. And digital twin models I think are on the same path, albeit slightly behind.

Digital twin models started as completely physical copies of live systems, which is obviously incredibly expensive. But as computation costs come down and technology advances, we're able to do more and more virtually. This will enable even more experimentation in the future and I'm sure we'll see impressive results across a wide range of fields.



MODEL THE COMPLEXITY

A GKN Auto Success Story

GKN optimizes EV inverter performance to offer a competitive product, enhance driving experience and increase driving range.
By Randall Newton

Automotive manufacturing is engaged in a paradigm shift towards electric vehicles (EVs). GKN Automotive intends to be a leader in that shift. The company is recognized for its expertise in optimizing electric drivetrain components.

Using Simcenter™ Amesim™ software, GKN Automotive has streamlined its development processes, significantly reducing time-to-market and the need for costly prototype iterations.

Almost 50 percent of new cars worldwide feature GKN Automotive systems and solutions, which means hundreds of millions of cars with GKN Automotive technology are driven everyday.

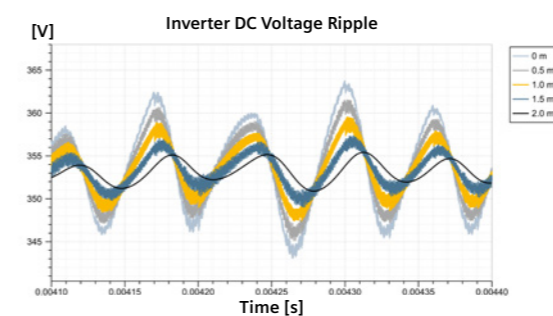
Optimizing inverter performance

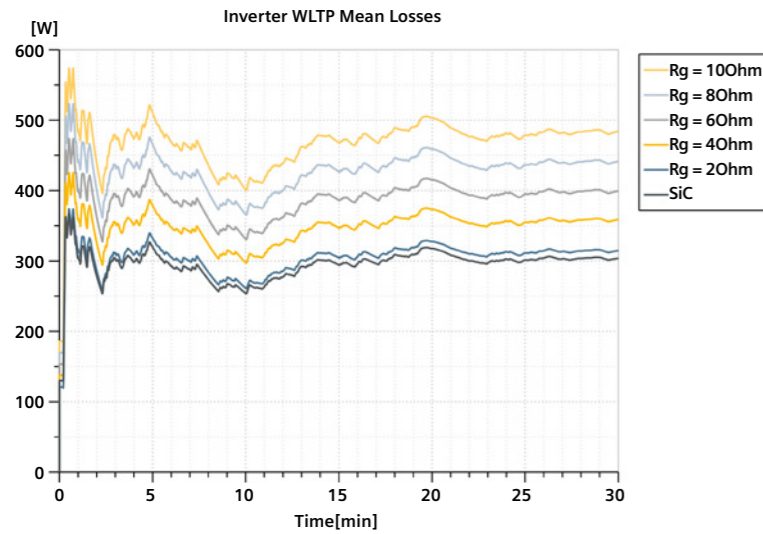
Developing new designs for high-performance EV inverters is a challenging task. The company realized that optimizing inverter performance was essential to offer a competitive product, enhance the driving experience, and increase the EV's driving range.

Inverter development is centered around the 3-in-1 system, comprising a gearbox, an electric machine and a traction inverter. This transition from mechanical to mechatronic design posed unique challenges, particularly concerning the inverter, the most complex and costly component of the 3-in-1 system. The inverter had to provide the required power, ensure efficiency and remain cost-effective.

In most cases, vehicle manufacturers regard the 3-in-1 system as a black box, delivered as a single, complete solution. In the case of GKN, the gearbox hosts additional features, such as park lock or disconnect systems as well as the basic gear set. The inverter provides the electric machine control functionality.

Suppliers such as GKN must therefore have the ability to deliver components that meet the design and performance specifications set by customers.





"We faced engineering challenges to change from mechanical to mechatronic design," notes Björn Nemitz, a system engineer at GKN ePowertrain. This shift in design philosophy is both a challenge and an opportunity. Poor design decisions can have a massive negative impact on cost and performance. At the same time, well-considered and carefully implemented decisions on interfaces and internal design can lead to significant performance improvements and cost efficiencies.

GKN relies on Simcenter Amesim software, part of the Siemens Xcelerator business platform of software, hardware and services, for developing and optimizing its traction inverters for electric vehicle 3-in-1 systems.

GKN Automotive was able to utilize Simcenter Amesim's capabilities to conduct comprehensive

analysis across multiple product dimensions, including thermal, electrical and mechanical aspects.

Simcenter Amesim allowed GKN Automotive to simulate various aspects ranging from semiconductors to the entire 3-in-1 system. The team analyzed static and dynamic load cycles, electromagnetic compatibility scenarios, safety, failure analysis and complex lifetime cycles.

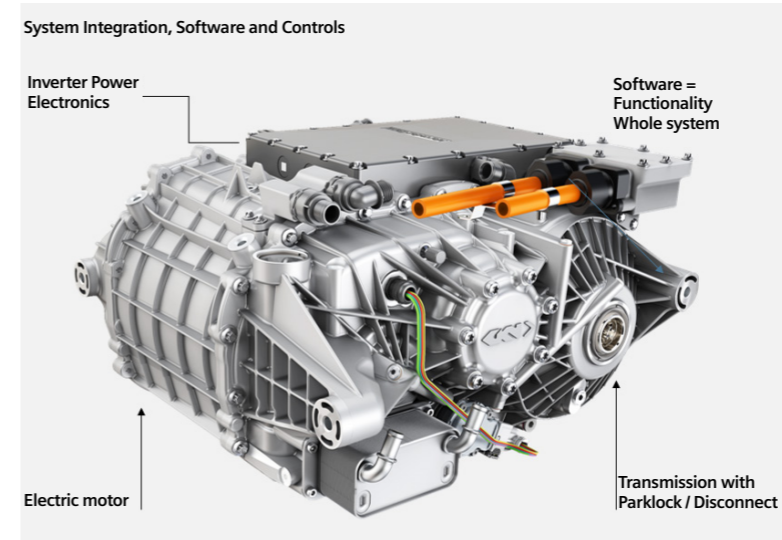
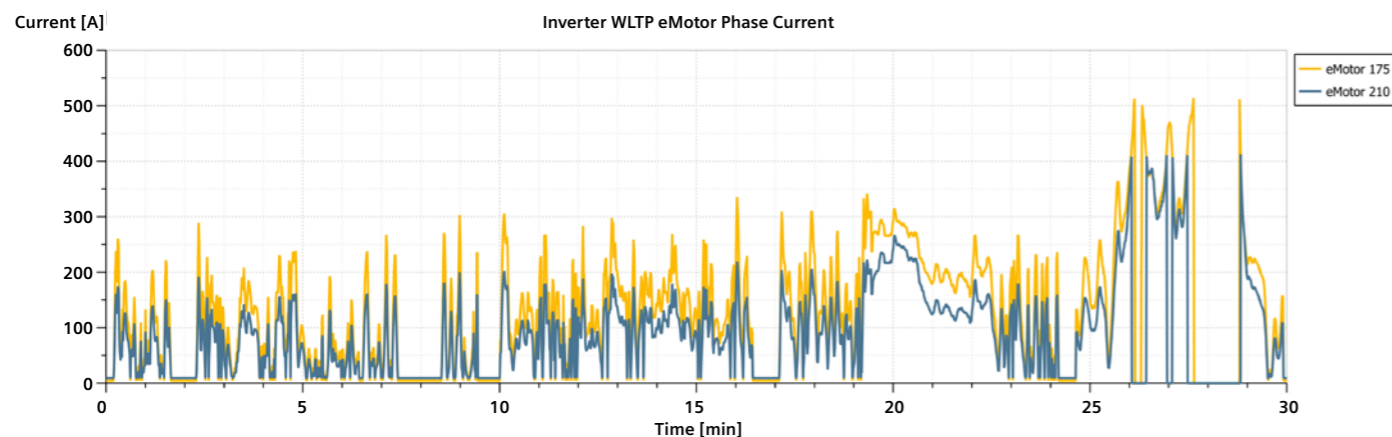
The ability to create models representative of real systems significantly reduced the reliance on physical tests. Simcenter Amesim's capabilities translated to fewer hardware-in-loop tests and prototype loops, enabling quicker and more cost-effective development processes.

"Simcenter Amesim has helped me to expand my technical expertise regarding the individual components and the system as a whole," says Nemitz. "I now have a much better understanding of the physical behavior of the components and how they affect each other."

Driving the future of electric vehicles

GKN Automotive says the successful implementation of Simcenter Amesim has revolutionized their design and development processes. The platform has provided the depth of detail and complexity of analysis needed to optimize the inverter's performance while minimizing overdesign and slashing development costs.

GKN Automotive's adoption of Simcenter Amesim underscores the tool's utility in navigating the



automotive industry's transition from combustion engines to EVs.

Through multidimensional simulations, GKN Automotive has enhanced their understanding of how components interact and affect each other. This knowledge is pivotal in making informed decisions early in the development process and aids in producing cutting-edge eDrive technologies.

Nemitz says operational capabilities to be tested can be as complex as needing to solve for a fully loaded vehicle with a trailer, operating at -40 Celsius (°C) ambient temperature, on a steep hill with a nearly depleted battery. Designers must adjust parameters to find the optimum distribution of load between the interconnected components. Nemitz and his team rely on the variety of tests possible in Simcenter Amesim to make sure they achieve an optimal solution.

"GKN has developed standardized models and processes to use in the product development cycle," comments Nemitz. "That way we can use the simulations for each project right from the start and have a validated base for our design and development."

As the automotive industry continues to evolve, GKN Automotive's reliance on the digital twin model facilitated by simulation technologies will be a key factor. This approach will enable GKN Automotive to rapidly design and produce high-performance EV components at lower costs, further solidifying their position at the forefront of the eDrive technologies market.



Simulating a Printed Heat Exchanger

By Nigel Ravenhill

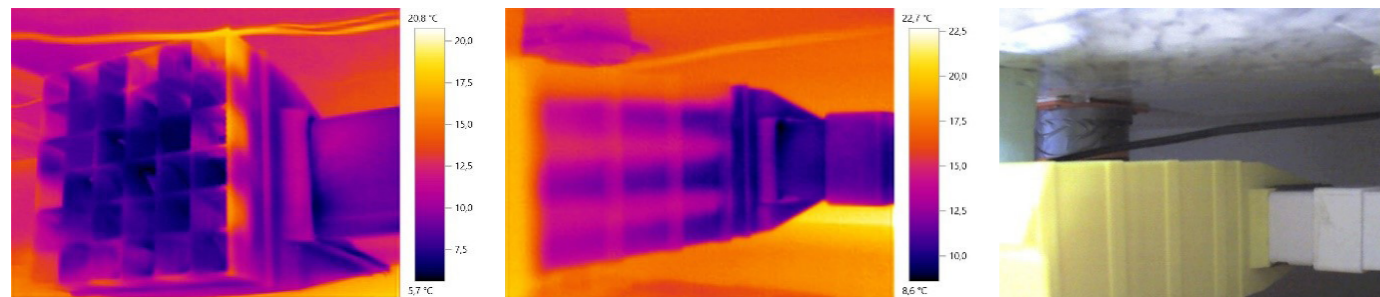
A solution to rising home energy costs in Europe could well be a combination of curiosity, patience and Siemens' portfolio of design and analysis software. At least for Siemens Engineer Matthias Duerr.

During the past 18 months, the manufacturing technologies and automation expert has been prototyping a heat exchanger design for his house. It's been a trial-and-error education as he has progressed from Computational Fluid Dynamics (CFD) newbie to increasingly confident and competent non-expert.

Duerr's self-made challenge was to improve the energy efficiency of his 1970s home without incurring major expense or necessitating extensive remodeling. Installing a central regenerative ventilation system—while desirable—would require far too much renovation work and invasive piping. To meet his goals of relatively low cost and minimal structural impact, Duerr identified small room-sized recuperative ventilation as the technology area he needed to study and pursue.

Trial #1: Early Failures

Duerr's initial prototypes were both failures and lessons. Built in a basement lab he had outfitted with 3D printers, thermal imaging and other gadgets, these counter-flow heat exchangers proved too bulky and ineffective.



An early heat exchanger (left-to-right): Cross section. In-operation. What it really looks like



Swirler as used in gas turbines as shown at the 2015 Hanover Fair

Lessons from University

Reflecting on aerodynamics lectures from his university days, and later gas turbine projects as a professional, Duerr recalled that heat exchanger efficiency improves as wall thickness decreases and a certain type and amount of turbulence is brought in. To avoid creating a laminary flow in which heat exchange is limited to the outside layer (or lamina), his design needed to spin and rotate air while varying the cross section.

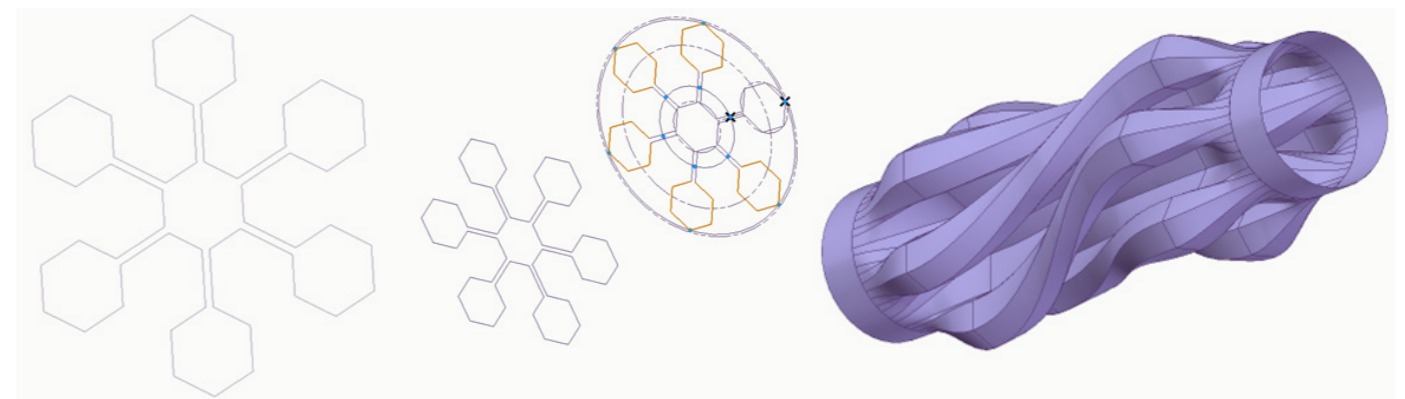
Trial #2:

Most 3D printing software used for the slicing of designs provides a mode called "Spiral Vase". Using "Spiral Vase" you can quickly print a single-layer surface (approx.0.4mm thick). Shapes that gradually change (like aerodynamic designs) can be very accurately rendered. Duerr used Siemens' Solid Edge CAD software to define a single body, which, despite having only a single cross section, includes a high surface and several channels to guide the flow.

Once printed, the Spiral Vase design was inserted into its airflow container, a PVC wastewater pipe connected to two bilge blowers. Several thermometers were attached to measure temperature while an anemometer measured air speed. Duerr crossed his fingers and let the air flow.

"I was both disappointed yet satisfied. The incoming air, traveling about 5m/s, rose 5°C while passing through the heat exchanger. Better than opening the window but not very impressive. As my first real attempt, though, I was satisfied and

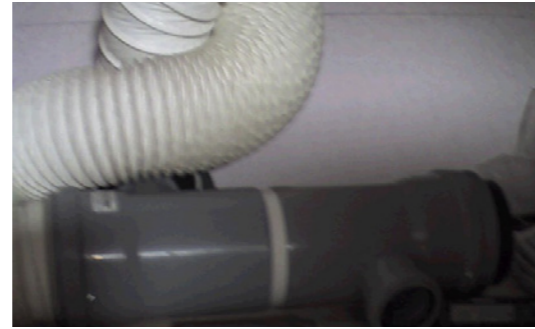
"I found that I had fallen into the same trap as I had on previous occasions, too focused on designing for 3D printing and not freeing my mind of the limitations of traditional manufacturing, such as common extruded plastic profiles where the manufacturing process does not allow for undercuts and changing cross sections. 3D printing largely doesn't have to deal with them. The design approach could follow a much more physics requirement rather than be limited to tubing catalog options from suppliers that utilize traditional manufacturing processes."



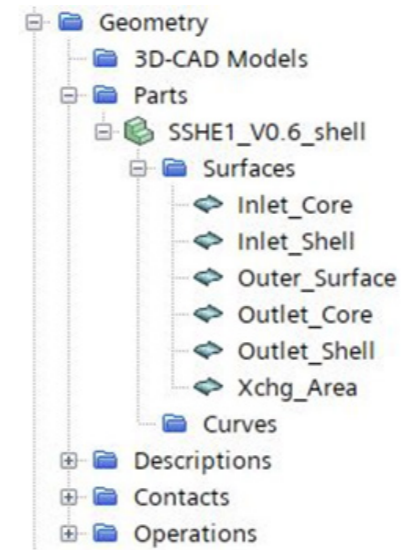
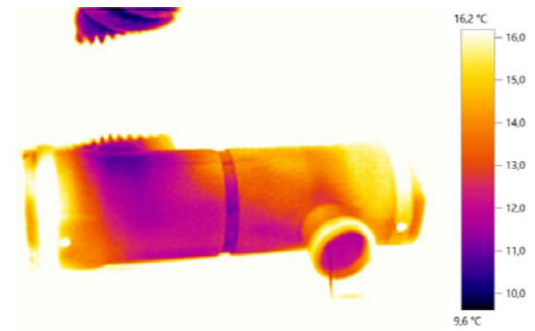
Spiral Vase design for a heat exchanger surface



3D printed heat exchanger



Test in operating environment



volume mesh and thus energy and matter exchanges between adjoining bodies. Consequently, there are requirements for the congruency of adjoining surface meshes to align structure of the surface meshes that are addressed by the imprint function.

After disassembling the CAD data into surface meshes, re-assembling them and adding end caps, the result was two adjoining “regions” which circumscribe the respective fluid volumes:

1. Outward Flow: The stream of initially warm exhaust air within the exchanger surface.
2. Inward flow: The stream of initially cold fresh air between the exchanger surface and outer cylindrical wall.

How Does Simulation Happen?

Essentially, you have to fill the “regions” with a static volume mesh consisting of cells. Calculations for energy and matter exchanges between cells, etc. are then performed for each cell in each simulation cycle. To advance from describing geometry to this point, Duerr needed to provide more input, specifying different criteria such as orifice type, physical behaviors and properties.

He later learned from a much more knowledgeable colleague that his somewhat casual selection of inlets and outlets without specifying velocity only made another somewhat unusual design decision work: the use of a single “continuum” for both inward and outward flow. A more experienced CFD enthusiast would have chosen two continua (specifying what’s in the fluid volumes) respectively, allowing for opposing initial flow velocities.

The volume mesh, however, was still missing. Decisions about the appropriate level of detail of the simulation needed to be made because the physical effects in different parts of a flow vary; life is much more turbulent for the fluid at the boundary between a fluid and a solid than in the middle of a laminary flow, for example.

In highly turbulent areas, more (read: smaller) and better adapted cells are needed. While the shape and size of the cells are not physics properties, they affect the accuracy of the simulation to the

immediately began to think about improvements. How could I modify the exchanger pattern? What about adding more and smaller quasi-channels or improving distribution over the cross-section area? How would more length and twisting, or better conducting material and outer insulation help? I had a lot of questions to answer.”

As Spring approached, Project “Heat and Cool My House for Less” went into hibernation as Duerr took a break.

An Education in CFD

Duerr’s paused heat exchange project restarted when he decided to explore 3D flow simulation through Siemens’ Simcenter™ STAR-CCM+™ CFD tool, part of the company’s broad portfolio of simulation software covering applications as diverse as CFD, computational chemistry, electromagnetics, automation and process workflows.

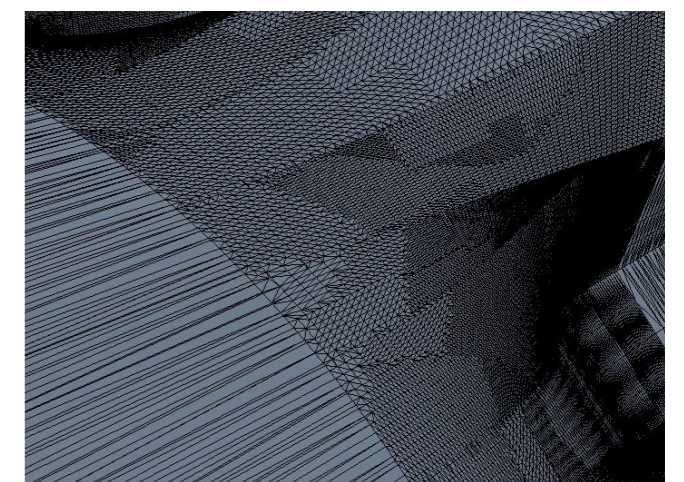
Like any new software user enthusiastic about progress, he started with tutorials. Several tutorials into his CFD apprenticeship, though, he already understood the clear difference between CAD and CFD software; CAD programs are used to design tangible objects, whereas CFD tools are for

designing fluid bodies and describing their boundaries, properties and relations.

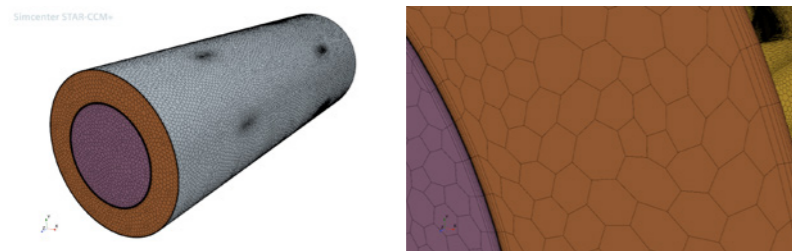
CAD data can describe the outer shape of fluid bodies, but surface meshes are what really matter when working with fluid bodies. While programs like Solid Edge can easily convert CAD data into surface meshes, how you work with these meshes is critical—and what ultimately advanced Duerr’s heat exchange simulation.

The body imported from CAD is split into several surfaces, which are then used to assemble the fluid bodies, parting walls, fins, etc. In Duerr’s model above, the hollow shell of the heat exchanger is a perfectly complete part of a CAD model. In his CFD context, though, “end caps” (inlets and outlets) had to be modeled to fully close the fluid space.

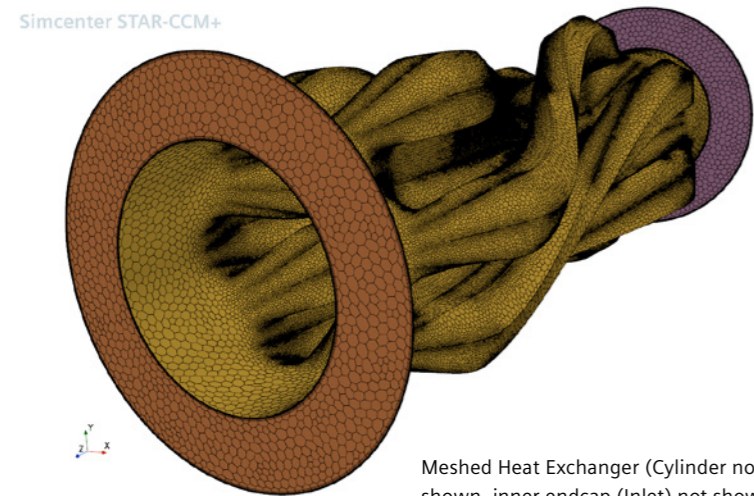
The body defined by the surface meshes resembles what is known within the 3D-printing community from STL- and 3MF-data, also involving criteria such as watertightness, and surface orientation. There are key differences: the surface mesh in 3D printing is not required after slicing, whereas the CFD structure of the surface mesh influences the generation of the fluid body’s



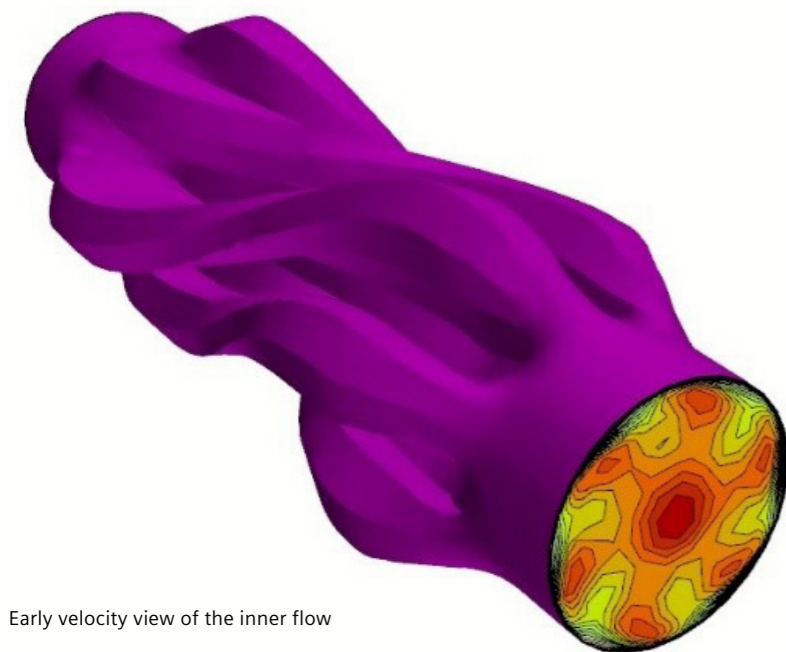
Editor for meshes (with exchanger surface and “endcap”) and a close-up of a complicated junction



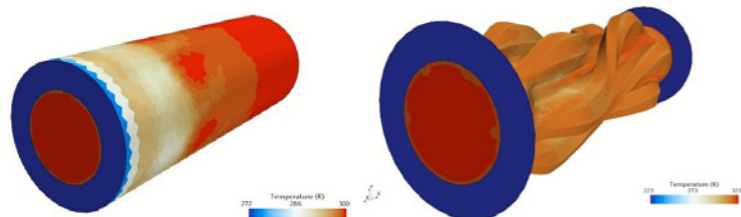
Meshed Heat Exchanger (Cylinder shown); detail showing 2 types of mesh and 3 boundary layers



Meshed Heat Exchanger (Cylinder not shown, inner endcap (Inlet) not shown)



Early velocity view of the inner flow



Left: Cold from the outer inlet reducing down the cylinder's skin temperature, while the pressure begins to move the fluid. Right: No exchange of heat. Oops!

prevailing physical effects. Hence, there are several types of mesh generators to choose from, manually, if the automatic selection needs to be overridden by an expert. Finally, Duerr had to describe the applicable physics models because there's a clear difference between a supersonic flow and a gentle breeze (much closer to his heat exchanger speed).

Trial #3:

The art of creating a useful simulation is to abstract and simplify the problem to such an extent that real-world hardware can generate a meaningful result reasonably quickly, say, in the time required to make an espresso compared to a 3-day ski weekend in Garmisch Partenkirchen.

Much like a sculptor chooses what to remove and what to leave, the CFD aspirant must decide what to select, approximate and ignore. How did Duerr then cope, not being an aerodynamics engineer?

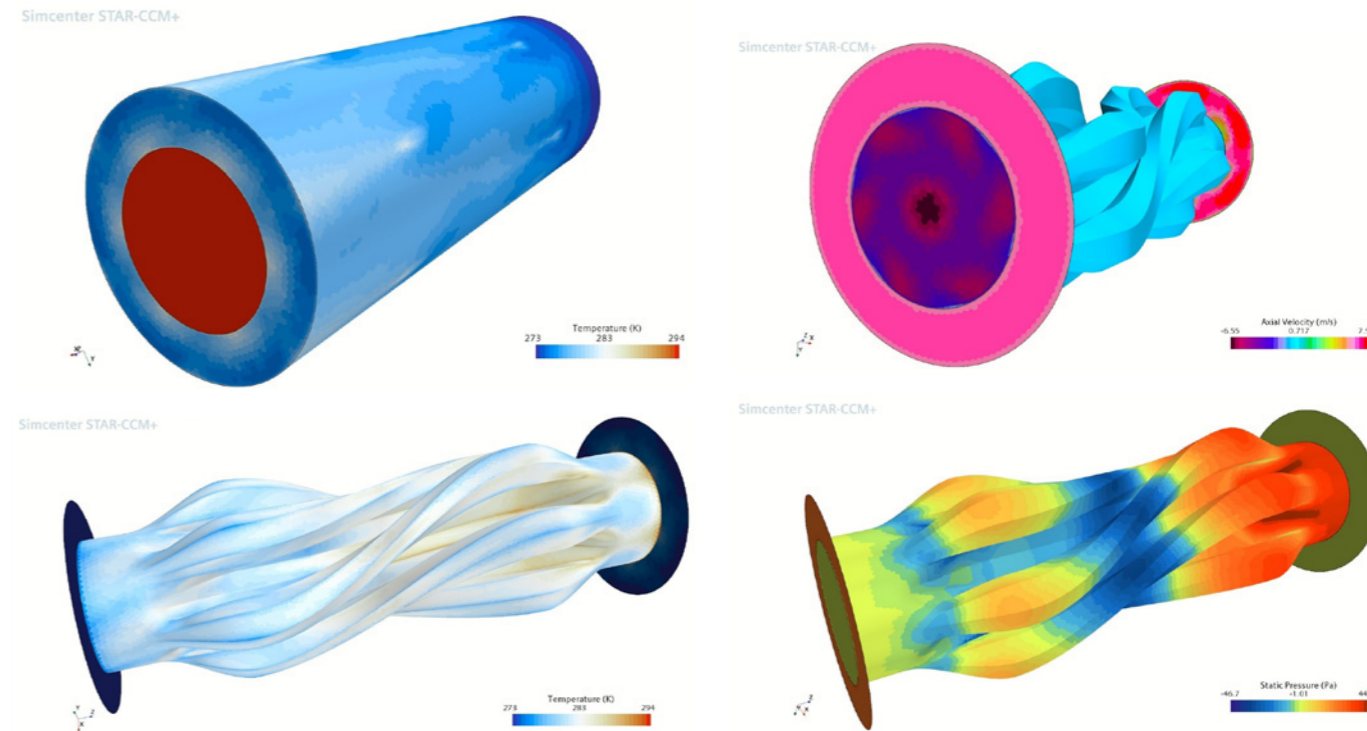
"Quite frankly, I began by copying the settings from a very basic tutorial—not an optimal solution but it permitted me to create my very first working model. Based on this, I started to modify the physics models and the mesh, playing with different turbulence models, boundary layer thickness and surface roughness, whilst bearing in mind the indicative measurements from the test setup. I was able to see where differences occurred (and what stretched my workstation to its processing breaking point). After some more minor preparations, including defining velocity, speed, temperature, I started the whole thing and watched."

The Necessity of Describing Your Work

It wasn't long before Duerr identified an obvious error; failure to describe the heat transfer. The two volumina were ignoring each other. The error was a "bad setting" caused by only specifying an aerodynamic property so there was no heat loss or gain on the heat exchanger surface. The correction was to identify the surface as a "baffle", fulfilling its role as an interface.

Progress Through Iteration

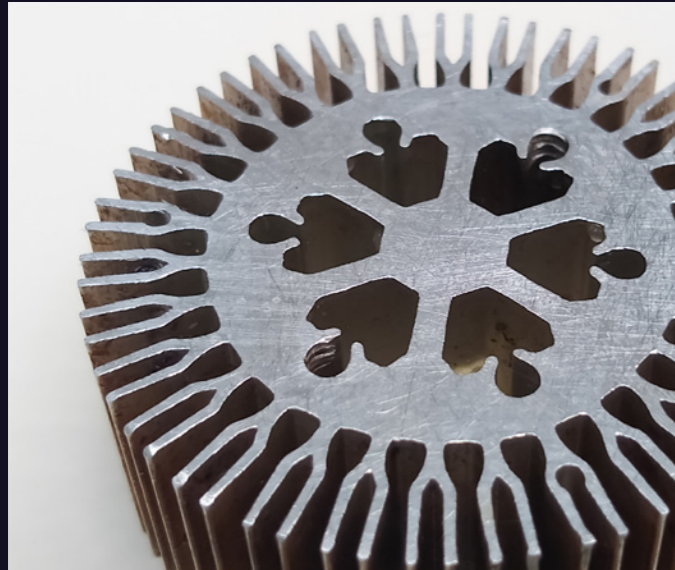
As Duerr's CFD knowledge has grown, he has continued to test other parameters and introduce



more variables such as decreasing volume flow, raising the temperature difference or replacing the material from plastic to aluminum. As a CFD professional, this is the point where the benefits (cost-savings, etc.) from avoiding making lots of physical prototypes would become patently obvious, including running multiple "what if?" scenarios.

After 18 months, tutorials, clarifying questions to colleagues and many simulations, Duerr has become a serious CFD amateur. Siemens' Simcenter STAR-CCM+ has enabled him to skip building physical prototypes while testing dozens of configurations. In his pursuit of a cozier house in winter and a cooler home in summer, Duerr's simulation journey has shown that learning never stops for a curious engineer.

“Quite frankly, I began by copying the settings from a very basic tutorial—not an optimal solution but it permitted me to create my very first working model.”



Test 1 - Heatsink

BROWNIAN MOTION

The random musings of a Fluid Dynamicist

From Creative Cat to Creative ChatGPT

With the rather boisterous appearance of ChatGPT, there has since been a lot of discussion, soul-searching and, dare I say, hype about what it means for us, our careers, our leisure time and for humans in general!

The chatter hasn't passed me by, and I have been considering what it means to me as a marketer. Will ChatGPT make my job redundant? Despite it still being in its infancy, I've already seen how well it can create content that would take me days. Since being good with words is something we in marketing pride ourselves on, will it eventually write better marketing content than any trained marketer?

How clever is Chat GPT?

There have been many, many ChatGPT experiments. My favourite so far has been a comedic talk-show, who told the audience at the

beginning of the show that Chat GPT wrote one of the jokes that would appear that evening. At the end of the show, the audience had to choose which joke that was. Amusingly, the audience got it wrong! So already, the tool is fooling us.

What do humans have over ChatGPT? I hope that humans have a creative edge over this type of AI. We are not always logical, which means that we walk a more colorful and creative path. I decided to test the creativity of Artificial Intelligence, so this is my ChatGPT experiment. It tests not only the technical knowledge of writing a crochet pattern, but also creating a 3D design through the patterns.

Test 1 – Heatsink

'ChatGPT, create me a crochet pattern for a heatsink.' At this point the engine warned me that it would not work as an actual heatsink as it was made of yarn. Having confirmed I was aware of the limitations of a yarn-based heatsink it went on to write a pattern.

Creating a crochet pattern for an optimized heatsink may be challenging as crochet is primarily used for creating fabric and decorative items. Heatsinks, on the other hand, are typically made from metal or other conductive materials to dissipate heat effectively. Crocheting may not provide the necessary thermal conductivity required for an efficient heatsink.

If you're looking for a decorative item inspired by a heatsink, such as a coaster or a trivet, I can help you with that. However, please note that it won't function as a real heatsink. Let me know if you'd like me to provide a crochet pattern for a heatsink-inspired decorative item.

I was touched to see it give me a warning after the pattern as well. it seemed genuinely concerned for my well-being:

Your heatsink-inspired coaster is now complete! It can be used to protect your surfaces while adding a touch of geeky style. Remember that this coaster is purely decorative and not intended for actual heat dissipation. Enjoy your crochet creation!

Having followed the instructions exactly including the specified silver coloured thread, paired with a 'contrasting colour', this result was slightly disappointing, I'll probably give it to my baby niece to wear as a beret instead! Round 1: **Humans 1 - ChatGPT 0.**

I cannot conclude the experiment at one test, with plenty of yarn left I gave ChatGPT another chance



Test 2 - EV of the future

since the pattern itself did make sense. To a seasoned crocheter, you could see that it didn't quite know the ins and outs of crochet design, for example, the joins were not quite right. But only an experienced crocheter would notice these details.

Test 2 – EV of the future

As ChatGPT seemed so concerned about making sure I knew that heatsink would not be useable IRL (in-real-life), I made sure to ask him next, to create a pattern for a representation of what an electric vehicle (EV) of the future might look like.

Round 2: Humans 2 - ChatGPT 0.

I'm beginning to feel secure again about AI of the future and have another hat for my niece. Let's try something more challenging, maybe ChatGPT wants to stretch its virtual muscles.

Test 3 – Moon pool

Inspired by our story in this issue about moon pools, I decided to push ChatGPT with a pattern to represent (in case I try to sail it of course), a ship with a moon pool. I started following the instructions exactly as written and I got as far as creating a brown rectangle, before the pattern turned to gibberish. After trying to interpret it in different ways, and a lot of art-rage, I admitted defeat. My poor friend ChatGPT had failed me, and after just 3 rounds it is **Humans 3 - ChatGPT 0**, let's give him one last shot.

Test 4 – A Simcenter Mascot

One last chance my friend. I wanted to see how creative he could get with a much more open brief. What character could he conjure up that would represent Simcenter?

Here is the result, I think we can conclude on:

Humans 3 - ChatGPT 1



Test 4 - A Simcenter Mascot