Ansys

ADVANTAGE

EXCELLENCE IN ENGINEERING SIMULATION

ISSUE 2 / 2022

Simulation: Teaching Students and Launching Startups

Ansys

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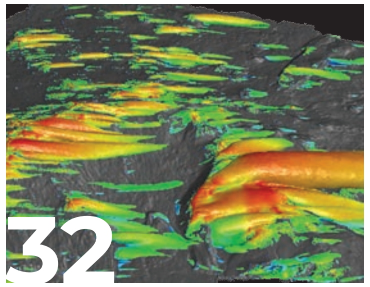

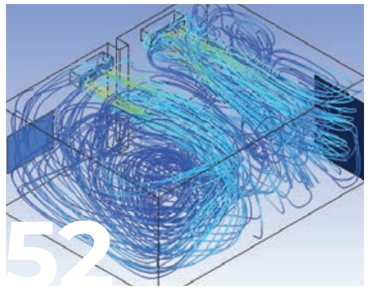

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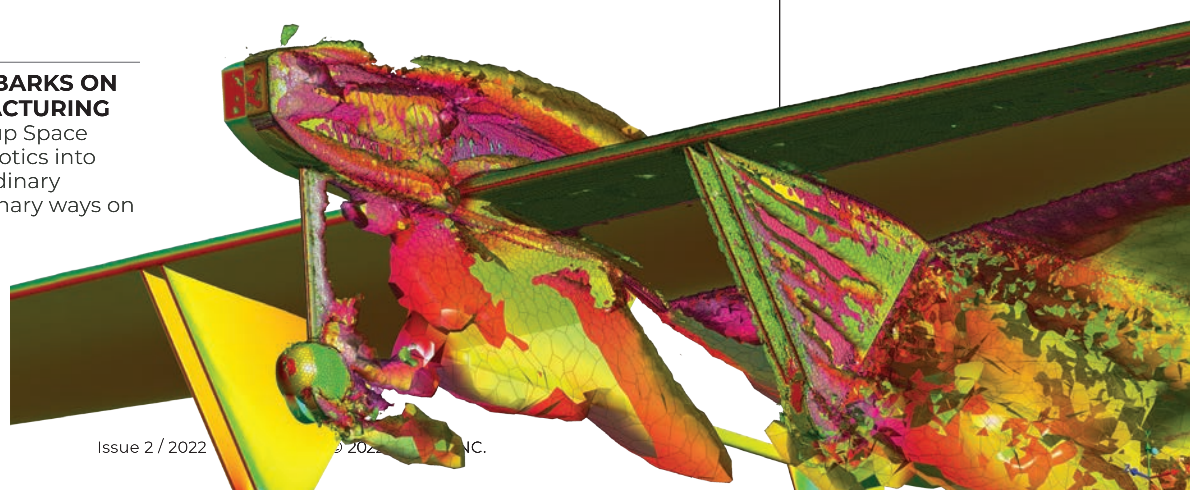

ADVANTAGE

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

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Take a Leap of Certainty ... with Ansys
When visionary companies need to know how their world-changing ideas will perform, they close the gap between design and reality with Ansys simulation. For more than 50 years, Ansys software has enabled innovators across industries to push boundaries by using the predictive power of simulation. From sustainable transportation to advanced semiconductors, from satellite systems to life-saving medical devices, the next great leaps in human advancement will be powered by Ansys.

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

Enabling the Next Generation of Innovation

By **Susan Coleman**, Director of Academic and Startup Programs, Ansys

At Ansys, we have always had a goal of lowering the barrier of entry to learning simulation. Nowhere are our efforts to attain this goal more evident than in our Ansys Academic and Startup Programs. Both are devoted to making Ansys simulation software accessible to those who need it in order to achieve a better tomorrow: engineering students in university programs, and startup companies whose existence depends on demonstrating success rapidly while raising funding.

To be accessible to these groups, engineering simulation software must be easily learned and financially affordable. Ansys provides free student software through the Academic Program, along with reduced rates for universities that want to use Ansys software as a teaching or research tool. We also work with qualified early-stage startups to make our software affordable through our Startup Program.

LEARN WITH THE ANSYS ACADEMIC PROGRAM

Today, more than 3,300 universities across 92 countries use software through our Academic Program for teaching and research on campus. We see Ansys software being used to empower some of the most groundbreaking research coming from academia while also playing a key role in undergraduate- and graduate-level curriculums.

August 2015 marked the start of free student software downloads with the advent of Ansys Student, our Ansys Workbench–based product that made Ansys Mechanical and Ansys computational fluid dynamics (CFD) products available to students at no cost. Since then, we have added Ansys Discovery Student, Ansys Electronics Desktop Student, Ansys SCADE student, and Ansys LS-DYNA Student software to the mix. We are proud to note that more than 2.23 million free student software products have been downloaded, with the numbers climbing rapidly.

Getting our simulation software into the hands of students is one achievement but getting it into their brains is another. In July 2020, we introduced the first of our Ansys Innovation Courses, which are freely available to university students and self-learners at all levels. We now offer more than 230 courses in physics and engineering disciplines, with more courses added every month. They are taught by Ansys professionals and professors from various universities. We also find that early career engineers often take our courses to develop a new skill set or make themselves eligible for promotion or new roles. Course topics range from using simulation to introduce and reinforce basic engineering concepts to more specific Ansys simulation application areas. Courses include video lectures, handouts, starting files, and quizzes to reinforce what was taught. Many educators have found value in assigning these as supplemental learning to their in-classroom curriculum.

Rounding out the offerings of the Academic Program, the Ansys Learning Forum is an online gathering place where students and professionals alike can interact to ask questions about simulation and physics, and get answers from their fellow engineers or our Ansys Customer Excellence (ACE) staff. The Learning Forum brings students and self-learners full circle in their learning journey because now they can access our free student software, learn using our free Innovation Courses, and ask questions and get clarifications or support via our forum.

STARTUPS AND ACADEMICS BY THE NUMBERS

3,300+	*universities across 92 countries use software via the Ansys Academic Program*
2.23+	*million free student software products have been downloaded*
230+	*free Ansys Innovation Courses available*
1,500+	*members of the Ansys Startup Program*

SUPPORTING INNOVATIVE STARTUPS

Following a successful pilot program, we formally launched the Startup Program in September 2016, offering affordable simulation software to eligible startup companies. To date, more than 1,500 startups in 53 countries have joined. Participants are spread across many industries, with high tech representing 20%, energy 15% (many focused on alternative clean energy solutions and sustainability), aerospace and defense 14%, healthcare 10%, automotive 7%, and a variety of others. Companies involved are working on autonomous driving, commercial space flight, the internet of things (IoT), 5G communications, electrification of cars and airplanes, robotics, cancer treatments, and many more challenges.

With limited funding, often borrowed from family and friends and supplemented by venture capitalists, they must spend their money wisely and stretch it as far as they can. We never want a startup to miss the opportunity to propel their innovation forward during the most critical stages of their development. The Startup Program has created an easy entry point for engagement and growth. Later, once they are well-established, they often tell us, “We couldn’t have done it without the Ansys Startup Program.” That’s a win–win that warms our hearts every time we hear it because we see firsthand how these startups are changing our world.

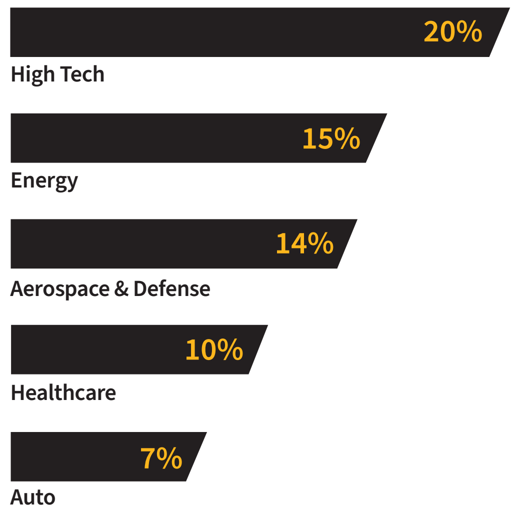
ONE PROGRAM HELPING THE OTHER

We know that students learning our software in schools makes a difference because we see them joining the companies using our software and contributing on day one. In some cases, newly hired graduates even become advocates at companies that may not be benefiting from simulation yet. But what is truly amazing is when the journey goes full circle for an engineer and we see the programs work hand-in-hand.

For instance, a team of undergraduate students working on a race car for a competition develops ideas that help them compete and, in some cases, win. They use the Ansys software and learning resources available to them on campus via our Academic Program. Then sometimes they realize that they can take their ideas a step further and bring a new solution to market, so they found a startup company once they graduate. They join our Startup Program as they build a business around their idea, growing to become a more established Ansys customer. It’s one of the most inspiring use cases to witness, and the power of simulation is behind them all along the way.

This issue of *Ansys Advantage* tells just a few of the many success stories that came out of the Ansys Academic Program and the Ansys Startup Program. Many more stories have already been told in earlier issues of the magazine and in the Ansys blog. We hope they inspire you to include Ansys in your lifelong learning experience, no matter where you are in your journey.

INDUSTRY SECTORS OF STARTUP PROGRAM PARTICIPANTS



Engineering a 'Soft Collision' Between Humans and Humanoid Robots

By Ansys Advantage Staff

Halodi Robotics was founded in 2015 by CEO Bernt Øivind Børnich and COO/CFO Stein Erik Maurice to innovate humanoid robot helpers that they couldn't believe were not already in existence. What was the roadblock? After a lot of deep thought about what they wanted from such a robot, they used simulation and their considerable ingenuity to create Eve, "the world's first robot to operate with human strength, in near silence, to safely work among (and interact with) people." After talking with Børnich, we wanted to share his fascinating insights into the intersection of the human and robotic worlds with you.

Bernt Øivind Børnich

Ansys Advantage: What inspired you and your colleagues to start Halodi Robotics?

Bernt Øivind Børnich: The goal from the start has been to get robots out of factories, among people. It's been a lifelong dream for me and everyone else in the company. We're all waiting for robot helpers around us, and it didn't seem to be happening by itself. So, we really started by sitting down and looking at why it is not happening. What are the major barriers to enter this market? What's actually lacking to make it happen? Because it's one of those rare things where everyone's asking for it, everyone wants it, but it doesn't exist.

AA: And what did you conclude from these discussions?

Børnich: We figured out that there are some fundamental principles about how we build robots that don't align with how you would get robots to be useful in human environments. In brief, we need to make robots that are safe, capable, and affordable. There have been a lot of products through the years that have had two of these, but none that have had all three.

AA: Can you give us some examples?

Børnich: Yes. There are some human-like products that can wave and talk, things like that. But in my opinion, they are not real robots because a robot is an automator — it automates work. And if you can't automate physical labor, you're not really a robot. They are relatively safe, relatively affordable, but they are not capable. And then you have the capable robots, which I would say are the industrial robots. They're capable, they're starting to get affordable, but they're not safe. Whenever they're picking up something, there's a pattern — they move quickly and precisely, and then they almost stop, and then they move again. And this is because, when moving, the energy in the system is so high that if the robot touches anything, either the robot breaks or whatever they're touching breaks. They're inherently not safe. They can be made safe in a controlled factory environment, around trained personnel, but there are still safety barriers to enter the market for general interactions with humans.

AA: What are you doing at Halodi to make robots that are safe to work with humans?

Børnich: We are getting rid of all this energy so that the robot can just collide with the world without breaking the world or itself. That's what we humans do. When you go down the hallway in your office space, you're not afraid of bumping into your colleague. It might be awkward, but it's not dangerous.

Our design for our first robot, Eve, is very much inspired by biology. And it just comes down to that: We humans are masters of minimizing impacts and we're inherently "over damped." So, whenever we do anything, we have so little energy in our motions that collisions are very low energy. We don't care about the impacts. When I pick up something, I do that by colliding with it. Even when I pick up my coffee cup, I collide with the cup.

Eve can interact with things, including humans, in a compliant, soft, natural manner. It's able to exert a lot of force, but it's moving with minimal energy. And this is really where our system sets itself apart. When you interact with our robot, you'll feel it; it's just like interfacing with a human, everything is just soft

> ***"The other simulation tools aren't the same quality, and we've evaluated all of them. So, the Startup Program has been very empowering, and we're very grateful for it."***

and compliant and everything gives way, but it can still exert a lot of force because those two things aren't necessarily related. So, Eve can be very strong, but still very low energy. And that's something that's been missing in robotics. It's really what opens up the market to us because it enables us to be safe.

AA: Getting to more practical details, these features are all a function of gears and motors and connecting cables between the joints of the robot. How did you engineer these capabilities into Eve?

Børnich: We use very similar systems to human muscle fiber — synthetic fiber threads that are shared between a lot of our actuators to move the robot. And we do that together with very-low-speed motors that have very, very high torque and very low weight. Eve has about three times more power-to-weight than anything you can buy commercially off the shelf in that size, so it's really a game changer.

At the core of this problem is: How do you get force or torque density so that you can have a lot of power with very little speed and still very little weight? Because then all of your other problems become not simple, but a lot simpler. And it's a very hard problem to begin with. So, we've been spending a lot of time doing large optimization models, utilizing Ansys simulations among others to figure out the best way to design electric motors.

AA: How did you decide on Ansys software?

Børnich: Originally, Ansys software was prohibitively expensive for us as a startup. We would not have been able to use it without the Ansys Startup Program. That's been hugely beneficial to us because the other simulation tools aren't the same quality, and we've evaluated all of them. So, the Startup Program has been very empowering, and we're very grateful for it.

AA: Which Ansys products do you use most?

Børnich: If you look at hours spent, it's Ansys Mechanical, because everyone in the engineering team working on the product is doing so much simulation on the component side. But the big work we're doing is on the motor side, which I'm super hyped about. My key contribution early in the company was doing all the motor designs. I still do most of it — that's where I keep my hands dirty. For that we use a mix of some in-house tools and Ansys Motor-CAD.

Motor-CAD has a very efficient way of solving simulations for motors, so that you can actually iterate on large-parameter models and do optimization. We do a lot of analysis of frequency-dependent losses. Which of our frequency-dependent losses actually matter at the speed that we're running the motors, and how can we use that to either improve performance or simplify the system and then verify that it works in the real world? We're utilizing Ansys solutions among others to figure out what's the best way to design electric motors.

And now we're spending a lot of time on "design for manufacturing" for motors, especially for a new generation where we're setting up proper assembly lines for high-volume production.

AA: So you're planning on mass production?

Børnich: Exactly. And having really good simulation models there is invaluable, because you always have your production engineers asking: "Can we do this? This will make manufacturing a lot simpler." And we need to decide how this proposed procedure would actually affect performance. Sometimes we run a design for manufacturing simulation and discover that it would completely wreck performance. And other times we learn that it wouldn't affect the performance much, so we say, "Let's do that."

Being able to answer such questions within a couple of hours using simulation is super important. For the company, now, it's a really big thing to go deep on the manufacturing side and make sure that what we have is not only very high performance, but that it satisfies the original three criteria: safety, capability, and affordability. If you do a really good job on automating your manufacturing, you can also make your product at a disruptively low cost.

AA: What are your target markets?

Børnich: We want to get into security, retail (such as warehouse work), logistics, and healthcare, for starters. We're seeing a lot of traction right now in physical security. We just closed the largest deal ever for humanoid robotics, with 140 robots scheduled to ship late this year to a security firm.

Because our robots are powerful, in addition to being able to patrol around and observe and report, our robot can open doors, including heavy doors. In secure facilities, you have heavy doors with heavy door pumps. You need to exert a lot of force to be able to open them.

We are also able to map humans really well to the robot. So, we have a very powerful avatar mode where we map all of the kinematics of the human to the kinematics of the robot. The robot actually has exactly the same joints and ranges of motion on joints as a human, including the leg, except that it has one leg with wheels instead of two legs.

This enables us to do remote labor very efficiently. Our robot can do fine manipulation, like closing a window, removing a bag that someone put in a door, etc. So, in this application, we have a fleet of robots covering a building with a central human operator overseeing the fleet. When a robot finds a bag blocking a door that should be closed, it asks for help. The operator takes control of the robot, removes the bag, and the robot continues automatically. And this enables us to cover all the edge cases. Every time the robot doesn't know how to handle a situation and a human steps in and does it through avatar mode, the robot learns how to do it.

This also delivers better service for the customer because there's a lot of things robots are really good at and things that humans are really good at, and we want to use them both for whatever they do best. If a robot is doing after-hours patrolling and there's not supposed

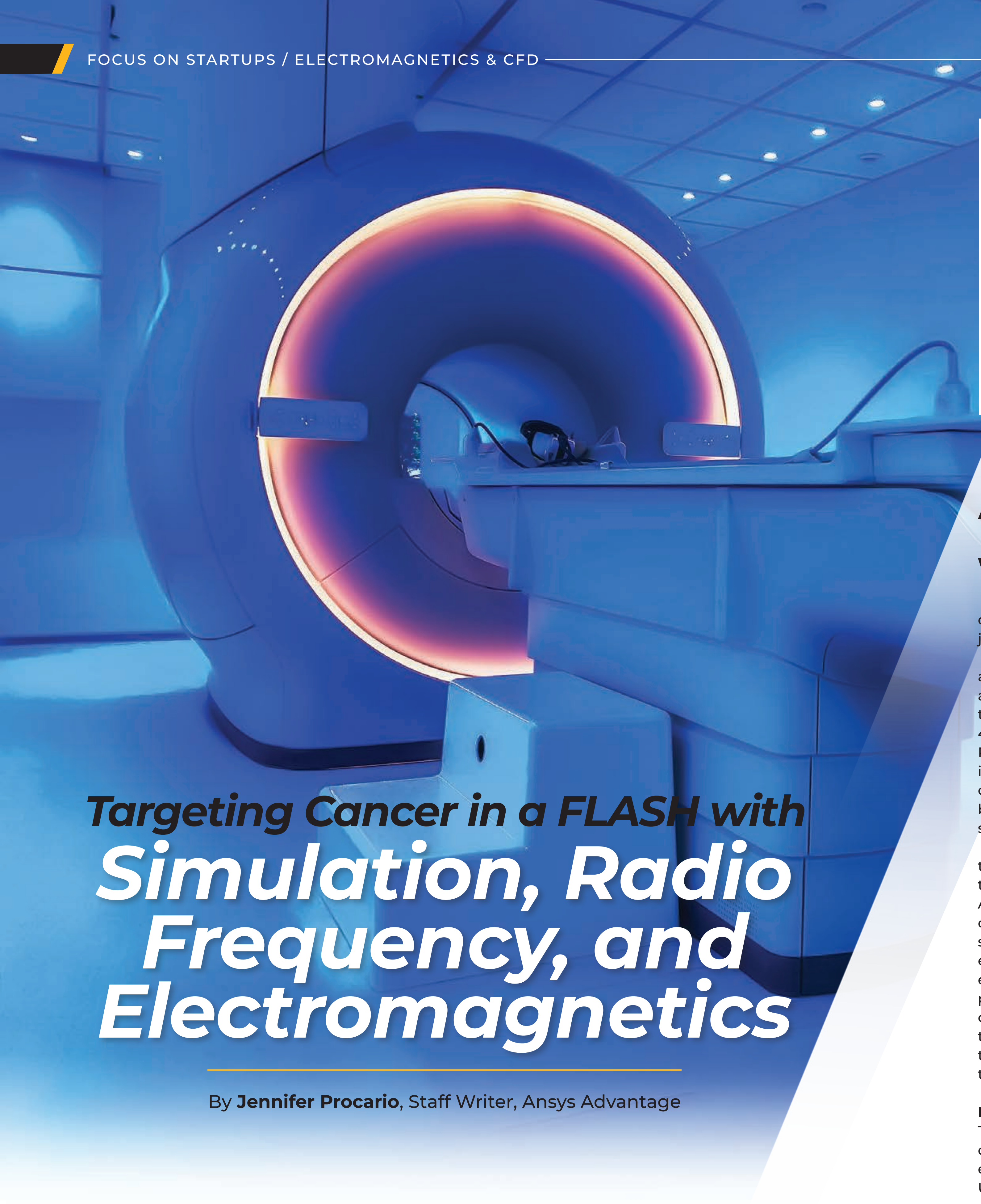
to be anyone there, and he opens a door and sees a person in the room, he alerts the operator. The operator talks to the person through the robot, including mapping his body language through the robot, to resolve the situation.

AA: You also mentioned healthcare applications. How do you envision that?

Børnich: As the human population ages, assistive robots can help people to live better, more independent lives without leaving their homes through use of technology. They can also help with care in hospitals, like moving patients around in wheelchairs or helping them to get dressed. Simple things like getting out of bed in the morning when you want to get up, not when the nurse has time. Or bringing you food when you're actually hungry, or helping you dress when you want to go out. Helping people — that's really what gets me up in the morning. That's where we want to take Halodi Robotics in the long term.

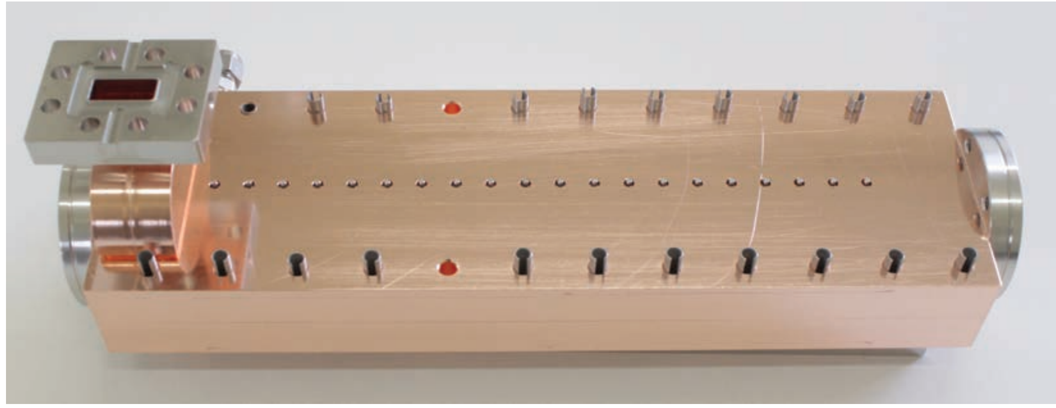
Engineers at Halodi Robotics have designed Eve as a platform that is available for other roboticists to develop and test their own control algorithms without having to create all the new hardware. In this way, they hope to help researchers advance the field of robotics faster than they could otherwise. This selfless approach is part of their effort to realize the human helper robots that they thought would be ubiquitous by now. It's all summed up in their motto:

OUT OF THE LAB. BEYOND THE FACTORY FLOOR. HALODI ROBOTS ARE READY TO WORK IN HUMAN SPACES. WITH HUMAN STRENGTH. AT YOUR SERVICE.



Targeting Cancer in a FLASH with Simulation, Radio Frequency, and Electromagnetics

By **Jennifer Procario**, Staff Writer, Ansys Advantage



The PHASER has 16 accelerators that electronically target tumors with unprecedented speed for revolutionary radiation therapy treatment.

While every cancer case is individual, there is one shared truth: Time is critical. We often hear how time is crucial in diagnosis or early detection, but it is just as imperative to treatment.

Engineers and radio frequency (RF) experts at medical technology manufacturer TibaRay are developing a groundbreaking radiation therapy (RT) system that will irradiate tumors 400 times faster than today's conventional RT. As a result, the accelerated treatment is expected to solve problems that prevent curative treatments for individual patients and benefit a greater number of patients in the same amount of time as current methods.

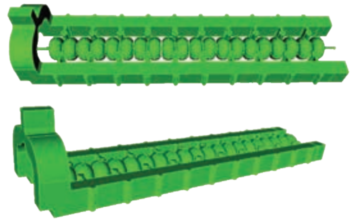
As a member of the Ansys Startup Program, the California-based company is developing the next-generation RT technology by applying Ansys' electromagnetic (EM) solvers and computational fluid dynamics (CFD) simulation software for faster, more accurate, and cost-efficient solutions. More importantly, TibaRay is employing simulation in the hopes of ultimately providing an essential contribution to curing cancer and bringing this treatment — which they describe as the "holy grail" of cancer therapy — to market before the end of the decade.

PIONEERING SOLUTIONS WITH ANSYS

TibaRay was founded in 2014 when a group of experts in radiation oncology, RF, and engineering with deep roots in the Stanford University community pooled their knowledge and resources to create a revolutionary solution for cancer treatment.

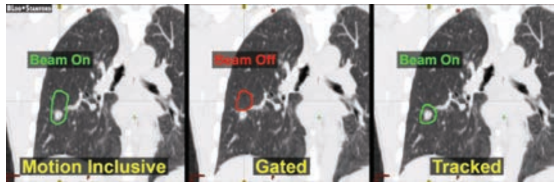
Dr. Bill Loo, a radiation oncologist at the Stanford Cancer Institute who has substantial experience using radiation to treat lung tumors, recognized a recurring issue between the breathing-induced movement of tumors and the challenge to deliver radiation more accurately, quickly, and efficiently without irradiating surrounding healthy tissue. He was searching for a solution when he reached out to Sami Tantawi, a microwave RF expert and electrical engineer from the SLAC National Accelerator Laboratory, a U.S. Department of Energy National Laboratory operated by Stanford University.

Tantawi and his team had just made a breakthrough discovery in developing state-of-the-art particle accelerators — machines that use EM fields to propel charged particles at very high speeds and energies through carefully formed beams — which far exceed the capabilities of existing technology. In other words, they were developing linear particle accelerators, also referred to as linacs, that could solve Loo's primary challenge.



Simulation of linear accelerator designs in Ansys HFSS

Loo and Tantawi immediately teamed to transform current RT systems by integrating the latest developments in particle physics with cancer treatment. To equip themselves with the latest simulation tools, the pair learned about the Ansys



The PHASER produces radiation so rapidly that the treatment is finished before the tumor target moves, unlike current radiation therapy methods that must monitor breathing-induced tumor motion, as illustrated in the animation above, to deliver treatment while the tumor is in motion.

Startup Program through Ansys' Elite Channel Partner, Ozen Engineering, Inc., and became a member in 2016. The program encourages early-stage startups by providing affordable access to Ansys' simulation solutions coupled with technical support to help advance their businesses.

Today, TibaRay has roughly 15 full-time employees and a handful of part-timers who rely on Ansys' simulation and predictive accuracy to develop a first-of-its-kind RT system they call the PHASER, an acronym for pluridirectional, high-energy, agile scanning electronic radiotherapy.

The PHASER combines linear accelerators with RF sources and components to create a nonlinear, fully electronic approach to radiation treatment that offers motion-freezing precision at record-breaking speeds from various angles to better destroy the tumor — without moving heavy mechanical parts around the patient.

"What we're trying to do is a very heavy lift. It's very intensive in terms of the design and the many components that we're modeling with Ansys HFSS," says Arun Ganguly, Chief Operating Officer and Chief Technology Officer at TibaRay. "It's not a typical startup where it's just a couple of years and then you have your product ready and one year or so of the Startup Program helps. We need the startup help for quite a bit of time, and the help we receive from the Ansys Startup Program is very much appreciated."

In addition to HFSS 3D high-frequency EM simulation software, TibaRay uses Ansys Maxwell for low-frequency EM machine modeling, Ansys Fluent for CFD analyses, and Ansys Mechanical for stress analyses.

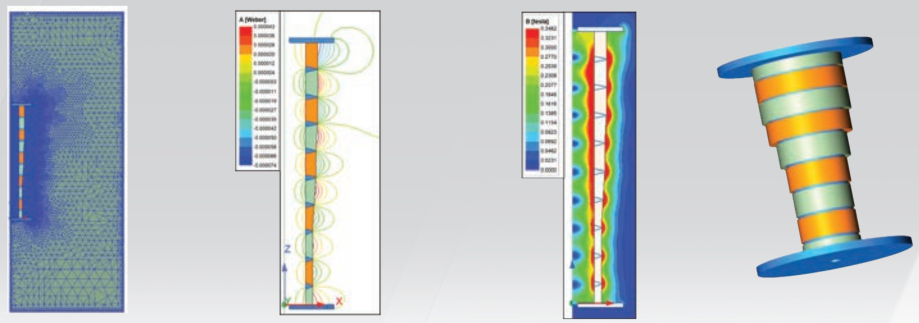
To understand the breadth of the PHASER, think of an octopus and multiply that by two. The PHASER is equipped with 16 accelerators — or limbs — that attack the tumor from different sides and angles. But because everything is electronic, there is no need to move any of the 16 parts.

But let's back up. First, to power the PHASER, TibaRay designed an efficient klystron — a linear-beam electron vacuum tube — that uses periodic permanent magnet focusing and requires a much lower high-voltage power supply for operation than typical klystrons.

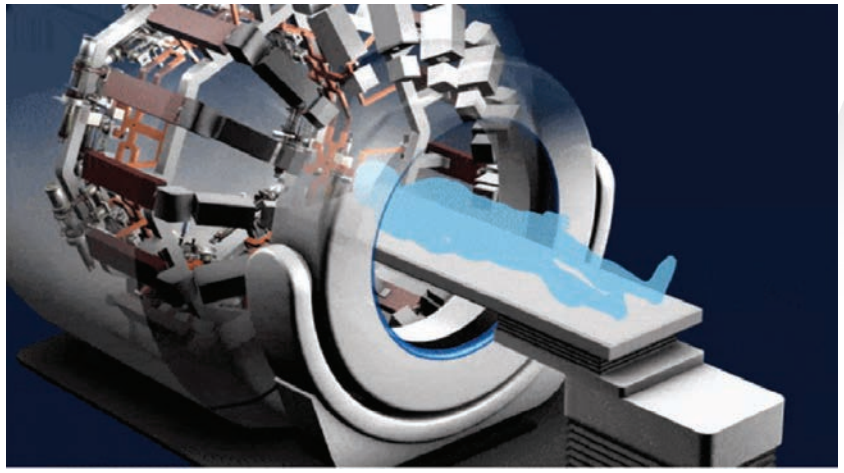
By pairing this high-efficiency klystron with RF combining technology, TibaRay engineers are able to generate peak power that can be scaled almost without limit. This creates more compact and efficient RF sources for the accelerators, which are fueled by the klystron source — the microwave generator.

Electrons are injected into the particle accelerators and interact with the microwaves to produce X-rays, which are then used in the radiation treatment. It is important to note that X-rays used for treatment purposes are at much higher radiation dosages than X-rays used for diagnostic imaging.

And because the PHASER is designed with simulation to operate electronically, the accelerators are not required to move. Instead, the microwave power is electronically toggled between each accelerator, which allows the team to shift the focus of the beam at unprecedented speed without any interference.



Design of periodic permanent magnet stack in Ansys Maxwell



The PHASER operates electronically, using 16 different accelerators to target tumors from 16 different angles without having to move heavy equipment around the patient.

"What we're trying to do is a very heavy lift. It's very intensive in terms of the design and the many components that we're modeling with Ansys HFSS."

Radiation sessions that normally take several minutes — whether three, 10, or 20, depending on the treatment regimen — are reduced to under a second.

ELECTRIC RESULTS WITH SIMULATION

Simulation is an integral part of operations at TibaRay, so much so that Ganguly refers to HFSS as the "bread and butter" of the PHASER's design.

Each particle accelerator is injected with low-voltage electrons. In addition, each accelerator has a series of resonant cavities that are powered by the microwaves coming from the klystron. As the electrons pass through these cavities they interact with the microwave power inside them, gaining momentum and increasing in energy with each cavity. How much momentum? Within 2 feet, the electron power progresses from approximately 10,000 electron volts of energy to 10 mega electron volts of energy.

During this energy buildup, Ganguly and her team study where the resonant cavities are located along the path of the beam. This data, which comprises accurate and precise positions, is then entered into HFSS to determine the resonant frequency of each cavity, including the phase angle and field distribution within each, while stress analyses are performed in Ansys Mechanical. Based on these results, the team modifies and manipulates the cavity shapes to achieve the ideal direction for the charged energy and subsequent radiation.

Different devices are designed for varying resonant frequencies — the PHASER is equipped for an X-band frequency of 9.3 GHz. A few popular devices that operate at similar X-band frequencies include machines used in air traffic control, police radars, and military air traffic control.

By tweaking parameters in HFSS, TibaRay is able to design and influence the flow of the microwaves through the beam. The ultimate goal is for the microwaves to flow from the klystron source toward the accelerator, through the beam, without any power rolling or flowing back in the opposite direction, which could damage the klystron. HFSS also helped the team design a monitoring diagnostic tool to measure the beam itself.

While the EM simulation prowess of HFSS plays an integral role in the PHASER's system design, Fluent allows the team to monitor and adjust thermal activity within the accelerator.

With such a high amount of power pumping through the beam, it is imperative to ensure that the temperature in the accelerator maintains thermal stability and that it is being cooled by circulating water. Thermal simulation

“There are other tools available to the high-energy physics world, but I would say Ansys’ simulation is the friendliest and most reasonably accurate way of being able to simulate all of our systems before going and cutting metal.”

also influences how the cavities are aligned during design to keep the most consistent flow in relation to its direction and temperature.

As the team sees HFSS as the bread and butter of the PHASER’s design, Maxwell could be considered its well-stocked pantry. TibaRay uses its low-frequency EM simulation to design the klystron — the PHASER’s main source of power — which requires a specific and strong magnetic field. With automatic adaptive meshing and advanced magnetic modeling, Maxwell enables the team to achieve the desired EM power within the klystron and understand its performance.

“There are other tools available to the high-energy physics world, but I would say Ansys’ simulation is the friendliest and most reasonably accurate way of being able to simulate all of our systems before going and cutting metal,” says Ganguly. “You visualize what you want to do before you actually go ahead and do it.”

ON-THE-MARK TREATMENT IN A SNAP

A distinctive feature of the PHASER is its fully electronic operation, which removes the need for mechanical movement and significantly increases its precision and speed.

But a recent scientific discovery has increased the PHASER’s relevance even further. It is a common occurrence in conventional RT that surrounding healthy tissue inadvertently becomes damaged when targeting tumors. However, scientists recently identified a biological effect, commonly referred to as the “FLASH effect,” that eliminates this problem by delivering the same amount of radiation in much shorter times. FLASH targeting has demonstrated that surrounding healthy tissue touched by radiation recovers without scarring or damage, due to this surprising effect.

While this breakthrough came to light separately, Ganguly explains that it is essentially what the PHASER was already being designed to achieve. However, the FLASH effect is being studied in a totally different regime using protons, requiring machines and equipment with costs around $100 million.

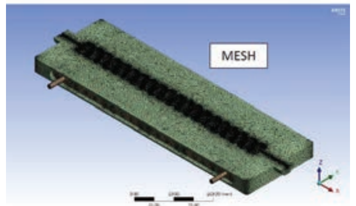
Alternatively, and more advantageously, the PHASER uses electrons that produce high-energy X-rays, and its equipment costs run in line with traditional costs for RT machines, which are significantly more affordable at one-tenth of the price of a proton FLASH machine. Most importantly, it can deliver the same FLASH effect with the same motion management, speed, and precision.

The PHASER is also an all-in-one machine with a built-in CT scanner, whereas typical RT systems only have a flat panel detector capable of 2D projections. With a CT scanner integrated directly into the system, the PHASER produces real-time high-quality images during treatment for up-to-the-instant accuracy. Once the location of the tumor is identified with imaging, the treatment is finished before it moves.

HIGH-POWERED PERFECTION TAKES TIME

Developing the first engineering prototype of the PHASER takes time, but not as long as you might think.

As on-premises computing can only handle a certain amount of data and calculations, Ganguly plans to leverage Ansys’ cloud computing capability to expedite development. While the team will continue to determine individual parameters locally, Ganguly intends to optimize and accelerate larger, full-system calculations in the cloud.



Accelerator model mesh used for Ansys Fluent computational fluid dynamics analysis

At this rate, TibaRay expects to have the PHASER prototype completed in four years to request a 510(k) clearance from the FDA, which will allow it to be marketed as safe and effective for radiation therapy. Once this is secured, TibaRay will coordinate with leading radiation oncology centers to place PHASER machines on-site to treat patients in clinical trials and collect enough data to support the technology.

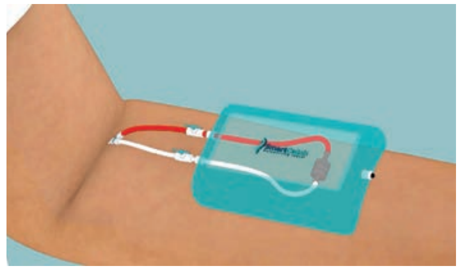
Capturing Cancer with SMARTCATCH

By **Aliyah Mallak**, Staff Writer, Ansys Advantage

Almost everyone knows at least one person who has or has had cancer. With over 1.9 million new cases of cancer every year in the United States alone, it’s hard not to know someone affected by this terrible disease.

Biopsies, which involve removal of tissue to examine under a microscope, are the most common way to diagnose cancer. The type of biopsy a patient receives is based on where the tumor is located. While some biopsy techniques are noninvasive, others require surgery that can be expensive, uncomfortable for the patient, and require longer healing times. Another downside of traditional biopsies is that a diagnosis based on the analysis of a single-tumor biopsy only reflects a single point in time of the whole disease.

But there is an alternative: liquid biopsies.



Representation of the CTC-Pheresis concept

CATCHING CIRCULATING TUMOR CELLS WITH LIQUID BIOPSIES

A liquid biopsy is a minimally invasive procedure that tests blood for circulating tumor cells (CTCs) that travel in every patient’s bloodstream. CTCs are cancer cells that escape from a tumor and migrate through the body. Some of these tumor cells travel through the bloodstream until they potentially develop a secondary tumor or metastasis.

Because they are pieces of the original tumor, they carry information about the presence, nature, and aggressiveness of the solid tumor. CTCs provide crucial information like number, genetics, molecular pathways, and mechanisms of immune evasion. Their detection, counting, and analysis could help doctors refine cancer diagnosis and prognosis, adapt therapies at the individual level, and closely monitor the evolution of the disease over time and the effectiveness of the treatments.

The challenge is that these cells are incredibly rare, with only one CTC per billion normal blood cells. They are also difficult to capture while maintaining their physiological integrity. Because they are difficult to detect, they are not used in clinical routines as biomarkers, missing a great opportunity for early detection of cancer.

But CTCs are relatively larger and less deformable than other blood cellular components. Using a micro mesh capture device developed with cutting-edge technologies and advanced computational simulations, SmartCatch is working toward liquid biopsies that enable a one-step, selective isolation of CTCs from blood in physiological conditions.

LIQUID BIOPSY	TRADITIONAL BIOPSY
Sample derived from body fluid (usually blood) *Noninvasive*	Sample derived from surgical biopsy or needle biopsy *Invasive*
Less risk and pain	Some risk and pain
Easily and repeatedly obtained	Often not easily or repeatedly obtained
Real-time detection of comprehensive tissue profile	Spatially and temporally limited tissue profile

Liquid biopsy vs. traditional biopsy[1]

HOW SMARTCATCH CASTS ITS NET

Based in Toulouse, France, SmartCatch was founded in 2016 as a spinoff of the French National Centre for Scientific Research (CNRS). It was jointly founded by an academic team specializing in micro and nanotechnologies from the Laboratory of Architecture and Analysis of Systems (LAAS-CNRS) and urology surgeons of the University Institute of Cancer (IUCT) and Montauban Uropole.

"Our goal is to develop highly normative technologies that are affordable, easy to use, patient friendly, and do not require particular training so that everybody can use them," says Aline Cerf, Chief Executive Officer and Co-founder of SmartCatch. "We just want to detect cancer better, earlier."

Cerf explains that the idea occurred to the founders in 2012.

"We came up with this crazy idea of developing 3D fishnets at the microscale to isolate these tumor cells that everybody was really looking to be able to capture," she says. "Because if you're removing the most aggressive elements, the ones that are responsible for metastasis, then you can prevent metastasis altogether."

FILTERING CELLS WITH ANSYS FLUENT

The SmartCatch team uses Ansys Fluent to simulate many filter design ideas.

"It would take us a full day to fabricate just one design and it was a lot of work as we had thousands of ideas per minute! So, we were wasting a lot of time. Ansys was the only tool that gave us the possibility to resolve the hydrodynamic phenomena at the scale and the meshing we needed to study them," explains Cerf.

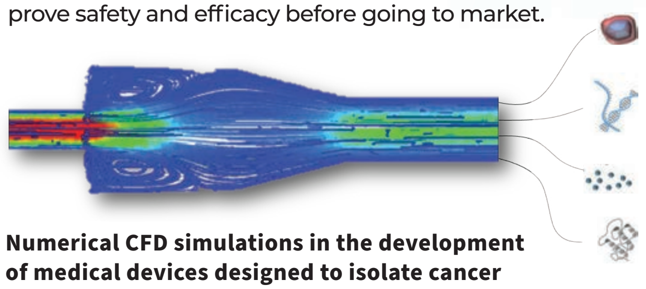
Blood, which is a complex viscous and multiphase fluid, is a very complicated liquid to simulate. All the cells within blood have different stiffnesses and deformability sizes. Part of the problem when SmartCatch began the project was that the technology just hadn't caught up to where they were yet.

"For several years we had known the technical bottlenecks liquid biopsies were facing," says Cerf. "We have reached a point where biology at the cellular level and the outstanding progress of micro/nanotechnologies now meet, and we can finally solve these bottlenecks."

Fluent has enabled SmartCatch to isolate CTCs directly from fresh, whole blood with no pre-processing steps to provide unaltered, high-quality capture material.

OVERCOMING REGULATORY HURDLES WITH SIMULATION

Every country has its own governing body that regulates pharmaceuticals and medical devices. Each agency has different rules, but the same basic principle applies to all of them: You must prove safety and efficacy before going to market.



Numerical CFD simulations in the development of medical devices designed to isolate cancer biomarkers from circulating blood

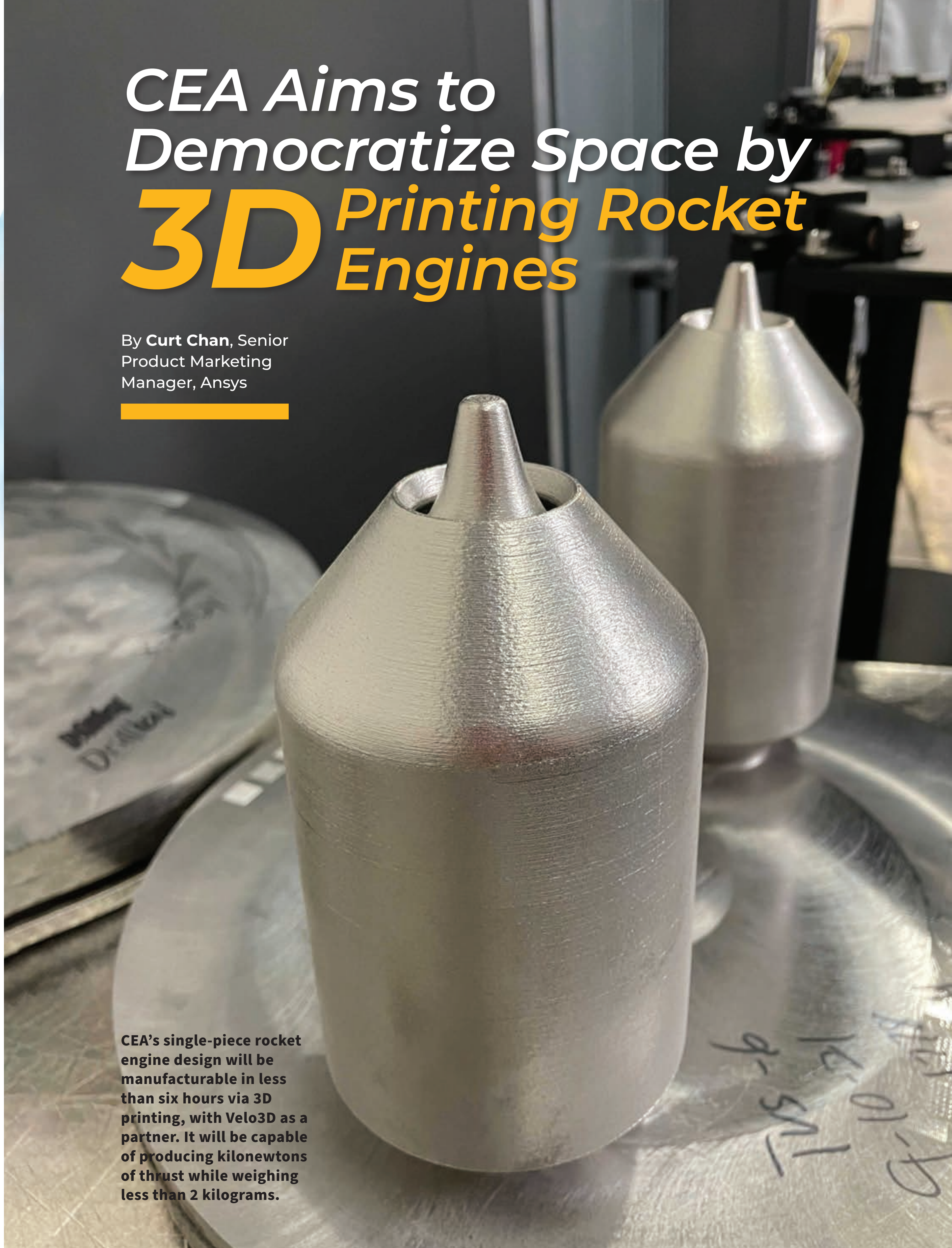
"For us, most importantly, we need to demonstrate that we're not altering the rest of the cells, that our technology is completely inert," says Cerf.

Because SmartCatch is in silico — using computer modeling and simulation — Ansys products are helping them prove to regulatory authorities that their products do in fact work efficiently and are safe for human use.

"Simulation is a very powerful argument to back up our experiments," says Cerf. "We're not replacing physical experiments (in vitro) with simulated ones (in silico), but it's complementary information that in the end explains why we're making these choices."

Reference

[1] Qi ZH, Xu HX, Zhang SR, Xu JZ, Li S, Gao HL, Jin W, Wang WQ, Wu CT, Ni QX, Yu XJ, Liu L. The Significance of Liquid Biopsy in Pancreatic Cancer. J Cancer 2018; 9(18):3417-3426. doi:10.7150/jca.24591. Available from https://www.jcancer.org/v09p3417.htm



CEA Aims to Democratize Space by 3D Printing Rocket Engines

By **Curt Chan**, Senior Product Marketing Manager, Ansys

CEA's single-piece rocket engine design will be manufacturable in less than six hours via 3D printing, with Velo3D as a partner. It will be capable of producing kilonewtons of thrust while weighing less than 2 kilograms.

Among the more surprising business trends of the last decade has been the dramatic privatization of space launches and exploration. According to a recent article in *The Guardian*, private businesses now account for approximately 80% of the $424-billion worldwide space industry.

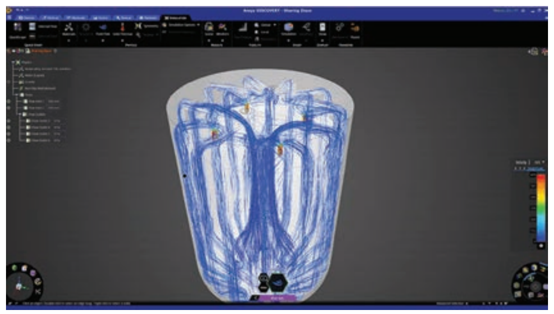
While a handful of mega-wealthy individuals — including Richard Branson, Elon Musk, and Jeff Bezos — have received plenty of media attention for their efforts to establish space tourism, the potential of space for a range of business applications is enormous. From launching satellites to transporting goods, the worldwide space industry represents untapped opportunities for product and service commercialization. It may well be the "final frontier" for a new generation of ambitious entrepreneurs.

One such entrepreneur, (and a self-confessed space evangelist) is Ewan Craig, who founded Connect Everything Aerospace (CEA) in the UK in 2020, based on a novel idea he developed during the early months of the COVID-19 lockdown. While many of us were taking long walks, assembling puzzles, or baking bread, Craig was imagining an unexpected way to make space more accessible, more affordable, and more democratic by 3D-printing rocket engines.

Less than 18 months later, with support from the Ansys Startup Program, Craig is preparing for his first test launch. Recently I talked with Craig about his unique vision — and how he's managed to realize it so quickly.

Ansys Advantage: When I hear the words "additive manufacturing," rocket engines don't seem like a natural fit. After all, we use "rocket science" to express the most extreme example of product complexity. So how exactly did the concept for CEA originate?

Ewan Craig: I've always thought aerospace engineering is just the coolest thing we do as human beings. The moon landing, sending rovers to other planets, having men and women living in orbit around our planet — it's so incredible. So during the initial COVID-19 lockdown, I did an online open course, an introduction to basic rocket science, created by the Massachusetts Institute of Technology (MIT). I just loved it. I started doing some research, and I learned about an aerospike engine design that was conceived in the 1960s but never really got off the ground, pun intended. And there was a moment when I thought, "Hold on a second. Should I try and redesign this for today?"



CEA relied on Ansys Discovery (pictured) and Ansys Fluent in creating and verifying the design.

The engine has an unique design that allows it to deliver maximum thrust as it climbs through the atmosphere, self-adapting to the changes in ambient pressure to support optimum exhaust expansion. But that unique design makes it heavy, hard to manufacture, and expensive to produce using conventional materials and fabrication processes. Additive manufacturing, or 3D printing, is really the only way to produce it at scale.

With 3D printing, complexity is not really an issue. As long as you optimize the design, it's just a matter of pressing a button. By combining the really modern technology of 3D printing with this rather old invention of the aerospike rocket engine, you can actually make something that's viable today, both financially and practically. And that was the genesis of CEA.

AA: Once you have the ability to mass-produce rocket engines, quickly and affordably, what does that make possible?

Craig: The opportunities for a printable rocket engine are huge. I like to think of it as similar to the Ford Model T moment in cars. If you're able to start making these things at a fraction of the price and with far less labor — and skilled labor, especially — then it means you don't need a massive, government-funded operation like NASA to put things into space. It can become a cheaper, more accessible enterprise.

You can have much smaller rockets powered by cheaply built rocket engines. You can have small companies offer services like satellite launches. You could have loads of little startups popping up in the UK or in America or all over the world, especially in developing nations where space exploration is something that's just not happened. Right now it's a game for the richest men on the planet, and that should change. A company like CEA actually can start instigating that change.

AA: What are the business challenges you've faced as a young entrepreneur with a big, ambitious idea?

Craig: From the get-go, this was never really a business enterprise for me. I was doing this work out of a scientific curiosity. I was just trying to solve the technical problems. But, in doing that, I was challenged because I didn't have access to the best tools for my design exploration and simulation needs, specifically Ansys Discovery and Ansys Fluent. Being able to access Ansys software through the Startup Program was incredibly important.

If you imagine the internal structure of this rocket engine, it's a labyrinth of channels, passages, coolant flows, and all manner of different areas and surfaces. You can't make a million prototypes and destroy them. You have to be absolutely confident in your designs before you start printing them, and Ansys delivers that confidence quickly. I couldn't have proven my concept, founded a company, applied for patents, and identified a 3D printing partner without the credibility Ansys provided me.

I've been hugely supported by Ansys throughout the engineering phase, and now it's time to start thinking about commercial viability and making a profit — whether that means manufacturing rocket engines in-house or licensing the technology to others. I like to describe CEA as being in the pre-revenue phase, but it's brilliant to imagine where this company could go. And I wouldn't be at this stage without Ansys.

CEA has designed an innovative rocket engine in one part, 3D-printed to contain an injection manifold, regenerative cooling channels, a combustion chamber, and an entirely unique aerospike nozzle. CEA relied on Ansys Discovery and Ansys Fluent in creating and verifying the design.

AA: Where are you in the development cycle — and what's next for CEA?

Craig: On October 11, we officially produced the world's first single-piece rocket engine, 3D-printed by our partner Velo3D. In the world of rocket engines, once you've built the first one, you do what's called a static test fire. So you strap the thing to the ground and you fire it. You pump your oxidizer and your fuel through it, and you see how well it keeps itself cool, as combustion releases an incredible amount of energy and heat. We're planning a test flight soon and, if it works, that will be the first time one of these engine designs from the 1960s actually ever got off the ground. I'm excited and I'm also confident. My Ansys simulations say it's going to work, and so I expect it to work.

Hitting the Trail

How electric vehicle software is democratizing off-road adventure

By **Laura Carter**, Staff Writer, Ansys Advantage

Electric vehicles (EVs) are already reshaping everything we know about driving, and it's anyone's guess how much change we can expect to see in the near future. Biometric identification, personal voice assistants, and an autonomous parking feature that can help you find a good parking spot are all on the table, but what's ahead for those of us who just love to drive? Despite these trends, there's still significant interest in recreational cruising, which is why Sam Poirier, Co-founder and CEO for Potential Motors, is taking electrification off-road and enhancing the driving experience through software.

Lower control arm mesh in Ansys Mechanical

"We came up with an initial design before realizing that it did not meet the requirements for the loading that it was going to undergo. Using Ansys simulation software helped us do a redesign that was more appropriate to our overall design strategy."

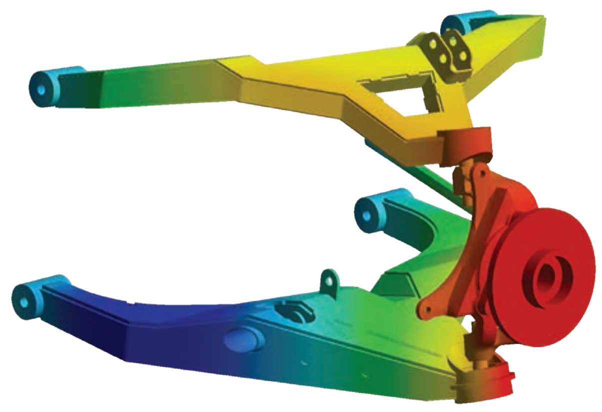
It was Poirier's initial interest in EV conversions that would set him on a path to something much bigger. Through this work, Poirier saw a big shift happening in the general mobility space toward electrification that extended beyond hardware, and he decided to capitalize on that to take the technology off-road.

Poirier now wants to enhance, rather than diminish, the interaction off-road between the driver and the environment. The trick to this is adding a layer of software to co-pilot the vehicle in extreme conditions. The software should respond based on the skill level of the driver without diminishing the feeling of control that comes from navigating through mud bogs and over rocky terrain. Gathering data through Ansys simulation software was an important part of interpreting what this connected experience should be.

"One of the things we're working on is proactive control over the suspension, for example, and changing the dampening in each corner of the vehicle as you pass over different types of terrain," says Poirier. "Today, you can either do that with a button or you have to get out and manually change your suspension, which requires a certain level of skill. There will be extremes in either direction, depending on the driver, so having software that enables driving options of varying degrees based on the user is important."

EV SOFTWARE DEVELOPMENT FOR CLEANER, QUIETER RECREATION

EVs require greater levels of software control over different components, such as suspension actuation, steering, and torque vectoring (differential technology for varying torque within an electronics system), which requires control over different motors in the vehicle. At the same time, automotive manufacturers are focused on improving performance in adverse conditions while reducing hardware complexity. With help from the Ansys Startup



Off-road suspension: simulated displacement field result

Program, Potential Motors is developing advanced vehicle control software for electric off-road vehicles that improves driving in adverse conditions while centralizing and simplifying EV architecture through holistic control of the drivetrain.

Poirier describes the software as the "brain" of off-road vehicles and believes it is the key to electrifying off-road experiences. As with on-road applications, he believes that his

Potential Motors' simulation expert integrates various simulation tools.

simple, scalable software program will lead to more efficient enablement of new off-road features and performance enhancements supporting cleaner, quieter outdoor adventures.

"What's really driving vehicle innovation in electrification is software," says Poirier. "And what's really interesting about that is the demand for experience in this realm — and that we had already started to build a team with a ton of experience there. We take it a step further using software to improve driving in the most extreme conditions that will open up opportunities for recreational off-roading for more people. It's also a great test bench for original equipment manufacturers (OEMs) in the development of more traditional on-road EV applications."

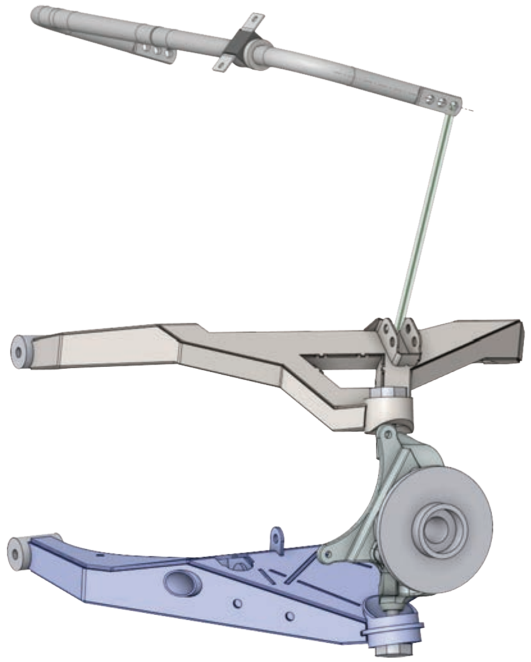
SIMULATING UP AND OVER BIG ROCKS AND THROUGH MUD BOGS

Confident testing of load cases before release was central to overall software development. Off-road vehicles need to be able to withstand some pretty significant loads while driving — they'll be used to go up and over rocks and back down again, putting a lot of stress on the suspension and frame. Potential Motors has been able to model all of that with the tools that are available through the Ansys Startup Program and ensure that the structure of the vehicle will hold up under different loading conditions.

Access to Ansys software was extremely valuable in testing load cases and other areas fundamental to advancing the overall vehicle design. It gave Potential Motors' engineers an understanding of how the vehicle would survive the rugged off-road environment. Without simulation, making such determinations would involve hours of hand calculations to check and validate that a design was appropriate for off-road use. Actual validation touched on multiple critical vehicle aspects, including the chassis, suspension components, battery pack design, and steering system, and extended to other aspects, such as wire harnessing and occupant layout.

Potential Motors used many Ansys tools to achieve their objectives during validation, including:

- **Ansys SpaceClaim**, a user-friendly 3D computer-aided design (CAD) modeling software to enable easy geometry preparation for simulation of the suspension, chassis, and related components
- **Ansys Workbench**, a simulation integration platform to help the team keep all design iterations in one place.

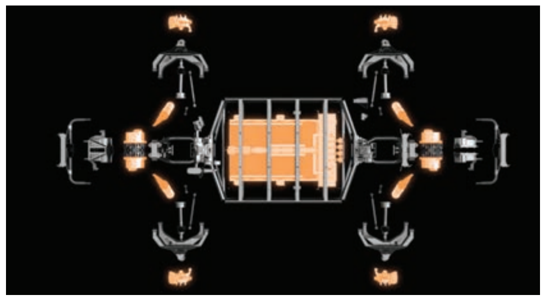


Preparing off-road suspension assembly in Ansys SpaceClaim for simulations

- **Ansys Mechanical** finite element analysis (FEA) software to help identify thermal elements available in the user interface without having to use commands
- **Ansys Fluent** fluid simulation software designed to help them solve large, complex problems
- Successful data sharing with SolidWorks

MECHANICAL PUTS EV BATTERY TECHNOLOGY TO THE TEST

Potential Motors has mostly benefited from Mechanical so far, given the focus of their work to date to assess loading on the vehicle, including the impacts of loading on the battery pack. As part of their off-road vehicle design, the vehicle battery modules were mounted to the actual battery enclosure.



Exploded view of the Potential Motors platform with components highlighted

The battery pack enclosure contains all the electronics and battery modules. Each of the battery modules within this box is separate and needs to be mounted down, then connected to the busbars — solid bars used for electrical current distribution between the incoming source and outgoing terminals of the vehicle's electrical distribution system. In this scenario, the surrounding wiring and electrical components also need to be considered. It's important that the battery pack and its related components remain still while the vehicle is in motion to prevent shorting that leads to thermal runaway, which in turn can create smoke, fire, and possibly vehicle explosions.

"Basically, we were able to do a lot of the analysis up front and actually went through a couple of iterations of the design around how the battery packs were going to be mounted," says Poirier. "We came up with an initial design before realizing that it did not meet the requirements for the loading that it was going to undergo. Using Ansys simulation software helped us do a redesign that was more appropriate to our overall design strategy."

ANSYS MECHANICAL SORTS OUT LOAD DISPLACEMENT IN ANTI-ROLL BAR DESIGN

Vincius de Almeida Lima, vehicle simulation engineer at Potential Motors, is intimately familiar with Ansys simulation software and used it to understand the maximum deflection of their anti-roll bar (ARB) design. Essentially, he wanted to find out the degree an element of the suspension system could be displaced under a load, which can happen in certain dynamic off-road conditions.

Potential Motors' P0 test platform

To do this, Lima first ran a full vehicle dynamics model in a CarSim environment to get the maximum suspension displacement at the wheel center. Data coming from this model was then fed to a detailed subsystem model in Mechanical, where displacement or acceleration could then be applied, depending on inertial effects, as boundary conditions to an FEA of the full suspension system (arms, steering, and ARB or torsion-spring modeled).

"The ARB is integral to the suspension geometry — it connects all suspension elements shared between wheels on the same axle," says Lima. "Most articulations in our model use Mechanical's rigid body dynamics solver during the first iteration. If I notice any stress concentration, I can easily remodel the contact region to arrive at a more feasible design."

Riding the Second Wave of Electrification with Ansys

Potential Motors is excited to join the second wave of electrification in powersports as an innovator and major force in off-road electric vehicle (EV) technology, with support from the Ansys Startup Program. One of the team's biggest challenges is modeling off-road environments. To overcome it involves a mix of simulation and real-world data: collecting data using an off-road EV prototype through real-world testing, then using that information to validate their simulations.

"I would say that overall, our experience with Ansys has been quite good so far," says Poirier. "Using the simulation tools in the Startup Program has helped us speed up our design process. We certainly wouldn't be where we're at without simulation, and Ansys' support in this area has definitely filled that void for us."

SPACE FORGE
Embarks on In-Orbit Manufacturing

By **Jennifer Procario,**
Staff Writer,
Ansys Advantage

Imagine building a product from scratch without gravity, buoyancy, or other earthly hindrances. Think about constructing the most sensitive inner workings of a superconducting device without worry of contamination. Dream of manufacturing in an environment where nothing can compromise the integrity of your product.

These suggestions may seem a bit out there — because they are. In fact, they start about 500 kilometers — or roughly 300 miles — above the Earth's surface in the beginning of the exosphere.

Engineers at Space Forge, a manufacturing company based in the United Kingdom, are sending robotics into orbit to assemble ordinary material in extraordinary ways on returnable satellites.

As a member of the Ansys Startup Program, the small-yet-mighty team is employing Ansys simulation solutions to facilitate these two-way trips to space as safely and efficiently as possible.

A rendering of one of Space Forge's returnable satellites from their signature ForgeStar fleet

> ***"The vast majority of software we just didn't even consider because it couldn't do the job, but our experience with Ansys is that it's doing the job."***

Early concepts for Space Forge began in 2018 when Andrew Bacon, an aerospace engineer, and Joshua Western, a satellite sales executive, recognized the potential of in-orbit manufacturing followed by return to Earth. But they knew they would need to create safer and lower-cost reentry technology to make it happen.

With an official company launch slated for March 2020 and having just quit their day jobs, it was less than ideal when the coronavirus pandemic sent most of the world into lockdown.

Still, as its name suggests, Space Forge was prepared to forge ahead. The dynamic duo used the time in isolation — largely spent connecting virtually from a garage — to strategize business plans and get things off the ground, literally.

Space Forge became a member of the Ansys Startup Program in early 2021 via Ansys' UK Elite Channel Partner, EDRMedeso. The program encourages early-stage startups by offering affordable access to Ansys simulation solutions, including technical support for additional assistance.

By April 2021, the co-founders secured their first office space in Cardiff, Wales, ready to grow their business and team. Today, Space Forge has more than 30 employees and expects to reach 45 by the end of the year.

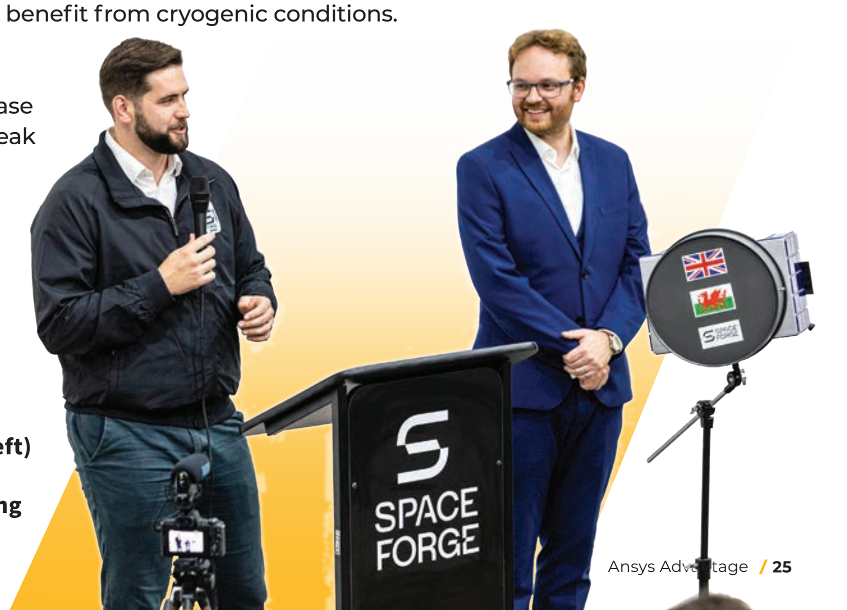
The driving force behind Space Forge is its innovative ForgeStar Platform, which operates a fleet of uncrewed returnable satellites. Space Forge is unique in that everything they send up comes back down during a safe reentry and landing, while similar launch vehicles tend to leave material behind to burn up in space.

The main reasons that the satellites are human-free are safety and cleanliness. To remove potential contamination, all products are manufactured by robotics. Additionally, Space Forge adheres to all regulations from the Civil Aviation Authority, which monitors aviation safety in the UK and determines policy for the use of airspace, including which materials are allowed to make the trip.

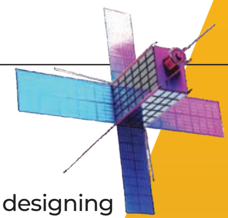
With cleanliness and safety in place, Space Forge can embrace the other core benefits of manufacturing in space, including microgravity, ultra-high vacuum pressure, and near-absolute-zero temperatures — a trio of benefits that Bacon calls the "triple advantage of space."

For example, quantum devices such as optical sensors are incredibly delicate mechanisms that greatly benefit from cryogenic conditions. As Wien's displacement law states, an increase in temperature causes a decrease in wavelength at which the peak amount of energy is radiated. This can disturb the sensor's precision, so low temperatures are optimal and near-absolute-zero temperatures are ideal for manufacturing these sensors.

Other instruments that benefit from space conditions include medical



Co-founders Joshua Western (left) and Andrew Bacon speaking at the Space Forge grand opening



implant sensors that detect heartbeats and ultrasensitive compasses that let you know exactly where you are in the world instead of just indicating due north. In materials manufacturing, superalloys benefit from space too. Here on Earth, buoyancy prevents perfect alloying in metals of different densities. In microgravity conditions, buoyancy is eliminated.

MANUFACTURING IN SPACE

So, how does space manufacturing work for a huge piece of equipment? For now, Space Forge will avoid huge components and focus on the nuts and bolts that hold large components together.

Let's look at a wind turbine blade. Sending entire blades to space one by one to manufacture could be quite cumbersome. However, the bolts that connect the parts of the blade actually undergo the most stress and are much smaller and easier to ship to space. By perfecting the bolts, you can increase the size of the blade.

Likewise, for aircraft turbine blades, the superalloys that fasten the blade to the engine are equally important to the overall endurance of the blade.

The same "less-is-more" concept is true for semiconductors in mobile connectivity. While it would be too expensive and time-consuming to manufacture the semiconductors of every cell phone in space, it's more feasible to manufacture a smaller selection of semiconductors that are used in cell phone towers. Most instances that Space Forge is considering right now do not require a lot of product or material to make a significant impact. Of course, the company envisions large-scale production in the future when space manufacturing is more routine.

Trip time varies depending on the project, which is an uncommon luxury. The International Space Station, for example, typically requires years to get experiments to and from space. But through the ForgeStar Platform, trips can range anywhere from two weeks to six months. Biological research or pharmaceutical manufacturing typically require shorter trips, whereas semiconductor manufacturing or projects that involve vaccine research take longer periods of time.

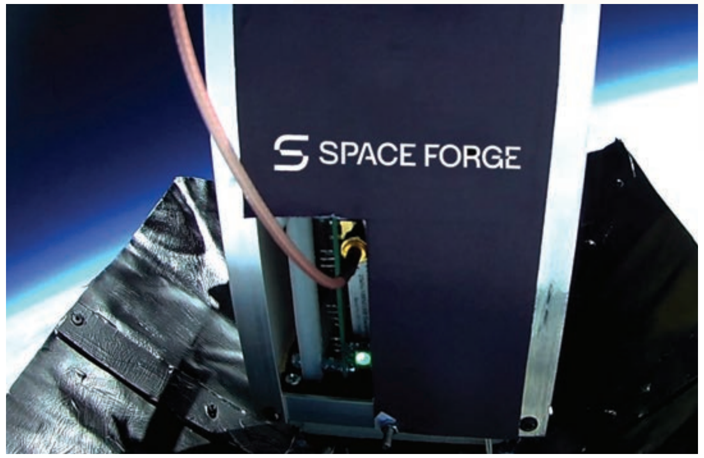
As Bacon explains it, Space Forge is all about embracing the trifecta of ideal conditions in space to create the "perfect manufacturing environment" while enabling lower-cost precision in return, which they make possible using the predictive accuracy of Ansys software.

ANSYS VALIDATES SAFER REENTRY

One of the most important factors in designing a reentry vehicle, or returnable satellite, is accounting for the contrasting levels of speed and altitude within a short amount of time to maintain stability.

Within an hour, the vehicle drops from an altitude of approximately 400 kilometers, or about 250 miles, at a speed of Mach 25 — more than 19,000 miles per hour — to sea level at around 20 miles per hour.

"You're transitioning through a whole range of different speeds and altitudes, and it's really important that your vehicle is stable," Bacon says. "We looked at which software could model anything from sea level up to hypersonic speeds, and Ansys won that trade-off with its computational fluid dynamics (CFD) and the Ansys Fluent module in terms of what range it can simulate and what kind of geometry it can handle."



A close-up of return technology at Space Forge

Combined with the engineering confidence that Ansys simulation supplies, Bacon and his team embrace additional benefits of the Startup Program, including cost-efficiency and technical assistance, which Space Forge received from Ansys experts at EDRMedeso.

"There are other packages out there, but their support is not great," Bacon adds. "We knew we were going to be doing something quite advanced, so support is really necessary. Comprehensive knowledge coupled with the ability of the EDRMedeso technical team to embrace our particular approach to simulation have been key factors to our success. And the Ansys Startup Program pricing is pretty fantastic, along with the fact you get access to all the other modules as well."

Naturally, reentry was the first challenge Space Forge explored and validated using Ansys simulation.

"Ansys is a great balance between performance, accuracy, capability, and usability, which you don't get with a lot of packages — you usually get two out of four."

To test the satellite's return, the team built a simplified, cone-shaped version of the satellite and modeled it in Ansys Fluent to analyze its dynamic stability, particularly when spun around as if caught in a gust of wind. The team took the cone to Pembrey West Wales Airport and dropped it from a drone about 400 feet overhead. While it worked the first few times, as the wind intensified, the cone flipped over and rolled out of control. In reviewing their simulation results, the team confirmed that although the center of mass was in the correct location in the simulation and demonstrated dynamic stability, they didn't implement the correct center of mass for the actual drop test.

Out of curiosity, they ran the simulations again, inputting the incorrect center of mass from the failed attempt, and the simulation showed the cone spinning out of control.

At that moment, the team knew they had verifiable, trustworthy solutions and wouldn't again stray from the simulation data or "cut corners," as Bacon says.

"Satellite reentry is probably one of the hardest problems you can try to do in space, and to do it you need the best software," says Bacon. "The vast majority of software we just didn't even consider because it couldn't do the job, but our experience with Ansys is that it's doing the job."

To improve satellite reentry further, Space Forge engineers developed Aether, a predictive analytic tool that they use in conjunction with Fluent, to better determine reentry landing locations.

Engineers analyze the static and dynamic stability of the satellite using Fluent and consider varying regions throughout its flight, including a range of speed from Mach 25 down to Mach 0. After collecting an aerodynamic database of coefficients, the team inputs the data into Aether to calculate landing locations while applying the direction and wind speed as input values for potential drag.

As a bonus, Space Forge can automate their calculations and simulations within the software, which streamlines the team's workflow and allows for more consistency and longer run times. Automation is particularly helpful as many of the team's simulations run for weeks at a time.

Another advantage and selling point for Bacon and his team was the ability to implement Ansys simulation on Amazon Web Services' (AWS) cloud platform to run simulations with even more computing power — a capability made possible through a long-standing relationship between Ansys and AWS.

In addition to CFD, the Space Forge team uses Ansys Mechanical for its thermal analysis and ray tracing capabilities — another requirement that Bacon and his team had in order to advance structural, thermal, and optical performance.

"When we're doing a thermal model, it's really important to be able to do ray-traced thermal modeling so we can see because we have deployable solar panels that shade part of the platform, so we need to be able to understand that and then overlay the thermal input from reentry," says Bacon. "So being able to input lots of interfaces and handle our geometry — a very detailed model with quite thin elements in the solar arrays — and have a good meshing tool with Mechanical were very important as well."

The team most recently used Mechanical to model stresses when developing a sea vehicle that serves as a water-based net. The team playfully refers to it as "the fielder" because its concept bears a similarity to the catcher position in the game of cricket.

Saltwater is damaging to the satellite, but the fielder serves as a buffer, "catching" the vehicle as it lands in the sea. The sea vehicle is lightweight and highly maneuverable but must be durable enough to withstand impact, even if the satellite lands at 20 miles per hour.

FUTURE MISSIONS FOR SPACE FORGE

As Space Forge continues to grow their business, Bacon and his team expect to manufacture at scale in another five years. They also plan to keep Ansys simulation on board as an integral part of operations.

"A lot of advanced simulation software has been written by scientists, who are fantastic at many things, but user interface development is not usually one of them," says Bacon. "Ansys is a great balance between performance, accuracy, capability, and usability, which you don't get with a lot of packages — you usually get two out of four." /\

A Glimpse into Deep Space with Extreme Optical Engineering

By **Daewook Kim**, Associate Professor of Optical Sciences and Astronomy, University of Arizona, Tucson, and Erik Ferguson, Staff Writer, Ansys Advantage

In the past few decades, optical science has pushed far beyond the foundations originally laid by Galileo and Newton 400 years ago. The planned deployment of new ground- and space-based telescopes dedicated to seeing farther into deep space in more detail than ever before will provide astronomers with increased opportunities to find Earth-like exoplanets and answer questions about how galaxies formed and evolved billions of years ago. To help make those plans a reality, researchers at the University of Arizona are using Ansys structural and optical simulation software in the design, fabrication, and testing of the next generation of telescope optics that will enable another giant leap for our knowledge of the cosmos.

Artist's concept of the completed Giant Magellan Telescope, which will be situated in the Atacama Desert some 115 km (71 mi) north-northeast of La Serena, Chile.

Courtesy of Giant Magellan Telescope – GMTO Corporation

The University of Arizona is at the center of several major telescope research and development projects. With its world-leading large optics laboratories and the Wyant College of Optical Sciences, researchers are at the forefront of creating the optical components that will power ground-based systems like the Giant Magellan Telescope and future space-based concepts like the proposed OASIS space observatory.

THE LARGEST MIRRORS EVER BUILT, TIMES SEVEN!

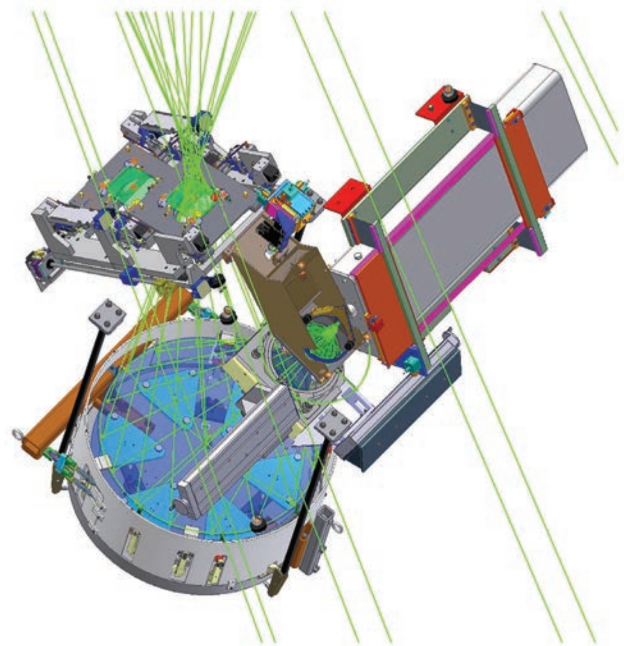
Upon its expected completion in the late 2020s, the Giant Magellan Telescope (GMT) will be among the largest ground-based telescopes ever constructed. GMT is the product of an international consortium of 13 universities and scientific institutes across five continents. The structure itself will reside on Las Campanas Peak in Chile's Atacama Desert at an elevation of about 2,500 m (8,200 feet) above sea level. The location was chosen for its dry climate and remoteness that will reduce optical interference from light, air, and humidity.

To capture enough photons to see billions of light years across the universe with enough clarity, the GMT project requires the creation of seven enormous mirror segments — a center segment and six off-axis segments that surround it — that will comprise the primary optics. Due to the size of the light collection area, the image resolution will be about 10 times greater than the Hubble Space Telescope launched in 1990, and about four times greater than the James Webb Space Telescope (JWST) that was successfully launched in 2021.

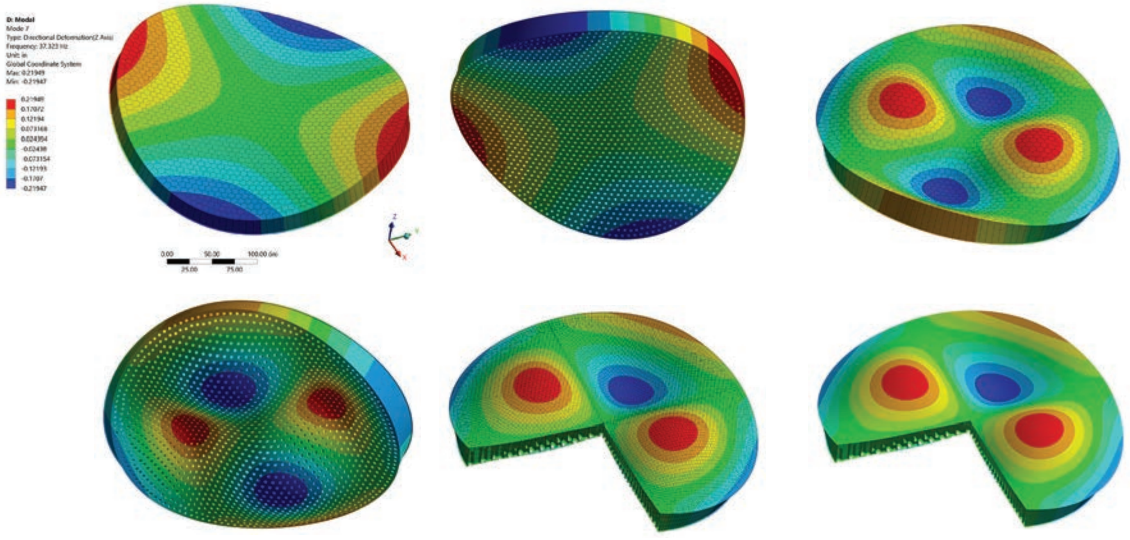
Each GMT mirror segment is 8.4 m (28 feet) in diameter, weighs about 16 tons and takes about six years to complete, including the casting, polishing, and testing processes. These are the largest mirrors in the world and are produced at the Richard F. Caris Mirror Lab at the University of Arizona. The first two segments have been completed, while segments 3, 4, 5, and 6 have all been cast and are in various stages of surface polishing and measurement.

A major challenge of using such a large mirror is bending caused by its own weight and by wind forces. The mirror can only bend by about 100 nanometers (nm) before the images become too blurry, so balancing the stiffness with the weight was of paramount importance. Using Ansys Mechanical software, the researchers modeled the mirror structure to predict the expected deformation of the optical surface. With the initial structural analysis complete, they then used Ansys Zemax's Structural, Thermal, Analysis and Results (STAR) module to load the finite element results from Mechanical into Zemax OpticStudio, where they could simulate the optical performance of each mirror segment due to the surface deformation.

Following the full optomechanical analysis, the team designed the mirror's central structure as a lightweight honeycomb, consisting of several 0.5 -inch-thick ribs in a hexagonal pattern holding together the 1-inch-thick glass facesheet and backsheet.[1] To cast the rough mirror, chunks of borosilicate glass are loaded over a mold inside a furnace spinning at 5 rpm, which forces the glass up the sides of the mold as it melts into the concave parabolic shape that is required to focus light from a distant celestial object. Over the next three months, the furnace slowly stops rotating and the glass cools to room temperature.



Computer-generated hologram (CGH)-based interferometry configuration for the 8.4-m diameter Giant Magellan Telescope (GMT) off-axis segment surface shape metrology



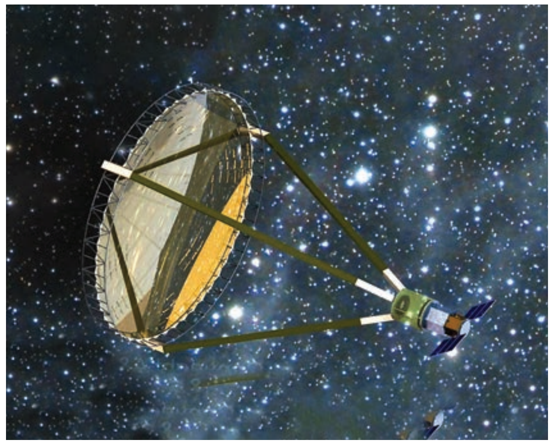
Simulation results showing the two bending mode shapes of the 8.4m GMT off-axis primary mirror segment (in different views)

Once cooled, the next step is the long process of polishing the mirror to the requisite optical quality and surface figuring to achieve the desired shape, which requires an accuracy of a small fraction of the wavelength of light being received. The surface has to match an ideal off-axis (or on-axis for the center segment) parabolic surface to within 25 nm, which is smaller than one-thousandth the width of a human hair. Because the surface is aspherical, the team needed to have very fine local control over the shape. Using two different types of polishing tools at different locations on the mirror surface, they selectively target high spots of different scales while the abrasive material slowly removes the glass, molecule by molecule.

Being deterministic is the essential component of this precision optical figuring exercise. If the researchers could not model, simulate, optimize, and predict the glass material removal prior to a typical week-long polishing and figuring session, they would not know whether they were removing the right amount of material from the right locations. The duration to manufacture each mirror segment would then be much longer than six years and delay the program by many more years, or even decades.

To avoid such a trial-and-error scenario, the team measured the mirror's surface shape using laser interferometry and visible deflectometry after each polishing session. Using Mechanical and other structural analysis tools, they then modeled the gravitational and thermal deformation of the surface during the measurement and compensated for that predicted deformation in the measurement surface errors. Thus, the team focused the next rounds of continuing optical figuring runs on meaningful optical surface error correction without being confused with optomechanical surface bending effects.

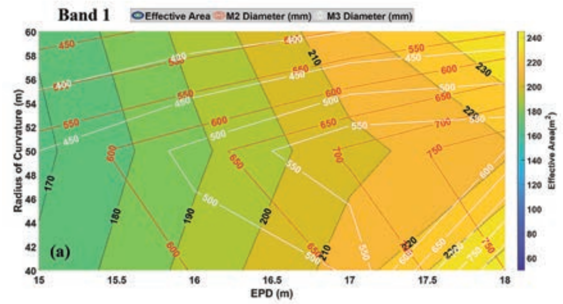
Before any surface figuring and polishing begins, the surface is only accurate to within about 30 µm (30,000 nm), which is three orders of magnitude away from the target accuracy of 25 nm. Improvements to the polishing process, aided greatly by simulation, helped the team reduce the calendar time required to achieve a specific surface accuracy measurement by a factor of four. For segment 1, it took about 300 days of polishing to improve the accuracy from 2400 nm to 320 nm. For segment 2, the research team achieved that same result in just 70 days, and they expect it to be even faster for the next segments.[2]



3D rendering image of the OASIS Space Terahertz Telescope observing in the submillimeter to far-infrared

OASIS SPACE OBSERVATORY: IS THERE WATER OUT THERE?

One of the practical limits for space-based telescopes has been the size and weight of the optics. Issues like wind and light pollution are removed, but you must be able to fit the components inside a rocket and lift them into orbit. The full mirror diameter of the James Webb Space Telescope is 6.5 m— smaller than a single GMT primary mirror — and it still had to launch with its 18 hexagonal segments folded up. To launch anything with much larger optics would require using radically different materials.



Inflatable optical design solution space contour plots of as-designed models for the OASIS observation band 1. Effective photon collection area and diameters of M2 and M3 mirrors are plotted as a function of A1 radius of curvature and entrance pupil diameter (EPD).

In response to a recent NASA Medium-Class Explorers opportunity, the Orbiting Astronomical Satellite for Investigating Stellar Systems (OASIS) telescope is a concept for a space-based observatory with a primary mirror (or antenna) made of a metallized polymer membrane — effectively a gigantic mylar balloon. When fully deployed from its spacecraft, the reflector would be inflated to a diameter of up to 20 meters (66 feet). Together with active and/or adaptive optics techniques, OASIS will be designed to provide high-resolution observations at terahertz frequencies in the far infrared spectrum (around 660 µm to 63 µm). This will allow it to search for water both in local asteroids and on planets or moons in other star systems.

Because the primary mirror is an inflatable material, its shape is a function of pressure, which is a unique challenge for the optical design. Using an in-house analytical model, the Arizona researchers evaluated a parametric solution space to determine the location and size of the telescope optics such as the secondary mirror that will be needed to correct for the changing surface profile of the antenna. In parallel, the team performed ray tracing analysis using Zemax OpticStudio to predict the photon collecting area of the antenna. The OpticStudio results verified that both analytical and numerical membrane models are suitable to accurately predict the optical design parameters of the inflatable optical surface.[3]

If the project is selected by NASA, the envisioned launch date will be in 2028, whereby OASIS will operate in an orbit around the L2 Lagrange point. This is one of the locations where a satellite can be positioned so that the gravity from the Sun and Earth balances the satellite's motion. The L2 point is almost a million miles farther out than Earth from the Sun, and also the celestial neighborhood of the JWST. Other orbits are also being considered as more science cases are being discussed and technology developments are actively achieved.

COUNTDOWN TO DEPLOYMENT

Many of the Arizona team working on GMT and the OASIS concept were inspired by the success of the Hubble program over the past thirty years and the famous deep space images it revealed to humanity. The gifts from Hubble were only possible due to the decades of optical science and engineering that came before to enable its successful launch and operation. Indeed, the team shares a dream of passing along a similar gift to future generations as both projects get closer to realization at the end of this decade.

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Getting a Bird's-Eye View

Using CFD to understand changing wind behaviors

By Ansys Advantage Staff

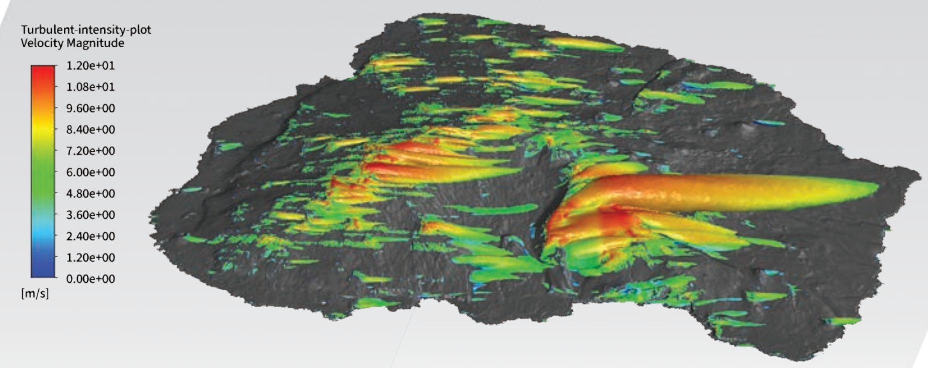
Marion Island, off South Africa's coast, is a pristine natural laboratory and a protected bird sanctuary. But the island's harsh environment, including high winds, is becoming even harsher due to climate change. A team at the University of Pretoria leveraged Ansys Fluent to develop a computational fluid dynamics (CFD)–based wind map of the entire 115-square-mile island. This model is providing critical insights about changing wind patterns — and their likely impact on wildlife and native plants.

Google Earth map of Marion Island and Prince Edward Island

Located 1,340 miles south of Cape Town, Marion Island is a South African territory renowned for its natural beauty. This subantarctic island is home to a research base, a meteorological station, and over 2 million seabirds that represent at least 28 known, unique species, with many classified as endangered. It was designated a Special Nature Reserve by the South African government in 1995, and access is strictly limited to scientists and researchers.

With a latitude of 46° 54' 45", Marion Island sits in the region of the southern hemisphere called the "Roaring Forties" because of its constant and often high-velocity winds. As the effects of climate change increase, these harsh, windy conditions are beginning to affect not only the island's wildlife but also its vegetation. Soil erosion and higher levels of salt spray are destroying nesting habitats, as well as killing grasses, mosses, and other plants.

The South African National Antarctic Programme (SANAP) was looking for a way to understand and mitigate the impacts of climate change on Marion Island, particularly regarding wind damage. While SANAP's scientists had access to general meteorological information about wind, such as its direction and speed, they needed to understand exactly what was happening at ground level across the island's rugged terrain.



Simulated turbulent wind intensity plot across Marion Island

In 2017, SANAP researchers called on Professor Ken Craig at the University of Pretoria for help. As a senior member of the Clean Energy Research Group in the Department of Mechanical and Aeronautical Engineering, Craig heads the CFD research in this group.

Since 1999, Craig had been applying Ansys Fluent to develop models of solar receivers and generators; metallurgy and manufacturing processes; and other CFD-based problems in his research. He also uses Fluent in his undergraduate and graduate courses on fluid dynamics, CFD, and simulation-based design. But could Fluent accurately model an entire 115-square-mile island, characterized by cliffs, mountains, valleys, and wetlands?

"I strongly believe that Fluent provides a very accurate solution for CFD modeling — and that when you have as good a piece of software, you should stick with it," says Craig. "But I don't think Fluent has ever been applied on such a large scale to an isolated land mass. Not only was the scale intimidating, but so was the sheer amount of friction, turbulence, velocity, and other physics-based problems Fluent would need to solve."

Always up for a challenge, Craig agreed to join forces with an existing SANAP program to gain a better understanding of changing wind behaviors on Marion Island. He enlisted master's student Kyle Goddard to lead the island-wide wind modeling effort, which would become the basis for Goddard's thesis, as well as of a recent paper published in the scientific journal *Ecological Modelling*.

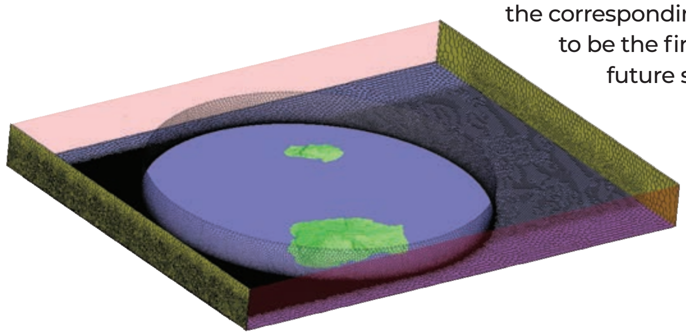
MODELING AIRFLOWS AND TERRAIN: A COMPLEX PROBLEM

The University of Pretoria team set up Fluent simulations that reflected 16 different wind flows approaching Marion Island from different directions. To map the island's terrain, team members relied on digital elevation models from airborne drone studies.

Craig and Goddard experimented with different approaches for generating a mesh that was finely detailed enough to reflect the island's terrain, but still large enough to encompass the entire landmass. They settled on a mesh with polyhedral cells and devised a novel strategy for reusing a single mesh system to simulate multiple climatic conditions and wind directions around Marion Island. This strategy basically entailed using a common region to all the models, and extending the upstream and downstream sea regions in the respective wind direction.

While the final generated mesh was very large, ranging between 87 and 214 million cells, the team was able to solve it by relying on the national South African high-performance computing (HPC) cluster, which distributed complex physics problems such as turbulence across hundreds of cores. Post-processing made the final wind models more manageable and user-friendly.

All of the wind direction simulations were then combined into a single wind velocity map, generated by weighting each of the simulations by the frequency of wind prevalence measured in the corresponding wind sector. This island-wide map, believed to be the first of its kind, will have many applications in future scientific studies of Marion Island.



Mesh around Marion Island and Prince Edward Island

In conjunction with the computational simulations, the team installed 17 wind data logging stations at key locations on the island. Raw outputs from these stations were cleaned and converted into an easily accessible database — the Wind on Marion Island (WMI) dataset — that now reflects all physical wind measurements gathered since 2018.

To validate the accuracy of its wind models, the team compared its simulation results against actual collected wind data from the WMI database. Team members focused on three directions that account for over 74% of the island's wind patterns: north westerly, westerly, and south westerly. The Ansys Fluent simulation results predicted the wind direction to within 5% and velocity and turbulence levels within 30%. It should be mentioned that the wind measurements were constrained because of environmental regulations and anchoring limitations that only allowed for measurements up to a one meter height.

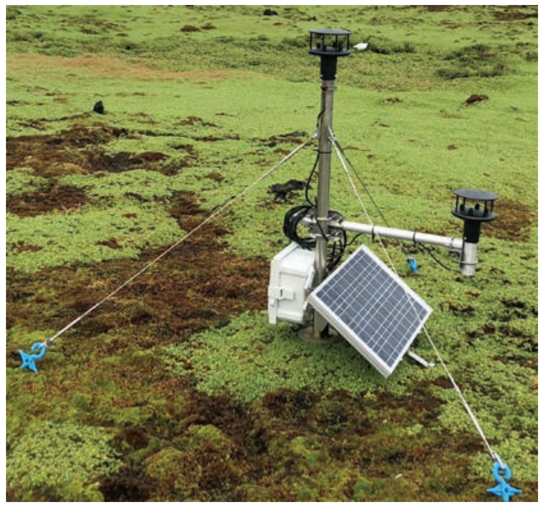
"When supporting scientific research in the field, it's critical to have an accurate tool that replicates real-world conditions in high fidelity," notes Craig, "and Fluent provided us with that tool. It's extremely powerful — and one of only a few solutions I can think of to create this kind of morphology at such a large physical scale.

"We were very pleased with the relative ease of setting up the mesh in Fluent once we became proficient and with the accuracy of the results. I wouldn't know how to solve such a large, complex problem using any other tool."

ONE RELIABLE MODEL WITH DIVERSE APPLICATIONS

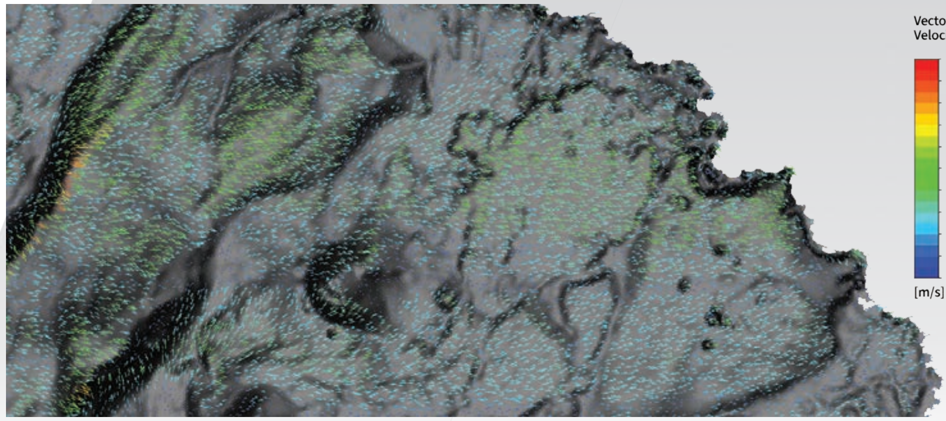
Thanks to the efforts of Craig and his student researchers at the University of Pretoria, SANAP and other environmental protection groups have a reliable means of estimating wind properties near ground level on Marion Island. Average wind speeds, turbulence, gusting, and other fine-scale wind behaviors can be recreated at any location on the island without using environmentally intrusive physical surveillance methods.

Climate change scientists can use the model to assess how wind patterns are evolving over time and how those changes will impact the island's bird and plant species. Already, the Fluent wind model is being applied to predict plant seed dispersal, investigate bird flight and nesting behaviors, and



One of 17 wind data logging stations on Marion Island

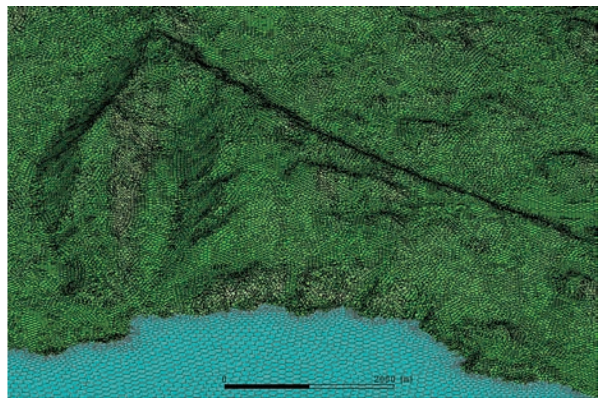
"When supporting scientific research in the field, it's critical to have an accurate tool that replicates real-world conditions in high fidelity, and Fluent provided us with that tool. It's extremely powerful — and one of only a few solutions I can think of to create this kind of morphology at such a large physical scale."



Wind velocity vectors across the island simulated by Ansys Fluent

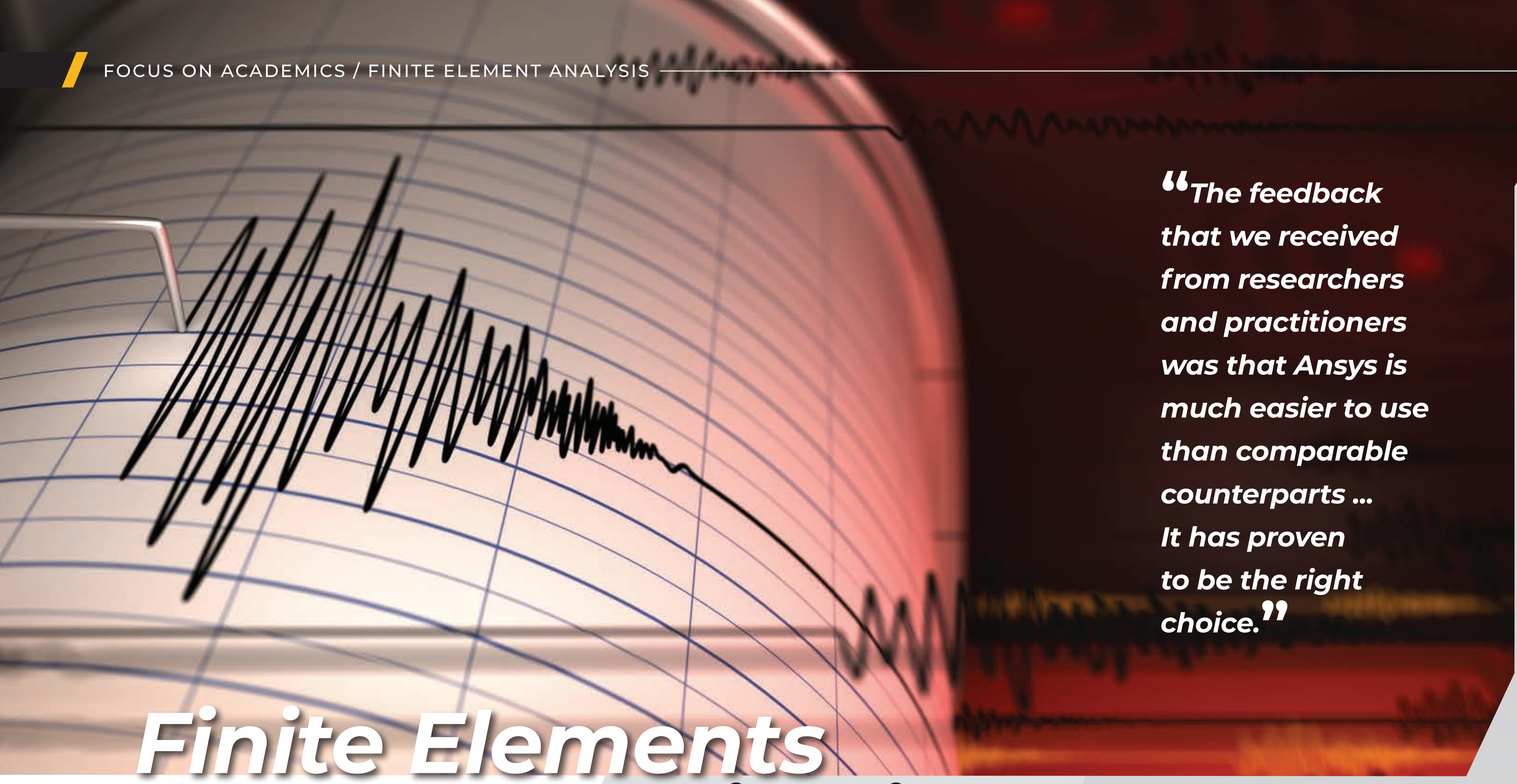
study the wind's impact on mortality rates for both animal and plant species.

In 2024, conservationists plan to eradicate house mice from Marion Island, as these rodents are killing the chicks of endangered species such as the wandering albatross. Introduced by seal hunters in the early 19th century, today these rodents are overrunning the island. An effort called Mouse-Free Marion plans to use helicopters to strategically spread rodenticide across the island. The wind models produced by Craig and his team will help in creating flight maps, assessing landing and take-off conditions, and predicting the most effective means of dispersing bait during the campaign.



Meshing Marion Island

"The Marion Island wind modeling project is a great example of the value delivered by simulation," Craig says. "Given the extreme weather conditions and the pristine state of Marion Island, it would be impossible to create physical stations to measure and study changing wind patterns. Everyone invested in protecting this island is grateful that Fluent was able to produce such a compelling approximation of the real atmospheric phenomena occurring on Marion Island without the need for permanent wind measurement systems or other environmental impacts."



Finite Elements Shake Up Seismic Research at UCLA

By **Jennifer Procario,** Staff Writer, Ansys Advantage

Researchers at UCLA are conducting groundbreaking research funded by the California Energy Commission (CEC) to analyze the seismic risk posed to natural gas pipelines when they intersect with earthquake fault lines — and even when they don't. The study affects nearly 40 million residents of the state, and that's just one element of the project.

Historically, civil engineers have used computer-aided design (CAD) or finite element analysis (FEA) modeling in similar research, but Professor Yousef Bozorgnia of the Department of Civil and Environmental Engineering at the University of California, Los Angeles (UCLA) is leading a team of graduate students and post-doctoral fellows to optimize seismic simulation using Ansys' multiphysics FEA simulation.

In multiphysics simulations, FEA possibilities expand by giving researchers the ability to simulate across engineering disciplines when needed, such as when studying the interaction between structural mechanics and fluid flow, all within a single, unified simulation environment.

"The feedback that we received from researchers and practitioners was that Ansys is much easier to use than comparable counterparts … It has proven to be the right choice."

Through the Ansys Academic Program, which provides universities with affordable software for use in the classroom and in research, Bozorgnia and his team are integrating Ansys Mechanical for structural analyses while benefiting from the simulation software's built-in tools for customization and generated scripting.

Further, Ansys introduced the group to the Texas Advanced Computing Center (TACC) at the University of Texas at Austin, which designs and operates some of the world's most powerful computing resources.

With the support of Ansys and TACC, Bozorgnia and his team are able to perform next-level seismic simulations that require millions of iterations and affect millions of people in a fraction of the time and cost of previous seismic analysis methods.

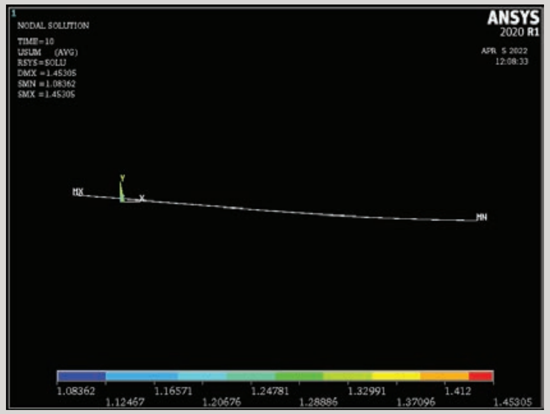
FINITE ELEMENT ANALYSIS FOR NEARLY INFINITE ELEMENTS

While Bozorgnia heads the project for the university's Samueli School of Engineering, the team's research is part of a larger operation. The project is funded by the CEC to quantify the seismic risk of natural gas pipelines throughout the state — a massive infrastructure consisting of thousands of miles of pipelines embedded in soil. Added complexity to this, pipeline size varies significantly, with measurements ranging from 8 to 44 inches in diameter and from 0.2 to 1.2 inches in thickness.

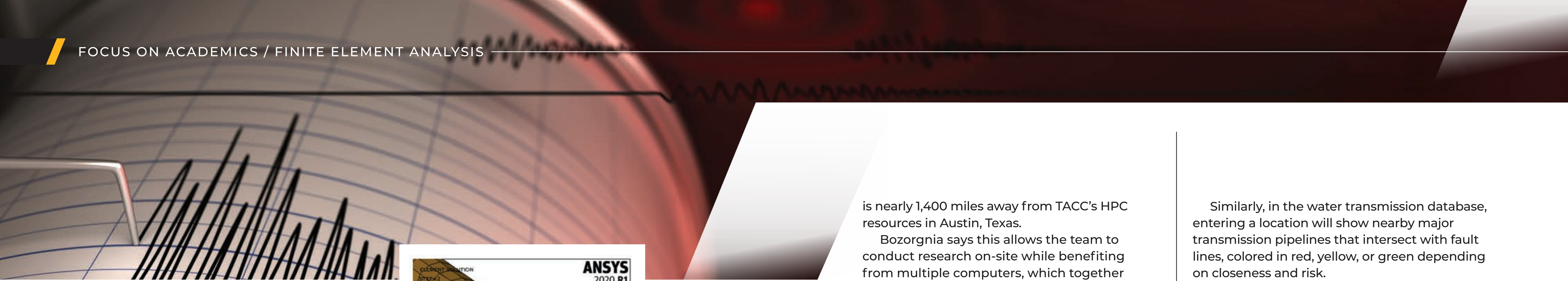
Plenty of geometrical and geological variables also contribute to the complexity of the analyses. For starters, if an earthquake causes a rupture along a fault line, what happens to an intersecting gas pipeline? Next, depending on the size and physical characteristics of the specific gas pipeline, how much of it is embedded in soil? Also, at what angle does the pipeline cross the fault — and what kind of fault line is it? It could be a strike-split fault (like the well-known San Andreas Fault, where two blocks of rock or land slip past each other horizontally). But it could also be a reverse, thrust, or normal fault; each involve vertical shifting, yet in different directions and at distinct angles.

In addition to variables surrounding fault displacement, other scenarios to consider involve landslides and soil liquefication. During a landslide, with a mass of soil headed straight toward a pipeline, what happens to that pipeline? Also, depending on the soil's physical characteristics, such as texture, structure, and porosity, an earthquake can cause soil to "liquefy," creating a flow that could also disturb the pipeline.

With all the variables combined, there are more than a million analyses to consider, which requires millions of iterations. To handle this complexity, Bozorgnia and his team use Mechanical to model the gas pipelines and soil with finite elements while using the high-performance computing (HPC) capabilities



Ansys Mechanical model of the deformation of a 3-km natural gas pipeline subjected to multi-support excitation, simulating the effect of an earthquake for 10 seconds



of TACC to run a significant number of simulations for every scenario. Fortunately, due to the nature of the research, the extra compute power is free. The National Science Foundation supports TACC with any research project related to natural hazards, which enables UCLA to access their computing resources at no cost.

"Research funding is always limited," says Bozorgnia. "We couldn't do this project if it was not for Ansys and their cooperation, access to the software through the Ansys Academic Program, and interacting with TACC."

Support and funding are crucial for the project, which stretches beyond pipeline and fault line crossing points to include further examination of how pipelines respond during an earthquake, regardless of whether they intersect with the fault line.

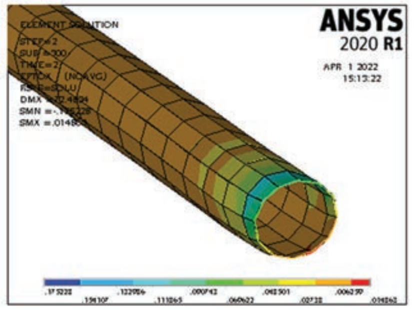
SOFTWARE FOR SEISMIC SIMULATION

Before embarking on the project, Bozorgnia carefully considered which software to use by polling respected members of the research community.

"More than two years ago, we asked which software we should use and the feedback that we received from researchers and practitioners was that Ansys is much easier to use than comparable counterparts," says Bozorgnia. "Obviously, Ansys' accuracy and productivity also are important, but for us, to begin with, the short time to learn and use it was the key point that led us to go with Ansys, and we are really happy about it. It has proven to be the right choice."

Some newer doctoral students on the team had limited prior experience using FEA software. Still, they were able to quickly learn Mechanical with guidance from other team members and additional assistance provided by the Ansys Academic Program, including the Ansys Learning Forum as well as a repository of learning resources online.

Along with its ease of use, Bozorgnia's team finds the solid element selection in



Simulation results in Ansys Mechanical of a 55-inch water transmission pipeline under 6-feet fault displacement with a section-cut view of the deformation at the pipe cross-section

Mechanical — particularly elbow elements — to be effective in modeling the nonlinear shape of a pipeline in its entirety. In contrast, some researchers may prepare similar models using shell elements, but that option would only capture the pipeline's exterior.

With a variety of elements to choose from, the team can model pipelines spanning different lengths and sizes, including thickness. The nonlinear capabilities of Mechanical also enable them to examine the interaction between the pipeline and surrounding soil by placing nonlinear springs along the pipeline in the model.

After creating several pipeline models, the team analyzes and considers all the variables for each by applying a multitude of stresses and strains. Based on the simulation results, they can accurately predict which conditions may cause the pipe to break and when, while observing any other potential damage scenarios likely to happen.

In the traditional way, it would take the team between one to two weeks to script language from scratch to prepare and complete just one model. Today, the team completes a model within 10 to 30 minutes using Mechanical integrated with MATLAB code generation. Likewise, TACC's supercomputing contributions greatly accelerate the timeline further.

Also, with the software's remote solve management capabilities, the team is able to perform large-volume calculations and simulations from the UCLA campus, which is nearly 1,400 miles away from TACC's HPC resources in Austin, Texas.

Bozorgnia says this allows the team to conduct research on-site while benefiting from multiple computers, which together provide thousands of central processing unit (CPU) cores.

HIGH-POWERED, FAR-REACHING PROJECTS

By the end of 2023, Bozorgnia expects to have the final stage of the project completed, which is an interactive database of natural gas pipeline and earthquake fault line locations. With all of the team's findings and pipeline combinations cataloged, interested parties will be able to enter a pipeline location and discover the nearest fault line and risk.

As the team compiles their natural gas pipeline research, they're also working on another massive undertaking — examining the seismic risk to water transmission pipelines that run in southern California. Akin to the first project, Bozorgnia leads the group to analyze water transmission pipelines and crossing earthquake faults. Though the properties and contents of water transmission pipelines differ from natural gas pipelines, the team employs the same technology, simulation, and finite elements to model and analyze all the variables. The group is also creating a separate interactive database for this research, which is slated for completion by mid-to-late 2023.

When entering a pipeline location in the natural gas pipeline database, the software will present a probability of failure based on the variable cases within the database, including proximity to fault lines.

Similarly, in the water transmission database, entering a location will show nearby major transmission pipelines that intersect with fault lines, colored in red, yellow, or green depending on closeness and risk.

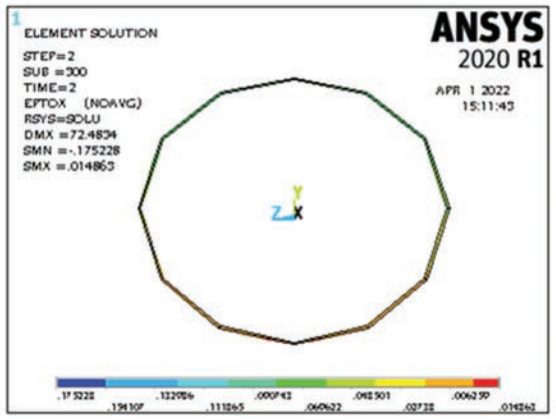
Both databases are expected to have a substantial reach. The team anticipates that both platforms will be used by individuals and state agencies such as the CEC as well as utility companies that use natural gas or water.

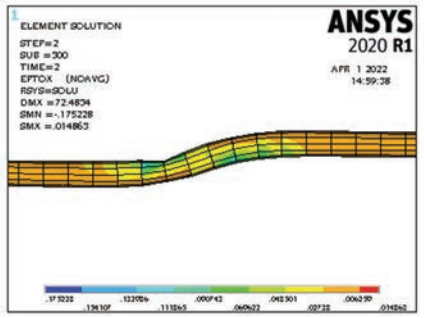
"The agencies and companies can enhance their facilities for seismic issues and, consequently, the residents of California will have less risk in relation to water and natural gas," says Bozorgnia. "The beneficiaries of the whole project are going to be the millions of people living in California, especially in southern California, with about 13 million residents."

POSITIVE AFTERSHOCKS

Bozorgnia's team will share the team's research and results in journal papers within the industry. However, neither milestone will mark the end of the team's exploration with pipelines, fault lines, or simulation.

"That's a part of academic research: If there is a feature we haven't used and we want to solve a complicated, complex problem, we always have to try new things," says Bozorgnia. "The problem we are solving is a very real problem, so we will always try new simulation software and technology, finding new ways to analyze our data. Ansys has helped us significantly to solve complex real-world infrastructure problems."





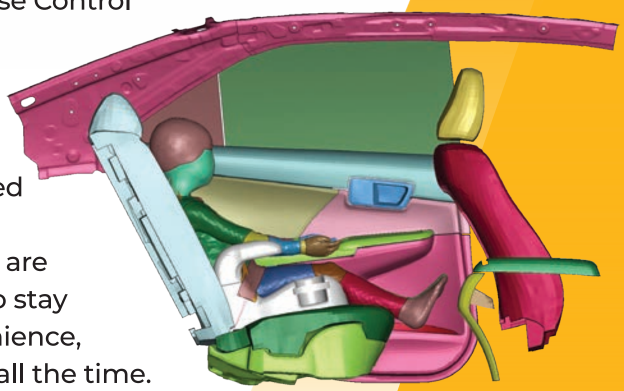
Simulation results in Ansys Mechanical of a 55-inch water transmission pipeline under 6-feet fault displacement illustrating the deformation of the pipe cross-section (left) and the strain distribution along the pipeline near the earthquake fault zone (above).

STEERING CAR SEAT DEVELOPMENT IN A SAFER DIRECTION

By **Laura Carter**, Staff Writer, Ansys Advantage

Kids require a lot of special gear, and parents' confusion over what to buy often begins even before a newborn baby leaves the hospital. Child safety is a huge focus for most parents-to-be, and car seats are at the top of the list. That's not surprising because the Centers for Disease Control and Prevention (CDC) identifies motor vehicle crashes in the United States as a leading cause of death for children ages 12 and younger.[1]

With the baby car seat market projected to grow by $1.68 billion between 2021 and 2022,[2] vehicle and car seat manufacturers are closely following consumer preferences to stay ahead of their demands for safety, convenience, and affordability. Child seats are evolving all the time. Today's car seat designs are very different from what they were 15 years ago. Overwhelmingly, parents want seats that are safer, lighter, easier to use, and more portable, which requires additional testing of materials and new seat design.



Simulation of child in car seat before deceleration begins

> ***"Using simulation and human body models, we can analyze occupant protection for children across a wide range of scenarios to ensure our most valuable passengers are protected on the roads."***

CAR SEAT RESEARCH GETS ITS CHOPS

To address these challenges, researchers at the Center for Injury Research and Prevention at Children's Hospital of Philadelphia (CHOP) are using Ansys LS-DYNA simulation software for collision simulations to better understand how to optimally protect children in car seats.

"The mission of our center primarily is to pursue innovative solutions to prevent injuries in children, youth, and young adults through rigorous research and collaboration with industry, policymakers, and governmental agencies to improve product design policies and educate parents and caregivers about correct child seat use," says Jalaj Maheshwari, MSE, Research Project Engineer and a Lead Project Investigator at CHOP. "Ansys simulation helps support the computational modeling efforts in the safety research we're conducting."

Maheshwari and his team are tasked with assessing car seat safety systems designed for children across a wide range of ages, which increases the complexity of testing. Pediatric occupants are a particularly challenging population to model. There isn't a set anthropometry, or human body measurement, that you can use for all cases. The algorithm inputs of an 18-month-old child are completely different from that of a 3-year-old, which are completely different from that of a 6-year-old, and so on. Restraint systems change dramatically during the birth-to-11-year trajectory as a child grows, moving from a rear-facing to a forward-facing seat, and finally a belt-positioning booster seat.

Traditionally, children's car seats have been evaluated using physical crash tests by securing a child-sized crash test dummy onto a properly installed car seat. The test bench, or sled, is then accelerated and decelerated at various pulses that mimic different crash scenarios to test occupant movement and injury potential. During testing, all the elements, from the dummy positioning, harness and chest clip positioning to harness tightness, must be in accordance with federal testing standards. Testing helps ensure that the child seat provides adequate protection by ensuring the occupant surrogate or crash test dummy complies with the injury thresholds, or the protocols identified by the National Highway Traffic Safety Administration (NHTSA), Consumer Reports, and other regulatory or consumer information bodies.

Physical testing using a crash dummy to verify simulation results

These physical tests are expensive, which makes investigating multiple crash scenarios economically challenging for all involved. While physical testing is an essential aspect of safety assessment and cannot be eliminated, manufacturers have discovered that combining it with simulation can speed up restraint assessment and enhance development of car seats that perform well in all types of crashes.

Simulation of a child passenger in a car seat before a side impact collision (left) and during collision

YOU CAN'T ALWAYS PREDICT … OR CAN YOU?

More often than not, children are fidgety, and don't necessarily sit straight up and look forward all the time. Further, research by CHOP and others indicates that a large percentage of child restraint systems are installed with at least a minor user error[3,4], like loose belts, unused or out of position chest clips, and so on. Using LS-DYNA enables the simulation of real-world, in-vehicle scenarios, such as different seating postures where the occupant is leaning forward or leaning inward[5], and installation errors. Other test-worthy scenarios — including pre-crash maneuvers such as swerving or sudden braking enabled by advanced driver assistance system technologies — can also dramatically change the child's position in the car seat.

For researchers at CHOP, it's important to assess what happens when a child is in as many positions as possible when a crash occurs. Will the seat belt slip off, and if it does, is there a way to prevent it from happening? Or is an advanced restraint system mechanism needed that pulls the seat belt in such a way that it provides a better fit on the child in the event of a crash?

MOVE OVER, DUMMY

Anthropomorphic test devices or crash test dummies are essential tools to assess injury and restraint performance in physical crash tests. While crash test dummies are human-like, they're not exactly human. To advance safety, it's important to understand how an actual human body behaves. Using LS-DYNA with validated virtual human body models, CHOP can simulate different crash conditions with child models of varying anthropometries.[6] To do this, the team must first develop a 3D computer-aided design (CAD) model of the child seat and the vehicle seat/test bench from specific dimensions according to engineering data. After that, the finite element (FE) model is generated by meshing each component and assigning it appropriate material properties. The individual FE models of the child, child seat, and vehicle seat/test bench are brought into one environment, positioned as necessary, restrained with seatbelt FE models, assigned boundary conditions, and then loaded into a processor to run the crash scenario being investigated.

Using a virtual human body model during simulation requires a variety of mesh sizes within different boundary conditions. Researchers evaluate their meshes and assign them to each body part. This activity often involves finer meshing in certain areas of the body to maintain the features and the complexities of the geometry they are using.

Human body models are a key component of Maheshwari's simulations to help evaluate how safety aspects of the child restraint could change across a wide range of child age and size. The resulting data enable vehicle safety system and child restraint design for children of all sizes and ages, and also help policymakers shape policy and testing standards that effect positive change on child safety.

ANSYS LS-DYNA SUPPORTS INDUSTRY AND ACADEMIC RESEARCH

CHOP uses Ansys LS-PrePost within LS-DYNA to pre-process, submit simulations, and post-process their results. Maheshwari starts by bringing in individual models he has created meshes for with specific material properties. The seating environment is defined, and LS-PrePost is then used to position the occupant in the seating environment, which could be a full vehicle or a test sled with the child in an age-appropriate child seat.

Different types of pre-simulations run in LS-DYNA help position the occupant and deform or compress the seat to reflect the physical world. The child seat and human body model are positioned in the vehicle environment and adjusted in accordance with gravity. Once those models are settled, the team restrains the child seat and child to the vehicle, applies the desired boundary conditions of the crashes, and runs the simulations.

In the physical world, says Maheshwari, vehicle crashes are over in an instant, lasting 120 milliseconds; however, simulation times can take anywhere from two hours to seven days depending on the complexity of the model they are using. Once the simulation is complete, the data can be exported for further analysis.

CURBING RESEARCH COSTS, NOT TESTING

With all of this testing, costs can really add up, which is what makes simulation an excellent option for academic research. Ansys supports Maheshwari's research by making licenses more affordable for the team. An Ansys license doesn't limit the team to how many tests they can run, but to the life of the license. Using LS-DYNA, they can run as many parametric simulations as they wish. Right now, they are at 100+ full-impact simulations and counting using a virtual human body model — an achievement that would be economically prohibitive and time consuming with a physical sled test.

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The virtual human body models CHOP uses have a detailed skeletal structure and internal organs[7] to help the team assess the kinematic and kinetic responses of an actual human body, which provides additional data on restraint performance along with data gathered from physical anthropomorphic test devices. If they're investigating a frontal impact involving a child seated on a booster seat, for example, they can virtually look beneath the skin to understand how a seat belt is loading the abdomen and the internal organs. This helps them to identify what stresses are generated in different body regions, and identify high-stress regions during an impact. By stripping away layers of the body using software, they can perform what are essentially "virtual autopsies" on digital human models and assess the potential for injuries. Although the field has advanced to a stage where these human models closely mimic the responses of actual humans, accurate injury assessment is a work in progress, with these models constantly evolving and being validated with physical test data. Virtual models need to be complemented with physical testing to ensure safety system development for all types of occupants.

Maheshwari is excited by the potential these models have to inform autonomous vehicle (AV) development. AVs of the future will present more flexible, modular seating configurations in vehicles that enable more movement among all passengers, including children. For example, a child may be facing the side or the back of the vehicle, so the forces acting upon them during a crash will be different from the standard forward-facing position. In this scenario and others, it is important to evaluate current restraint systems for the potential to provide protection. Investigating those types of scenarios using Ansys LS-DYNA and virtual human body models enables CHOP to take a much deeper look at the different loads a body sustains to help recognize injuries coming out of various types of impacts.

"We can absolutely go that deep," says Maheshwari. "Using simulation and human body models, we can analyze occupant protection for children across a wide range of scenarios to ensure our most valuable passengers are protected on the roads."

Artist's rendering of an earlier version of Blue Sky Solar Racing's Borealis

CATCHING SOME RAYS

Students design solar race car with simulation and the sun

By **Jennifer Procario**, Staff Writer, Ansys Advantage

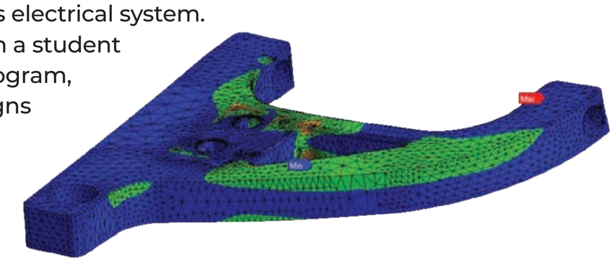
As millions of college students soak up the sun this summer on vacation, engineering enthusiasts at the University of Toronto have other plans for the fiery sphere. The university's Blue Sky Solar Racing team is designing a solar race car to catch enough rays to finish as a top contender at the World Solar Challenge (WSC) next year.

With more than 60 current members, the student team consists mostly of undergraduates with backgrounds in engineering, computer science, business, and marketing. Despite their diverse areas of study, they're all gaining hands-on simulation experience.

From the front- to the rear-end of the vehicle, the team is integrating Ansys simulation solutions to design a winning solar race car with the least amount of aerodynamic drag, the highest solar energy intake, and the lowest energy losses in its electrical system.

With access to Ansys simulation tools through a student team partnership under the Ansys Academic Program, the team iterates calculations, models, and designs more quickly, accurately, and seamlessly across all parts and subsystems of the car. The partnership provides student teams with free research software and support for use with their competition designs.

As a result, their solar car is well-equipped for competition and, with real-world engineering experience, the team is well-equipped for life after graduation.



Blue Sky Solar Racing completes a static structural analysis in Ansys Mechanical to ensure the safety of their solar race car, Borealis. This simulation illustrates the lower control arm of Borealis' rear suspension.

"We currently use Ansys simulation across all subsystems of the car, including mechanical, structural, and aerodynamic. A lot of the proof and justification for our design documentation to the competitions' regulatory boards actually comes in the form of simulation results."

SIMULATING FOR THE SUN

This isn't the team's first rodeo — or race. Blue Sky Solar Racing has been around since 1997. Historically, the team participates in the biennial WSC race — a 3,022-kilometer (roughly 1,878-mile) race spanning the Australian continent — faithfully every two years.

The team's latest race car, named Borealis, marks their 11th-generation race car model and bears a similar lean and lengthy resemblance to the earlier models at 5 meters long (the maximum length allowed by WSC) and around 1.1 meters in width and height.

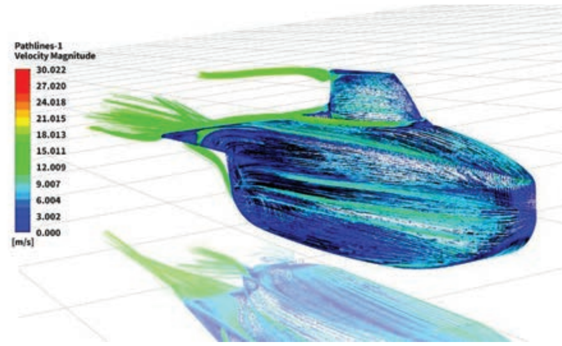
Leo Han, the team's project manager, says a long and skinny design reduces aerodynamic challenges, but aerodynamics isn't the only matter of concern. Race regulations include a host of requirements, including the vehicle's energy storage, occupant space, driver's and electrical safety, steering, brakes, and more.

"We currently use Ansys simulation across all subsystems of the car, including mechanical, structural, and aerodynamic," says Han. "A lot of the proof and justification for our design documentation to the competitions' regulatory boards actually comes in the form of simulation results. We send over our Ansys simulation results, plots, and data to justify that our design is safe and meets regulations."

For Borealis' development, the team has used Ansys Mechanical and Ansys Fluent most for structural and fluid analyses, respectively, while relying on Ansys Speos in the past to optimize headlight reflectors — an optical design that is still being used to boost the car's beams.

While the size of the team fluctuates from year to year, at least 20 members actively use Ansys' finite element analysis (FEA), computational fluid dynamics (CFD), and optical design software during most development periods. The team has several departments, including mechanical, aerodynamics, electrical, array, electromechanical, structures, strategy, fabrication, and advancement.

All groups share a dedicated space on campus across from one of the university's main engineering buildings. The shop is outfitted with a garage door to easily transport the car in and out, as well as an adjacent computer lab with multiple workstations where team members perform analyses, calculations, and simulations. The team makes good use of the facility year-round in preparation for the race, which involves prerequisites. In addition to sending advance documentation to meet regulation standards, the WSC requires the solar car to pass a preliminary "scrutineering" round one week before the competition in order to race in the main event.

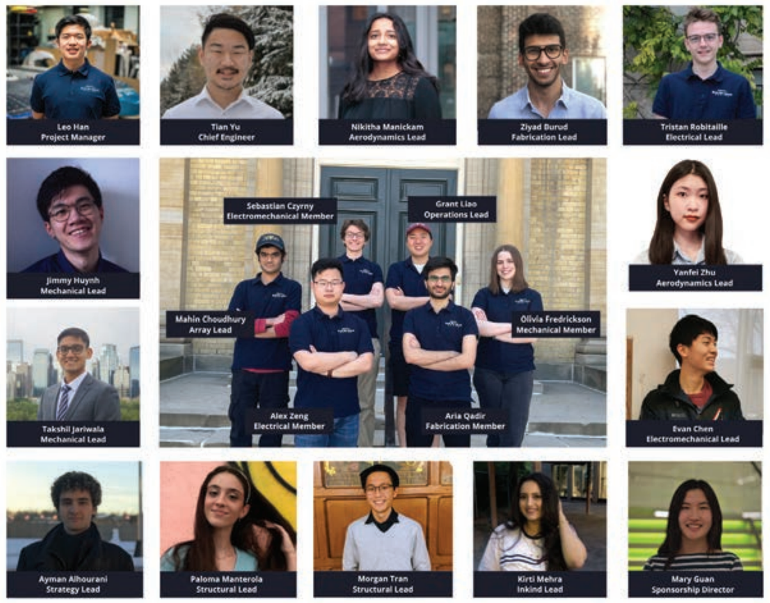


Members of the team's aerodynamics department use Ansys Fluent to analyze velocity and speed. This simulation shows a study done using a NACA airfoil.

Scrutineering typically consists of mechanical and electrical inspections as well as dynamic tests such as U-turns and figure-eight maneuvers. While the full WSC schedule for 2023 has not been released as of press time, the competition generally runs up to two weeks, including about five days for scrutineering.

BUILDING A WINNER, SAFELY

Aside from energy efficiency, the most important aspect of a solar race car — or any race car — is safety. While safety affects every



The Blue Sky Solar Racing student team at the University of Toronto is designing a solar race car to compete at the World Solar Challenge next year.

facet of the car, one of the most critical areas to secure structurally is the space surrounding the driver.

Paloma Manterola, a Structural Lead on the team, uses Ansys FEA simulation to ensure safety around this hot seat.

"I've mostly used Ansys Mechanical to optimize all the chassis or the roll cage, which are basically the parts that surround the driver and protect them in case of a crash, rollover, or any kind of disaster," says Manterola. "Protecting the driver is the main issue and the main goal of the team. Ansys simulation has really helped us in that regard while also helping us to potentially perform well in the race."

The primary challenge for Manterola and her group has been to optimize the chassis, which is made of sandwich panels consisting of carbon fiber layups, while balancing weight and strength. The goal is to optimize the chassis so it doesn't weigh down the vehicle, while still safeguarding the driver in any scenario.

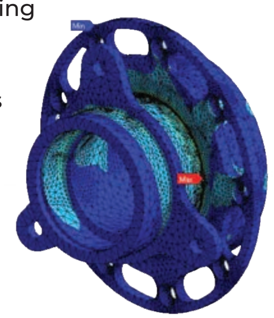
To achieve this, Manterola and the rest of her group use Mechanical in combination with Ansys Composite PrepPost (ACP). ACP is an integrated tool in the Ansys Workbench simulation integration platform with pre-processing (ACP-pre) capabilities for composite laminates modeling and post-processing (ACP-post) capabilities for advanced analysis using failure tools.

First, the team uses ACP-pre to construct the sandwich panels and carbon fiber layups. Next, the members shift to ACP-post to get the results of structural analyses, including maximum principal and stress deformation.

Once this data is collected, the group uses Mechanical to identify values for points of maximum deformation or maximum principal stress. After these points are identified, it's back to design.

The team can then determine which areas of the chassis they can adjust. Some areas may suffice with fewer layers of carbon and a lighter core, while other areas require more layers of carbon and a stronger core for extra strength. A similar process is completed for the Borealis' outer body to reduce the overall weight of the vehicle while still protecting the driver.

Jimmy Huynh, a mechanical lead, explains how their team also uses Mechanical to test the vehicle's suspension system.



Simulation showing maximum stress generated in hub

"We use Ansys Mechanical to test the loads that we calculate based on the regulations that the WSC sent out, and we use rigid dynamics to get proper mechanical movement and test the entire suspension system to make sure there's no clashing," he says. "We make sure that the car moves with the wheel characteristics that we've set up, and then also that it doesn't interfere with any of the other subsystems."

They also employ Mechanical's rigid dynamics capabilities to test smaller mechanical systems throughout the car, such as hinges.

Additionally, the aerodynamics group uses Fluent to understand and improve the aerodynamics inside and outside of the car with built-in tools for electric motor cooling, turbulence modeling, and combustion models.

GETTING AN EDGE ON THE COMPETITION

Another component that the team must consider is weather. If you wondered if a solar race car fares best on sunny days, it does. But it's not just the sun that impacts conditions.

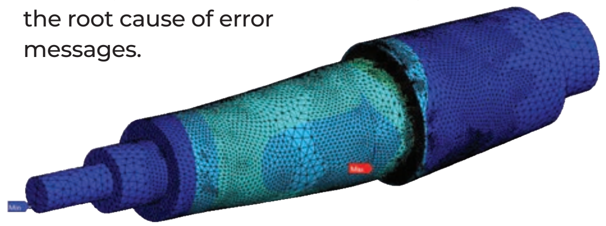
While a cloudy day can reduce Borealis' energy input by two-thirds, a strong headwind could double power consumption due to aerodynamic losses. On the other hand, a tailwind could help reduce aerodynamic losses. To consider all weather-related variables, the team analyzes forecast data, then inputs the information into Ansys' simulation software. Using these results, the team runs additional simulations for a wide range of conditions to determine possible solutions, such as at what speeds to operate the vehicle during certain wind conditions to perform best in the race.

Though the bulk of Borealis' power is dependent on the sun, all teams are allowed to start the race with an initial full battery pack charge, which allows around 3 hours of driving at 70 km/h.

While this could be considered a slight head start, it pales in comparison to the edge that Ansys' predictive accuracy has given the team, at least according to its members.

"We're doing simulations on a 5-meter-long car, and just the sheer volume of that, you wouldn't expect simulation to give you that much accuracy. But every time I refine the mesh, Ansys Mechanical gives me more and more knowledge of how I need to fix something — maybe change a corner angle to make it less sharp," says Manterola. "Just being able to have that information really helps a lot. And yes, Ansys can work with this massive model while also giving accurate and fast results. It also allows us to easily move back and forth from other tools to Ansys' simulations, which makes the iteration process so much faster."

Manterola applauds the Ansys Academic Program for not only providing tools, but also for offering support online. By using the Ansys Learning Forum and Ansys Learning Hub, Manterola and her teammates found solutions for many common issues, including the root cause of error messages.



Ansys Mechanical simulation showing maximum stress generated in an axle

Additionally, Tak Jariwala, another Mechanical Lead on the team, helps new recruits learn the software through the team's onboarding training program. In his experience, even members new to simulation embrace Ansys' tools rather quickly.

"Overall, I think the learning curve is generally steep because a lot of our recruits come in as first-year or second-year students, where they haven't had much experience with our coursework yet," says Jariwala. "But we try to make our training modules fairly intuitive, and I think Ansys' simulation especially is easy to learn once you have exposure to one or two sessions. It's fairly straightforward and easy to pick up with time."

With forecasting and simulation well understood, the only thing left for the team to figure out is who will take the wheel. Ideally, the team selects three drivers to alternate driving and alleviate the burden, which includes daily 9-hour driving shifts for about a week.

However, few team members don't have their driver's license yet due to so many test cancellations during the pandemic. Adding to this challenge, the size restrictions of Borealis' driver hub create another hurdle, favoring the team's shortest and smallest drivers.

As the group tries to find additional candidates, Han plans to take one for the team and get behind the wheel. In the meantime, Borealis is ready and waiting to be steered to a victory.

RACING INTO THE FUTURE

Though the team isn't finished with Borealis just yet, they're already thinking of design concepts for their 12th-generation solar race car model.

The team plans to integrate Ansys Discovery 3D simulation software into design plans to accelerate and streamline workflows by using more tools within the Ansys ecosystem. They will also engage Ansys Speos again to maintain optimum efficiency across all optical designs.

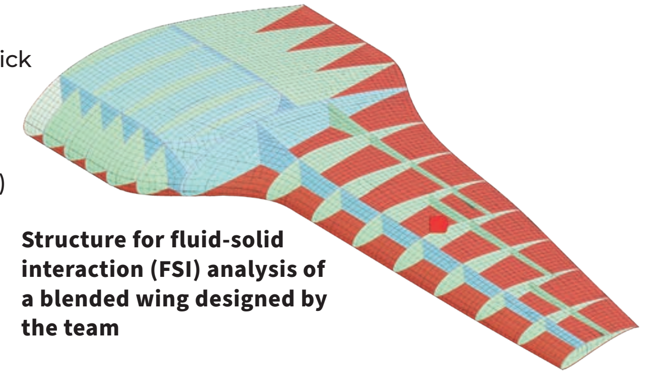
Helping Students' Dreams Take Flight

By **Laura Carter**. Staff Writer, Ansys Advantage

UNAM Aero Design Team at Biblioteca Central Universidad Nacional Autónoma de México (Mexico City)

"We had to work as a team, and Ansys gave us the flexibility to collaborate remotely or participate on campus as needed to successfully achieve our goals."

Most kids love things that fly, especially airplanes — whether it takes a simple flick of the wrist, a rubber band winding, or a battery-powered remote control to send them airborne. This fascination can lead to science, technology, engineering, and math (STEM) learning opportunities beyond grade school. For Miguel Cobian, a student responsible for leading the mechanical design system efforts of the aero design student team at the Universidad Nacional Autónoma de México (UNAM), the opportunity to join a student engineering team to design aircraft was really a childhood dream come true.



Structure for fluid-solid interaction (FSI) analysis of a blended wing designed by the team

"I've always been fascinated with planes," says Cobian. "As a kid, I would try to imagine how such heavy things like airplanes could ever leave the ground. At the university level, the technical and scientific aspects took hold, to the point at which all I wanted to do as an engineering student was to keep learning and understanding these phenomena to design very big, heavy things that can actually fly."

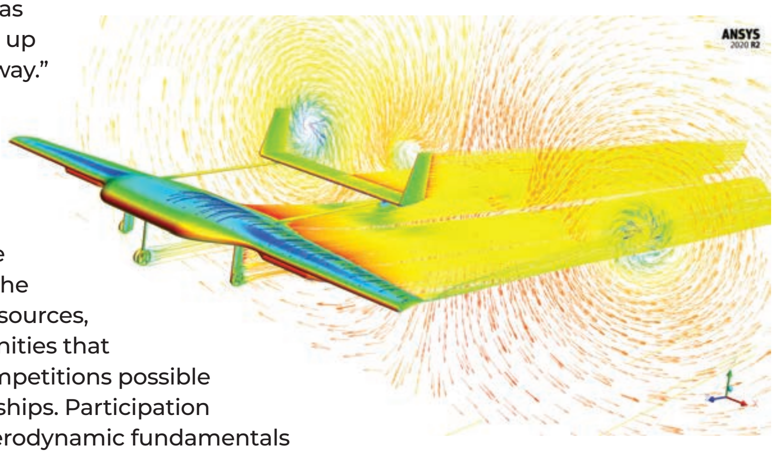
Cobian manages the students and the schedule, plotting out the team's trajectory — e.g., who will do what job where and how many events the team will take on during the year. All of the team's hard work is focused on winning Society of Automotive Engineers (SAE) aero design student engineering competitions.

His partner, Chief Technology Officer Michel Gordillo, is responsible for managing all of the technological resources of the team, including the free simulation software they receive through the Ansys Academic Student Team Partner Program. Gordillo must ensure that their aircraft is competitive, legal, and in compliance with current regulations. He leads the team through the technical challenges of the competition and makes major design decisions. Both Gordillo and Cobian are at the top of their class and are on a great academic trajectory, but they recognized that knowledge based strictly on passing exams was not going to fly in the real world.

"I wanted to be confident of my knowledge," says Gordillo. "I wanted a steeper learning curve, and I think you can only experience it by imposing new challenges on yourself, which is why I joined the team. I also like the aerospace sector and thought our team was the best place to learn and pick up valuable experience along the way."

SIMULATION HELPS FUTURE ENGINEERS SPREAD THEIR WINGS

The Ansys Academic Program supports student teams like the UNAM Aero Design team with the simulation software, training resources, and access to learning opportunities that make participation in these competitions possible through Student Team Partnerships. Participation enables the team to take the aerodynamic fundamentals and theoretical equations they've learned in class and



Fluent analysis of Mobula

apply them in the real world using simulation to design unmanned aircraft.

With help from Ansys, student teams can learn the ins and outs of simulation software and sharpen their skills through online tutorials or university courses as they go, as well as interact with other Ansys users in the Learning Forum. It's a win-win for students, who will graduate with industry-ready skills that will help them to prepare for and secure jobs after graduation. Ansys' continuous collaboration with the team began about four years ago. The UNAM Aero Design team is one of more than 500 Ansys-sponsored teams that have access to free software, resources, and support through partnership with Ansys.

Mobula aircraft designed by the UNAM Aero Design team, winner of second place overall, SAE Aero Design East: Advanced Class 2021

"It's a real-world application," says Vishal Ganore, Academic Project Manager at Ansys. "In designing a mini-sized aircraft, students are gaining hands-on experience and insight into how they can design a bigger aircraft. If they encounter a company in the aerospace domain, they have the expertise needed to demonstrate their knowledge of small aircraft design using simulation and land a job right out of college. And we know these students are some of the most sought-after by employers."

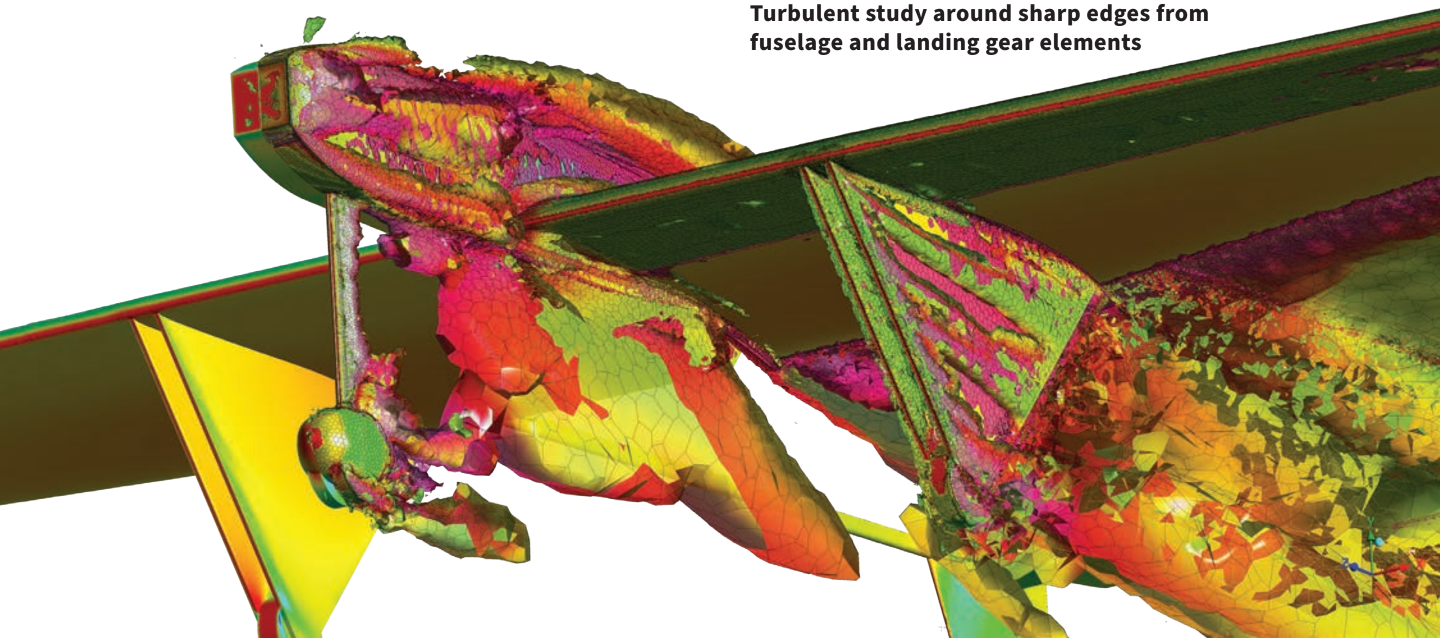
TEAM UNAM SOARS THROUGH COMPETITION

The Society of Automotive Engineers (SAE) connects and educates engineers while promoting, developing, and advancing aerospace, commercial vehicle, and automotive engineering. One of the ways SAE achieves its objectives is through student competitions. During these events, student teams from multiple universities, including UNAM, are challenged to build remote-controlled, mini-sized flying aircraft in multiple categories: regular class, advanced class, and micro class.

At 54 members strong, UNAM's Aero Design team is among the largest teams at the university and the only aero design team to date. They mainly compete in the advanced class, where they are tasked with delivering an aircraft capable of carrying and releasing various payloads. It also requires the related telemetry to monitor flight information around very complex missions.

Team UNAM manufactures a prototype of a mini aircraft using Ansys tools to look at aircraft efficiency and the external aerodynamics of the aircraft. They also perform structural analysis of the aircraft wings to make sure the structure is stable, which provides an excellent opportunity for students on the team who are interested in the aerospace industry. Participation involves real-world project experience connected to aerospace, plus the chance to apply important engineering

Turbulent study around sharp edges from fuselage and landing gear elements



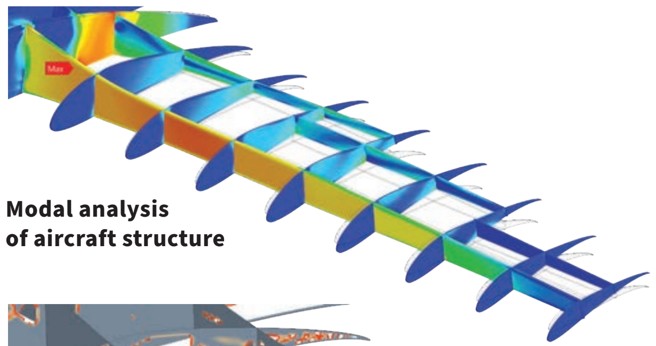
"Our team used a lot of Ansys products and was able to learn them all without any previous experience. The interface is very pretty and easy to understand ... Once you get the basics of one Ansys simulation tool, it's easy to extrapolate this knowledge and apply it to other Ansys simulation tools."

knowledge and the fundamentals they receive in class to explore industrial software, including flagship products like Ansys Fluent, Ansys CFX, and Ansys Mechanical.

"Our team used a lot of Ansys products and was able to learn them all without any previous experience," says Cobian. "The interface is very pretty and easy to understand. So, if you understand, for example, that you have to go from left to right preparing your analysis using this specific method in Fluent, you can apply this user experience to Mechanical. Once you get the basics of one Ansys simulation tool, it's easy to extrapolate this knowledge and apply it to other Ansys simulation tools."

WITH ANSYS, THE SKY'S THE LIMIT

In any given year, participation in multiple competitions is not unusual — including this year with advanced competitions in the United States and a regular competition in Mexico. To meet different timing and requirements, two or three unique aircraft designs are required, as well as extreme coordination among team members to get them done. Moving in and out of design phases, the team often runs tasks in parallel, or sequentially when they can't, using Ansys products to optimize their workflow structure and meet competing deadlines. This level of coordination was particularly important during the pandemic.



Modal analysis of aircraft structure

Topological optimization of aircraft structures performed in Ansys Mechanical

"What might be different from past student teams is the level of ingenuity that went into the past two years — keeping the team together, sometimes in isolation, sometimes on campus," says Gordillo. "We had to work as a team, and Ansys gave us the flexibility to collaborate remotely or participate on campus as needed to successfully achieve our goals."

To access simulation software off campus and facilitate information sharing, Gordillo set up a server at home using remote desktop software to extend the resource pool beyond individual laptops. This enabled team members to communicate directly with the server to activate licenses and run simulations off campus from wherever they were. The setup also enabled team members to obtain values for different design conditions via simulation, then share the data coming out of those simulations among themselves to successfully work through their concepts.

"Everyone is very keen on giving their best and going all out on the work they are doing," says Gordillo. "I think competing has been a huge learning experience, and I'm just grateful that I found in the team a community of super capable, intelligent people in which we are free to innovate, to bring ideas to the table, and not be afraid to test them."

Just how has all this teamwork paid off? In 2021, the UNAM Aero Design team won second place overall internationally and second place in the technical presentation for the Advanced Class competition in the U.S. So far this year, the team also took first place twice in Mexico for their technical report and technical presentation, and is looking forward to more wins in the future.

"So, as you can see, all these things we're implementing, and all the support we are receiving from Ansys, is really helping us in competitions," says Cobian. "We constantly keep growing and keep going forward as a team."

SOMETHING IN THE AIR

By Ansys Advantage Staff

IIT BOMBAY STUDENTS USE ANSYS FLUENT TO ESTIMATE HOW AIR CIRCULATION CAN MINIMIZE VIRUS SPREAD

In an accelerated world where the future is arriving faster than ever imagined, society literally can't wait for the next generation of engineers to become accomplished professionals. According to Janani Srree Murallidharan, Assistant Professor in the Department of Mechanical Engineering at the Indian Institute of Technology (IIT) Bombay, the demands are so great now that engineering schools have to "make experts as quickly as possible."

For Murallidharan, engineering expertise is built not just on learning theories and solving equations. She believes that as part of their preparation for tackling real-world problems, engineering students need to recognize the social relevance of what they're studying. What's more, they have to understand how solving challenges as engineers will contribute to societal goals.

"Engineers can select the equations they need in Fluent, and they can mix and match different models. Fluent will translate those complex conditions very quickly into a visual animation."

Fast-tracking the training of future engineers while helping them become productive world citizens might seem like an ambitious undertaking. But when the fourth-year students in Murallidharan's fall 2021 Computational Fluid Dynamics & Heat Transfer course took on the complex problem of analyzing ventilation in campus facilities during the COVID-19 pandemic, the experience resulted in decidedly down-to-earth applications.

Janani Srree Murallidharan, Assistant Professor in the Department of Mechanical Engineering at the Indian Institute of Technology (IIT) Bombay

Equipped with Ansys Student — a free download that includes Ansys Fluent — on each of their laptops, class members found out how to use advanced learning to solve practical (and in this case, universal) problems. They estimating how frequently the air inside a confined space needs to be circulated to minimize the spread of infection and how to introduce more fresh air into the enclosed environment.

MIXING, MATCHING, AND AHA! MOMENTS

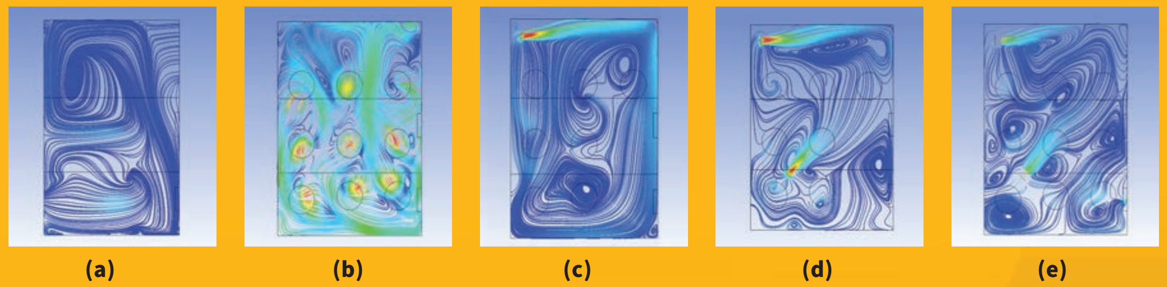
Murallidharan expects that the students who complete her course will be able to understand fluid flow in any environment they'll eventually work in, whether they'll be designing airplane wings, heat transfer systems for electronics, or wind turbines.

That's why she appreciates the flexibility of Fluent, which is used by professional engineers in multiple disciplines.

Before they can graduate to Fluent, so to speak, her students spend their first years at IIT Bombay calculating fluids phenomena the old-fashioned way: writing equations and coding computer programs.

Mastering the fundamentals is necessary and provides a firm footing in fluid dynamics. However, learning exercises don't provide the kind of insight young engineers will be required to have on the job.

"Because the students have to do all these steps themselves, the problem to which they will apply this fundamental capability is very rudimentary in the sense that they would probably take a very ideal room and study how air will settle into it," Murallidharan says. "They're spending most of their time trying to learn the very core of these equations. But at the end, they have difficulty understanding how the math can translate to helping industry."



Velocity streamline contours for (a) baseline case simulation, (b) simulation with ceiling fans and an exhaust fan switched on, (c) simulation with one exhaust fan and one pedestal fan, (d) simulation with one exhaust fan and two pedestal fans, and (e) simulation with two exhaust fans and two pedestal fans

> ***"There is no way the kids could have coded the mesh themselves for such complex geometries as a room. Fluent's sphere of influence mesh sizing easily let them identify regions where they wanted more complex or final meshes."***

By contrast, Fluent lets the students easily see complex conditions without having to actually type and code every bit of it, Murallidharan says.

"Engineers can select the equations they need in Fluent, and they can mix and match different models," she explains. "Fluent will translate those complex conditions very quickly into a visual animation. For students, Fluent lets them relate the engineering aspects to a design and helps them quickly assess the impact of flow problems and ideate solutions."

IIT Bombay campus building

Those robust numerical and functional capabilities seem purpose-built for Murallidharan's class, which had two parallel tracks. Students spent part of their time learning concepts and then used Fluent to solve actual problems that build on foundational computational fluid dynamics (CFD) theory. There was a lot of back-and-forth learning, Murallidharan says, that helped students better understand the fundamentals and the applications, and enabled them to see what the concepts do in the real world. It also resulted in many "aha!" moments.

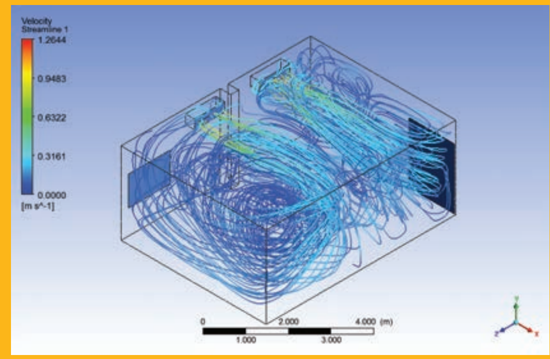
PLOTTING A SAFE RETURN

Bringing real-world issues into the engineering classroom is often tricky, and is even trickier when a pandemic prevents the students from being in the classroom themselves and they have to rely completely on remote, online learning.

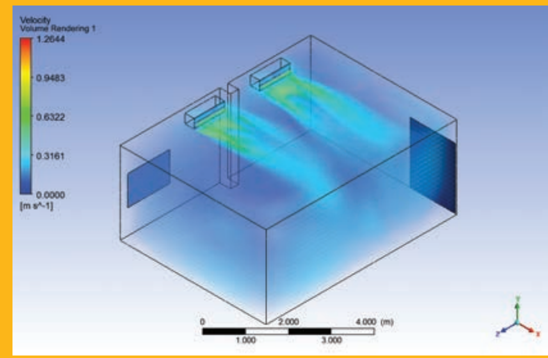
Yet these adverse circumstances turned out to provide a unique opportunity for these young engineering students. With the problem of COVID-19 all around them, it became an obvious focus for their semester-long project. Figuring out whether labs and other shared learning spaces were ventilated well enough to prevent the transmission of the virus would help Murallidharan's students:

- Learn that fundamental CFD is not something removed from their lives. One objective, she says, was to show how these "cold, very dry equations fit into our very chaotic world."
- Recognize how CFD can be used to solve socially relevant problems and make a difference in people's lives. Students and engineers are often disconnected from society, Murallidharan says. But learning to contribute to the world — even if it's something like designing a simple pump that helps a farmer irrigate his crops — can be more valuable than "landing the high-paying job."
- Be able to provide specific, concrete recommendations to overcome a challenge. As she notes, if the issue they were working on was too abstract or so large that there's no way to arrive at a feasible solution (e.g., ending pollution), it would be demotivating.

Ultimately, the students' work could have a huge and meaningful impact on the technology college itself. If they could figure out how to improve ventilation, or at least ensure that what's already there is safe, it might be possible for everyone to return to campus sooner.



Streamlines depicting the flow path taken by the air entering the room from the air conditioners



Volume rendering of the velocity of the flow field inside the room

Some questions remained, though: How could any of this be done without the students accessing the facilities that required analysis? And how could Fluent help?

ALL PROBLEMS ARE LOCAL

They say that all problems are local; if that's true, so are the solutions. At least they were in this case.

With a campus visit off-limits, Murallidharan asked the students to start looking at ventilation issues in their own homes. That quickly brought the issue into context, she says, as everyone was interested in making the rooms where they and their families live as safe as possible.

Broadening the investigation involved taking advantage of an ace in the hole. Although IIT Bombay was largely closed, the school allowed a handful of doctoral candidates to come onto campus. They served as mentors to Murallidharan's class, answering questions about the labs and other spaces being analyzed and taking photos to provide at least a virtual sightline.

Working on the assumption that recirculated air was likely laden with the coronavirus, the students used Fluent to simulate the effects of bringing in fresh air and drawing out the old. Murallidharan says that Fluent's robust meshing and simulation capabilities "made a world of difference," enabling students to mesh large rooms efficiently and easily incorporate various flow effects such as ceiling fans, exhaust fans, and air turbulence parameters.

"There is no way the kids could have coded the mesh themselves for such complex geometries as a room," she says. "Fluent's sphere of influence mesh sizing easily let them identify regions where they wanted more complex or final meshes. They could see why some meshes didn't work, make changes quickly, and then see how that affected the results. It was a huge learning experience."

Using Fluent to visualize the flow of air in the rooms was also essential.

"Fluent's animation capabilities actually showed them how the flow behaved rather than them having to imagine something," Murallidharan says. "They saw flow visualized in the rooms, tried out different simulation options available in Fluent, and worked with add-on numerical capabilities, such as solving for a user-defined scalar (UDS), which was crucial for predicting the residence time of air in various parts of the room. Ultimately, the students realized the importance of ventilating dead zones to limit infection spread."

AN ELEGANT SOLUTION

In the end, the students recommended an elegant, cost-efficient, simple, and universal solution: adding exhaust fans to the spaces and leaving any windows open just a bit to increase flow circulation and velocity. From start to finish, the work took just four months. There was no coding from scratch, just a few hours of clicking per week on their computers. The short timetable made the experience especially empowering, Murallidharan says. Using Ansys Fluent accelerated the students' abilities, and thanks to their study of something in the air, they'll be able to hit the ground running as professionals.

Penn State Students Take on Digital Missions

By Jennifer Procario,
Staff Writer,
Ansys Advantage

Professor Gregory Huff and a student examine a scale model of a single engine aircraft in an anechoic chamber. They are evaluating embedded antenna radiation patterns and linking performance studied in Ansys STK for in-flight scenarios involving remote agricultural sensor data acquisition and navigation-based sensor fusion.

Students at Penn State are developing mission-ready simulation skills. By pairing electronics modeling software with a digital mission engineering platform, electrical engineering professor Gregory Huff takes his classes on a trip beyond the lab, the curriculum, and the electromagnetic (EM) spectrum.

From antennas on the ground to radars in the sky, Huff teaches hundreds of students each semester how to use Ansys HFSS 3D high-frequency simulation software and the Ansys Systems Tool Kit (STK) digital mission engineering platform in tandem to optimize emerging research in electronics, aerospace and defense, meteorology, and more.

With affordable access to the software through the Ansys Academic Program, Huff incorporates both technologies for a multifaceted teaching approach that cultivates a unique and desirable skill set for a wide range of students outside of the engineering majors.

Coupled with the program's free resources for additional self-learning, students gain hands-on experience inside and outside of the classroom, which prepares them for real-world challenges — and missions — as their careers take off.

DIGITAL MISSION: POSSIBLE

As students' curiosity about STK grew due to the popularity of digital mission engineering industry initiatives and accessible online certification programs, Huff introduced the platform into some of his classes to allow students to experience the software within an active learning environment.

The STK certification program offers three tiers, including level 1 STK certification, master level, and grand master level. It's a sought-after program for many undergraduates as they stock their toolbox to stand out to recruiters after graduation.

First, Huff demonstrated the advantage of pairing HFSS with STK in telecommunications. From ground station antenna systems to satellite communications, Huff's goal was to present students with tangible ways to understand and explore electronic transmission and connectivity.

"If you look at any text on satellite communications, it's treated very lightly: 'Here are some antennas, use these equations, and they'll just work, or contact your local antenna person and good luck,'" says Huff. "I can write all that on the board, or we can use these really fabulous simulation software programs and platforms through the Ansys Academic Program, where real physics can be learned."

Huff guided students through an evaluation of ground station antennas and phased arrays, which are used on spacecraft. Students generated antenna radiation patterns in HFSS, then imported the data into STK to analytically and visually demonstrate how a phased array would perform.

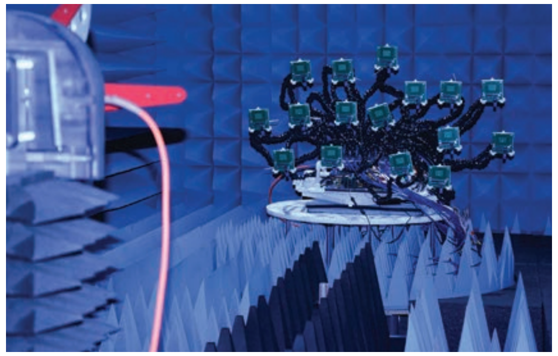
This bilateral analysis expanded research variables to include queries such as:

- Would the antenna work in a communication link?
- What is the impact of putting this antenna on a platform?
- Is there any blockage, interference, or scattering from other objects affecting the antenna?

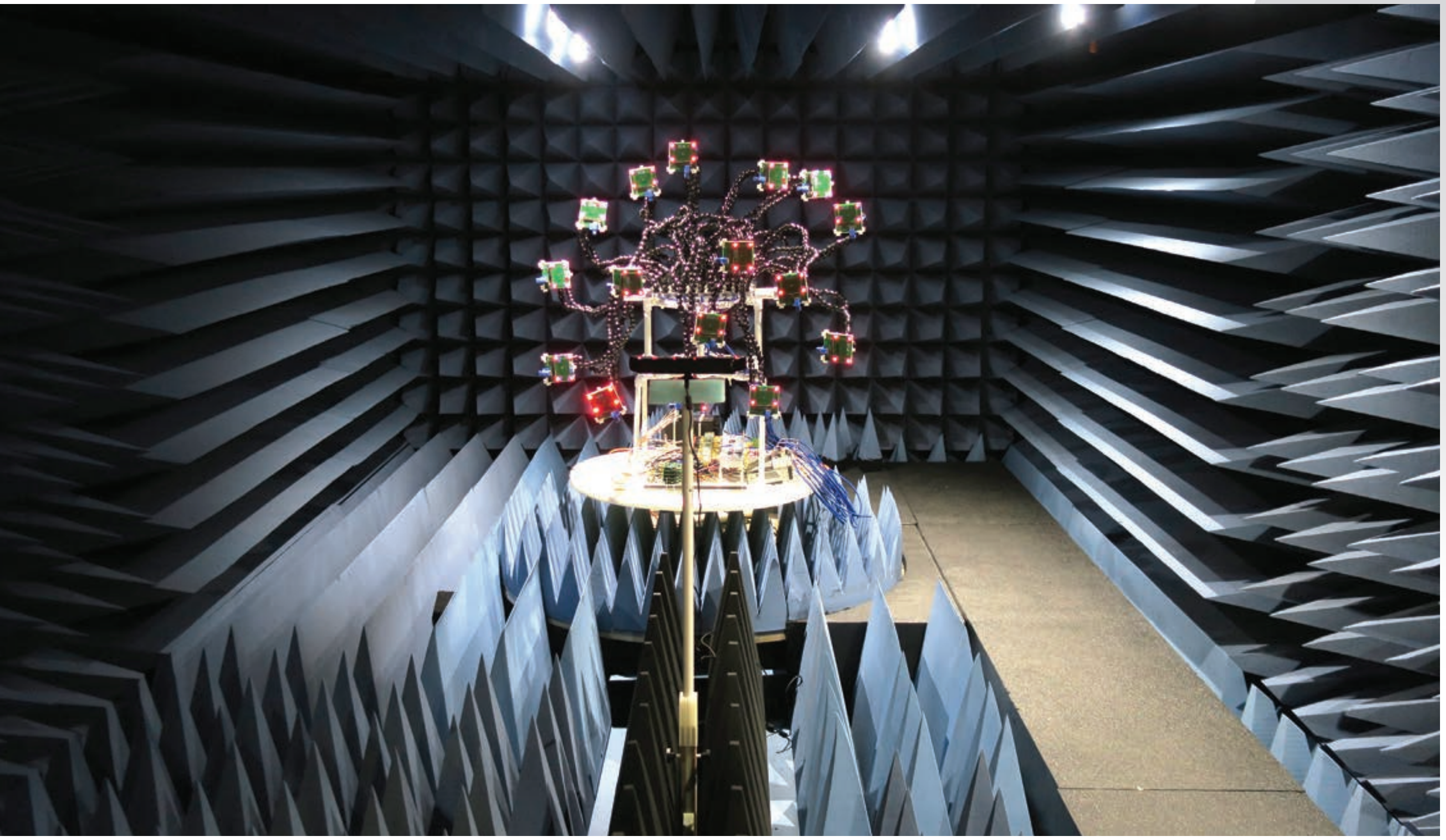
Huff's EM courses focus on communication radars and remote sensing, using STK to demonstrate both the communication and orbital mechanics components in an applied setting.

However, electronics engineering students aren't the only learners gaining an edge. The courses entice students from a variety of science, technology, engineering, and mathematics (STEM) majors and interests, including aerospace and mechanical engineering, as well as meteorology.

To unite different fields even more and keep things interesting for all students, Huff assigns two projects each semester that involve real-life missions — one locally and one across the country. For a local reference, students study equitable broadband access to learn how to establish wireless



The MEDUSA platform



The MEDUSA platform was developed in Professor Gregory Huff's laboratory to evaluate collaborative beam-forming techniques for unmanned aerial vehicle swarms using a computer vision-based system.

connectivity to underserved populations in rural areas surrounding Penn State campus locations throughout Pennsylvania. With wide-ranging weather, geography, and topology, the state offers a host of areas and conditions to explore, from fog, rain, and snow to hills, mountains, and more.

Students investigate which areas and conditions will permit or prohibit select data links to determine how to improve satellite transmissions in different scenarios common to rural regions. The ultimate goal is to discover innovative ways to create strong links for high-speed connectivity while preventing or mitigating any interference.

The class analyzes transmitters on the ground and in the sky to assess which antennas can support communication links by using HFSS for any EM data and STK to "mission-plan around that," says Huff.

"We're moving toward 5G and really not getting away from wireless, so we should be teaching more students how we embrace wireless design and how to prepare for it," he adds. "And part of that preparation is when we talk about the STK component."

Expanding nationally for the second project, students learn how to use radio frequency identification (RFID) tags to track spotted lanternflies — an invasive species to the United States that was first detected in Pennsylvania in 2014. Due to their feeding behavior, the unwanted plant-hoppers present a threat to many agricultural crops and forest plants throughout the country and the world.

By pairing HFSS with STK for these projects, Huff says he can show students through real-life projects not only what EM can do, but also what simulation and technology can do — and further, that digital mission engineering is not just for extraterrestrial exploration.

"STK is giving us an opportunity to go full circle in demonstrating digital mission engineering: Here's how you can do this and here's what it looks like in an application," he says. "And that doesn't necessarily mean we're using outer space for that."

Huff reminds students that STK can be used to prepare and plan a wide range of simulation-powered missions right here on planet Earth. To demonstrate this on-the-ground usage, some of Huff's students recently paired HFSS and STK to track and locate lost hikers.

VITAL SIMULATION TOOLS FOR EMERGING CAREERS AND FIELDS

According to Huff, academic simulation integration is crucial to preparing students for careers in engineering, as well as other related fields.

"We need to augment or complement the traditional classroom experience with some type of hands-on experiential learning that reinforces the theoretical and traditional framework that we have in place for textbook learning," says Huff. "In EM, this is a little bit more of a challenge because the cost of equipment is high, but having access to Ansys' suite of design tools is a game-changer. We can do a lot of the research that we want to do in the lab a priori, then come in and really put your hands on it and measure it, while also walking through what happens if I change XYZ parts of this. Without the Ansys Academic Program, we would not be doing this."

So far, Huff's students have embraced the tools and are excited to study at home through the Ansys Learning Hub, the Ansys Learning Forum, and free Ansys student version downloads. In fact, Huff says the Ansys portion of the syllabus is usually the only part that students have read before the first day of class, often having already downloaded and explored the software at home.

This engagement not only equips students with readiness and confidence, but also provides them with a skill set that is sought out by potential employers. Huff views the relationship between academia and industry as symbiotic.

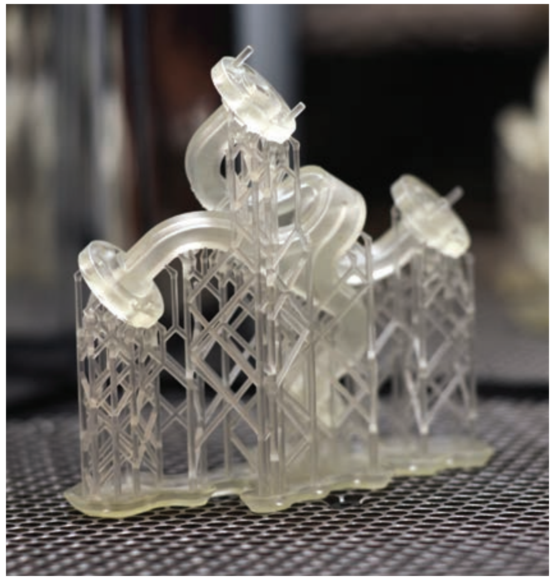
"We have people in industry who come specifically to find graduate students because they know when students come out of this program, they are knowledgeable and are using state-of-the-art industry-standard design tools, simulation tools, measurement techniques, and that they have a strong theoretical background to go along with it," says Huff. "One key thing that separates Ansys, and a few other companies that have a similar philosophy, is that we're not here to be a revenue-generating machine; the goal is for us to train students and do it in the best way possible, using the most advanced and timely tool sets that we can have."

Many of Huff's former students have gone on to work at national labs and global companies, including Ansys.

Huff also facilitates post-graduate research projects to help students transition into their careers with deeper exploration. Two recent projects applied HFSS to develop origami-inspired antennas and predict the radio frequency (RF) performance of EM devices for fabrication in additive manufacturing (AM).

With access to additional tools through the Ansys Academic Program, Huff plans to apply more multidisciplinary integration in three key emerging areas: equitable wireless connectivity, hypersonic vehicle design, and 3D printing.

As mentioned earlier, Huff integrates HFSS with STK to study equitable broadband access and approach EM from a social science perspective. As research deepens in this area, Huff plans to incorporate Ansys structural analysis tools, such as Ansys Mechanical, to examine how architecture also affects broadband access. Similarly, Huff will integrate Ansys Fluent for its computational fluid dynamics (CFD) capabilities to assess aerodynamic heating in projects involving the design of antennas for hypersonic vehicles.



An additively manufactured curvilinear V-band waveguide hybrid coupler designed in HFSS shown before post-processing to remove supports and create conductive walls using pressure-driven electroless metallization

Huff would like to explore Ansys' AM tools as well. In collaboration with a 3D printing company, Huff currently has AM specialists review his students' HFSS EM designs to provide feedback so students can optimize and enhance the designs for 3D products. This has opened up a new area of interest for many students as they create unique structures and shapes, including "crazy and fantastic contraptions that work," according to Huff.