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Digital Engineering

July/August 2020

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Review: CorelCAD 2020 P.47

GOLD MEDAL DESIGN

- SPORTS ENGINEERING AT PURDUE
- MOTORSPORT SIMULATION
- SIMULATED SOCIAL DISTANCING

Peerless MEDIA, LLC

| DEGREES OF FREEDOM |

By Brian Albright

Major League Adjustments

MY FAMILY AND I love watching the Olympic games. You can imagine how disappointed we were when the COVID-19 pandemic led organizers to push the games back a year. Not only that, but all other sports have either been cancelled, delayed or shifted to spectatorless facilities so that ESPN and Fox Sports have *something* to broadcast other than reruns of games we've already watched.

Of all of the changes that the pandemic has wrought, the lack of live sports has probably been the biggest disappointment for my children. They usually spend the summer playing rec league baseball, softball and soccer. Here in Cleveland, we're a 15-minute drive from an Indians game, but we make even longer treks to take in minor league games, Major League Soccer in Columbus, minor league soccer on numerous college and high school football fields, and by late August my young son is already embracing the hope and heartbreak of the Cleveland Browns.

World events have gotten in the way, and my plans to tie this issue into the Olympic Games had to be set aside, along with my plans to fly to Florida, send my kids back to school in the fall, and have anything remotely resembling a normal week.

But innovation still continues in the sporting world, which is why we went ahead with our focus on sports engineering. This particular field is somewhat unique, in that it involves an intimate marriage of physics, engineering and biology. And as simulation technology, 3D scanning and 3D printing have advanced, the convergence of these tools has made it possible to create extremely effective sports apparel and equipment that can be tailored to individual athletes.

Innovation Under Pressure

In this issue, we're highlighting a number of innovative use cases, from optimized prosthetics for athletes to more efficient prototyping processes for a motorized surfboard, and the ways that simulation is improving motorsports.

On a somewhat related note, writer Beth Stackpole takes a look at how advanced human body modeling is being leveraged across industries to improve person-machine interactions.

The fact that this type of innovation has continued despite the limitations placed on industry by the pandemic is indicative of just how resilient the engineering community has proven to be. As I write this, there have been major software releases from Ansys, Dassault Systèmes, Siemens Digital Industries Software and others. These new and upgraded tools had to be developed by widely dispersed teams working under less-than-ideal conditions, but they've made it across the finish line anyway.

As you'll see in this issue, the CAASE20 event was also able to quickly pivot from a live to a virtual event. The organizers at NAFEMS pulled off a minor miracle, organizing hundreds of sessions in a very short time. You can read about it in our report, but the sessions are still available on demand at nafems.org/caase20.

The designers and engineers using the tools highlighted at CAASE20 have also continued to innovate, finding ways to work from leveraging a new generation of high-performance workstations, cloud-based software, remote access solutions and flexible licensing programs.

That need for flexibility is only going to increase, as we are not out of the woods yet. COVID-19 spikes are shifting to other areas of the country, supply chain issues continue to dog certain sectors, there is a high degree of economic uncertainty and we're still likely months away from any type of measurable improvement.

But it's still summer. There is soccer (at least on TV). Baseball is about to start, and will be competing for viewers with a very late basketball season. The world is still turning, and our audience is still thriving and innovating.

As a reminder that hope still springs eternal, my son is also telling me that THIS could be the year the Browns finally make the playoffs.

Have a great summer, and I hope you enjoy the issue.

DE
Digital Engineering

TECHNOLOGY FOR OPTIMAL ENGINEERING DESIGN

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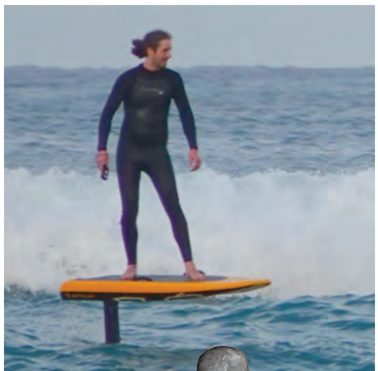

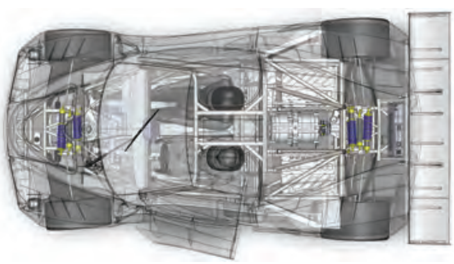

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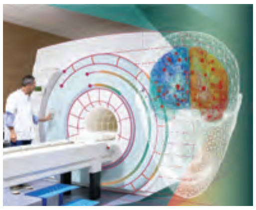

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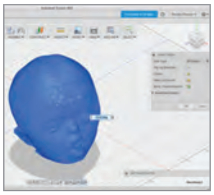

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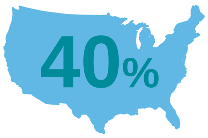
BY THE NUMBERS | TECHNOLOGY GROWTH

Growth of Hyperscale Data Centers

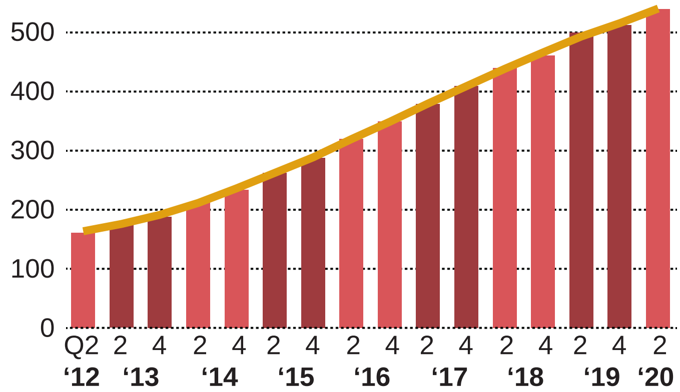
541 Number of **large data centers** operated by hyperscale providers

That is more than double the number from the **mid-2015** count **2X**

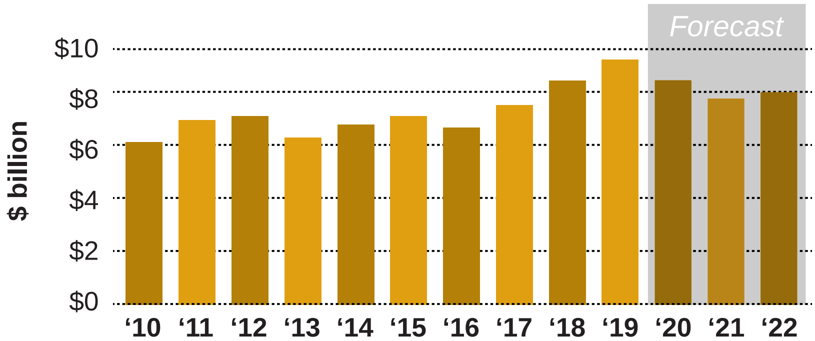


The U.S. accounts for almost 40% of major **cloud** and **internet data** center sites

Number of data centers (worldwide)



Source: Synergy Research Group



Total CAD Revenue

The **2020** CAD Report from Jon Peddie Research originally predicted the CAD market to grow to **$9 billion** by **2022**. The COVID-19 pandemic, however, has changed things, and that forecast has fallen to **$8 billion.**

Big Spending on Data Analytics

Spending in **2026** by manufacturers and industrial firms on data management, data analytics and associated professional services, according to *ABI Research forecasts*.

$19.8 BILLION

$3.7 BILLION

Total additive manufacturing software revenues forecast for **2027**, according to SmarTech Analysis. In **2020**, revenues stand at **$460 million**.

Source: "Opportunities in Additive Manufacturing Software Markets 2020," SmarTech, 2020.

"For many manufacturers, there is an appreciation that operational decisions need to be based on empirical evidence rather than guesswork. The challenges are not necessarily capturing and analyzing data, rather what to analyze in the first place."

"The findings need to have a meaningful impact on operations and so manufacturers need to take a step back and devise precise objectives."

–Michael Larner, principal analyst at ABI Research

CAASE20: Simulation in a Rapidly Changing World

BY DE STAFF

The CAASE20 Virtual Conference launched June 16-18 with dual keynotes from author Geoffrey Moore and analyst Monica Schnitger. The event was co-presented by NAFEMS and *Digital Engineering*.

Matthew Ladzinski, vice president, Americas at NAFEMS welcomed attendees, noting the fact that the shift from an in-person event to a virtual conference opened up CAASE20 to even wider participation. According to Ladzinski, more than 500 companies from 45 countries participated in this year's conference. The event drew more than 2,700 registrants.

NAFEMS CEO Tim Morris was also on hand to provide an update on the organization's activities in light of the COVID-19 pandemic. Although NAFEMS working groups and meetings continue to move forward, all face-to-face activities have been cancelled, rescheduled or shifted to online platforms.

Morris also noted the creation of a new computational electromagnetics working group and plans for a new working group on engineering data science that will focus on artificial intelligence and data analytics. He also announced that the in-person NAFEMS World Congress would be held next June in Salzburg, Austria.

Andretti Autosport driver Alexander Rossi also made an appearance, providing a look at an IndyCar simulation. (CAASE20 was originally slated to be held in Indianapolis.)

During the opening keynotes, author Geoffrey Moore, best known for his book, "Crossing the Chasm," outlined the technology adoption lifecycle model, and how companies can best leverage product acceptance by different types of users.

Analyst Monica Schnitger focused on the use of simulation in the modern enterprise.

"No matter what you do, development cycles are getting faster," Schnitger said. "More outside pressure is being put on what you do and how you do it."

CAASE20
The Conference on Advancing Analysis & Simulation in Engineering
Virtual Conference • June 16th - 18th
Co-hosted by: NAFEMS DE Digital Engineering

On day 2 of the conference, Gartner analyst Marc Halpern and Predict Change consultant Peter Langsten suggested "Simulation Governance is Key to Delivering Best-of-Class Products in the Age of COVID-19" in their presentation.

For Halpern, the narrow room to operate suggests inevitable changes. "We need to prepare to do business in a very different way. It's going to be more socially distanced, more distributed, with reduced travel, probably doing fewer physical prototypes, more simulation, fewer people in the lab even when we do prototyping, wearing masks …," he outlined.

As a result of the pandemic, engineering teams are adopting more cloud technologies, from collaboration to design tools. "Back in 2012 I had predicted that cloud will be the mainstream platform for engineering by 2017. My prediction was wrong," Halpern admitted. "Most cloud adoptions by 2017 were pretty modest, actually. A lot of cloud for back-office stuff, such as email. When it comes to CAD, CAE, it was relatively modest. The reason: the on-premise software was deeply ingrained, and the cloud tools were weak in functionality."

But COVID-19 changed all that. "All of a sudden, there's high interest in having high-performing engineering tools in the cloud. Simulation governance and model-based engineering are going to become increasingly important," said Halpern.

"Before now, social distance was not a priority. Now this is mandatory, and automation is replacing physical reality," noted Langsten. "The automation of simulation governance is a prerequisite to the automation of the product. Simulation is an enabler for full automation."

Diving into STEM Diversity

In the final keynote session, Maria Klawe, president of Harvey Mudd College, provided insights into how the college had tackled academic diversity in its STEM programs.

Klawe wasted no time diving into Harvey Mudd College's efforts to overhaul how they handle diversity and minority training in the engineering field. From 2006 to now, HMC went from being a little bit less than one-third female to 50% female today. Additionally, from 2012 to now, the college's ethnic makeup shifted, from 54% Caucasian in 2012 to 31%. Faculty also saw a jump in the number of females represented—from 20% female in 1996 to 40% female in 2016.

"Forty percent female faculty is quite extraordinary when you compare us with other science and engineering institutions like MIT and Caltech, which tend to be around 15% female faculty," Klawe said.

When Harvey Mudd initially started focusing on increasing racial diversity, the school acknowledges it took time to get at the root of the issue. "We didn't have a good understanding until about 7 or 8 years ago of what causes African American families to choose a particular institution and what causes Hispanic or Latinx families to choose a particular institution," Klawe said.

The college additionally focused on providing early access to internships and research for students—at the end of the summer between the first and second year, which opened up access to diverse role models.

The college's board was also retooled so that half are now alumni; 20% are parents; and the other 30% are leaders in STEM fields. An interesting find as leadership delved into the process was that one particular department—computer science—really led in terms of its focus on how to attract more women and students of color.

"It's different from every other area of engineering in that it's the only discipline where participation by women has declined from the early 1980s to now," Klawe said.

The year before Klawe assumed her role as president, she said the computer science department had very few women majoring in computer science. Within a 10-year period, the number of female computer science graduates went from 10%-15% in 2006 to 50% female in 2016; computer science faculty from 2006 to 2019 also jumped from 33% to 50%.

Likewise, racial diversity from 2013 to 2020 followed similar patterns, though even more "dramatic," according to Klawe.

Specifically, the number of whites declined from 75% to 27%, while the number of Asians climbed from 10% to 19%; Hispanics jumped from 2% to 18%; and blacks rose from 0% to 4%. On the faculty side, from 2006 to 2018, the racial diversity went from 0 of 9 to 3 of 18.

According to Klawe, the department was able to make these strides, in part, by changing the introductory computer science from Java programming to team-based creative problem-solving in science and engineering using computational approaches in Python. Students were also provided with opportunities to pursue summer research experiences between the first and second year. They additionally were given a chance to pursue early internships. Lastly, the department paid more attention to ways to recruit faculty and women of color.

It really matters how recruiting positions are advertised, according to Klawe. "Stress creativity, collaboration and communication as well as technical skills and knowledge. List technical skills as desirable rather than required," she advised.

Second, the interview process is critical. "Avoid adversarial technical interviews," she suggested. "Ensure that some of the interviewers are diverse. And train interviewers on diversity and inclusion."

Third, build confidence and community among diverse groups. Finally, she says not to lose sight of the ultimate goal: "demystify the path to success."

To access the CAASE20 conference presentations, visit nafems.org/caase20. **DE**

Designing to Win

Welcome to the wide world of sports engineering.

The 2020 Tokyo Olympics have been postponed for a year because of concerns around the COVID-19 pandemic in a rare decision that has left both athletes and fans deeply disappointed. The last time the games were cancelled or postponed was during World War II However, while current events have changed the way the world enjoys sports, competition has continued around the world. Soccer and NASCAR are back (albeit in facilities with no spectators), and in the U.S., officials are struggling to find a way to make a fall football season happen.

Sports innovation is also continuing in the burgeoning field of sports engineering. Technology has increasingly played a larger role in athletics. Advanced design technologies, simulation and, more recently, 3D printing are being leveraged to create better equipment, improve facility designs and enhance performance.

Over the years, we've seen these technologies put to use to create better swimwear, generate shoes that can cut precious seconds from race times, increase the safety of race cars and create lighter and safer helmets and bicycles.

In the following stories, you'll see how advanced simulation and manufacturing technologies are being used to improve safety for athletes, while also helping them achieve unprecedented performance.

GOLD MEDAL DESIGN

Driving Innovation to Sport

The Ray Ewry Sports Engineering Center at Purdue University will explore sports with modern innovation and technology to enhance the experience of sporting events and competitions in multiple ways.

BY JIM ROMEO

Imagine a bike race in which riders from around the globe compete, without ever leaving home. A virtual bike race is precisely what researchers at the Ray Ewry Sports Engineering Center at Purdue University, which officially opened in October of 2019, are working on with partners. The new research center located in Lafayette, IN, on the campus of Purdue, is named in honor of their record-setting Olympian and graduate.

The center will collaborate with sports organizations, technology firms and many others to focus on how engineering can influence and help balance competition with entertainment in sport, use available and innovative technology in the stadium environment of a sport, and maximize the fan experience also. It all sounds philosophic, but it's a new and enlightening approach to sports research. By introducing engineering and innovation, it seeks to take advantage of the rapid adoption of innovation characteristic of performance sports.

Research to Bridge Competition and the Entertainment of Sport

Professor Jan-Anders E. Mansson is a professor, part founder and executive director of the newly created Ray Ewry Sports Engineering Center at Purdue. He is also the director of the Composite Manufacturing and Simulation Center (CMSC), and founder of Purdue's Manufacturing Design Laboratory (MDLab) as well as other institutions in Indiana and Purdue. Mansson has worked with the International Olympic Committee and the center plans to work closely with them in their research.

"What we normally mean by competition sport is always challenged with entertainment sport," says Mansson. "In here, we try to keep the value and excitement of more classical sport. So now when we maximize excitement without maximized risk, we must make sure all the safety equipment we can use, all the things that come with that, can be fulfilled. But we also must make sure we have good integrity. We keep a level playing field. So that's the other issue to be sure of. So, then we have to deal with making sure that we have fair technology going out to equipment stadiums."

Mansson also explains that the center is dedicated not just to athletes and their technology, but also to fans. He says one of the underlying goals of the center is to ensure that the fan experience is maximized.

"When they come in to [the] fan experience, and these are all the digital tools possible, how can we integrate that into the sport to maximize the excitement for the fans? And to attract young people?" asks Mansson. Also along those lines, that's very much a theme in working with the Olympic committee, according to Mansson—"how to

Cycling, simulation and modeling are among the many types of research and exploration Purdue's new sports research center plans to conduct.

Purdue's new sports research center will explore many different aspects of sport—from fan experience, to performance factors and beyond. *Images courtesy of Purdue.*

maximize fan experience, but with good integrity and good health and safety precautions."

The fan experience is also paramount in finding ways to change the charisma of sport and infusing the passion and excitement into the event, differently perhaps.

"I talk in the Olympic spirit here," says Mansson. "But we work with motorsports, with Speedway and all those sports, and you'll see, they are very open-minded. They look in all directions, maybe not to have them as an Olympic sport, but as part of the sports community. They are addressing the same issue. So, they want to learn from motorsports. They want to learn from American football."

Mansson says American football has the Super Bowl and that turns a city upside down for a week with happy fans celebrating and enjoying the event. Can motorsports become as mainstream and take on the same persona? It sounds like an underlying objective when introducing technology to a niche sport—to try to make it mainstream.

e-Sport, like the virtual bike race they participated in, is another topic that the center plans to exploit. While there's competition taking place virtually, there are also live athletes participating in the sport. Thus, it's a hybrid sport of sorts. That concept is one they hope to help develop—not just in cycling but in other sports as well.

"Right now, that's the most up-to-date project," explains Mansson. "We are starting to develop a homologation [approval] process for virtual cycling for the trainers. Today you have professional riders. They go on competition sitting with the trainers at home and they compete [in] Tour de Suisse and different competitions. Now we need to homologate them to make sure they have the same conditions of the competition and the resistance they get from the trainers."

Advent of 5G in Sport

Mansson sees 5G as a game changer when it comes to sport. It provides favorable latency and a rapid data exchange. Data and information may be accessed rapidly.

"I worked with The Union Cycliste Internationale and the Bike Federation," explains Mansson. Two weeks before the start of 2012 Tour de France he was eager to find ways to monitor the Peloton as the race progressed. There may be 75 riders for whom they wish to track heart rate. "We want to have a cadence. We want to have force. We can't do it with Wi-Fi [currently]; we can't do it with Bluetooth. We need another much faster system to gather information—that's where 5G comes in."

Now such monitoring may be possible and allow the teams to be monitored, but it also allows data to be processed for sports improvement. That approach will factor into how engineering may be used to enhance sport and improve it for all stakeholders: athletes, fans and the landscape the sport operates within.

The earlier example of the virtual bike was created with a firm called Kiswe. "We worked very closely with Kiswe in developing this whole system around virtual biking," explains Mansson. "And I don't call it fully virtual; I call it hybrid biking. We use the professional athletes. You must be a good biker to perform. It's not a sit-in-front-of-the-PlayStation and train. You must be physically active and a top-level athlete to do it. So both the production system and the homologation of the trainer are very much surrounded about interface between mechanics and digital techniques."

Driving Innovation to Sport

The world loves athletic competition. Traditionally, performance sport has been quick to adopt innovation and use technology to improve performance. With a new research center at Purdue, the use of innovation and technology for sport, in many ways, provides a pathway for innovation and technology to find its way to performance sport.

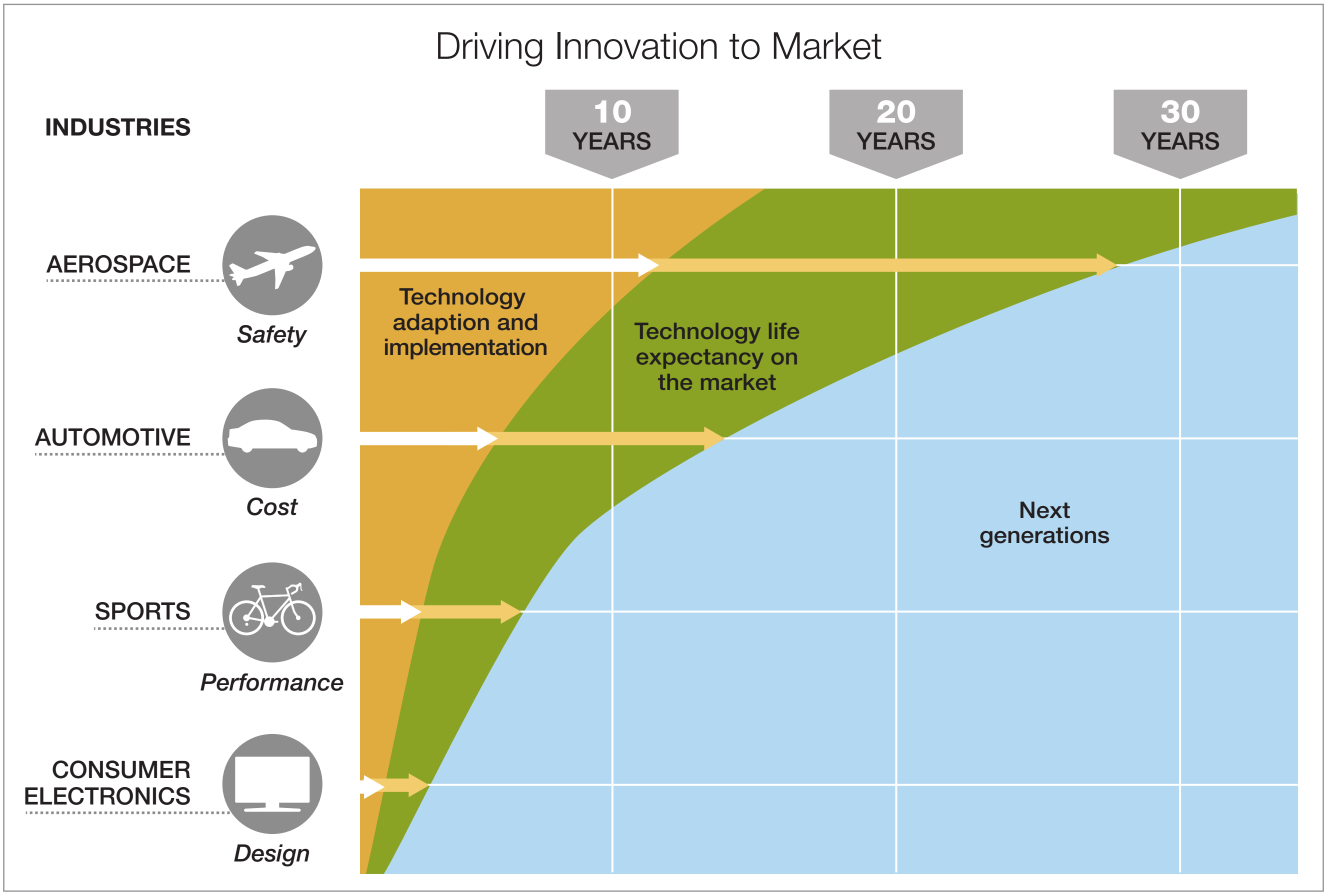
The virtual ride of cyclists, competing in real time around the globe, is symbolic and somewhat representative of how technology, innovation and sport may converge to improve it for fans, athletes and all involved. DE

Jim Romeo *is a freelance writer based in Chesapeake, VA. Send e-mail about this article to de-editors@digitaleng.news.*

MORE INFO

- **Purdue University:** Engineering.purdue.edu
- **Kiswe:** Kiswe.com

For more information on this topic, visit DigitalEngineering247.com.



Technology adoption for performance sports is quick relative to other industries that are sluggish in adopting new technology. *Image courtesy of Purdue.*

GOLD MEDAL DESIGN

On the Right Track

Palatov Motorsport takes CFD simulation farther and faster.

BY KIP HANSON

Imagine driving 12.42 miles up a steep mountain road. The average speed is nearly 100 mph, there are 156 turns to navigate and you have to reach the 14,115-foot summit in less than 10 minutes. Plus, there could be some snow and hail involved. This is no computer-generated simulation, even though it's simulation software—in this case, SolidWorks Flow Simulation—that makes such feats possible.

The scenario just described is the Pikes Peak International Hill Climb in Colorado. Palatov Motorsport LLC has competed since 2012, when owner Dennis Palatov first set his sights on winning the annual competition with the company's cars. In five years of running, he and his team have achieved six podium finishes, including two class wins, and have no plans to take their foot off the gas; thanks to a recent hardware upgrade, their job is about to become a bit easier.

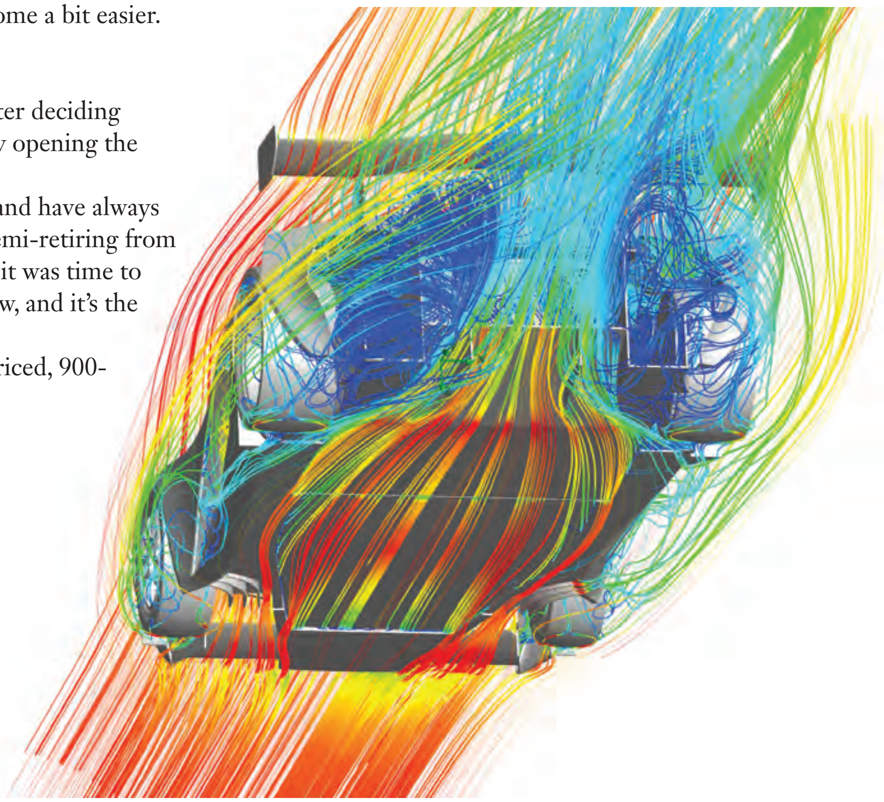
From Computers to Cars

Palatov first began building cars in 2008, after deciding to pursue a desire he's had since boyhood by opening the Portland, OR-based company.

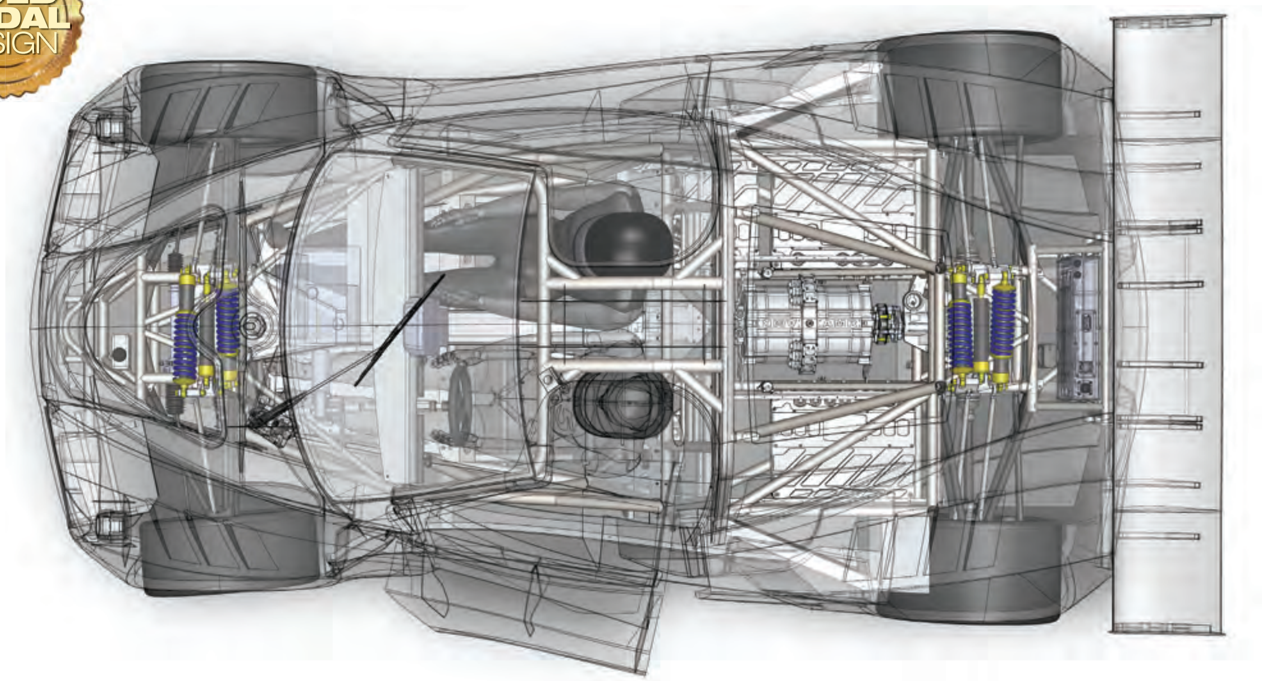
"I started drawing cars at five years old, and have always been interested in building them, so after semi-retiring from a career in computer engineering, I figured it was time to chase the dream," he laughed. "I'm all in now, and it's the most rewarding thing I've ever done."

His race cars range from the modestly priced, 900-lb., 185-hp Palatov D4, designed for "track-day enthusiasts" to the surprisingly street-legal D5, a 1,000-hp, four-wheel drive supercar for deep-pocketed buyers (the MSRP starts at $300,000). Others include the D1 and D1 PPS (Pikes Peak Special), the two-seat D2 and a host of machined suspension components and motorcycle parts, all available on the company's website.

Palatov will tell you that designing cars from the ground up is no easy task. Each contains thousands of parts, many of them custom, all of which must fit precisely together and function without failure at white-knuckled speeds. The stakes are high, and if the driver is to win the race, the vehicle must also be aerodynamic but able to hug the ground—a factor



Computational fluid dynamics (CFD) software, as shown here in this screen grab from SolidWorks Flow Simulation, is an invaluable tool for designers of automobiles, aircraft and other aerodynamic products. *All images courtesy of Palatov Motorsports.*



Race cars contains many thousands of parts that must not only fit together perfectly, but perform at white-knuckled speeds.

called downforce—to avoid becoming airborne.

All of this requires capable software, Palatov noted, which is why he has relied on SolidWorks together with its full-featured computational fluid dynamics (CFD) solution since before their first Pikes Peak competition.

"I like SolidWorks because it functions the way my brain does," he says. "It's all parametric, so you can get the design intent down without worrying too much about the details, then tweak the numbers afterwards until everything works together."

Slowing on the Curves

Modeling individual components or even an assembled race car is one thing; simulating its performance at extreme velocities is another. Palatov explained that, until recently, each CFD run took 12 hours or more, during which his workstation—an Intel Core i7 processor with AMD Radeon Pro WX 7100 graphics—was unusable for other tasks.

"It was fine for SolidWorks, but bogged down so much during CFD that I was limited to running it at night, after I'd gone home," he says. "And because the CFD process is very incremental, you have to be disciplined. So you'll change one thing during the day, rerun it that night and learn what effect it had the next morning. Depending on the number of parameters I had to adjust, it was taking weeks and sometimes months to optimize a design."

That all changed. After speaking to a colleague, he opted to upgrade his workstation, switching to a 16-core AMD Ryzen 3950X processor and AMD Radeon Pro W5500 graphics. Palatov is now able to run CFD simulations in the background and continue to work during the day.

"I'll still run it at night, but the new setup has basically tripled or even quadrupled my throughput," he says. "It's also a lot more pleasant to use. I can pan and zoom without any lag at all, and it allows me to focus on the task at hand instead of figuring out how to see what you need to see. In fact, there's another new project that I'm working on right now where I've made huge progress because of the upgrade. So the return on investment has practically been immediate."

Dialing In

Aside from enhanced productivity and usability, the new graphics processing unit opens additional doors. When Palatov first started with CFD simulations, he rented an airstrip and test-drove a car equipped with strain gauges and similar instrumentation. He then took that data and modeled it in SolidWorks.

After repeated iterations, he was able to make the simulations correlate "almost perfectly" with real life. The mesh settings and other parameters have remained static since then, Palatov says, and although he has no plans to revisit that lengthy setup process, he admits it's a possibility.

"It was a steep learning curve," he says. "It took us a long time to figure out which parameters matter most and how to set them. That's the biggest trade-off with CFD, because it's always a balancing act between simulation precision and available compute time, memory and graphics capabilities, but at the same time, you need enough resolution to actually have meaningful results."

Palatov says that his current CFD parameter settings are tuned quite well to the cars they build and the types of surfaces they generate, but there are limitations. It won't pick up small vortex generators, for example, although he was

When Dennis Palatov first began CFD analysis of his race car designs, he rented an airstrip and test drove a car equipped with strain gauges and similar instrumentation, then modeled the resulting data in SolidWorks Flow Simulation.

quick to note that these have a fairly insignificant effect on vehicle performance. Still, given the computing resources they now have available, he suggested they could probably adjust the mesh to simulate details like that, even though it would mean validating the results all over again.

"We haven't really had the opportunity or even the need to tackle that," he adds. "What I really like about the SolidWorks Flow Simulation, in particular, is that it does adaptive meshing, which means that it actually refines the mesh based on local flow conditions. Normally in CFD, meshes are one of the biggest challenges, and if you get this part wrong then the results are worthless. In other tools, you usually have to set mesh types for the various regions manually, a task that's very labor-intensive and requires a high level of skill. But SolidWorks does an excellent job of doing that automatically. It's a huge time-saver." DE

→ MORE INFO

- **Palatov Motorsport LLC:** Palatov.com
- **Dassault Systèmes:** 3DS.com
- **AMD:** AMD.com

For more information on this topic, visit DigitalEngineering247.com.

Controversial Shoe Design

Can a show design make marathon runners faster? According to a 2017 study of Nike's Vaporfly 4%, the answer is yes. Nike commissioned a study (conducted by the University of Colorado at Boulder) that found runners could improve efficiency by 4% wearing the prototype shoe. The results were later confirmed by independent researchers, and a "New York Times" study delivered similar results. The performance boost comes primarily from the Vaporfly's compressible foam, which returns 87% of the energy it stores upon impact. That's 10 to 20 percentage points better than comparable high-end running shoes. The shoe also includes a carbon fiber plate in its midsole.

The design was so successful that the latest iteration, called the Air Zoom Alphafly NEXT%, faced controversy from runners and officials who equated the shoe with "technical doping." Kenyan marathoner Eliud Kipchoge ran a marathon in less than two hours wearing the shoe. The organization that governs world track and field events (the International Association of Athletics Federations) has since released rules that attempt to address shoe technology disparities that could affect race outcomes. DE

→ MORE INFO

- **Nike:** Nike.com/running/alphafly

For more information on this topic, visit DigitalEngineering247.com.

Aerodynamics of Contagion

Researcher re-examines social distancing for joggers, runners and cyclists with simulation.

BY KENNETH WONG

During the peak of the COVID-19 outbreak, the U.S. Centers for Disease Control and Prevention prescribed safety distance for social distancing at 6 feet (or 1.8 meters). As outdoor exercises are still permitted, many joggers and runners do their best to keep up their daily regimen—or a reduced form of it—in low-traffic streets and parks.

Professor Bert Blocken, Eindhoven University of Technology, has done extensive aerodynamic research on group cycling events, known as peloton. His findings suggest certain positions in the group are more advantageous due to minimal air resistance. (For more, read "Jostling for the Best Position in a Peloton," October 2018.)

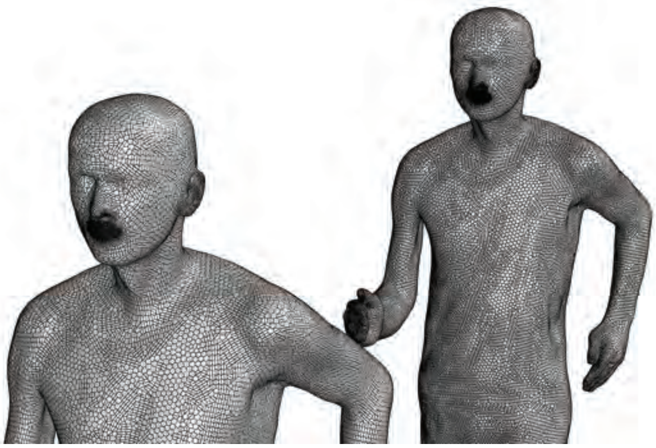
Blocken then decided to use the same method to study the effects of joggers under social distancing, to see if the recommended 6 feet is sufficient for the joggers to avoid each other's pathogens.

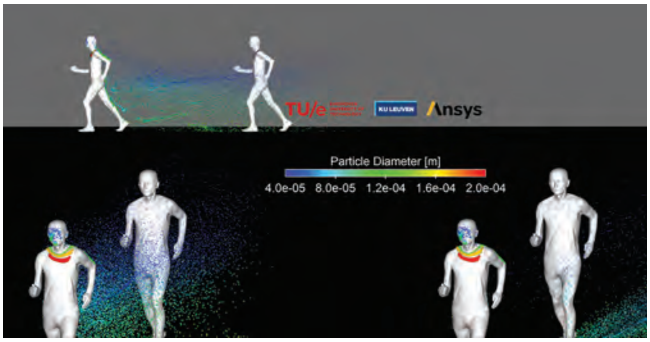
The study is aerodynamic in nature, to investigate "whether a first person moving nearby a second person at 1.5-meter distance or beyond could cause droplet transfer to this second person," wrote Blocken and his coauthors in their paper ("Towards aerodynamically equivalent COVID-19 1.5 m social distancing for walking and running").

The simulation was conducted in ANSYS Fluent CFD (computational fluid dynamics) software. The paper states wind tunnels validated aerodynamic drag on the runners and the micro-droplet movement and evaporation. The team looked at droplet dispersions involving two runners or two walkers. It shows the runner directly behind another runner receives the highest droplet exposure. In contrast, runners running shoulder to shoulder at the same speed receive the least exposure.

Based on these findings, Blocken suggests runners "keep a distance of at least four to five meters behind the leading person while walking in the slipstream, ten meters when running or cycling slowly and at least twenty meters when cycling fast."

"This study does not draw any conclusions on the infection risk associated with particular social distances or droplet exposure," Blocken cautions in the follow-up Q&A published. "It is obvious that no or reduced droplet exposure is better than larger droplet exposure. Therefore, the adjusted and equivalent social distances are to be preferred over the single value of 1.5m." **DE**





Using Ansys Fluent CFD software, Professor Bert Blocken, Eindhoven University of Technology, and his colleagues study the effectiveness of the recommended safe distance for social distancing in jogging scenarios. *Images courtesy of Blocken and the Eindhoven University of Technology.*

→ MORE INFO

- **Eindhoven University of Technology:** tue.nl/en/

For more information on this topic, visit DigitalEngineering247.com.

A Diamond-Studded Football Helmet

From the outside, Riddell football helmets look like a solid piece but underneath the shiny, hard shell, an intricate lacework of diamond-shaped structures offer breathability, protection and comfort. The internal structures are fabricated in 3D printing, using Carbon's Digital Light Synthesis (DLS) technology.

In the announcement of their partnership with Riddell, Carbon reveals, "Each helmet is made up of more than 140,000 individual struts, carefully orchestrated into patterns for attenuating impact forces while providing excellent comfort and fit. The result is a Carbon DLS-printed, custom fit, impact-absorbing helmet liner designed to advance the state-of-the-art in head protection."

With the latest advances in sensor technology, the Riddell helmets offer new possibilities. "Riddell's proprietary database of over five million impacts captured by Riddell's smart helmet technology will allow for custom and individualized tuning of lattice structures in the future," Carbon speculates.

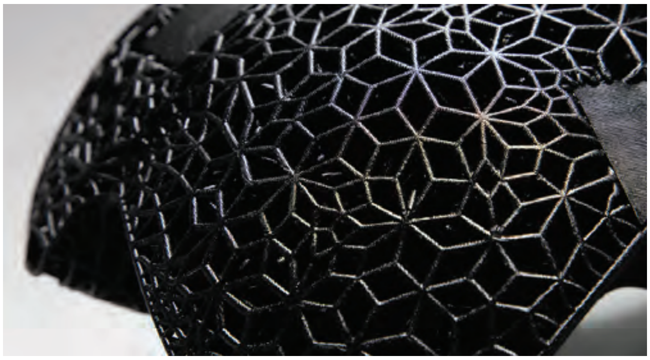
No two football players are alike in their style and strategy. "With the SpeedFlex Precision Diamond, players are not only experiencing the latest in head protection, they can also dictate where the helmet is positioned to improve sightlines and maximize field vision," says Peyton Manning, Riddell strategic advisor and brand ambassador and former NFL player.

To produce a precision-fit helmet, Riddell says it gathers the player's preferences, "such as helmet positioning, then scans the unique contours and shape of each player's head to create one-of-a-kind pad sets."

In April, while sporting events were on hold, the NFL and the National Football League Players Association (NFLPA) continued to work in the lab with biomechanical experts to determine which helmets best reduced head impact severity. According to the results announced recently (www.playsmartplaysafe.com), the Riddell SpeedFlex Precision Diamond model is the top-performing helmet.

The Riddell SpeedFlex Diamond helmet is listed at $499 (Varsity) and $429 (Youth). The helmet maker warns that COVID-19 might cause delays in delivering orders.

The 2020 NFL Draft was a virtual event this year. It's still unclear how training can occur to prepare for the NFL 2020 season set to begin in September. DE



In partnership with Carbon, football equipment maker Riddell produced the diamond-patterned frame nested inside its Riddell Diamond helmet series. *Images courtesy of Carbon, Riddell.*

→ MORE INFO

- **Carbon:** Carbon3d.com/riddell
- **Riddell:** Riddell.com

For more information on this topic, visit DigitalEngineering247.com.

Going the Distance

Carbon fiber composites engineer takes additive manufacturing in new directions.

Dimitris Katsanis loves bicycles—fast bicycles, to be exact. A former member of the Greek National Cycling Team, he has designed and manufactured some of the fastest bikes on the planet. The Olympic Games, Tour de France, the UCI World Championships—these are just a few of the competitions in which Katsanis-designed handlebars, frames and other bicycle components have taken home nearly 200 world medals over the past three decades.

Katsanis' material of choice has long been carbon fiber. In fact, he earned a degree in composite engineering from the UK's Plymouth University in 1998 and has spent most of his adult life working the strong but lightweight material into award-winning designs. Today he is the founder and chief executive officer of Derbyshire, UK-based Metron Additive Engineering Ltd., and although he is still a big proponent of carbon fiber, Katsanis has added a new entry to his very short list of favorite materials: titanium.

In 2015, Metron invested in an electron beam melting (EBM) machine from GE Additive, and has since begun producing 3D-printed titanium components that perform better and weigh less than those made of carbon fiber. It was a step that is now taking his company in entirely different directions, among them the production of parts for the aerospace, medical and motorsports industries.

Metron CEO Dimitris Katsanis (left) manufactured his first composite racing wheelchair for a Greek Paralympic athlete who competed in the Barcelona Paralympics. Katsanis is standing by one of his award-winning bicycle designs. *Image courtesy of Metron.*

"Previously, there was no way on earth to make a bicycle part from metal that is stronger and lighter than carbon fiber," he says. "Additive manufacturing has changed all that, primarily because you can create internal structures impossible to replicate using traditional manufacturing methods. One of our first and most notable projects was a set of titanium handlebars, which Bradley Wiggins used to set a new hour record—the longest distance cycled in one hour from a stationary start—in 2015."

As of today, Katsanis has produced more than 100 sets of 3D-printed handlebars, most of them earning their riders world championships and Olympic gold medals. Yet Katsanis is quick to point out that additive manufacturing isn't as simple as loading the machine with metal powder and pushing the start button. Success requires extensive design experience, the right software tools and a willingness to think outside the box.

He starts by scanning each rider and

matching his or her 3D model to one of several standard bicycle frames, then optimizes the handlebar around the two.

"A winning design needs the right balance of aerodynamics, strength and usability," he says. "We tried several brands of topology optimization software, and although they did a good job on the structural aspects, they came up a little short on aerodynamics. I'm sure they'll improve over the coming years, but for the time being, we are using RHINO and SolidWorks for the design portion and then applying its finite element analysis [FEA] capabilities to optimize things like wall thicknesses and internal structures. The rest is all know-how and a good eye for detail." DE

→ MORE INFO

- **GE ADDITIVE:** GE.com/additive

For more information on this topic, visit DigitalEngineering247.com.

Unlike most laser-based metal powder bed 3D printers, GE Additive's competing EBM (electron beam melting) technology allows parts to be stacked in the build chamber, providing greater use. *Image courtesy of Metron.*

3D Printing Assists Wounded Warrior

The New Zealand Defence Force has used additive manufacturing to help an injured navy veteran enter the world of competitive cycling. In 2010, Stevin Creeggan was the sole survivor of a helicopter crash at Pukerua Bay. He sustained a number of severe injuries, some of which required his right leg to be completely reconstructed with plates, screws and rods, leaving it shorter than his left leg by 2.5 cm.

To maintain his fitness after the accident, he turned to cycling. He plans to compete in the Invictus Games, an event for wounded and injured former service personnel. To accommodate the difference in his legs, Creeggan had originally made a spacer to fit between his foot and the bike pedal. That spacer was made of a heavy, unwieldy material called bog.

Creeggan's Invictus sports team manager approached the New Zealand Defence Force engineering team to see if a new spacer could be made of lighter material. The team printed some carbon fiber prototypes, and then worked with GE Additive (using the GE Additive Arcam Electron Beam Melting machine) to print a spacer out of titanium, which reduced the weight from 250 g to 50 g, with a design specific to Creeggan's shoe. DE

NZDF engineers adjusting the PLA 3D printed prototype to ensure good form and fit. *Image courtesy of GE Additive.*

→ MORE INFO

- **GE Additive:** GE.com/additive

For more information on this topic, visit DigitalEngineering247.com.

GOLD MEDAL DESIGN

3D Printing Hangs Ten

3D printing and production-grade materials are helping Alameda, CA-based Kai Concepts accelerate part development and testing for its Jetfoiler electric hydrofoil surfboard.

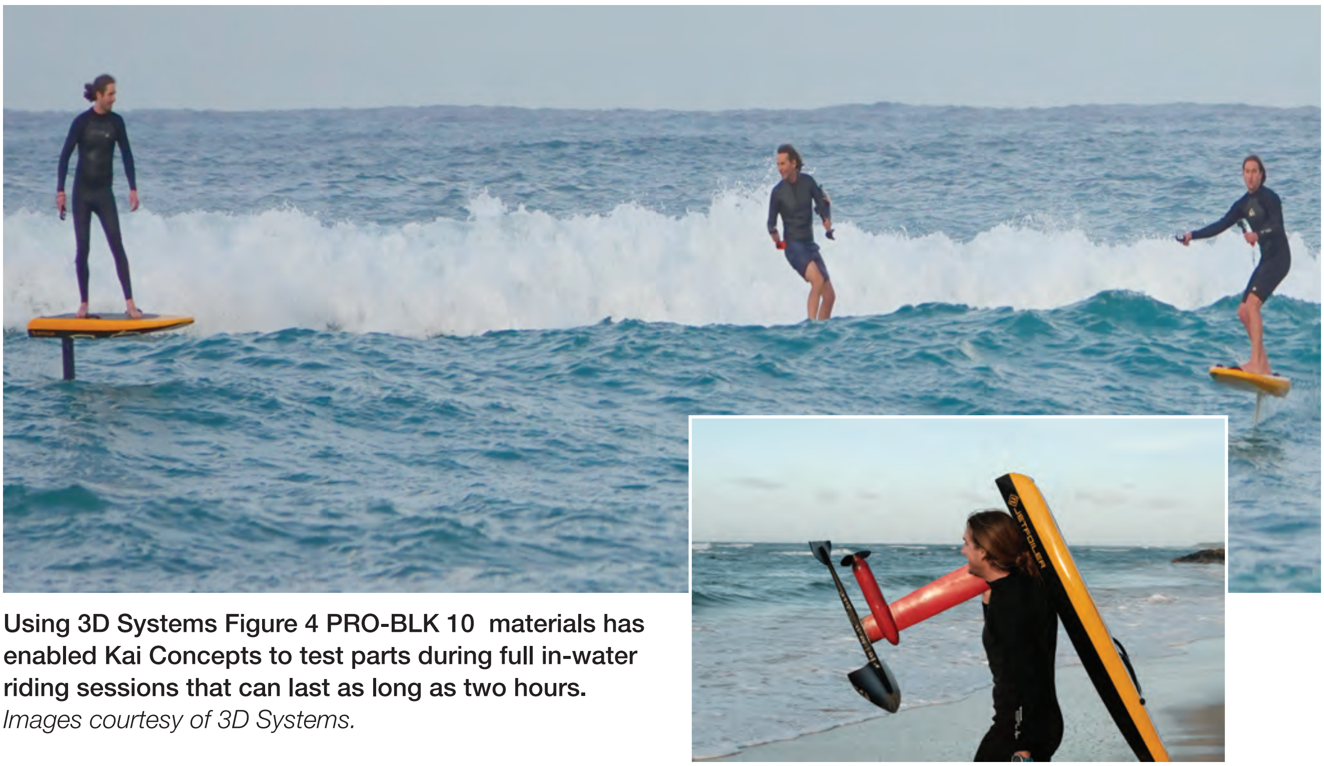
The Jetfoiler electric hydrofoil is a motorized surfboard from Kai Concepts. The company has replaced a previous desktop 3D printing system (used for part development) that required nearly three times the amount of time to complete builds. Using the 3D Systems Figure 4 Standalone 3D printer, Kai Concepts can print prototypes and test parts faster with better precision and improved durability.

Prints can be completed, and go through post-processing in time for afternoon testing in many cases. Previously, parts would take a full day just to print.

"By the end of the day, we're already working on revision B," says Kai Calder, logistics and operations lead at the company. "The overall process of designing something and reiterating has been cut down immensely for us."

The company is able to print a variety of parts, including motor mounts, propeller guards and Kort nozzles. Kai Concepts can use the more accurate parts it has generated on the new printer to communicate information to its machinist. Having more accurate reference parts makes it easier to troubleshoot and refine designs before production starts.

Using 3D Systems Figure 4 PRO-BLK 10 production-



Using 3D Systems Figure 4 PRO-BLK 10 materials has enabled Kai Concepts to test parts during full in-water riding sessions that can last as long as two hours. *Images courtesy of 3D Systems.*

grade materials has also improved operations. Kai Concepts is able to test parts during full in-water riding sessions that can last as long as two hours. Previously, the printed parts were too brittle to withstand these tests. The PRO-BLK 10 parts can remain intact during multiple rounds of testing while the Jetfoiler travels in excess of 15 miles per hour in the water.

"We have a reduced lead time for getting a part, and we're also getting longer longevity out of the part to be able to reuse it time and time again," says Calder. "3D Systems' material knowledge really helps us in making better pieces." **DE**

➔ MORE INFO

- **3D Systems:** 3DSystems.com
- **Kai Concepts:** Kai-Concepts.com

For more information on this topic, visit DigitalEngineering247.com.

The printed prototype parts are durable enough to withstand multiple rounds of in-water testing. *Images courtesy of 3D Systems.*

Evolved Prosthetics

When racer Mike Schultz lost his leg in a snowmobile accident in 2008, his career as an athlete could have been over. Instead, Schultz designed his own prosthetic leg, engineered for athletes, and formed BioDapt to design high-performance lower-limb prosthetics, including the Moto Knee and Versa Foot.

In 2018, he won a gold medal in snowboarding at the Paralympic Games wearing a prosthetic leg he originally designed in SolidWorks and built in his garage. He's also a nine-time X Games Gold Medalist in motocross, snowmobile and snowbike.

While the original prosthetic did what Schultz wanted it to do, the design was not ready to be offered as a commercial product. He turned to the Center for Advanced Design (CAD) where Jesse Hahne and Marc McCauley helped refine it.

With CAD's help, Schultz was able to reduce the weight of the leg and the cost, by eliminating 80% of the machining required for production. The CAD team has also gathered data from athletes using the leg to better optimize strength and make the leg more lightweight.

"We use SolidWorks simulation software to find ways we can add or take away materials," McCauley says.

The leg is almost infinitely customizable, so it can be tailored to fit a specific athlete's physicality and application needs. **DE**

The prosthetic was refined in SolidWorks. *Images courtesy of BioDapt.*

➔ MORE INFO

- **Center for Advanced Design:** CenterforAdvancedDesign.com
- **Dassault Systèmes:** 3DS.com

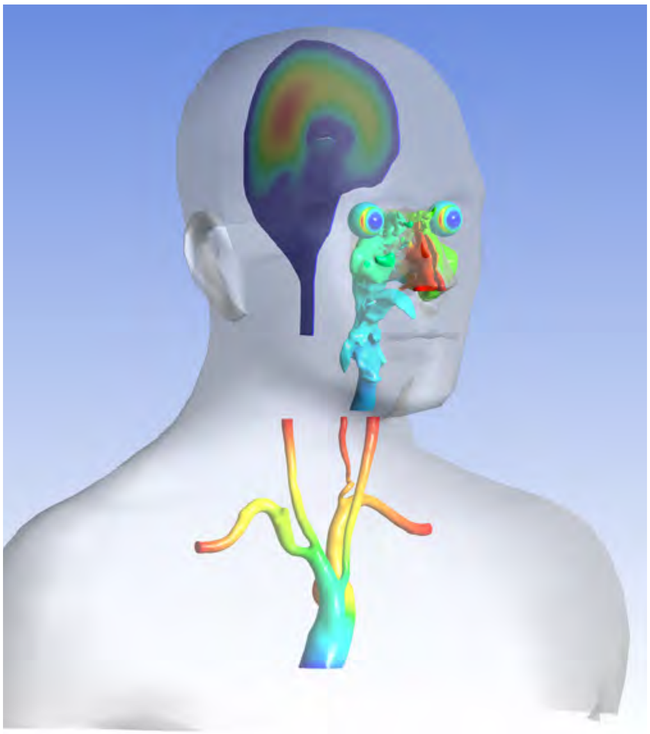
For more information on this topic, visit DigitalEngineering247.com.

The Human Side of Simulation

Incorporating human body models as part of simulation-driven design improves design outcomes, resulting in highly personalized, safer products.

BY BETH STACKPOLE

More robust and accessible computing power, coupled with advanced simulation and artificial intelligence (AI), is handing engineers another advantage for digital design practices: The ability to tap into realistic human body models in early design exploration, resulting in better optimized, highly personalized and safer products.



More powerful modeling capabilities can predict the outcomes of specific medical interventions for individual patients, allowing for more personalized treatments. *Image courtesy of Ansys.*

While inserting the human body into simulation isn't necessarily a new practice, the sophistication and realism of the human body models that can help inform design exploration has grown significantly.

Traditionally, engineers could insert a 3D representation of a human body shape—think mannequins in CAD software—into product designs such as airplane cabins or cars to gauge interaction with electronics. This helps determine the impact of crashes or to calibrate spacing considerations to bolster the utility and comfort of a design.

That dynamic has rapidly evolved to include full system models and highly personalized models of a particular individual's human form to take design exploration to the next level, ushering in a new era of human-centered design.

As human models and modeling capabilities become more robust, as well as readily accessible to non-expert engineers, their utility is growing. Human models are being used to ensure comfort and safety of products, whether an interior car cabin or the expanse of an airport terminal.

The combination of human modeling and simulation is getting a significant amount of traction in various medical applications as a way to create bespoke designs for medical devices like replacement hips or arterial stents. The technology is also being leveraged to create more efficient and safer work environments, particularly mapping out the placement of people and equipment on the plant floor as part of manufacturing process optimization.

"We need to consider the human throughout the whole engineering process—not just the object we're creating and how people interact with it, but also understanding how to assemble and service that product," says Ulrich Raschke, director of human simulation products for Siemens Digital Industries Software. "Having human simulation technology in the mix aids in human-centered design, which considers the human from the start so the design inherently accommodates the user."

Personalized Medical Applications

For some time, engineers have inserted human shapes into the design process to gauge interactions—for example, experimenting with the position of an athlete on a road bike in simulations to shave time off a downhill race to gain competitive advantage.

As the models and simulation capabilities evolved, engineers began tapping the technology to gauge the comfort or usability of a design—for instance, to explore the pressure points of a car or airplane seat on a passenger at different points of their body. This delivers a deeper set of useful information to the engineer as they iterate designs.

Today that process is evolving further, incorporating scanned images of real individuals as the base foundation for a human model that delivers a high degree of accuracy and realism, particularly for determining what happens inside the body as a result of standard interactions.

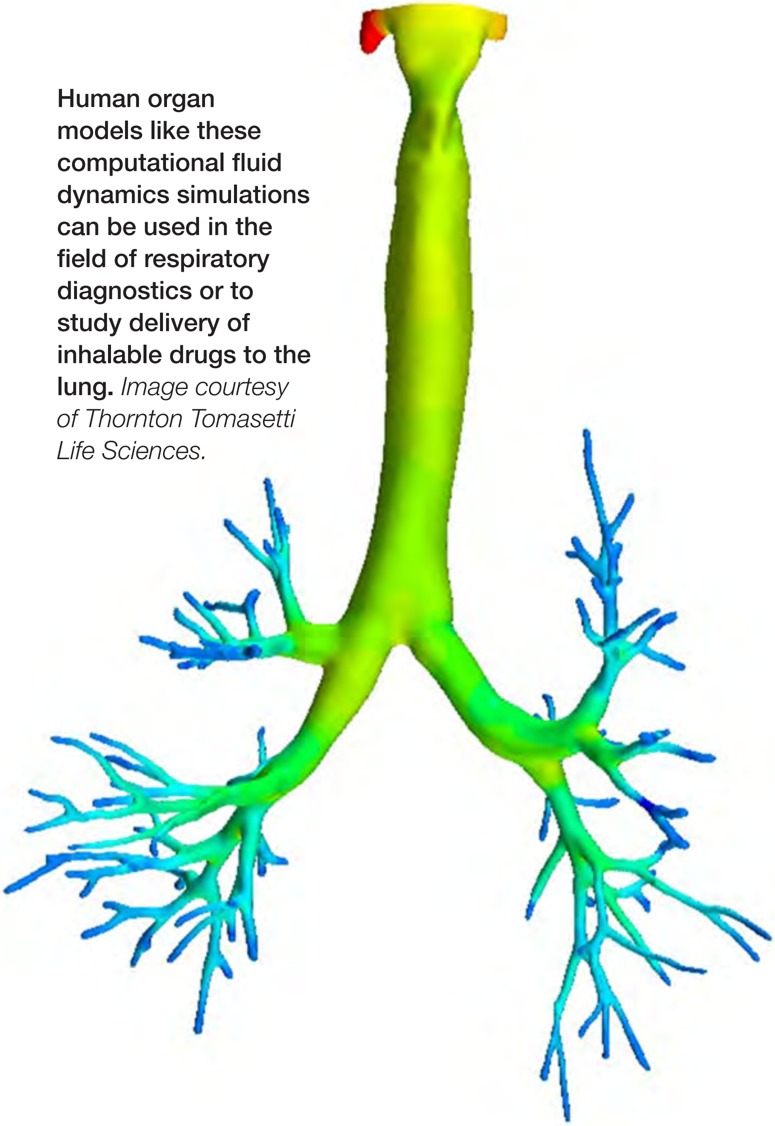
"Human body modeling is more powerful today because we can model what's happening in the body and use it to predict outcomes," notes Thierry Marchal, global director of the healthcare industry at Ansys. "With an external shape that you just place in a car, you can't calculate what's happening in the body—what pressure or loads are applied to the neck or spine."

When leveraging digital design processes to architect medical devices and related products, mimicking what happens inside the body in response to product performance is critical.

Offerings like Synopsys' Simpleware human body models provide realistic human anatomical representations to be used in simulations to improve the fit of devices, to mimic the mechanical wear of devices once implanted or to understand the electromagnetic effects of a device on the surrounding anatomy.

Beyond generic human body models, engineering teams are beginning to make use of scanning technologies and software tools that translate those images into a data format that can be leveraged and manipulated through simulation. As a result, designers can predict how an specific implant or medical device design will perform in a specific patient based on their individual physiology and treatment plan.

At medical device maker Kejako, for example, a 3D parametric full-eye model was developed using COMSOL multiphysics simulation software to provide insights into the root cause of the eye's degeneration over time as the natural aging process causes farsightedness. The full eye model covers a lot of physics ground, including fluidics related to the aqueous humour, the optical behavior of the lens and cornea material, and the refractive index replicated by modeling muscle ligaments.



Human organ models like these computational fluid dynamics simulations can be used in the field of respiratory diagnostics or to study delivery of inhalable drugs to the lung. *Image courtesy of Thornton Tomasetti Life Sciences.*

The solution is more than a generic eye model—it also has the potential to provide a personalized treatment plan for individual patients, which is important because everyone has different physiology in addition to experiencing various levels of presbyopia—the condition that causes the deterioration.

"Creating a model of the human eye turned out to be a complicated simulation combining structured mechanics and fluid flow," explains Bjorn Sjordan, vice president of product management at COMSOL. "It helped the team understand farsightedness more and helps determine what surgery is optimal—LASIK or corrective lens."

Medical device makers, researchers and medical professionals are jumping on the use of simulation, and human body models, in particular, as the pendulum swings toward more personalized treatments and individualized medicine. In the traditional design process, designers create mockups of products and go through a lengthy trial-and-error design process using benchmark physical tests on

The Human Brain Project employs simulation to replicate the brain and its workings in a virtual world. Simulation takes place at several levels, ranging from the molecular through the subcellular to cellular and up to the whole organ. *Image courtesy of The Human Brain Project.*

prototypes built in silicone rubber or other materials.

Today, much of that same exercise can be performed computationally, minimizing the number of physical tests, reducing reliance on animal testing and speeding up the process of clinical trials. In fact, the FDA has already recognized the public health benefits of modeling and simulation software for enabling in silico clinical trials and, in select cases, is behind use of them to replace or greatly reduce reliance on human and animal clinical trials.

"Instead of putting a device or stent into 200 or 300 people, you can take a scan of a person or animal, put the implant in a virtual cohort of different sizes and shapes of anatomy and cover a large segment of the population upfront," says Kristian Debus, vice president and leader of the Life Sciences team at Thornton Tomasetti, an engineering consulting firm. "At the end of the day, we're trying to reduce the number of patients we use in clinical trial while reducing the time and cost of those trials."

Dassault Systèmes is so committed to the idea of human modeling, it announced a strategy last February to create a virtual twin experience of the human body to transform medical and wellness treatments. Much like engineers have been able to build virtual twins of giant aircraft or carrier ships using the 3DEXPERIENCE platform, the company is now turning attention to modeling the entire human body, from DNA to organs, using a combination of modeling, simulation, information intelligence and collaboration.

"We want to understand how the whole human system operates," says Ales Alajbegovic, vice president, SIMULIA industry process success and services at Dassault Systèmes. "We've been modeling very complex products, and we've reached the point where we want to go one step further and simulate the most complex machine on the planet, which is us."

The virtual twin of the human body builds off of Dassault's Living Heart initiative, a research effort that develops and validates highly accurate and personalized digital human heart models. The heart models are designed to serve as a foundation for cardiovascular in silico medicine, including evaluating and testing pacemaker leads and other cardiovascular devices, and eventually using virtual patients constructed via computational models and simulation to improve the efficiency of clinical trials of new devices.

The Living Heart model, and eventual full human body model, can also be used in product development to provide better insight as to what might happen to a human during a car crash far beyond the insights provided by physical crash dummies or even simulated versions.

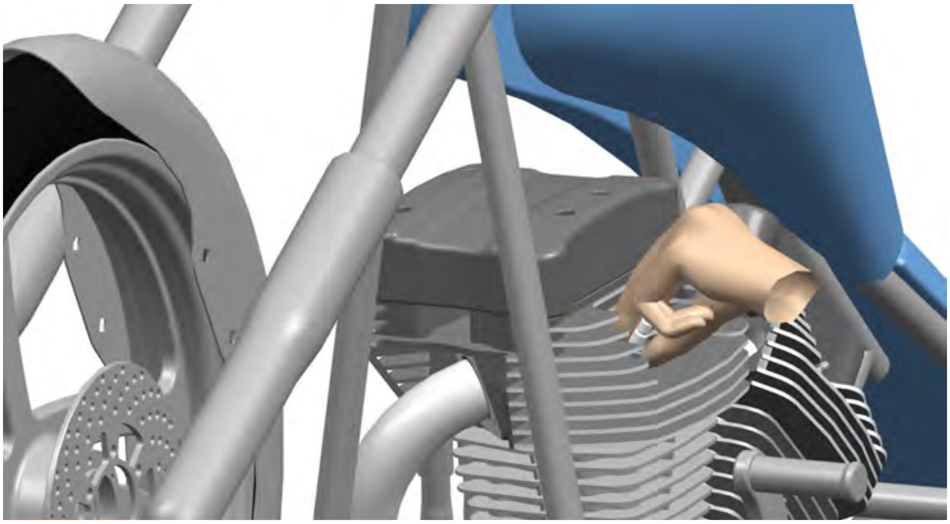
"Crash test dummies look like us on the outside, but they don't represent us very well on the inside," notes Steve Levine, senior director of virtual human modeling at Dassault. As vehicle innovation advances in areas like autonomous vehicles, the crash scenarios become more complex and therefore the physical loads on the body and what happens internally is different than in the past when you assume a uniform seating position, Levine adds.

Dassault Systèmes is also a partner in the Human Brain Project, which includes the Brain Simulation Platform. This similar digital twin project is attempting to model the human brain for research, medical and product development applications.

Using simulation technology and AI, the researchers aim to build virtual models of a brain and brain activity, including patient-specific representations, allowing doctors to mimic and test intervention procedures prior to surgeries to ensure the best outcomes.

Viktor Jirsa, director of the Institute of Neurosciences and Systems at Aix-Marseille University, likens the concept to a systems modeling exercise with outcomes similar to testing products in a flight simulator.

"When you simulate the flying of an Airbus, you are not just testing the functioning of the engine; you put the Airbus in a flight simulator where there is rain, wind and aerodynamics," he explains. "That's what we are doing with the virtual brain. We are taking all the brain signals and physical aspects into account."



Accurate hand models help designers consider user interaction and product safety throughout the design process. *Image courtesy of Siemens.*

Injecting a Human Element into Manufacturing

Beyond medical use cases, human body models and simulations are also playing a prominent role in process design and manufacturing. Siemens' Process Simulate Human technology (known as Jack) is incorporated in various platforms, including NX, Teamcenter and Tecnomatix, to provide engineers with insights to improve the ergonomics of products designs or to refine industrial tasks.

The software enables engineers to inject human body models that match its worker population into a digital twin representation of a factory floor or a product design to explore comfort, injury risk, line of sight and fatigue limits early in the lifecycle when it is less expensive and time-consuming to make changes, according to Raschke.

While the technology has been around for a while, improved predictive models and streamlined interfaces make the capabilities more accessible to a wider population of engineers.

"There's been an evolution of predictive capabilities and infrastructure to allow users to more easily do analysis than what was possible before," he explains. "As opposed to having a few experts familiar with the technology, now a larger community of engineers can take advantage."

Given the realities of the workplace due to the COVID-19 pandemic, human modeling and simulation also have relevance for designing workspaces and production lines with an eye toward employee safety and stopping the virus' spread. Siemens recently announced a new workplace distancing solution (bit.ly/2Z1TnDa) based on its SIMATIC Real Time Locating Systems (RTLS) technology and its Xcelerator portfolio of engineering, operational, industrial Internet of Things and cloud solutions.

The platform lets companies model employee interactions, including where they reside on a production line, and provide real-time visual feedback if people get too close. There is also an ability to identify "hot spots" so manufacturers can reconfigure layouts to mitigate potential risk scenarios.

Because of this and other scenarios, interest in human modeling and simulation is likely to remain on the rise.

"There is a need to understand how containment is propagated in environments from homes, but especially hospitals, vehicle cabins and airplane cabins," says Dassault's Alajbegovic. "The number of requirements we now see in those areas is skyrocketing." DE

Beth Stackpole *is a contributing editor to DE. You can reach her at beth@digitaleng.news.*

→ MORE INFO

- **Ansys:** Ansys.com
- **COMSOL:** COMSOL.com
- **Dassault Systèmes:** 3DS.com
- **Kejako:** Kejako.com
- **Siemens Digital Industries Software:** SW.Siemens.com
- **Thornton Tomasetti:** ThorntonTomasetti.com

For more information on this topic, visit DigitalEngineering247.com.

Ventilator Project Spurs Inventive Collaboration and Design Under Lockdown

Designers and engineers rethink ventilator functions, prototyping and production.

BY KENNETH WONG

In the early days of the COVID-19 crisis, as hospitals in the hard-hit U.S. East Coast struggled to cope with a spike of patients with respiratory problems, the alarming ventilator shortage came to light.

On March 24, during his daily live briefings on the crisis, New York Governor Cuomo said, "FEMA [Federal Emergency Management Agency] said they're sending 400 ventilators. Really? What am I going to do with 400 ventilators when I need 30,000?" ("Cuomo says NY needs 30,000 ventilators, pleads with feds for help," The Hill).

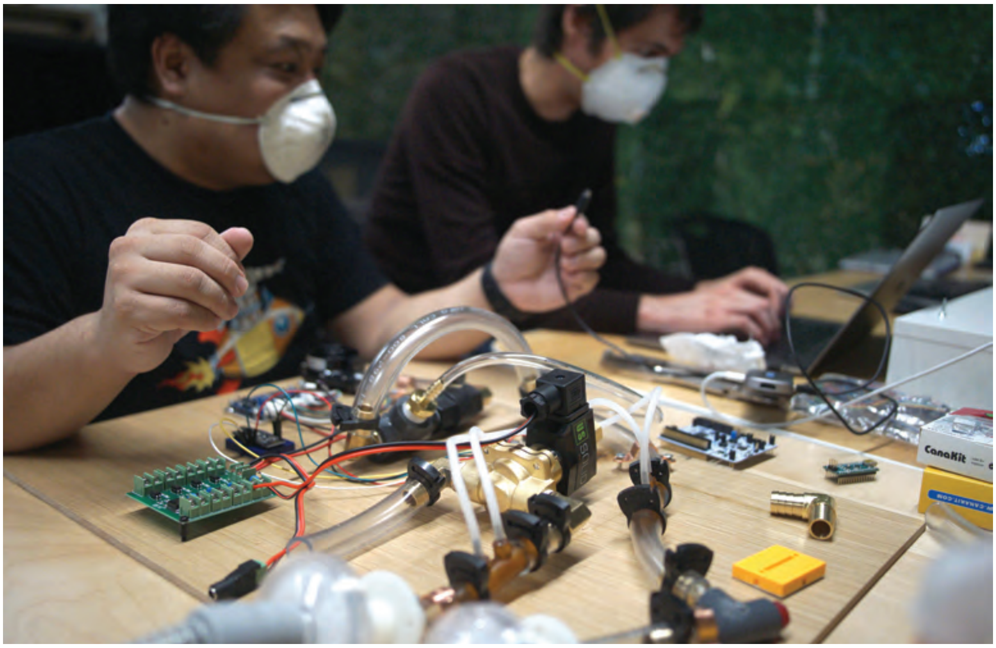
The crisis has spurred several leading carmakers into action. GM and Ford reconfigured their manufacturing lines to begin producing ventilators. In the private sector, maker communities, 3D systems suppliers and tech firms launched into action to design and deliver rapidly deployable ventilators.

This environment gave birth to CoVent-19 (also dubbed Innovate2Ventilate), a ventilator design challenge hosted on the GrabCAD community and supported by Stratasys. It came online on April 1, and is now entering Phase II, where the seven finalists are expected to begin developing working units and prototypes of their designs.

A Different Kind of Ventilator

On April 17, GM and its partner Ventec announced the first delivery of their ventilator called VOCSN V+Pro, made in GM's plant in Kokomo, IN, to Franciscan Health Olympia Fields in Olympia Fields, IL, and Weiss Memorial Hospital in Chicago. This is a hopeful sign that industry leaders and manufacturers are stepping up to meet the challenge.

Dr. Richard Boyer, Massachusetts General Hospital Department (Mass General), Anesthesia, is the founder



Some team members from RespiraWorks began assembling an early prototype of their ventilator. *Image courtesy of RespiraWorks.*

and director of the CoVent-19. He foresees the need for a different kind of ventilator that specifically caters to the COVID-19 crisis.

"Typical ICU [intensive care unit] ventilators cost about $30,000-$60,000. They are not simple devices. They have many flavors of ventilation, some of which may not be needed by a COVID-19 patient. For the challenge, we're looking for a ventilator that produces one or two types of ventilation specific to COVID-19, not everything under the sun," he says.

The CoVent-19 Challenge, therefore, does not seek to replicate commercial ventilators in function and scope. Rather, it's supposed to create a much simpler device, purpose-built for COVID-19 patients. Due to the device's simplicity, Boyer believes designing, prototyping and getting approval should be comparatively easier. The targeted per-unit cost of production is around $2,000-$3,000.

"The threat [of the ventilator shortage] is still out there, especially outside the U.S.; ventilators will still be needed in future waves of COVID-19," Boyer says. With experts predicting a spike in infection as the states reopen, such affordable ventilators could be part of the medical community's strategy to deal with the second and third waves of COVID-19.

Stratasys and GrabCAD

GrabCAD, the online community that hosts the challenge, is part of Stratasys. The portal grew out of a 3D content-sharing and collaboration space. It was acquired by Stratasys in 2014. Currently, GrabCAD is the online destination featuring collaboration software (GrabCAD Workbench), work order management software and 3D print preparation software.

"We were involved with the challenge since its inception," said Scott Drikakis, healthcare segment leader, Stratasys Americas. "We have more than 7 million active users on [the] GrabCAD community, so we hosted the challenge and promoted it there in the first stage. In Phase II, we are offering design services through our company and the Stratasys Direct Manufacturing division. Each team is working with an engineer of ours."

The winning SmithVent design from a team of alumnae, staff and faculty from Smith College in Northampton, MA. *Image courtesy of Stratasys.*

InVent Pneumatic Ventilator prototype parts from a Stratasys J850 3D printer. *Image courtesy of Stratasys.*

RespiraWorks

Ethan Chaleff, an engineer with a background in advanced energy, recalled discussing the ventilator shortage with his acquaintances in the health care and technology sectors during the early phase of the pandemic.

"We had a Slack channel, where we discussed how we might approach this problem and what we might do," recalls Chaleff. "My friend Edwin Chiu is an engineer. He has parts lying around in his house since we had worked on similar parts. So he decided to put together a prototype as fast as possible."

Chiu has designed the engine controller for the SpaceX Falcon 9 rocket and the electrical controls of the DeepFlight Super Falcon submarine. Eventually, Chaleff, Chiu and other like-minded people from their network became a nonprofit (501C status pending), operating under the name RespiraWorks.

The organization's goal is "to create a ventilator that can be built and deployed globally," states its website. "We're hoping to create something with usage that lasts beyond the pandemic," says Chaleff. The design submission from RespiraWorks is one of the finalists for the CoVent-19 Challenge.

"Research was easy under the lockdown," recalls Chaleff. "But as we got into implementation, it's been challenging. I have access to a workshop with equipment, so we get things delivered there, but I'm not the engineering lead. [To accommodate the geographically dispersed team] we had to buy duplicate equipment and kits so everyone in engineering has a copy of the design to tinker with. Ideally, everyone would look at the same prototype in the same space."

The digital twin—a dynamic systems model—is useful for research, but at some point, "we have to get people to put on masks, come to a workspace and put the prototype together," Chaleff says.

The team used Autodesk Fusion 360, with free licenses provided by the Autodesk Foundation. "It's a pneumatic system with lots of flexible piping connections. Fusion is helpful in helping us figure out the package, to understand if we have enough room left for PCB (printed circuit boards) or if we need a different case, and so on. To answer these questions, we can all look at the digital model in the software at the same time," says Chaleff.

System simulation was done using a 1D schematic with pneumatic and mechanical solvers, authored in Modelon Impact, a collaborative design software. "There aren't a lot of stresses on the design, so we weren't doing FEA (finite element analysis)," Chaleff explains.

3D printing has been helpful in the prototyping phase, but for mass production, injection molding could be more viable, Chaleff reasons.

fuseproject

Another finalist entry dubbed the InVent Pneumatic Ventilator came from San Francisco-based fuseproject.

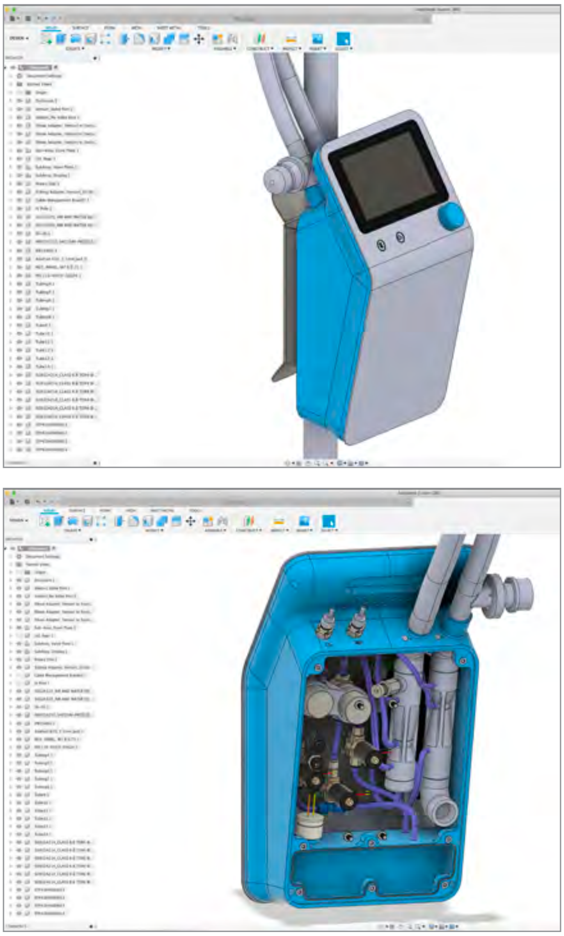
"We're used to working with startups. In these situations, we have to bring teams together very quickly—engineering, legal and management. So within a month, we had solutions to present," says Yves Behar, founder and CEO of fuseproject.

Ventilator design was new territory, so the team conducted interviews with health care experts to understand what works and what doesn't.

"One thing that became clear to us in our talk with the health care professionals was that space is very valuable in the ICUs," notes Daniel Zarem, senior industrial designer, fuseproject. "That led us to design a ventilator that can hang from an IV pole, without the need for a separate stand or a large footprint. The screens and the knobs are designed to be familiar to the doctors and nurses, because they wouldn't have time to learn a new UI [user interface] or software in the middle of a pandemic."

The fuseproject team relied on multi-material 3D printing to incorporate 3D-printed gaskets into the ventilator housing. They also relied on multicolor printing to include icons that clearly identify tubes and connectors for easy assembly.

"We used an app called Miro [for virtual collaboration] in the same way we would use a whiteboard in our studio, so everyone has the same view of the project," recalls Zarem. "To design the geometry, we used Autodesk Fusion 360, SolidWorks and a few other ECAD packages to visualize the circuits and diagrams to validate our design. We passed along STEP files so everyone can open the 3D model."



The team at fuseproject came up with a ventilator design that attaches to an IV pole, minimizing the need for additional space. *Images courtesy of fuseproject.*

Fuseproject, too, sees its design outliving the current pandemic. "Because of the breadth of features and sensors in our ventilator, we see its use beyond the current crisis, in resource-limited places like Africa, for example," says Zarem.

Winner Announced

Three months after the challenge's launch and 200 entries later, the CoVent-19 organizers announced on July 1st that the SmithVent, an entry from the 30-person Smith College team, was selected as the winner. According to the announcement, the SmithVent is "one-tenth the cost of traditional ventilators, combines economical proportional solenoid valve technology with an air-oxygen mixing chamber to meet the full set of requirements for COVID-19 ventilation … [and can be made from] readily available, off-the-shelf components."

InVent by fuseproject and Cionic was recognized as the second-place winner, and the entry from RespiraWorks as the third-place winner. The three winners will receive a total of $10,000 in credits from Stratasys. DE

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For more information on this topic, visit DigitalEngineering247.com.

When *Engineering* *Exits* the Building

Organizations must find the right technology to support engineers' data-intense workloads as work-from-home numbers increase.

BY RANDALL S. NEWTON

In a matter of months, the COVID-19 pandemic has changed much about how we conduct our professional and personal lives. Engineers who had always worked in the office suddenly found themselves working from home. For most home-based workers, the technology supporting the transition was in place. For engineers, the story is different.

Engineering software makes for high demand on computer and network resources. The office has the workstations, servers and network infrastructure to properly support engineering. When engineering leaves the building, it is more complicated than logging in from the family computer.

Digital Engineering talked with several vendors who support engineers working long term from home. Their experiences and observations confirm that product development is possible from home, but requires thoughtfully working through the entire process.

Dell is poised to release what it claims is the world's smallest and lightest 17-in. mobile workstation, the Precision 5750. It features a four-sided InfinityEdge display and can run an NVIDIA Quadro RTX 3000 GPU. *Image courtesy of Dell.*

The Right Computer

Today's mobile workstations have enough computing horsepower to match the performance of tower and desktop systems.

"It is not well understood that today's mobiles are more powerful than towers from four years ago," says Chris Ramirez, industry strategist for manufacturing and AEC workstations at Dell. "Many times mobile workstations equal or exceed the capabilities of desktop workstations. The fastest way to get up and running with the least amount of change to engineering workflow is to move from tower to mobile."

"Years ago, engineers might have had a small travel system, which could connect remotely to the office," adds Allen Bourgoyne, a senior product marketing manager at NVIDIA. "But it was not a full-power system. Now one system allows freedom to work from any location."

What do you look for in a new unit? Bourgoyne says every case is unique.

"If battery considerations are important, buy the biggest battery and don't buy more than a four-core CPU," Bourgoyne says. "Heavy graphics users need top-of-the-line CPUs and GPUs [graphics processing units]. These systems are wildly configurable. Every engineer can get exactly what they need."

NVIDIA offers Max-Q, a hardware configuration approach that combines design, thermal and electrical solutions and software. Max-Q balances power consumption with performance requirements in real time. Originally created for gaming notebooks, Max-Q has now been applied to desktop and mobile workstations from various vendors.

Bourgoyne says Max-Q made possible the development of new thin-and-light mobile engineering workstations now sold by several vendors.

HPCentral Connect links dedicated workstations to individual remote users. *Image courtesy of HP.*

Workplace Transformation

If you remove COVID-19 as a factor, and look at workplace transformation over the last couple of years, a few trends are obvious, says Mike Leach, a workstation portfolio manager for Lenovo.

"There are more satellite offices, more remoting, more hotdesking, more sharing talent from other regions. Companies must keep nimble," he says.

Buying the right mobile workstation is one step in the right direction, Leach says, but there is more to consider. The IT environment in the home office must be accessible to the remote user.

Lenovo offers its workstation users—mobile and desktop—Mechdyne TGX, a remote desktop utility designed for graphics-intensive applications. TGX enables users to access remote workstations and work with graphics and video at up to Ultra HD (or 4K) resolution. Data can be accessed remotely to either a physical or virtual machine, allowing the data to stay in the office while the work continues remotely.

TGX specifically works with NVIDIA Quadro GPUs, using a built-in encoder to compress and send information from the host to the client, where the data is decoded. A copy of TGX must be running on each end of the transaction.

Leach says TGX "allows engineers to connect to the office workstation and get an 'as local' user experience." The version of TGX that Lenovo ships is custom, designed with NVIDIA to work with GPUs; the standard TGX utility is CPU-based.

AMD bundles the AMD Remote Workstation with every professional GPU. It works with either Citrix Virtual Apps & Desktops or Microsoft Remote Desktop Services to support accessing a remote workstation.

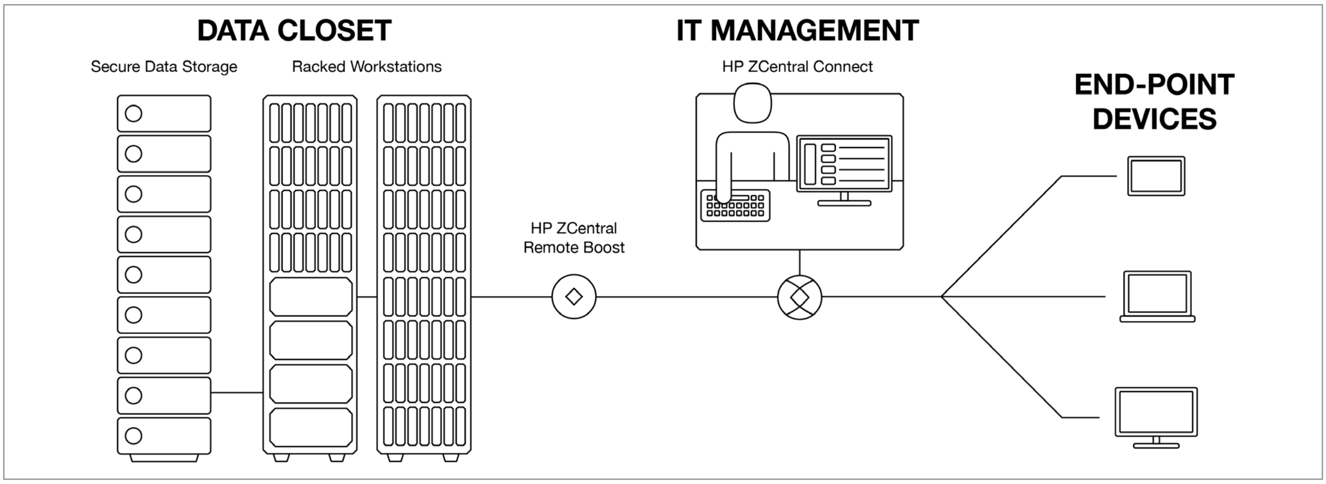
In 2018, AMD realized "we had a lot of IP we could borrow from our server work," says Emil Salavat, professional graphics software product manager for AMD.

Remote Workstation works with the leading IT remote computing stacks, Salavat says, because "we don't want to reinvent the wheel for remote visual applications that IT people already know and use." For users of AMD-equipped workstations, there is no extra software to install and generally no changes to settings are required.

AMD offers an application programming interface to software vendors who want to tweak their products to recognize and take advantage of the AMD utility. One reason is to help ensure latency is as low as possible.

"As a GPU provider we can help the most in the capture stage and the encode stage" to make sure graphics throughput is as fast as possible," says Salavat. "Our testing with CAD shows [a latency of] 150 ms [milliseconds] is OK; 100 ms is great and 50 ms or less is amazing."

The distance between the host workstation and the end user is an important factor in latency.



The map of how HP ZCentral Connect unites remote workers with the back office. *Image courtesy of HP.*

"When 5G arrives, this will be an important inflection point for network latency connectivity—it will drop to very low numbers. 5G will enable flexibility not seen previously," notes Salavat.

Future-proofing Remote Work

Dell views the challenges of work from home for engineers as a three-step process of updates and innovation. The first and most productive step, says Ramirez, is to move individual users from towers to mobile workstations. The second step is to implement a contemporary remote computing process.

"Traditional remote desktop protocol solutions are not effective for engineers," Ramirez says. Dell works with Teradici, maker of PC-over-IP (PCoIP), a display protocol that encrypts and transports pixels to user devices. Existing rack-mounted and deskside workstations are equipped with a PCoIP card; the remote user then connects directly to the required computer.

The third step is a long-term evaluation of how to future-proof remote work. The Teradici approach is a one-to-one connection.

"The next step is to use multiple GPUs in a workstation, with each GPU assigned to a dedicated remote," says Ramirez. One dedicated high-end workstation at the office equipped with four high-end NVIDIA Quadro RTX GPUs could support four engineers for less cost than the one-to-one approach.

However, Ramirez says this opens up a new issue: software licensing. Every CAD/CAE software vendor has their own approach to how they charge for their software. "With four dedicated users on one workstation, licensing becomes a thing. How do you apply licenses to one workstation and multiple users?" asks Ramirez.

Lead time to implementation increases with each of these steps, Ramirez notes. The move to mobile is "low touch;" using PCoIP is "medium touch;" and workstation virtualization is "high touch." By working through these steps, Ramirez says the best long-term benefit is "your employee pool is global."

In-House Approach

Most workstation vendors partner with other companies to provide their remoting capabilities. HP takes a different approach, according to Clifton Robin, an HP global technical product and planning expert. The company, which offers a broad workstation and server product line, supports in-house remoting technology.

HP ZCentral Connect is a new technology introduced this year. Robin says the initial plan was to "soft launch" in March, but "it became a hard launch and we started giving away licenses," Robin says. ZCentral Connect assigns dedicated workstations to individual remote users. It also allows the use

Lenovo offers a custom version of Mechdyne TGX, a remote desktop utility designed for graphics-intensive applications. *Image courtesy of Lenovo.*

of compute pools shared by multiple users. Each remote user needs a copy of ZCentral Remote Boost Receiver, which works with a variety of operating systems and browsers.

The HP ZCentral offers a "just like being there" experience, Robin says. "I use a SpaceMouse and have two 4k displays at work, and a 1080p display at home."

Robin's IT support sent a URL, which Robin used to find available pools of machines including one preassigned to him. "It assigned me a machine. I could power this remote workstation on or off as needed," he says. "The software started and my Windows 10 desktop came up. Scaling features gave me the full screen experience, with my desktop from work appearing on my remote screen." To remotely turn a workstation on or off requires the workstation to be equipped with an Intel CPU that supports remote power control.

Like other remoting solutions, ZCentral Connect moves pixels, not the data behind them.

"No worries about data on my remote computer," Robin notes. "If I can VPN into my company I can be anywhere on any computer and get to my office workstation." This approach to remoting "sidesteps licensing issues," he says. "We look at the pixel buffer and send the changes. We don't corrupt the primary user session—we just do remotely what a user would do in the office. It is still one session at a time."

ZCentral Connect technology began as a project for NASA to streamline the use of extremely large image files, as transmitted from space-based platforms like the Hubble Telescope. Licensing is free on the remote end; a 90-day free trial is available for ZCentral Connect on the office end.

Workstation-Strength Collaboration

The remote session offerings mentioned are for single users connecting to the central office. Yet working from home requires a more collaborative approach. For years, collaborating with intense graphics (whether for engineering; architecture, engineering and construction; or media & entertainment) required uploading and downloading large datasets.

NVIDIA recently released a software platform called Omniverse, designed for graphics-intensive remote collaboration. An AEC version is now shipping; a manufacturing version is still in development and is being tested at several customer sites.

Omniverse uses Pixar's Universal Scene Description (USD) as its foundational technology, and runs on new Quadro RTX GPUs. Pixar initially developed USD to provide smooth interchange of specific 3D assets and complete scenes. The technology now works with all forms of 3D geometry.

Real-time rendering is now possible on the workstation, but is not a remoting solution. Omniverse offers a new type of rendering, Omniverse View. It displays the 3D content aggregated from different applications, and can work with

Volvo Cars is testing NVIDIA Omniverse as a collaboration platform for design teams.
Image courtesy of NVIDIA.

Unity and Unreal 3D content engines. NVIDIA is working with companies including Autodesk, Trimble, McNeel & Associates, Adobe and Teradici to extend the value of Omniview for technical software in the enterprise.

"This technology can give our customers access to immersive, interactive and collaborative experiences across industries," says Amy Bunszel, Autodesk senior vice president for design and creation products.

Volvo Cars is testing Omniverse for design collaboration. "We immediately saw the opportunity for real-time collaboration," says Mattias Wikenmalm, senior visualization expert at Volvo Cars. "It's something we have been striving for throughout our efforts to optimize our design and development process." NVIDIA says other manufacturers are testing Omniverse for use in AR/VR applications, manufacturing collaboration and robotics. DE

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Made for You— Just You

Photogrammetry and AM open new markets for personalized healthcare, eyewear, jewelry and more.

BY KENNETH WONG

At conferences and corporate events, you collect cups and T-shirts with company names and brand logos. In expensive jewelry stores, you wait as the staff engraves your name or initial onto your latest purchase, either at a modest cost or no cost at all.

Beyond the self-aggrandizing personalization, a new kind of personalization is on the rise. Custom-fitted surgical masks for doctors on the frontline in the battle against COVID-19, tailor-made glasses for patients with abnormal cranial structures, tools that fit a specific worker's hand—these personalized products offer ergonomic benefits that go beyond simple aesthetics. In many cases, they are driven by affordable 3D printing and digital scanning at the click of a smartphone.

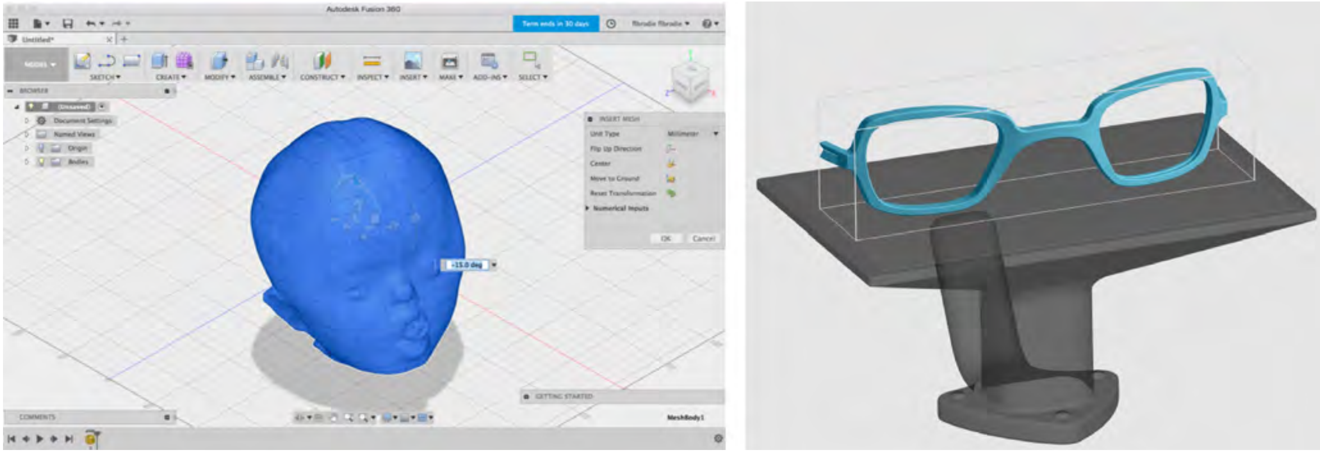
MyMask

Jesse Chang's wife and brother are physicians. When he heard that the hospital staff had been cleaning the typically disposable N95 masks with Lysol for reuse due to a personal protective equipment shortage, he sprang into action. His efforts helped launch the MyMask Movement, an online portal for making custom-fitted surgical marks.

"If you have the luxury of using a fresh mask with every patient, that's what you do, but that's rarely the case. Many doctors are now putting another mask over an N95 mask to extend its shelf life," says Stanley Liu, M.D., assistant professor of otolaryngology, and plastic and reconstructive surgery, Stanford University School of Medicine. He is also part of the MyMask team.

3D-printed face shields have been getting a lot of publicity as examples of crisis-driven ingenuity, but Chang, who was a venture capitalist in additive manufacturing (AM) startups, felt the technology is misused. "It shows 3D printing can step in as a stop-gap

3D-printed anatomical model for surgical guide is an example of personalized medicine, powered by additive manufacturing. *Image courtesy of 3D Systems.*



Loving Eyes Foundation uses magnetic resonance imaging and computed tomography scan to reconstruct a patient's head, then 3D-print custom eyeglasses. *Image courtesy of Carbon.*

solution, but in the long run, injection molding probably makes more sense," he reasons.

In Chang's thinking, the technology's personalization potential invites another use case: producing tailor-made masks, each a snug fit for the individual physician's unique face.

"With the technology we had three years ago, we could not have done this type of mass personalization with reliable, consistent results," says Chang. "What made it possible are the advances in stereolithography technology, powder bed fusion, and the HP Multi Jet Fusion and EOS machines we use primarily for production."

The MyMask project taps into the depth-sensing camera in iPhone 10 and newer models, allowing users to easily scan and upload their face geometry. It is the same face ID technology employed by iPhone 10 to let you unlock your phone with your face. The project's algorithm-driven generative design software automatically converts the user-supplied geometry to produce the 3D-printable file.

"It's really about comfort. With a standard N95 mask, the nasal region has a lot of air leaks. The metallic clip hurts your nose bridge, and it doesn't conform to the contour of your face," explains Liu.

To be reusable, the masks need to be able to withstand autoclave sterilization, a requirement for surgical equipment in hospitals. The mask designed by MyMask has been submitted and reviewed by the National Institutes of Health. It has received emergency use authorization, the organizers state.

MyMask's partners include MSC Software, part of Hexagon Software, which offered the team computational fluid dynamics simulation help to test the mask design.

Tailor-Made: From Nails to Tools

Stanley Black & Decker (SB&D) is the company behind many instantly recognizable products, from the Black & Decker vacuum cleaners and power drills to the Hugs baby monitoring devices. According to Marty Guay, VP of business development, SB&D relies on additive manufacturing (AM) or 3D printing for building prototypes and assembly aids, among others.

Paired with generative design technology, AM is a way to rethink solid parts for lightweighting. "Parts that used to be solid throughout can now be produced with honeycomb structures," Guay notes.

The company is now partnering with Connecticut-based Techstars that runs an accelerator program.

"The program gives us a chance to recruit from the startups that self-identify as AM companies," says Guay. "We pick the ones we can learn from, can drive new conversations within our company and can identify new use cases. In just a short time, we really got a good understanding of what's happening in AM."

Companies accepted into Techstars receive a 90-day mentor-driven program, office space and access to potential investors. One selected participant is ManiMe, founded by Stanford MBA students Grace Chiang and her friend Jooyeon Song. The startup uses photogrammetry to configure nails that perfectly fit the customer's fingers. It uses 3D printing to produce the individualized nail sets.

"We look at them to learn how they customize the nails using the photos their customers send in," says Guay. "That concept may lead us to, one day, produce tools that fit the customer's hands perfectly."

Other Techstars participants include Ireland-based CALT Dynamics, which uses 3D printing to produce custom parts; and Triditive, which develops metal AM system for volume production.

Spare Parts for Your Mouth and Body

Patrick Dunne, VP of advanced application development, 3D Systems, identifies health care as the primary sector for AM-driven personalization. The reason is obvious: the unique body types found across the human population.

"Certain medical devices yield better results when they have custom, conformal fit," he observed. "AM is infinitely flexible as a production tool in the sense that you have no tooling. Your digital design is your tooling. Reinforce that with the ability to scan and digitize objects, [and] AM can yield continuous custom outputs."

Orthopedics and medical implants, Dunne points out, are good examples of AM-driven personal health care offerings. Ancillary uses include producing surgical models and guides.

"The dental industry is essentially the largest custom spare parts replacement industry," Dunne quips. "Everything is made to order based on the way a patient bites, chews and eats."

The variety of printing materials now available, from polymer-based clear materials for nightguards to ceramic for implants, make AM a viable option, points out Scott Drikakis, healthcare segment leader, Stratasys Americas.

Although certain finished products, such as dental crowns, cannot yet be 3D printed due to the limitation in material science, "the process of making the crown can still benefit from 3D printing," Drikakis points out.

"Depending on the application, the materials need to comply with ISO 1099 standards, meet various biocompatibility and sanitization standards, and pass testing protocols. The longer the implant remains in the body, the more rigorous the requirements are," Drikakis says.

In the last five years, he'd started to see 3D-printed orthopedic implants: "knees, hips and shoulders, you name it," he adds.

Bragging Rights and Precious Memories

Another emerging additive manufacturing use is in corporate and luxury jet manufacturing, where the buyer tends to want logos, crests and personal identities integrated into the airplane's interior. From coat hangers and coffee cups to plates, anything is up for personalization in this sector, Dunne notes.

In high-end markets, custom jewelry is on the rise, Dunne says. The online jeweler Stuller, for instance, uses 3D printing to make engagement rings, graduation rings and anniversary pendants with your chosen text or message. Stuller, in fact, offers several Asiga MAX 3D printers in its catalog, under jewelry casting supplies.

"Jewelers like Cartier, for example, uses our DMP (direct metal printing) systems to produce gold bezels for watches or pen cases," says Dunne. "Filling 3D printers with gold dust, as you can imagine, is a very niche market, so that's an exception. The primary use of AM in jewelry is for printing the sacrificial wax."

A Better Outlook

After getting our eyes tested, most of us can point to a readily available frame in the optometrist's office to get our eyeglasses made. But it's not so easy for those with craniofacial anomalies, which calls for custom-fitted frames.

Loving Eyes Foundation found a way to help such customers using Carbon's digital light synthesis technology. In early cases, the foundation used computed tomography and magnetic resonance imaging to reconstruct the 3D model of a child's head, then used a Carbon printer to 3D-print the glasses. The RPU 70 resin used for the project passes biocompatibility tests for sensitization, irritation and cytotoxicity, Carbon states.

Resolution Medical, a medical device maker, is a partner in the project. "With a technology like Carbon, we are able to quickly iterate on designs that can have a direct impact on improving the quality of a child's life," says Shawn Patterson, founder and president, Resolution Medical.

Today, the process is much simpler. The head scan is done with a smartphone via photogrammetry. "There are many promising developments for buyers to do the scans themselves via smartphones they already own. MyFit Solutions in France is using smartphone scanning to make ear tips personalized with 3D Printing," says Dara Treseder, chief marketing officer, Carbon.

For large-scale production, Carbon printers' connected nature offers an advantage. "Digital designs for parts can easily be updated, shifted and manufactured as needed for any design or part," says Treseder. DE

Kenneth Wong *is DE's resident blogger and senior editor. Email him at de-editors@digitaleng.news or share your thoughts on this article at digitaleng.news/facebook.*

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Is PLM Up to the Digital Thread Challenge?

Engineers are reevaluating PLM's role in enabling digital thread development.

BY TOM KEVAN

At first glance, product lifecycle management (PLM) systems seem to be the perfect vehicle for creating and managing a digital thread and the corresponding digital twin. Viewed through the lens of the trend toward digitization, however, that assumption becomes less than certain.

The underlying factors contributing to this uncertainty lie in the metamorphosis of software and the fundamental nature of traditional PLM offerings. As a result of this uncertainty, software vendors and design engineers have begun to reevaluate PLM's role in the digital thread toolchain.

The question has become: Are these platforms the ultimate environment in which to pursue thread development, or is PLM just one element of a larger solution (Fig. 1)?

Fig. 1: Digital thread is all about data connections. The toolchain used to create a thread must be able to collect, aggregate and analyze a broad variety of data flows to create a holistic view of the asset. *Image courtesy of PTC.*

Catalysts for Change

To understand the question, it's imperative to look at software's new place in the hierarchy of design considerations. The proliferation of smart products and the emergence of the Internet of Things have turned the value proposition of products upside down.

Software is quickly surpassing hardware's dominance in the product development process, particularly in complex cyberphysical systems and industries such as automotive, aerospace, defense and medical devices.

Today's products heavily leverage software to drive functionality, improve user experience and enable continuous product refinement throughout the asset's service life. This expanded ability to add value to a design has greatly altered the dynamic between software and hardware, making embedded code a defining factor in many a product's success.

On the other hand, traditional PLM systems have long drawn their strength from hardware engineering competencies and their ability to support the physical design and manufacture of products. When these systems are required to manage software development processes, however, they fall short.

"PLM systems rooted in mechanical design structures and assumptions will fail because adaptation will require fundamental redesign of the platform's core," says Mark Reisig, director of product marketing at Aras.

Current demands find that traditional PLM platforms simply cannot meet all of the new challenges presented by digitization. For example, when the digital thread concept gained traction, many PLM systems were geared more toward playing the role of product data management systems, with emphasis on managing CAD files and revisions.

Consequently, when engineers tried to adapt these systems to thread applications, they often ran into problems with sophisticated software use for many of today's products.

"Traditional PLM systems typically manage software as a 'part' in the context of the product manufacturing process and have struggled with the management of software's complex agile development processes," says Mark Sampson, systems engineering expert, Siemens Digital Industries Software.

"Software has its own distinct lifecycle—with different information that needs to be managed, different collaboration processes and methodologies, different specifications and items—a lifecycle that has historically been insufficiently addressed by traditional PLM systems," Sampson adds. "As a result, software cannot successfully be developed and managed in a PLM system unless processes and methodologies are aligned."

Fig. 2: Application lifecycle management (consists of an amalgam of functions tailored not only to meet the unique demands of the software development process, but also to facilitate collaboration, speed software development and improve testing. *Image courtesy of Siemens Digital Industries Software.*

The Software Difference

Given these new conditions, the first step in determining PLM's role in a digital thread is to see how software design and development techniques differ from those of hardware, and to understand how much software developers rely on specialized tools and practices. The differences come into focus when comparing the overarching perspectives of the two design domains.

"The development of software mainly focuses on the language used to code and evaluate the program and interface, while the actual parts development leans more on computer-aided design," says Hedley Apperly, vice president of solutions management, Integrity, at PTC.

A case in point is 3D modeling. This technology works well with physical parts. Software, however, is intangible, so modeling languages such as the Unified Modeling Language are more applicable. Designers also use standardized development languages to automatically generate source code, in a conceptually similar way to the pairing of 3D modeling and 3D printing.

Software development also uses different practices. For instance, Agile software development methodologies leverage iterative regimens meant to help teams create faster, more efficient software development cycles. This work is accomplished by creating fundamental groups of professionals known as SCRUMs.

Each SCRUM works on a rapid development process called a sprint, which focuses on specific goals. Sprints commonly last 30 days. During this time, the SCRUM calculates its progress. Upon completion of the sprint, the engineers begin the next wave of software development. In many cases, sprints also focus on a minimum viable product to prove out a technology. The SCRUM then rapidly iterates the functionality though additional sprints to optimize the code.

"From a mechanical or electrical perspective, the Agile methodology largely fails to be useful," says George Lewis, vice president of business development and strategy for Arena Solutions.

"Where software development is simple from a logistical perspective, physical components require the consideration of logistics to assemble components and typically involve creating prototypes, often by an outside source," Lewis says. "Generally speaking, the fundamental processes of Agile methodology fall apart in hardware development because the concept of a sprint cannot be reasonably accomplished, especially in the later stages of development."

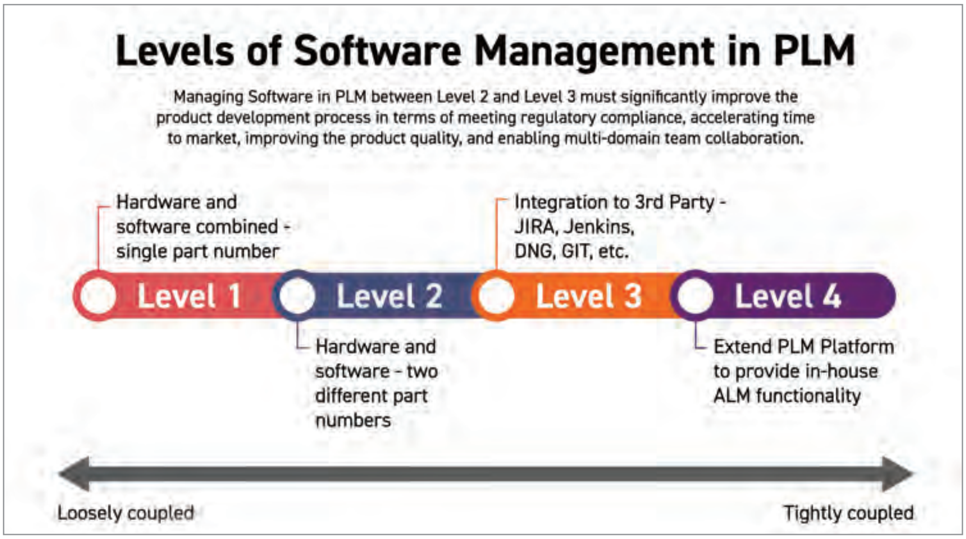

Fig. 3: In this graphic, level 1 represents the state of the art for application lifecycle management-product lifecycle management (ALM-PLM) integration today, with no way of distinguishing embedded software from hardware. In level 2, embedded software becomes representable in digital threads because the software has a unique part number. Level three represents when embedded software becomes fully accounted for in a PLM-managed digital thread and where the software regulatory compliance is fully verifiable against the entire system. In the final level, ALM and PLM Platform are completely integrated in a single platform, including embedded software source code management. *Image courtesy of Aras.*

Timing Is Everything

The Agile methodology highlights a major point of contrast between software and hardware development—the fast pace of software development. The disparity between the two disciplines' development rates has proven to be a major hurdle for integrated development projects and drives home the necessity of discipline-specific tools and practices.

During software development, code changes rapidly and revisions occur frequently. In fact, engineers continually push the envelope in this area using specialized tools for automated compilation, building, integration and testing. These technologies all seek to improve software engineering productivity.

This clash of cycle times also requires tools that provide a high level of integration of the two development processes.

"To manage software development successfully, a tool must align the release cadence and requirements between the software and hardware teams," says Josh Turpen, chief product officer at Jama Software.

"This can be difficult because for software the cycle time between deliverables is incredibly fast by hardware standards," Turpen adds. "Coordinating these disparate cycle times is critical to the success of a joint release. Idle time between the two units is not only costly, but an invitation for requirements drift that will cause testing delays and, eventually, delivery delays."

Adding to the Mix

Upon reviewing the ways software development differs from its hardware cousin, it becomes clear that another toolset must be used with PLM to effectively handle the software side of digital threads and digital twins.

A likely candidate for this role is application lifecycle management (ALM). In many ways, these software tools can be viewed as PLM for software. For example, similar to PLM, ALM encompasses the entire software development lifecycle, from requirements management through development, testing and maintenance of software products. Application project and portfolio management, integrated data management, design and use-case analysis, build and release management, collaboration, traceability and reuse—

these aspects are all incorporated in an ALM solution. However, these standardized tools and systems have specific software management capabilities (Fig. 2).

Using ALM systems for software is similar to using product data management vaults for work-in-process, mechanical designs, or a component library for electrical design purposes. Each is a point tool that serves specific engineering design teams and makes for a logical endpoint where data can be transitioned to PLM once ready for an extended product team discussion and final approval.

It seems that the best approach to managing software development is through something like an ALM solution. What is less clear, however, is how to best integrate the two systems (Fig. 3). Depending on the company's perspective, there is more than one way to reach this goal.

"We recommend one of two approaches," says Lewis. "Companies can connect the two systems through manual integration when code is published, or use an automated integration that can synchronize the released code. In either case, the responsible teams can collaborate around design, quality and bug-related issues that require synergy across the software and mechatronic teams—not just the software design team."

Playing to PLM's Strengths

Whichever integration approach a development team adopts, it should ensure that all design domains are tightly woven into a single fabric, driven by a cross-domain product architecture that acts as the blueprint for collaborating on hardware and software development. To do this, the system or approach must cover several key facets.

For example, ALM and PLM need links to a single source of higher-level system design and to the requirements for those designs. Furthermore, all lifecycles must run in parallel so that interfaces connect and changes can be assessed and applied as the designs evolve.

In addition to the testing of the individual parts, designers should also be able to test the whole product to verify that it works in its intended environment. This includes ensuring that the integrated system provides for ongoing maintenance, servicing and upgrades.

One way to implement these features is to leverage PLM's inherent capabilities.

"PLM is best suited to take the finished designs from each design team's system of choice and marry them together in a single system of truth," says Lewis. "While engineering teams create, review and approve designs in ALM, CAD and EDA [electronic design automation] applications, these systems are not intended for use by the larger product teams outside of engineering.

"This is where PLM comes into play, to not only provide a single system to evaluate the entire design but also a single system that enables interaction via the cloud among internal teams—like quality control, procurement and manufacturing—and external design partners, suppliers and contract manufacturers," Lewis adds.

Additionally, problems that span hardware and software design need a unified PLM system that allows the evaluation of interoperability, identification of issues and updating of designs in ALM, CAD or EDA tools as ongoing changes are introduced throughout the product lifecycle.

The typical linkage between ALM and PLM occurs at points where firmware or software is married to the rest of the electrical and mechanical design in PLM. This holistic view is necessary to ensure interoperability of all designs and provide a complete multi-tiered assembly of parts that can be passed to the manufacturing teams, partners and enterprise resource planning systems to plan and produce the finished product in volume.

PLM providers contend that their platforms remove the complexity barrier of entry, making it easier for all teams and partners to view, review and collaborate regardless of the technical aptitudes of those using the system.

The other typical synergy between ALM and PLM occurs in bug tracking and requests for change. A system like PLM can provide a holistic view of these workflows, allowing appropriate individuals to see the issues or enhancements, especially in cases where they exist at the crossroads of software development and product development.

"Today, organizations spend as much as half their program schedules doing system integration," says Sampson. "A tight integration of the software development processes into the overall product lifecycle is required to survive the system integration experience." DE

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MORE INFO

- **Aras:** Aras.com
- **Arena Solutions:** ArenaSolutions.com
- **Jama Software:** JamaSoftware.com
- **PTC:** PTC.com
- **Siemens Digital Industries Software:** SW.Siemens.com

For more information on this topic, visit DigitalEngineering247.com.

A Perfectly Portable Pair: Lenovo P1, X1 ThinkPads

These latest P-series laptops provide a great combination of performance, portability and price.

BY DAVID COHN

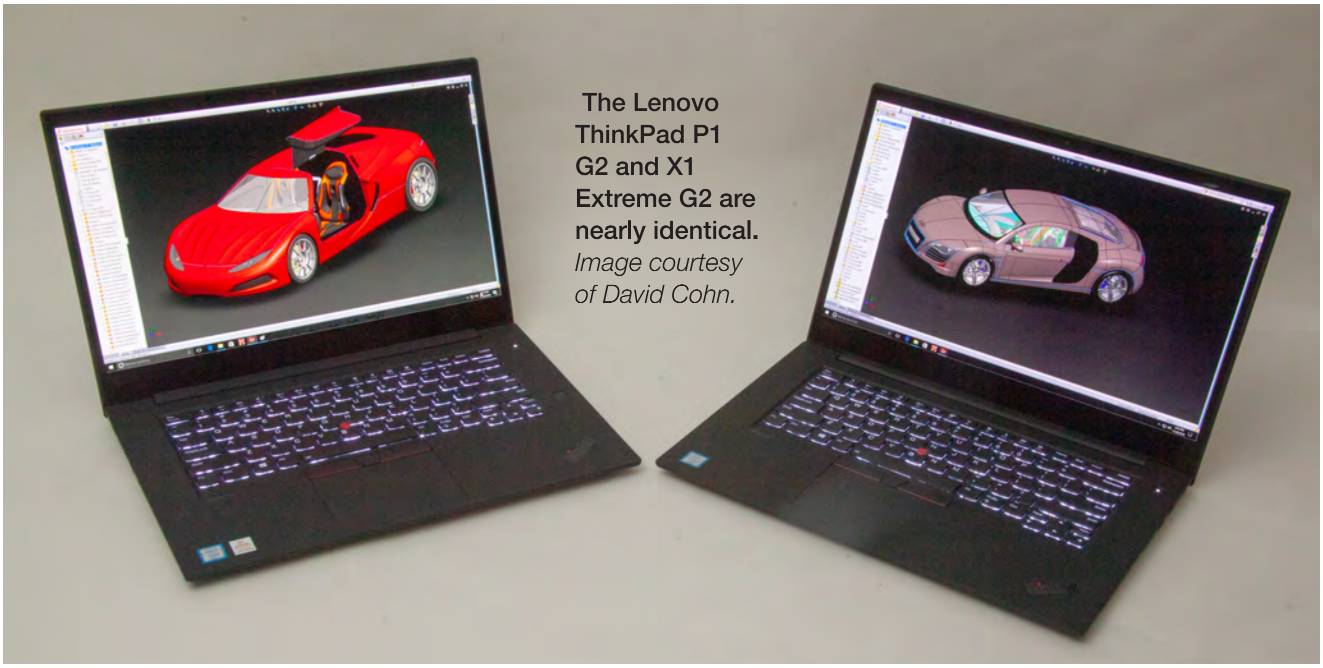
When we first reviewed the ThinkPad P1 (DE, March 2019; https://bit.ly/2W2JoMf), we deemed it to be the perfect combination of performance, portability and price. So, when Lenovo offered to send us the latest version of its powerful little mobile workstation, we jumped at the opportunity.

To sweeten the arrangement, in addition to the ThinkPad P1 G2, the company sent us the second generation of its ThinkPad X1 Extreme. Although not classified as a workstation (due to its consumer-grade graphics and lack of independent software vendor [ISV] certification), the X1 Extreme G2 would make for a fascinating comparison—particularly since both systems we received were equipped with discrete NVIDIA graphics processing units (GPUs) powering organic light-emitting diode displays.

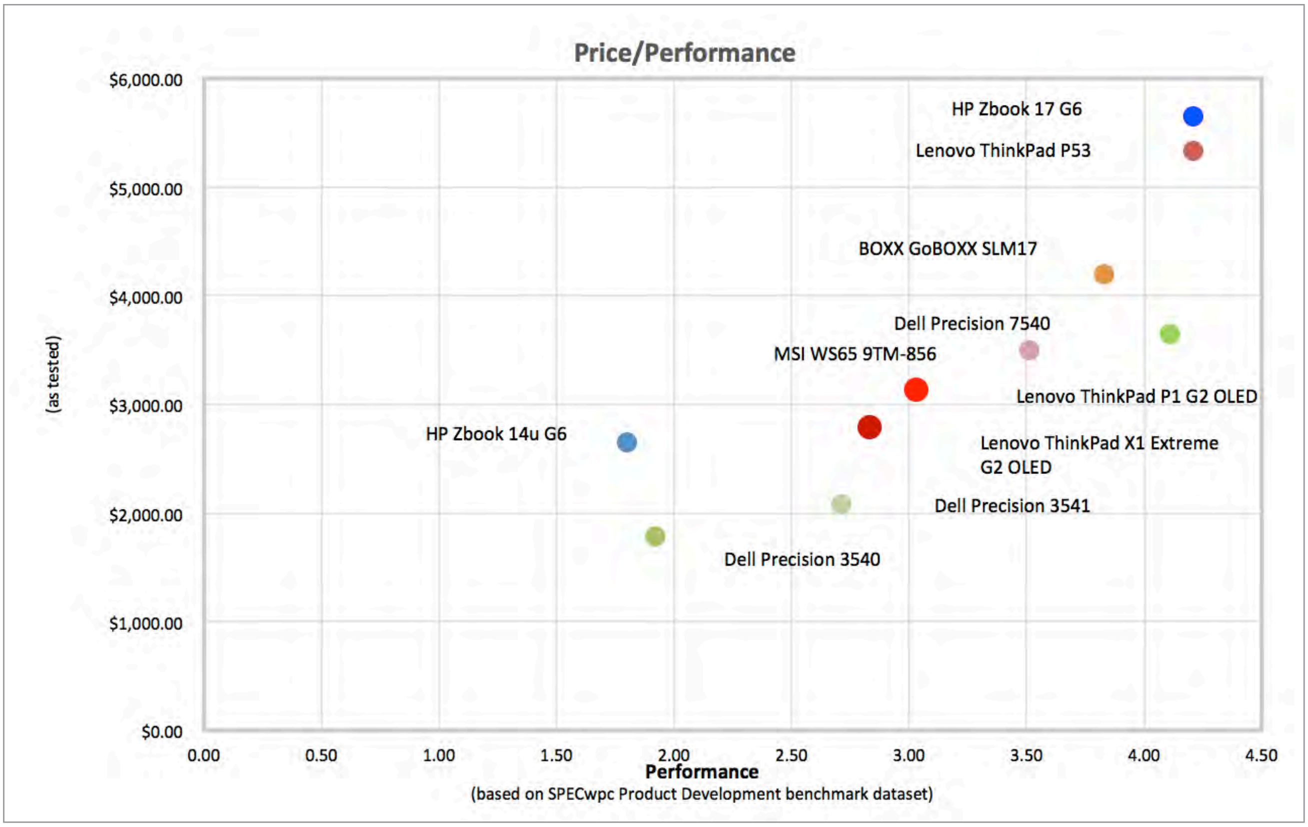
Based on their outward appearance, there is no discernible difference between the two computers other than an X1 model ID in addition to the ThinkPad logo with its glowing red dot over the "i."

Both come housed in a charcoal gray carbon fiber and magnesium alloy case with an updated carbon fiber weave that provides a subtle touch to the design. The systems measure 14.25x9.69x0.81-in. and weigh just 3.8 lbs., a few ounces less than the first-generation ThinkPad P1. Both also include identical 135-watt power supplies, which measure 4.9x3.0x0.9-in. and weigh a mere 0.9 lbs.

The ThinkPad P1 G2 base configuration has a start-



The Lenovo ThinkPad P1 G2 and X1 Extreme G2 are nearly identical. *Image courtesy of David Cohn.*



Price/Performance chart based on SPECwpc Product Development benchmark dataset.

ing price of $1,439 for a system with a 2.5GHz Intel Core i5-9400H quad-core processor, integrated Intel ultra high-definition (UHD) graphics, a full high-definition (1920x1080) in-plane switching anti-glare display with a rated brightness of 300 nits, 8GB of RAM, a 256GB PCIe solid-state drive (SSD), Wi-Fi and Windows 10 Home, backed by a one-year warranty.

The ThinkPad X1 Extreme G2 has a slightly higher starting price of $1,475 for a system with a 2.4GHz Intel Core i5-9300H quad-core processor and a discrete NVIDIA GeForce GTX 1650 GPU with 4GB of memory and 896 compute unified device architecture (CUDA) cores, but otherwise has the identical display, memory, storage, accessories, operating system and warranty.

But, of course, those are just the starting points.

Lots of Similarities

Raising the lid on either system reveals the same seamless spill-resistant keyboard with 84 mostly full-size keys as found on the original P1. Two levels of backlighting can be toggled by pressing the Fn key and spacebar. Although the systems lack a separate numeric keypad, the keyboard offers an excellent feel.

A round power button is located to the upper-right of the keyboard and a 4x2.75-in. touchpad with three buttons is centered below the spacebar. There is also the familiar red Lenovo pointing stick nestled between the G, H and B keys. The caps lock key has its own LED, as do the keys dedicated to the speakers, microphone and function lock. Both systems also include a fingerprint reader to the right of the keyboard.

A narrow bezel surrounds the display panel, yet still provides space above the panel for a 720p webcam, which now includes a privacy shutter. Lenovo offers a choice of four different display panels, including brighter (500 nits) full high-definition (1920x1080) and UHD (3840x2160) IPS anti-glare displays with Dolby Vision HDR.

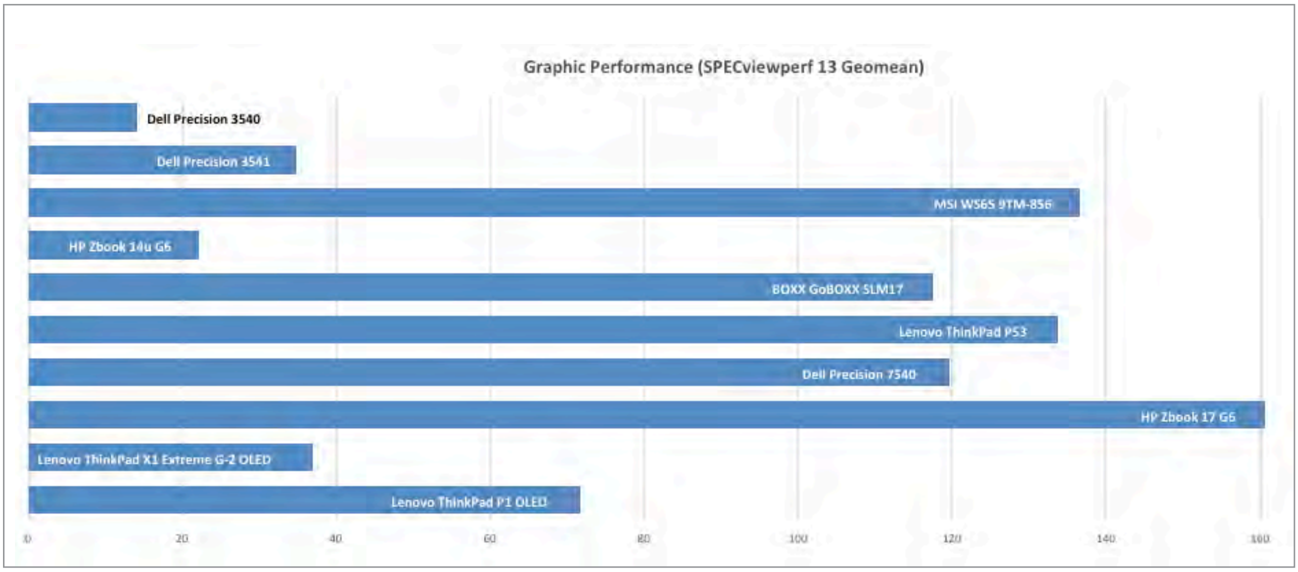
Both of the Lenovo ThinkPad systems we received came equipped with 15.6-in. ultra high-definition (UHD) OLED touchscreen displays with Dolby Vision HDR that were stunning, with more vibrant colors and deeper blacks than we've ever seen in a mobile workstation. The OLED panel adds $345 to the cost of the P1 while increasing the X1 Extreme's price by $380.

The similarities start to disappear, however, once you dive beneath the hood. On the ThinkPad X1 Extreme G2, Lenovo offers a choice of four additional CPUs, ranging from the same 2.5GHz Core i5-9400H in the base-model P1, to a 2.3GHz Core i9-9880H eight-core processor. Our evaluation unit came with an Intel Core i7-9850H, a six-core 2.6GHz Coffee Lake CPU (4.6GHz max turbo), which added $531 to the base price.

For the ThinkPad P1 G2, however, Lenovo also offers

Mobile Workstations Compared	Lenovo ThinkPad P1 G2 OLED 15.6.3-inch mobile workstation (2.80GHz Intel Xeon E-2276M 6-core CPU, NVIDIA Quadro T2000, 32GB RAM, 1TB NVMe PCIe SSD)	Lenovo ThinkPad X1 Extreme G2 OLED 15.6-inch mobile workstation (2.60GHz Intel Core i7-9850H 6-core CPU, NVIDIA GeForce GTX 1650, 32GB RAM, 1TGB NVMe PCIe SSD)	HP Zbook 17 G6 17.3-inch mobile workstation (2.40GHz Intel Xeon E-2286M 8-core CPU, NVIDIA Quadro RTX 5000, 32GB RAM, 512GBB NVMe PCIe SSD)	Dell Precision 7540 15.6-in. mobile workstation (2.40GHz Intel Core i9-9980H 8-core CPU, NVIDIA Quadro RTX 3000, 32GB RAM, 512GBB NVMe PCIe SSD)	Lenovo ThinkPad P53 15.6-in. mobile workstation (2.80GHz Intel Xeon E-2276M 6-core CPU, NVIDIA Quadro RTX 5000, 64GB RAM, 1TB NVMe PCIe SSD)	BOXX GoBOXX SLM17 17.0-in. mobile workstation (2.30GHz Intel Core i9-9880H 8-core CPU, NVIDIA Quadro RTX 3000, 32GB RAM, 512GB NVMe PCIe SSD)
Price as tested	$3,133.00	$2,794.00	$5,654.00	$3,646.00	$5,338.00	$4,200.00
Date tested	**2/16/20**	**2/16/20**	1/24/2019	10/25/2019	10/24/2019	10/23/2019
Operating System	Windows 10 Pro 64	Windows 10 Pro 64	Windows 10 Pro 64	Windows 10 Pro 64	Windows 10 Pro 64	Windows 10 Pro 64
SPECviewperf 13.0 (higher is better)						
3dsmax-06	76.32	85.73	185.09	155.08	181.47	148.65
catia-05	126.46	56.36	279.31	209.89	269.51	200.15
creo-02	101.20	75.12	243.95	187.29	255.96	185.52
energy-02	17.11	6.37	42.15	31.69	38.63	29.94
maya-05	102.12	100.62	272.88	183.66	261.90	187.67
medical-02	47.95	24.57	91.59	63.63	85.31	63.59
showcase-02	36.50	36.83	93.46	78.72	63.79	79.50
snx-03	191.81	11.29	361.04	217.45	223.64	218.39
sw-04	86.57	53.45	158.92	130.57	88.51	123.98
SPECapc SolidWorks 2015 (higher is better)						
Graphics Composite	2.81	n/a	5.24	4.27	5.47	5.03
Shaded Graphics Sub-Composite	1.41	n/a	3.23	2.55	3.53	3.01
Shaded w/Edges Graphics Sub-Composite	2.03	n/a	4.21	3.37	4.38	3.89
Shaded using RealView Sub-Composite	1.91	n/a	3.90	3.08	4.05	3.57
Shaded w/Edges using RealView Sub-Composite	2.60	n/a	4.54	3.83	4.73	4.35
Shaded using RealView and Shadows Sub-Composite	2.23	n/a	4.48	3.42	4.59	4.11
Shaded with Edges using RealView and Shadows Graphics Sub-Composite	2.76	n/a	4.85	3.92	4.71	4.56
Shaded using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	6.92	n/a	13.41	11.30	15.06	13.54
Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	7.79	n/a	13.20	11.13	14.58	13.35
Wireframe Graphics Sub-Composite	3.13	n/a	4.00	3.91	3.92	4.34
CPU Composite	3.19	n/a	3.06	3.76	5.32	5.33
SPEC Workstation v3 (higher is better)						
Media and Entertainment	1.63	1.70	1.87	1.88	2.07	1.98
Product Development	1.62	1.57	1.81	1.91	2.24	2.07
Life Sciences	1.54	1.31	1.94	1.67	1.77	1.99
Financial Services	1.53	1.17	1.96	1.75	1.69	2.16
Energy	0.99	0.99	1.32	1.36	1.37	1.32
General Operations	1.90	1.84	1.55	1.72	1.89	1.79
GPU Compute	1.79	1.84	3.34	3.20	3.31	3.09
Time						
AutoCAD Render Test (in seconds, lower is better)	49.00	44.10	35.40	34.80	49.20	45.90
Battery Life (in hours:minutes, higher is better)	7:14	6:45	4:45	7:51	5:30	8:37

Numbers in blue indicate best recorded results. Numbers in red indicate worst recorded results.



Graphic Performance chart based on SPECviewperf 13 Geomean.

a Xeon CPU. Our evaluation unit included an Intel Xeon E-2276M six-core 2.8GHz processor (4.7GHz max turbo). Xeon-based P1 systems have a starting price of $2,029, $590 more than the base-model with an Intel Core processor, but also include an NVIDIA Quadro T1000 discrete GPU with 4GB of memory and 768 CUDA cores.

Although the GeForce GTX 1650 is the only graphics card available in the X1 Extreme, P1 customers can choose the NVIDIA Quadro T2000, a GPU with the same 4GB of memory and same Turing graphics chip as the T1000, but with 1024 CUDA cores, yielding faster graphic performance.

Some Significant Differences

Although the P1 and X1 Extreme offer similar memory configurations, the cost and options vary. Both can accommodate a maximum 64GB of 2666Mhz RAM. For our evaluation, Lenovo equipped the ThinkPad X1 with 32GB, installed as a pair of 16GB DDR4 memory modules, an option that added $455. But for the Xeon-powered ThinkPad P1, we received 32GB of error-correcting code memory, which added $310.

The amount of onboard storage also differs between the two systems. In addition to the 256GB SSD in the base model X1, Lenovo offers just two other choices: a 512GB drive and the 1TB PCIe NVMe M.2 drive in our evaluation unit, a $591 option.

For the ThinkPad P1 G2, however, there is a choice of SSDs up to 2TB and the P1 can be equipped with up to two M.2 drives, for a total of 4TB of onboard storage. And the 1TB drive in the P1 we received added just $205 to the total cost.

In addition, by upgrading the display in the ThinkPad P1 to the UHD OLED display, the webcam was automatically upgraded to one that includes an infrared camera, adding $20.

Both the P1 and X1 Extreme provide identical ports. The left side includes the power input, a pair of USB Type-C Thunderbolt 3 ports, HDMI, a headphone/microphone combo audio jack and a special jack for an RJ45 Ethernet extension connector. This connector is $35 extra when included with the X1 Extreme but only $20 when ordered as part of the P1 configuration.

The right side provides a security lock slot, a pair of USB 3.1 Type-A ports (including one that is always on when the system is plugged in), a SD card reader and a slot for an optional SD card reader (a $20 option).

Both systems include an Intel Wi-Fi 6 AX200 adapter with Bluetooth and come with the same four-cell Li-Polymer 80Whr battery with Lenovo's Rapid Charge technology that can bring the system back up to 80% capacity in just an hour.

Battery life for the second-generation ThinkPad P1 was slightly improved—our evaluation unit lasted 7.25 hours on our battery run-down test. The ThinkPad X1 Extreme G2 fared a bit worse, shutting down after 6.75 hours. Both systems remained cool and nearly silent throughout our tests, even when under heavy compute loads.

Still Great Performance

We've come to expect Lenovo workstations to deliver excellent performance. Both systems matched or outperformed the first-generation P1 on most of our tests, delivering great results for a 15.6-in. thin, lightweight laptop.

On the SPECviewperf test, which focuses almost exclusively on graphic performance, the ThinkPad X1 Extreme G1 actually outperformed the ThinkPad P1 G2, often by a significant margin. Unfortunately, the X1's GeForce graphics card meant that we could not run the SPECapc SolidWorks benchmark, because the GPU does not support the SolidWorks RealView feature, which is an integral part of the test.

On the demanding SPEC workstation benchmark, the ThinkPad P1 outperformed the X1 Extreme, thanks to its faster CPU and more robust GPU. But the ThinkPad X1 Extreme G2 averaged 44.1 seconds to complete our multithreaded AutoCAD rendering test, compared to 49 seconds for the ThinkPad P1 G2.

Although both systems come with Windows 10 pre-installed, Windows 10 Professional in the P1 is included when you opt for a Xeon processor ($35 extra). On the X1, Windows 10 Pro is a $59 option.

Lenovo's standard warranty only covers the system for one year, with depot carry-in service. Additional coverage is available at the time of purchase that can extend the warranty for up to five years.

Our as-tested price includes an additional $109 to extend the warranty to three years. Other warranty options include onsite repairs, premier support, accidental damage protection and battery replacement warranties.

As a workstation, the Lenovo ThinkPad P1 G2 is ISV-certified for a wide range of applications from Autodesk, Dassault Systèmes, PTC and Siemens. It has also passed military certification tests and quality checks to ensure it can perform in extreme conditions. The ThinkPad X1 Extreme G2 does not include these certifications.

As tested, our Lenovo ThinkPad X1 Extreme G2 priced out at $2,794, while the ThinkPad P1 G2 we received totaled $3,133.

As you can see in our price/performance and graphic performance charts, the extra money yields improved performance and peace of mind of knowing that the P1 is guaranteed to run even your most demanding applications. Either way, however, these two second-generation ThinkPads deliver plenty of performance in an attractive, portable package. DE

David Cohn *is the senior content manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA and has been benchmarking PCs since 1984. He's a Contributing Editor to Digital Engineering and the author of more than a dozen books. You can contact him via email at david@dscohn.com or visit his website at www.dscohn.com.*

MORE INFO

- **Lenovo:** Lenovo.com

- **Lenovo ThinkPad P1 G2 OLED**

Price: $3,133 as tested ($1,439 base price)

CPU: Intel Xeon E-2276M 2.8GHz 6-core w/ 12MB cache

Memory: 32GB ECC DDR4 at 2666MHz

Graphics: NVIDIA Quadro T2000 w/4GB GDDR5 and 1024 CUDA cores

Camera: 720p with IR

- **Lenovo ThinkPad X1 Extreme G2 OLED**

Price: $2,792 as tested ($1,475 base price)

CPU: Intel Core i7-9850H 2.6GHz 6-core w/ 12MB cache

Memory: 32GB DDR4 at 2666MHz

Graphics: NVIDIA GeForce GTX 1650 w/4GB GDDR5 and 896 CUDA cores

Camera: 720p

- **Both systems share the following:**

Size: 14.25x9.69x0.81-in. (WxHxD) notebook

Weight: 3.82 lbs. (plus 0.84-lb. external 135-watt power supply)

Display: 15.6-in. UHD (3840x2160) OLED touchscreen w/Dolby Vision HDR

Hard Disk: 1TB SSD M.2 PCIe NVMe

Floppy: None

Optical: None

Audio: Built-in Dolby Atmos speakers, headphone/microphone jack, built-in microphone array

Network: Intel Wi-Fi 6 AX200 plus Bluetooth

Modem: None

Other: Two USB-A 3.1, one USB-C Thunderbolt 3 (with power delivery and DisplayPort), Ethernet extension connector, HDMI 2.0, SD card reader, fingerprint reader

Keyboard: 84-key spill-resistant backlit keyboard

Pointing device: Pointing stick and touchpad with three buttons

Standard warranty: One-year parts and labor (as-tested price includes three-year warranty)

For more information on this topic, visit DigitalEngineering247.com.

An Alternative to **AutoCAD**

CorelCAD 2020 continues to play catch-up.

BY DAVID COHN

Back in the day, Corel, a big-name software company in Canada was originally known for its flagship, best-selling product—CorelDRAW. More recently, the company acquired programs in markets such as design, illustration and photo and video editing. Earlier this year, the company released CorelCAD 2020, the ninth version of its 2D/3D CAD software.

CorelCAD is positioned as an affordable alternative to AutoCAD as well as a way to bring CAD tools to users of CorelDRAW. Based on the ARES CAD kernel from German developer Graebert—the same CAD engine that powers Graebert's own ARES Commander and Dassault Systèmes' DraftSight software—CorelCAD 2020 uses AutoCAD 2018 DWG as its own native file format. The software is available for Windows and Mac OS as well as mobile versions for Android and iOS devices. The latest edition features improvements to its 2D drawing and 3D modeling tools.

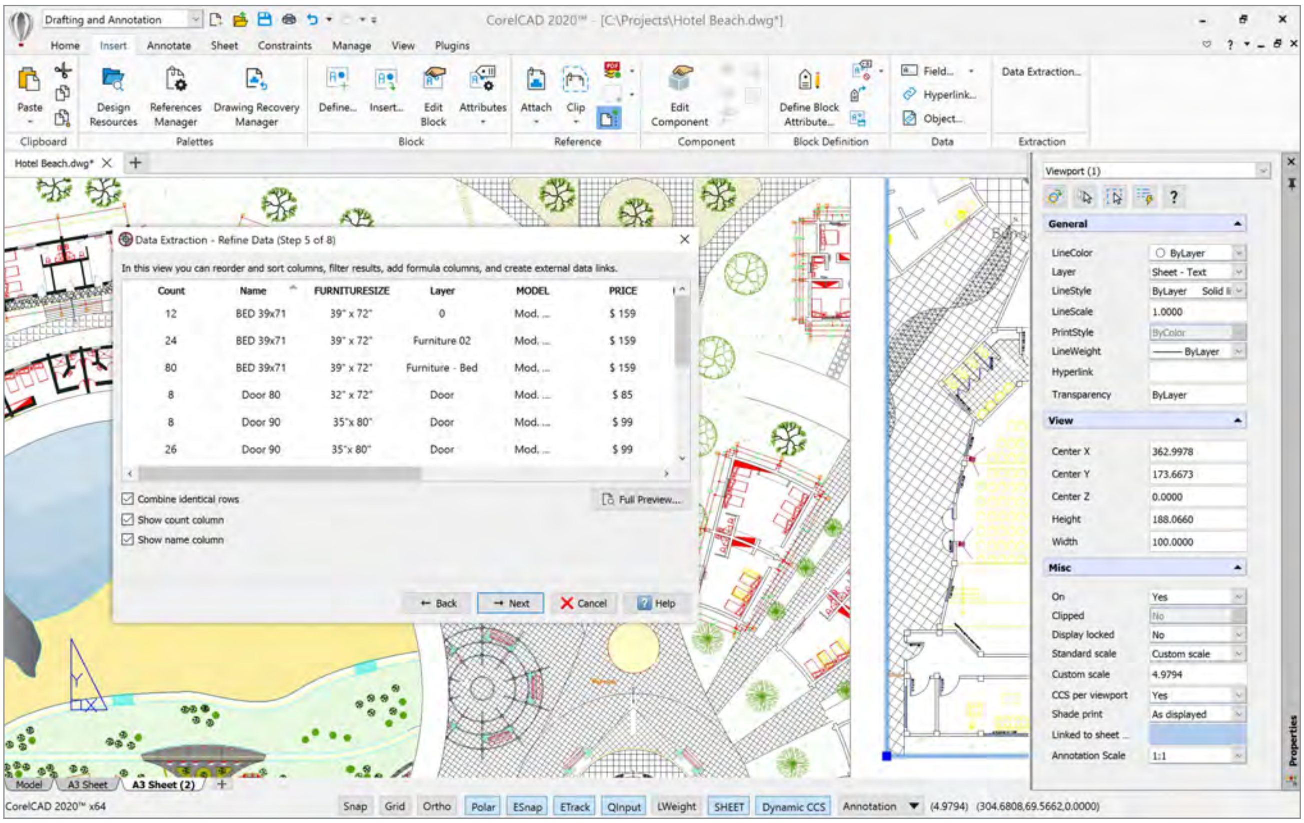


Fig. 1: CorelCAD 2020 users can extract attributes and object properties, displaying results as a table in the current drawing or saving data to an external file, but only in the Windows version.
Images courtesy of David Cohn.

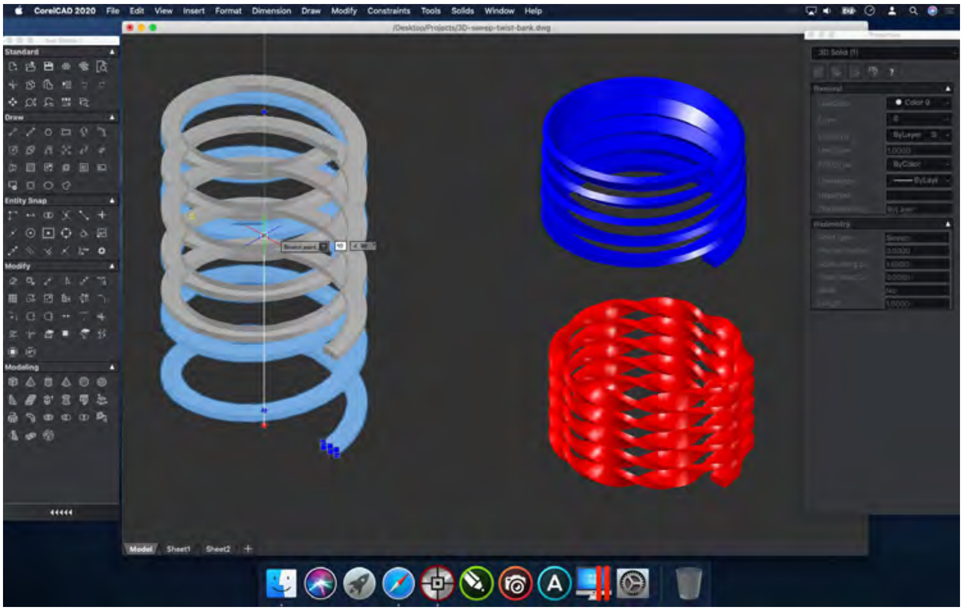


Fig. 2: 3D modeling enhancements in the Mac and Windows versions make it easy to create shapes that rotate along a specified sweep path.

Similar Look and Feel

When you first start CorelCAD, the program displays its "Classic" user interface, which includes pull-down menus and a host of toolbars with icon-only buttons docked around the perimeter of the screen, much like very old versions of AutoCAD. But as soon as you switch to the "Drafting and Annotation," "3D Modeling," or the new "CAD General" workspace, CorelCAD changes to a ribbon interface quite similar to modern AutoCAD versions. The new release also makes it easier to save your own custom workspaces.

Like AutoCAD, each drawing appears in its own window, identified by a file tab across the top of the drawing area. You can use the drawing file tabs to easily switch between drawings or start a new drawing and use tabs in the lower-left corner of the drawing window to switch between model space and multiple sheets—equivalent to paper space layouts in AutoCAD.

Other aspects of CorelCAD are remarkably similar to AutoCAD. For example, CorelCAD has a command window and you can start commands by typing, just like AutoCAD. Some commands have different names—such as PATTERN instead of ARRAY—but thanks to command shortcuts (like AutoCAD aliases), you can type the AutoCAD command name to start almost any CorelCAD command.

Playing Catch-up

Although CorelCAD 2020 still does not include every function found in AutoCAD, the list of missing features continues to shrink. For example, the new release adds a Lasso selection tool and the Layer Manager in CorelCAD now has a filter manager that enables users to reference layers together. Both are nearly identical to features that have existed in AutoCAD for many years.

When working in 3D, a new command in CorelCAD 2020 lets you create wireframe geometry from the edges of a specified 3D solid, surface, mesh or region. There is also another new command that offsets 2D entities from the boundary of a 3D solid or surface.

The Sweep command has been enhanced with the addition of a Bank option that lets you apply a consistent angle to a profile as it is swept along a path. Again, these features have long been available in AutoCAD. The rotate, copy and offset tools in CorelCAD have also been enhanced, essentially matching capabilities in AutoCAD.

CorelCAD 2020 also introduces a data extraction wizard that lets you extract attribute data from blocks and property data from entities. You can choose to display the results as a table within the current drawing or save the data to an external file. This long-awaited capability duplicates functionality that has been available in AutoCAD for more than 20 years. Like AutoCAD, however, the data extraction wizard is only available in the Windows version.

Missing in Action

After a briefing earlier this year, we were particularly excited to evaluate promised improvements in CorelCAD's custom block capabilities. Custom blocks, introduced in CorelCAD 2019, are similar to dynamic blocks in AutoCAD.

You create custom blocks in a special block editor environment where you draw geometry, add elements (such as grip points and custom properties) and "activities" to specify how the block changes when you manipulate grip points. Custom blocks in CorelCAD support capabilities very similar to those in AutoCAD, including the ability to define visibility states (so that a single block can have appearance variations) and the ability to control custom blocks using tables.

New in CorelCAD 2020 is a test mode that lets you try out changes you have made to a custom block before saving those changes. In AutoCAD, the block test mode opens within the block editor environment, while in CorelCAD, the block being tested actually opens in a separate drawing tab. Functionally, it is nearly identical to AutoCAD, but in CorelCAD it still feels a bit awkward.

In addition, when working in CorelCAD's block editor, the tools used to modify custom blocks are not as intuitive as those in AutoCAD, owing largely to user interface (UI) differences between the two programs. For example, AutoCAD provides a block editor contextual ribbon. Because CorelCAD lacks context-sensitive ribbons, the tools for editing custom blocks appear in a collection of icon-only toolbars. The UI lacks tools for entering and exiting the new test mode. Instead, you must type the commands.

The compatibility issues we noted last year still exist. In CorelCAD, if you open an AutoCAD drawing containing a dynamic block previously defined in AutoCAD, the block functions perfectly in CorelCAD. But if you open that AutoCAD dynamic block in CorelCAD's custom block editor and then save it, the block loses all dynamic functions, even if you made no changes to the block.

During our briefing, we were shown a new CorelCAD capability whereby you could convert an AutoCAD dynamic block into a CorelCAD custom block, which would then retain all of the original dynamic capabilities but would become a CorelCAD custom block. The command is even described in the CorelCAD help file. But when we attempted to use the CBConvert command, the program reported that it was an unrecognized command.

Other Enhancements and Unique Features

Other new features in CorelCAD 2020 include the ability to export PDF files that include layers, the ability to modify the shape of non-associative hatch objects and the ability to control the smoothness of STL files. In addition, CorelCAD has a unique feature that lets you create a new dimension style from an existing dimension that already has the desired style changes.

CorelCAD continues to provide good support for AutoLISP and ARX, and offers some capabilities not found in AutoCAD. For example, you can insert audio recordings into a drawing and then play them back later. Although AutoCAD does not support these Voice Notes, it has no problem opening drawings containing them.

The same is true for CorelCAD's custom blocks. If you define a custom block in CorelCAD and then open that drawing in AutoCAD, the custom block appears as a dumb block. But if you save the drawing and reopen the DWG file in CorelCAD, the custom block capabilities are once again present.

CorelCAD also supports other industry-standard formats, including SVG, ACIS and SAT, enabling users to import files from other CAD programs. You can also import CorelDRAW (CDR) and Corel DESIGNER (DES) files as model space objects and export CorelCAD files to both formats, but only in the Windows version.

At $699 for a perpetual license, CorelCAD is much less expensive than AutoCAD or even AutoCAD LT, which are only available by subscription. You can also upgrade from any previous version of CorelCAD for $199. If you prefer a subscription, however, Corel offers the Mac and Windows versions for $35 per month or $300 per year from the Apple and Windows app stores, respectively.

If you can live without the missing features, its low cost and AutoCAD similarities continue to make CorelCAD an attractive alternative for those on a budget. DE

David Cohn *is the senior content manager at 4D Technologies. He also does consulting and technical writing from his home in Bellingham, WA. He is a Contributing Editor to Digital Engineering and is the author of more than a dozen books. You can contact him via email at david@dscohn.com or visit his website at www.dscohn.com.*

→ MORE INFO

- **Corel:** Corel.com: CorelCAD 2020
- **Price:**
  Full version (includes 1-year mobile license) $699
  Upgrade (from any previous CorelCAD version)........ $199
  Subscription (via the Mac App Store or Microsoft Store): $35/month; $300/year
- **System Requirements**

Windows
OS: Windows 10, Windows 8, or Windows 7 (32-bit or 64-bit)
CPU: Intel Core 2 Duo or AMD Athlon x2 Dual-Core or higher
Memory: 2GB minimum (8GB or more recommended)
Disk Space: 500MB
GPU: 3D graphics accelerator with OpenGL v1.4 (OpenGL v3.2 or higher recommended)
Display: 1280x768 minimum (1920x1080 recommended)

Macintosh:
OS: Mac OS Sierra (10.13) or higher (incl. macOS Catalina (10.15))
CPU: Intel Core 2 Duo processor (or better)
Memory: 2GB minimum (8GB or more recommended)
Disk Space: 500MB
GPU: 3D graphics accelerator with OpenGL v1.4 (OpenGL v3.2 or higher recommended)
Display: 1280x768 minimum (1920x1080 recommended)

For more information on this topic, visit DigitalEngineering247.com.

EDITOR'S PICKS

Each week, DE's editors comb through dozens of new products to bring you the ones we think will help you do your job better, smarter and faster. Here are our most recent musings about the products that have really grabbed our attention.

Fast prep of files for powder bed fusion 3D printing

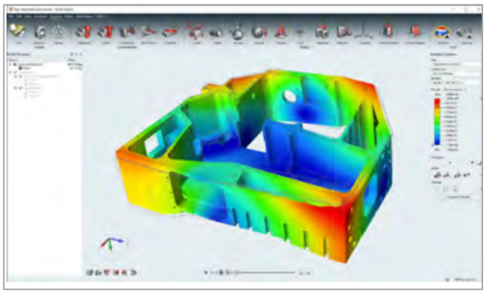
ESPRIT Additive for Powder Bed Fusion comes as an add-in to SolidWorks.

DP Technology introduces ESPRIT Additive for Powder Bed Fusion. This new application will support any file that can be opened in SolidWorks.

ESPRIT Additive for Powder Bed Fusion features "Part-to-Build" workflow, which streamlines the preparation of 3D files including the manufacturing information for 3D printing. In essence, this module is a "printer driver" for additive manufacturing. Multiple 3D CAD files can be combined into one build.
MORE → digitalengineering247.com/r/23947

Update adds solver for simulation-driven design

This includes SimSolid, Altair's software for analysis of complex assemblies.



Altair's update to Inspire is said to be intuitive and runs on standard laptops and workstations in use by designers and engineers; an upgrade to top graphics processing units is not required.

SimSolid joins two mature simulation tools: OptiStruct for topology optimization with generative design; and MotionSolve, for multibody dynamic motion simulation. Design changes can be made directly on models inside Inspire, without reverting to the original CAD system.
MORE → digitalengineering247.com/r/23928

Remote teamwork environment for engineering

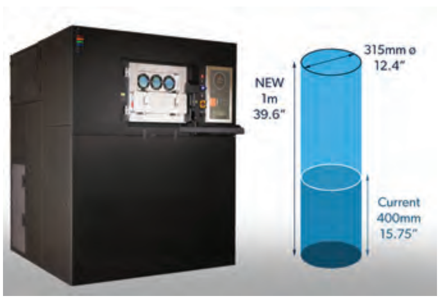
Telecollaboration system enables remote work and team work.

BETA CAE Systems introduces NEERE, an on-premise, web-based telecollaboration environment tailor-made for engineering.

BETA says NEERE is secure and enterprise-ready. It integrates tightly with the pre- and post-processing BETA applications ANSA, META and META VR. NEERE can be used for remote workstation access, allowing an engineer to connect to their workstation back at the office, providing access to BETA CAE applications. **MORE** → digitalengineering247.com/r/23910

Metal 3D printer with 1-meter-tall build chamber

The new Sapphire will be compatible with nickel-based alloys.



Velo3D introduces its Sapphire industrial 3D printer, featuring a 1-meter-tall build chamber. The Sapphire will be the largest closed-chamber printer that works with advanced metals. Target markets for the new printer include aerospace and oil/gas. Velo3D says other precision industries that require a tightly controlled, gas-regulated printing environment for large parts will also benefit.

The new Sapphire will be commercially available in late 2020.
MORE → digitalengineering247.com/r/23879

Student Competition Profile: Assistive Technology for At Home Living

Engineering Socially Relevant Solutions

BY JIM ROMEO

Miami University of Ohio's Center for Assistive Technology (MUCAT) focuses on identifying socially relevant problems and developing engineering solutions by engaging students and faculty across multiple divisions of the university.

The Miami University of Ohio's Center for Assistive Technology (MUCAT) aims to target socially relevant issues and generate beneficial engineering solutions by involving students and faculty from across the university. *Image courtesy of MUCAT.*

MUCAT conducts externally funded interdisciplinary research projects; engages students in socially relevant, experiential learning; and helps recruit female students to engineering majors. Each year they conduct an Assistive Technology for At Home Living competition.

Amit Shukla, professor at Miami University, is the interim chair of Mechanical and Manufacturing Engineering, and works with MUCAT and the College of Engineering and Computing. Professor Shukla along with James Chagdes, assistant professor, Department of Mechanical and Manufacturing Engineering, coordinated the event. We spoke to Professor Shukla to gain a better understanding of how this competition worked.

***Digital Engineering:* Can you provide an overview of the competition, how it came to be and the intent of the program?**

Professor Shukla: MUCAT is a cross-disciplinary scholarly research center to enable engineering solutions for socially relevant problems for improving quality of life by assisting the lives of older adults and people with disabilities.

The MUCAT Design Innovation Competition is a fast-paced, team-based design innovation challenge for students to identify quality-of-life issues, solve problems, develop prototypes and present entrepreneurial ideas to the broad community. This is an annual competition that started in spring 2017. Some funds are provided to each selected team for prototyping.

MUCAT works collaboratively with the university's Scripps Gerontology Center as well as the Center for Social Entrepreneurship in Miami [University of Ohio]'s Farmer School of Business.

***DE:* Who participates and how many participants are you expecting?**

Shukla: This competition is open to all undergraduate students at Miami University. Each year about 12 to 15 teams of four to five students participate in Phase 1. Some teams (usually four to five) are selected for Phase 2 and are provided seed funding.

***DE:* Do you have any demographics on participants?**

Shukla: Most of the participants have been undergraduate (sophomore and junior) students with over 45% participants being female engineering students.

***DE:* Can you tell us about some of the designs that are part of the event and how they came to be?**

Shukla: In 2017, the competitors designed an assistive lifting device for wheelchairs, a cerebral palsy hypertonia device, drones for detecting landmines and a market pricing app for Africa.

Then in 2018, the competitors redesigned an EpiPen, and designed a dialysis simulator, a brain-computer interface, a functional electrical stimulation device and a mobility system for the visually impaired.

In 2019, we saw the design of a smart cane, a virtual reality exposure therapy, a design of assistive robot and a redesign of an automatic life jacket

They are student-selected topics related to a problem definition in the area of the competition. Engineering design process is used in consultation with faculty mentors to design, develop and prototype the solutions.

DE: Does MUCAT have a stance on adopting an innovation that is linked to the program? What drove them to sponsor the event and coordinate it?

Shukla: While the competition is currently not externally sponsored, we are collaborating with CincyTech, a [public/private] seed fund and entrepreneurial advisory agency, which has graciously agreed to help with this competition.

CincyTech has provided several individuals who have been involved in startup companies to serve as judges of the design proposals for identifying the finalists as well as judges of the final projects in this competition.

In 2017 competitors designed an assistive lifting device for wheelchairs, a cerebral palsy hypertonia device, drones for detecting landmines and a market pricing app for Africa. *Image courtesy of MUCAT.*

DE: Is there anything else you'd like to tell us about the event that the above questions haven't given you the opportunity to express?

Shukla: This competition provides a unique opportunity to our students to explore their passions and truly solve problems in an interdisciplinary framework to enhance quality of life for others. DE

Jim Romeo *is a freelance writer based in Chesapeake, VA. Send e-mail about this article to de-editors@digitaleng.news.*

→ MORE INFO

- **Miami University Center for Assistive Technology:** MiamiOH.edu/cec/about/centers-institutes/mucat/index.html
- **CincyTech:** CincyTechUSA.com

Virginia Student Wins Aeronautics Competition

The American Institute of Aeronautics and Astronautics (AIAA) and Blue Origin have announced the winner of their Design/Build/Launch (DBL) competition.

Eleanor Sigrest, a senior enrolled in a dual program at Forest Park High School in Woodbridge, VA, and the Governor's School at Innovation Park in Manassas, VA, won the competition with her experiment, "Improving Fluid Management Through A Novel Microgravity Slosh Mitigation Technique," which will be the first AIAA-sponsored payload to go into flight.

"Ever since I can remember," Sigrest said, "I've looked at the stars and known I want to go to space. I want to be the first person on Mars. Through research, I feel I better my personal knowledge and contribute to a community, all sharing the same goal of exploring beyond our Earth and developing the technologies necessary to get to Mars – technologies that will also benefit all humankind."

Student Eleanor Sigrest won the DBL competition. Her experimental payload will be launched on Blue Origin's New Shepard rocket. *Image courtesy of AIAA.*

The DBL competition is open to high school students and designed to promote student engagement in microgravity and/or space technology research. Each entrant designs an experimental payload to be launched on Blue Origin's New Shepard rocket, and describes outreach plans to engage the public with the "promise and excitement of space."

For winning the DBL competition, Sigrest will receive a $1,000 grant to prepare her work to fly on a future New Shepard flight. She will report on the results of her experiment at 2021 ASCEND, AIAA's event dedicated to the space ecosystem. DE