December 2020

# DE247 Digital Engineering



# Technology Outlook

## 2021

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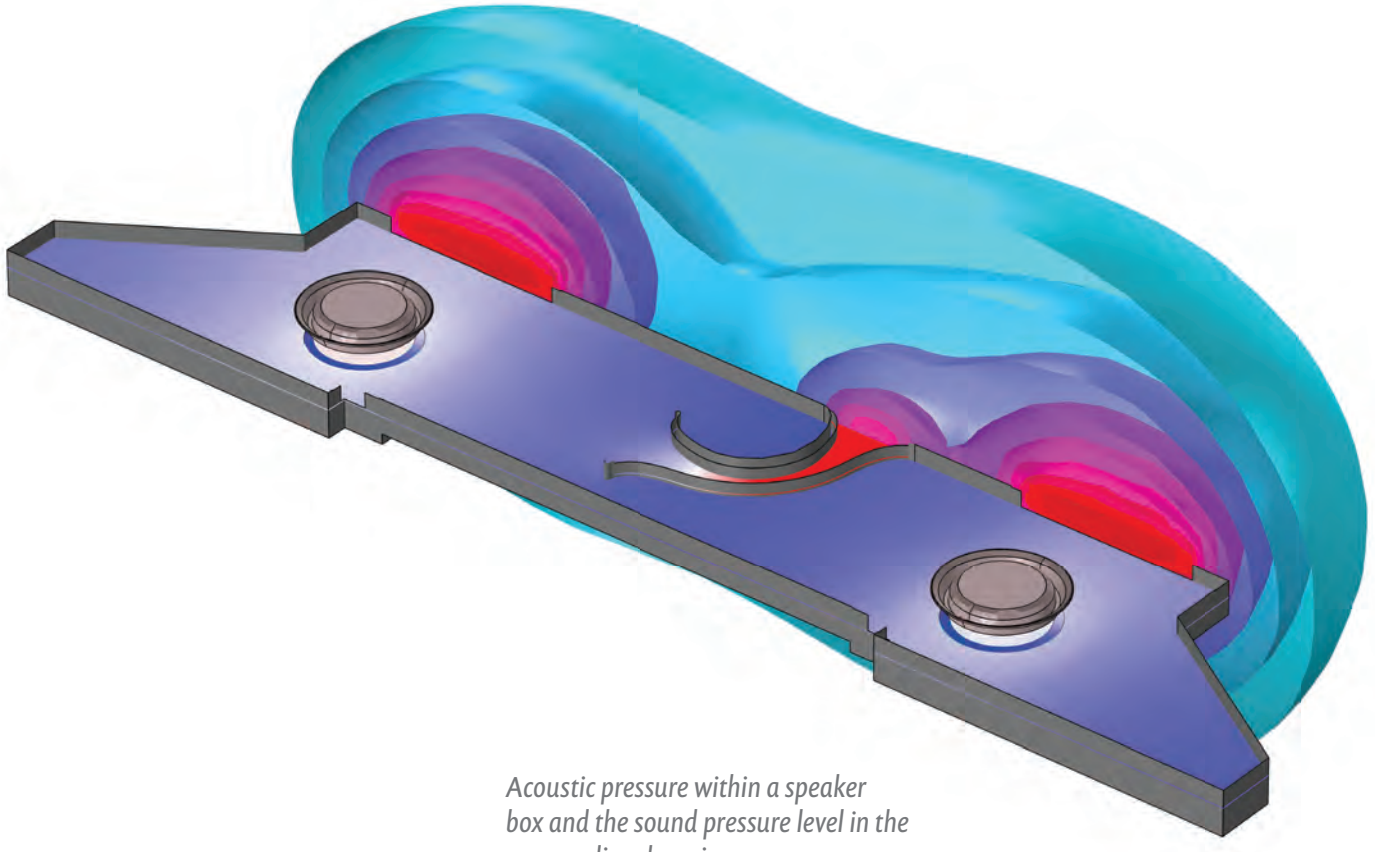
# *Simulation + testing = optimized loudspeaker designs*



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By Brian Albright

# A Year Like No Other

When I joined *Digital Engineering* in July 2019, I could never have predicted the roller coaster of a year that was ahead of me in 2020. As my first full year here closes, I can safely say that this has been the most unpredictable, exciting, grueling, and often disorienting start to any job I have ever had—and I once spent two years working in a parole office.

As I write this, the U.S. and other countries around the globe may be poised to institute an additional round of stay-at-home orders of varying degrees of severity, meaning that remote work (and for many, online school for their children) may continue well into 2021. Election Day in the U.S. has stretched into an Election Week of very slow vote counting. The uncertainty that arrived with COVID-19 in the spring does not appear to be going anywhere.

Despite this, the engineering technology sector has continued to innovate and generally thrive. We saw 3D printer companies rise to the occasion when there was a critical shortage of health care equipment earlier this year, and design and simulation software vendors quickly adapted to help their own customers remain productive while working from home.

Initially, the pandemic threw a monkey wrench into the product launch plans for many companies in the digital engineering space. Since the summer, though, we have seen rapid advancements across the product sectors we cover.

On the workstation and high-performance computing front, NVIDIA launched a powerful new GPU (the A6000), while rival AMD announced new GPUs and a potentially game-changing 64-core CPU. New mobile workstation launches from Dell, Lenovo, MSI and others have provided additional compute power for engineers working at home.

While the 3D printing space has been hard hit in terms of sales, we are still seeing interesting new product launches, as well as new management and quality control capabilities. In addition, additive manufacturing companies are working with software vendors to take advantage of generative design innovations, topology optimization and GPU-accelerated workflows.

In the CAD world, Autodesk has essentially called a truce with the Open Design Alliance, and cloud-based CAD tools continue to improve. Ansys, Dassault, Siemens, COMSOL and other major simulation players announced important new software tools and features in 2020.

**I am confident that our readers and the technology companies that provide the tools they need to do their jobs will continue to innovate.**

In this issue, our staff explores some innovative trends across these markets, including the use of digital twins, GPU acceleration and expanding simulation use cases. We have also included the results of our annual Technology Outlook reader survey, which provides a glimpse into what our engineering audience has planned for the coming year.

While everything feels like it is up in the air right now, I am optimistic about the future of the digital engineering market. I do not know yet when we might get to meet in person at a live trade show, or what the economy is going to look like next year, or when my children might go back to school, or even who the President of the United States is going to be. But I am confident that our readers and the technology companies that provide the tools they need to do their jobs will continue to innovate. DE

**Brian Albright**, Editorial Director
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DE247 Digital Engineering

TECHNOLOGY FOR OPTIMAL ENGINEERING DESIGN

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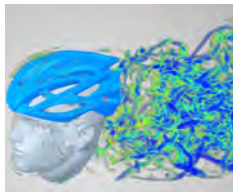
INSIDE



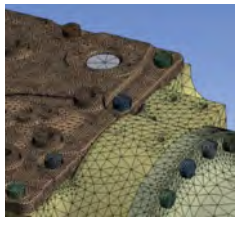















## PROTOTYPE AND MANUFACTURE



## REVIEW



## DEPARTMENTS



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# Massive Outsourcing Growth

During **2020-2024**, the global engineering services **outsourcing** market size is poised to grow by

**$207.85 BILLION USD**

progressing at a **CAGR** of almost

**23%**

throughout the forecast period

The year-over-year **growth** rate for 2020 is estimated at **21.57%**

The market is **fragmented** with several players occupying the market share

**41%** of the **growth** will originate from North America

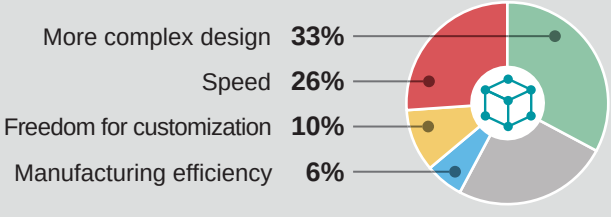
One of the key drivers for this market will be **cost savings** from lower labor wages

*SOURCE: Technavio*

## Simulation Software Growth

By **2025**, the **global market** for simulation software is expected to reach **$16.7 BILLION** and experience a **CAGR** of **9.33%**

*SOURCE: Transparency Market Research*




## Benefits of 3D Printing

When asked to identify the most significant benefit of 3D printing, respondents to a recent Stratasys survey cited **design freedom** as the top benefit, followed by **speed**.

*Source: Looking Forward: Additive Manufacturing in 2020, Stratasys*

## Reducing Wasted Time

Q: How important is it to **reduce time** related to each of the following activities? (Percentage who said "somewhat important" or "very important").

| | |
|---|---|
| **83%** | Accessing the correct design data |
| **82%** | Locating the correct design data |
| **73%** | Unproductive meetings |
| **72%** | Work loss due to crashes and data loss |
| **71%** | Technology maintenance |

*Source: State of Product Development & Hardware Design 2020, OnShape*

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# A LOOK AHEAD

*DE* readers provide an update on their use of engineering technologies.

**BY BRIAN ALBRIGHT**

This has been a very strange year for everyone in just about every market segment, so we here at *Digital Engineering* were curious what the results of our annual Technology Outlook Survey would look like compared to 2019, especially as we conducted it in October—eight months into a global pandemic that had caused widespread economic turmoil, and a month away from a U.S. presidential election that was generating quite a bit of uncertainty in many markets.

The good news is that engineers are holding steady in their embrace of new technologies. We saw a few changes, such as collaboration being cited as more of a challenge, and a drop in adoption of some of the more leading edge technologies we cover. That was to be expected. However, overall there were no dramatic drops in interest in emerging technologies. When you look at the overall health of the vendors in this space, we have continued to see growth and innovation as well. There has been continued demand for design and simulation technologies despite economic upheaval, and even with winter approaching, things do not appear to be slowing down.

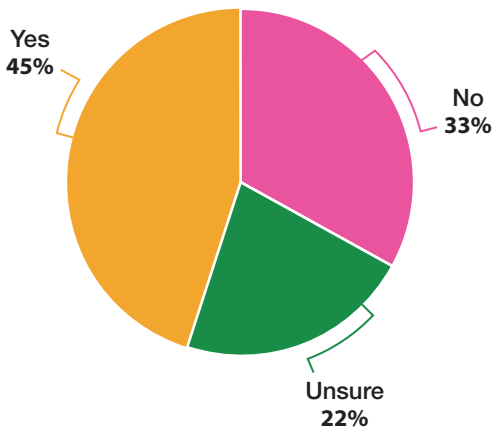
As we did last year, we asked *Digital Engineering*'s audience for their perspectives on the current and future technologies that are shaping design engineering work, along with the products and systems that they are designing.

We received responses from approximately 300 readers. The largest group of respondents described their primary role as product or system design engineering (26%), followed by research & development (14%), corporate management (11%), consultant/engineering service provider (11%) and engineering management (10%). Respondents were fairly evenly spread among market sectors, with most respondents hailing from the industrial machinery/products, electronic products & equipment, aerospace/aviation/defense, consumer products and automotive markets.

## Working Together

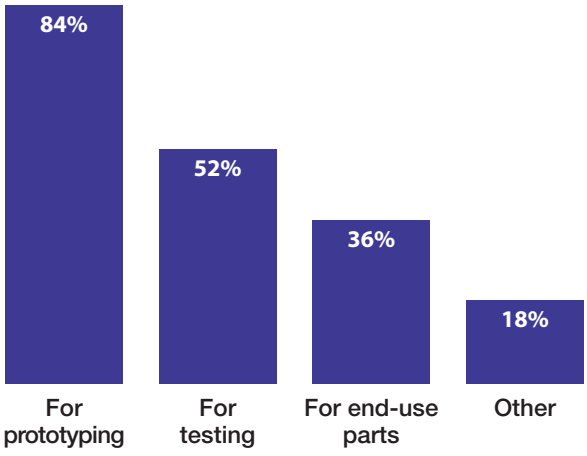
For the past three years of this survey, collaboration has been listed as an extremely/somewhat important challenge in the day-to-day work of design engineers. That has become even more apparent in the current climate, with a global pandemic forcing remote work upon engineers who previously worked in close quarters with colleagues and were able to travel to customer locations. Collaboration was listed as the top challenge again being cited as a very or somewhat important challenge by 91% of respondents (up from 87% last year). The second most common challenges were short product development deadlines, inefficient workflows and lack of adequate budget, which tied at 86%. Lack of training came in third at 81% (up from 79%) and regulatory compliance at 80% (up from 74% last year).

## Do you know what a "digital twin" is?



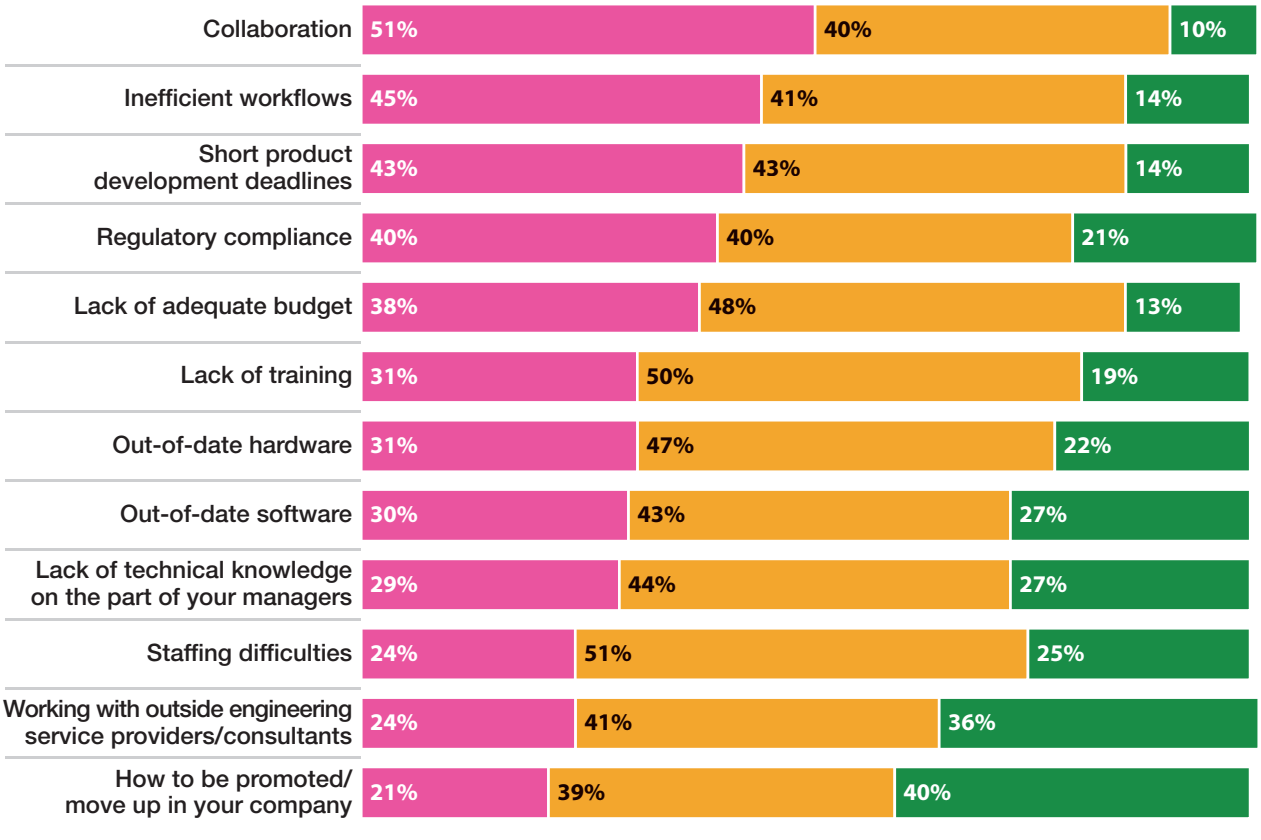

*Source: Peerless Research Group*

## How are you using Additive Manufacturing/3D Printing?



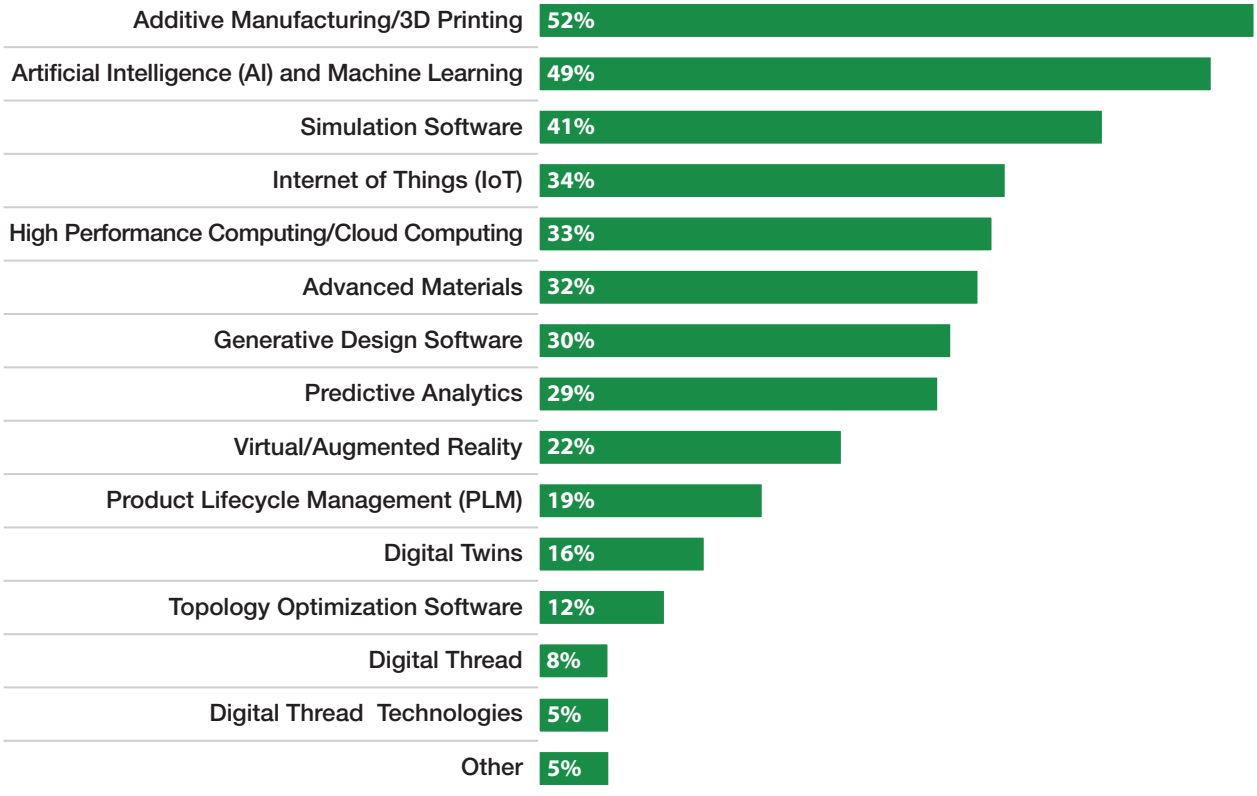

*Source: Peerless Research Group*

## How important are each of the following challenges in your day-to-day work?




*Source: Peerless Research Group*

Which technologies do you think will have the biggest impact on product design and development over the next 5 years?




*Source: Peerless Research Group*

## Additive Manufacturing Still Viewed Positively

When asked what technologies they thought would have the biggest impact on product design and development over the next five years, respondents cited additive manufacturing/3D printing at 52% as the top innovation. Artificial intelligence (AI) and machine learning came in second at 49%. Both of these technologies took the top spots the past two years (although they have switched positions each year). 3D printing received a significant amount of good press this year via companies leveraging the technology to address short-term supply chain disruptions.

Simulation software came in third once again (41%), followed by the Internet of Things (IoT) (34%), HPC/cloud computing (33%), advanced materials (32%) and generative design software (30%).

Virtual/augmented reality dropped from 32% last year to just 22% of respondents this year. This was also not surprising given the instability of that particular segment, with several companies being acquired or filing for bankruptcy and the lack of adoption outside of the gaming sector.

## Simulation on Top of the Technology Toolbox

We also asked readers what technologies they were currently using or developing products for, as well as which technologies they expected to adopt or develop in the next two years. As was the case last year, simulation software held steady as the technology that readers were most likely currently using/developing products for, with 57% of respondents reporting that they were doing so (up from 54% last year). Additive manufacturing/3D printing was second at 44% (up from 39%). Those were followed by PLM (34%), IoT (31%) and a tie between HPC/cloud computing and advanced materials at 27%.

Looking ahead, 28% of respondents planned to incorporate AI/machine learning within the next two years. Generative design came in second in terms of future plans at 26%, followed by HPC/cloud computing (24%), additive manufacturing/3D printing (23%) and advanced materials and virtual/augmented reality (both at 22%).

Additive manufacturing/3D printing still remains primarily a prototyping tool for 84% of recurrent users (pretty much identical to our findings the past two years). Testing dropped from 57% to 52% of users this year, as did end-use

parts applications (falling from 39% to 36%). The additive sector was hit hard over the past year as pandemic-related shutdowns put a damper on new pilot programs and equipment purchases.

Cost justification for additive manufacturing implementations closely mirrored last year's results, with 65% of current users citing shortening product development schedules as extremely/very important, followed by reducing/controlling costs (52%) and manufacturing designs that were not feasible with traditional manufacturing (42%). Improving collaboration was also cited as an extremely/very important benefit by 36% of respondents.

## Automated Design Technologies

Incorporation of artificial intelligence and generative design technologies is still relatively low in the engineering space, with just 15% of respondents currently using generative and 16% using AI/machine learning. Adoption plans have also slowed a bit (perhaps because of the economic downturn), with just 26% planning to utilize generative design (on par with last year's figures) and 28% planning to implement AI (down from 32% last year).

Impressions of AI and machine learning varied, with some respondents seeing great potential and others remaining unconvinced. Some respondents indicated that the use of AI could provide new ways to evaluate designs.

As one respondent noted: "I feel that AI is overhyped. It has a place, but like most technologies, AI is only going to be as good as the input data. If your problem falls within the bounds of the training data, it can give good results. But if you get too close to the edges or even outside of the training data, it can give misleading or incorrect outputs. So it is another tool that needs to be understood and have its limitations known ahead of time."

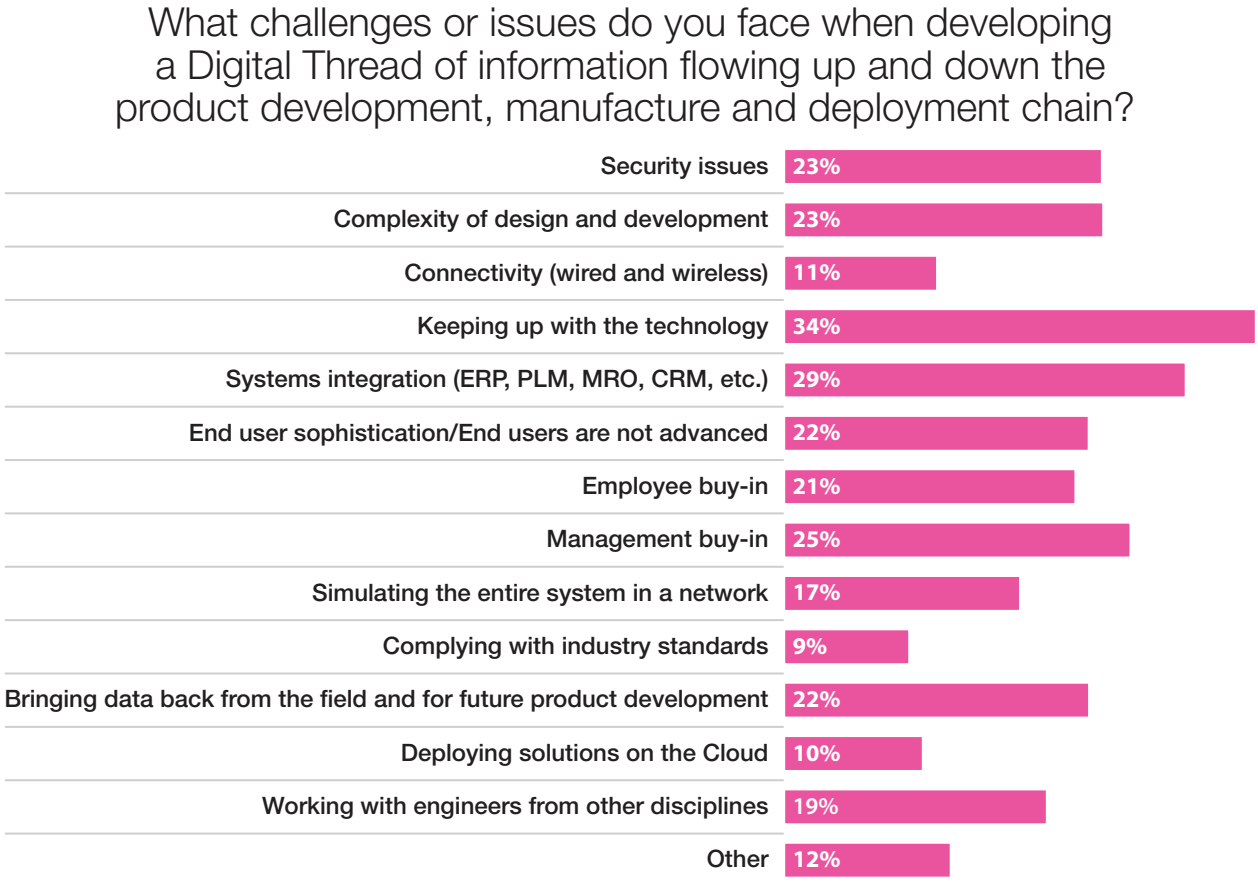
Generative design users are generally satisfied with its performance, with more than half (52%) saying they were extremely/very satisfied with its ability to help discover new designs, and 40% satisfied with the software's ability to help foster innovation in product development. Weight reduction was also an important benefit with 48% reporting they were extremely/very satisfied with results. On the negative side, 32% were not very satisfied or not satisfied at all with the software's ability to reduce or control manufacturing unit costs.

Asked their impressions of generative design software, respondents seemed to think it could provide new efficiencies and the ability to simultaneously generate multiple CAD-ready options, and that it could shorten the path to market and optimize costs for deployment.

One respondent indicated it had great potential to streamline designs, but that it was "difficult to get good designs as slight misunderstandings of boundary conditions result in very poor structures." Others believed the technology was too intertwined with 3D printing to be useful in their applications.

"The idea is neat, especially when paired with 3D printing to create all of the strange resulting shapes. But for products that are currently built from extruded tubes, rolled sheets, etc., it will be hard to make generated alternatives cost competitive. They will find a niche where weight is a major consideration," said one respondent.

Another high-profile but low-adoption technology was the digital twin, which has been implemented by just 9% of respondents, while 19% plan to deploy. According to the data, 33% of respondents do not know what a digital twin is, and 22% were unsure what it was.




*Source: Peerless Research Group*

## The Revolution Will be Simulated

While respondents last year were slightly less bullish on 3D printings ability to revolutionize the design engineer process, the technology improved its score with 61% strongly agreeing (compared to 59% last year). Simulation-led design also improved from 51% to 53% this year.

More than a third (38%) strongly agreed that the democratization of high-performance computing would revolutionize design, followed by big data/analytics and generative design.

"Additive manufacturing is the foundation of the 21st century industrial revolution," one respondent wrote. "Additive manufacturing will plug and play in generic assembly lines. The print is where the parts are made. The generic JIT assembly line will create products on demand near to the location where they will be used. Generic manufacturing depots will have 3D printing and JIT assembly and be able to print and assemble on demand. This will revolutionize supply chains in the future as optimal supply chain networks emerge with a renewed idea of channel assembly. Our supply chain networks will be modularized and hyper-modularization will follow on after 3D printing and JIT assembly nodes start to come into focus."

Familiarity with emerging technologies remains a hurdle for adoption, with just 9% indicating they were very familiar with digital twins (and 29% saying they were somewhat familiar). Just 12% of respondents were very familiar with generative design software. Compare that to simulation software (43% very familiar, 42% somewhat familiar), additive manufacturing (39% and 41%), PLM (32% and 41%), and the IoT (26% and 47%).

More than 30% of respondents claimed to not be familiar at all with digital thread or digital twin technology, and nearly a quarter were not familiar with topology optimization.

The vendors in all of these sectors still appear to have a lot of work ahead of them in educating the marketplace about these products, and how to effectively use them. DE

**Brian Albright** *is editorial director of Digital Engineering based in Cleveland, OH. Send e-mail about this article to de-editors@digitaleng.news.*

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SUPERMICRO

# Democratizing Simulation:
## Job Well Done or Unfinished Task?

Designer-friendly tools are on the rise, but some make the establishment uneasy.

**BY KENNETH WONG**

Vendors' attempts to broaden the use of simulation go all the way back to the 1990s, according to Keith Meintjes, executive consultant for Simulation, CIMdata.

"They were going to revolutionize engineering by giving embedded simulation," he recalls. "The vision was to bring simulation to the design floor. That was the promise."

In 1995, PTC, the company credited with advancing parametric modeling, acquired the leading simulation software MECHANICA from Rasna Corp. Later, the product was rebranded Pro/MECHANICA to be in line with PTC's flagship product Pro/ENGINEER.

Pro/ENGINEER has gone through several incarnations, evolving into what is now called PTC Creo Parametric. The efforts to broaden simulation's outreach—often referred to as democratizing simulation—also gave birth to a number of distinctly different approaches:

- embedding simulation tools in the designers' CAD packages;
- allowing experts to publish guided templates for novices and intermediate users;
- delivering repeatable, simplified simulation scenarios as on-demand apps; and
- providing computing platforms that integrate data management, geometry manipulation and on-demand (cloud computing) resources.

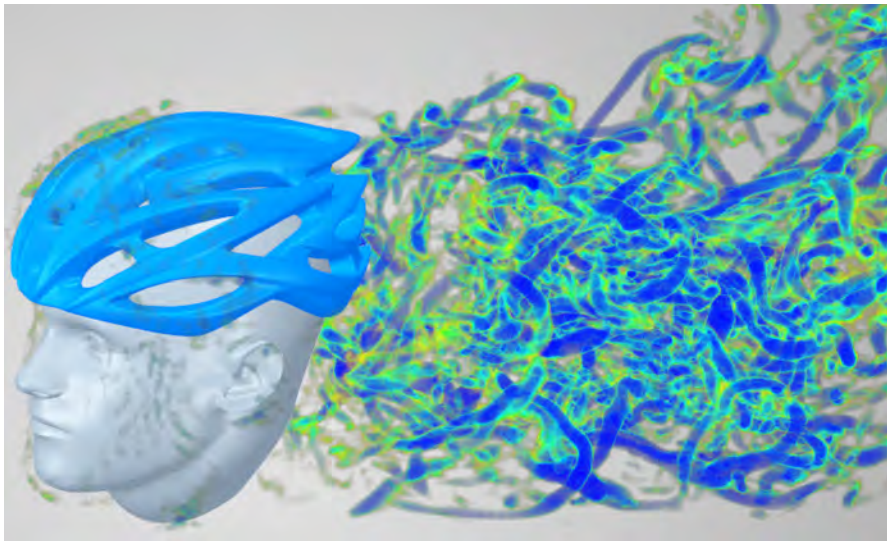
Twenty-five years later, have vendors' efforts paid off? Has the promise been fulfilled? Much has been accomplished, but much, too, is left undone.

### Know Your Audience

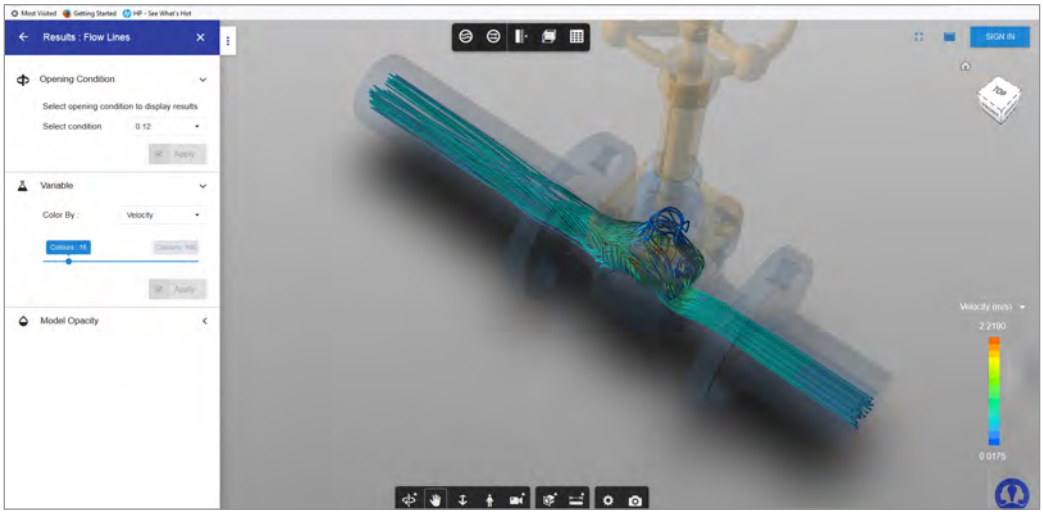
One of the stumbling blocks during the early phase was the nature of the target users, Keith recalls.

"CAD designers were software specialists who knew how to draw lines and arcs, create fillets and build geometry, but they were not all engineers. So they really weren't qualified to tackle engineering problems," he explains.

For better or worse, computer-aided design (CAD) software, enables people with little or no engineering knowledge to create complex parts and assemblies in 3D based on well-defined specs. Though the software was intended for engineers and architects, it came to be used by CAD specialist operators, whose skills were largely confined to software usage, and who were not necessarily engineers. For such CAD users, mastering simulation principles and incor-



**Ansys released Discovery Live, a GPU-accelerated simulation program offering near-instant feedback.** *Image courtesy of Ansys.*




**New startup simulationHub offers browser-based simulation under subscription licensing, eliminating the user's need to invest in dedicated hardware.** *Image courtesy of simulationHub.*

porating them into their design practice is a daunting task.

"The person using the simulation tools needs to understand the engineering problem that is being addressed," Meintjes warns.

Another issue was the way simulation was presented to the novice, non-expert users.

"The simulation embedded in the CAD programs were not the same ones used by the simulation experts," Meintjes points out. "So the experts weren't able to mentor the beginners."

Today, mainstream CAD programs such as Autodesk Fusion, Dassault Systèmes SolidWorks, and Siemens' Solid Edge all offer integrated simulation tools accessible from within the CAD modeling environment.

"These are not dumbed-down versions of the high-end tools. They are easier to use because of the simpler UI but the available physics are just as robust," Meintjes remarks.

They serve as stepping stones toward the expert-targeted simulation tools. This allows experts to mentor designers whose primary responsibility is CAD: geometry and manufacturability.

## Real-Time Simulation

Two years ago, Ansys launched Ansys Discovery Live, billed as "real-time simulation for rapid product exploration." The product came online with structural analysis, internal fluid analysis, lightweighting, thermal analysis, external fluid analysis and model analysis. For a company known for expert-level simulation programs, this was a dramatic departure and a new strategy.

Along with the product launch, Ansys also announced a partnership with PTC at the PTC-hosted LiveWorx18 user gathering, to offer real-time simulation to PTC Creo users.

"The combined solution will be sold by PTC as part of the Creo product suite. The solution will offer customers a unified modeling and simulation environment," wrote PTC in the press release.

Traditional simulation is a compute-intensive process. After setting up the problem and pressing the "run" command, many users would step away to make coffee or eat lunch, knowing the program takes anywhere from 15 minutes to a couple of hours to complete the process. By contrast, Ansys Discovery Live takes advantage of the GPU's processing cores, along with automation and approximation methods, to offer near-instantaneous results, making simulation as fast as geometry modeling.

Critics warn such programs are imprecise and less reliable than expert-level tools. But those championing a broader use of simulation argue the tool is meant as a first-stage design exploration tool to test out ideas and concepts, thus acceptable.

"These tools offer you guidance as you develop the design," said Meintjes. "If you are still far away from your final answer, accuracy doesn't matter that much. You just need a tool that shows you A is better than B. But you should not omit the final validation step," cautions Meintjes.

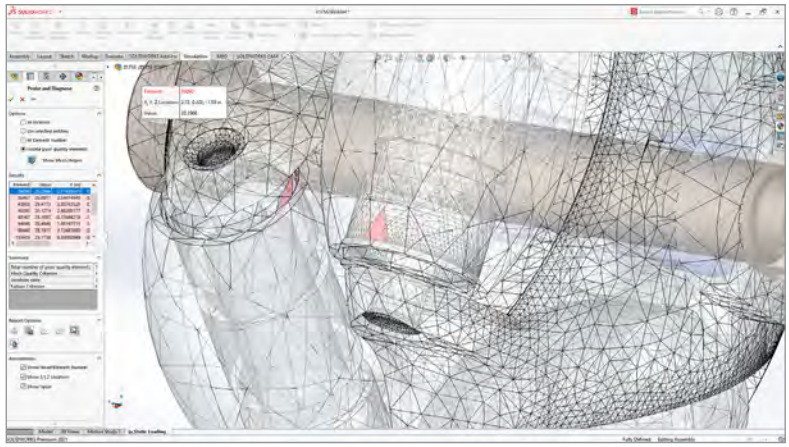
The final validation is usually done with a mixture of digital prototypes in high-end specialist tools and physical testing.

## Expert Guidance

Expert-authored temples are parts of simulation software such as COMSOL. In COMSOL Multiphysics 5.0, released in 2014, the company introduced the Application Builder, a feature allowing users to publish guided workflows for novices and nonexperts.

"Apps are built by experts who include only the parameters relevant to the design of a specific device or process. The apps then make the simulation engineer's expertise available to everyone involved in the design and manufacturing processes across all engineering disciplines in the organization," the company writes on the product's homepage.

Mastering domain-specific simulation (for example, simulating the mechanics of an aircraft landing gear or the thermal behaviors of combustion engines) takes years. Mastering the domains-specific software tools to digitally recreate these scenarios is also a multi-year process. This is arguably an un-



**CAD packages like SOLIDWORKS now integrate automatic meshing and simulation features.** *Image courtesy of Dassault Systèmes.*

fair burden to put on a design engineer.

"These expert tools and templates take a particular component that needs to be designed—be it a chassis or a suspension mechanism—and reduce it to a series of requirements: tensile strength has to be this much, this much bending and stiffness is acceptable, it has to be this strong and so on," Meintjes explains.

Expert-authored apps are one way to bypass simulation's steep learning curve. With this approach, engineering firms with a finite number of simulation experts can publish and distribute templates or apps for design engineers with limited simulation expertise.

However, for some simulation experts who have invested years in training and field knowledge, simulation democratization is a double-edged sword that cuts into their job security.

"Engineering managers have been enthusiastic about broadening the use of simulation. But there's resistance," Keith observes. "It comes from the simulation establishment. Experts are saying, you cannot have nonexperts using these tools."

## Cloud-Hosted Apps

Browser-based simulation software and apps are a relatively new phenomenon. Examples include OnScale, described as "cloud engineering built by engineers for engineers," and Simscale, described as "simulation software reinvented for the web." Their success may be tied to the success of browser-based or cloud-hosted design software, such as Onshape, acquired by PTC last November.

Recognizing the appeal of the Apple-inspired app-store model, established vendors such as Ansys have begun exploring the same approach. Ansys currently maintains an online simulation app store here. India-based startup simulationHub also offers a handful of browser-based apps as subscriptions: computational fluid dynamics analysis for valves, engine exhaust manifold flow analysis and pedestrian comfort analysis.

"The cloud's availability is important. This removes the need to build and maintain an expensive CAE [computer-aided engineering] infrastructure," Meintjes notes.

Browser-based simulation typically runs independent of the user's local computer. Therefore, the computing power—or the lack of it—in the user's hardware is no longer a deterrence. For firms with intermittent simulation use, these tools make more economic sense than the traditional simulation software that requires robust hardware investment, ranging from GPU-accelerated professional workstations to powerful clusters.

Simulation vendors have also begun offering simulation platforms for those who may not wish to invest in on-premise infrastructure: for example, Ansys's cloud services and Dassault Systèmes' 3DEXPERIENCE platform. Specialist HPC vendors such as Rescale also emerged to address the same need.

"None of these tools are silver bullets. Organizations have to figure out how simulation fits into their processes, and how they can be used effectively," says Meintjes. "We want to get better first-time designs. Otherwise, we get into an endless cycle of design and redesign."

Ultimately, broadening the reach of simulation may depends on the industry's willingness to embrace programs that employ approximation, automation and simplification to make the practice less intimidating for the designers. Though these tools are unsuitable for detailed analysis performed by experts, they play a crucial role in helping the designers determine if the early concepts are good enough to pursue, or not. Persuading the simulation establishment to adopt this new mindset is an unfinished task, even if the tools that can do the job are now in the market. 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.*

### MORE INFO

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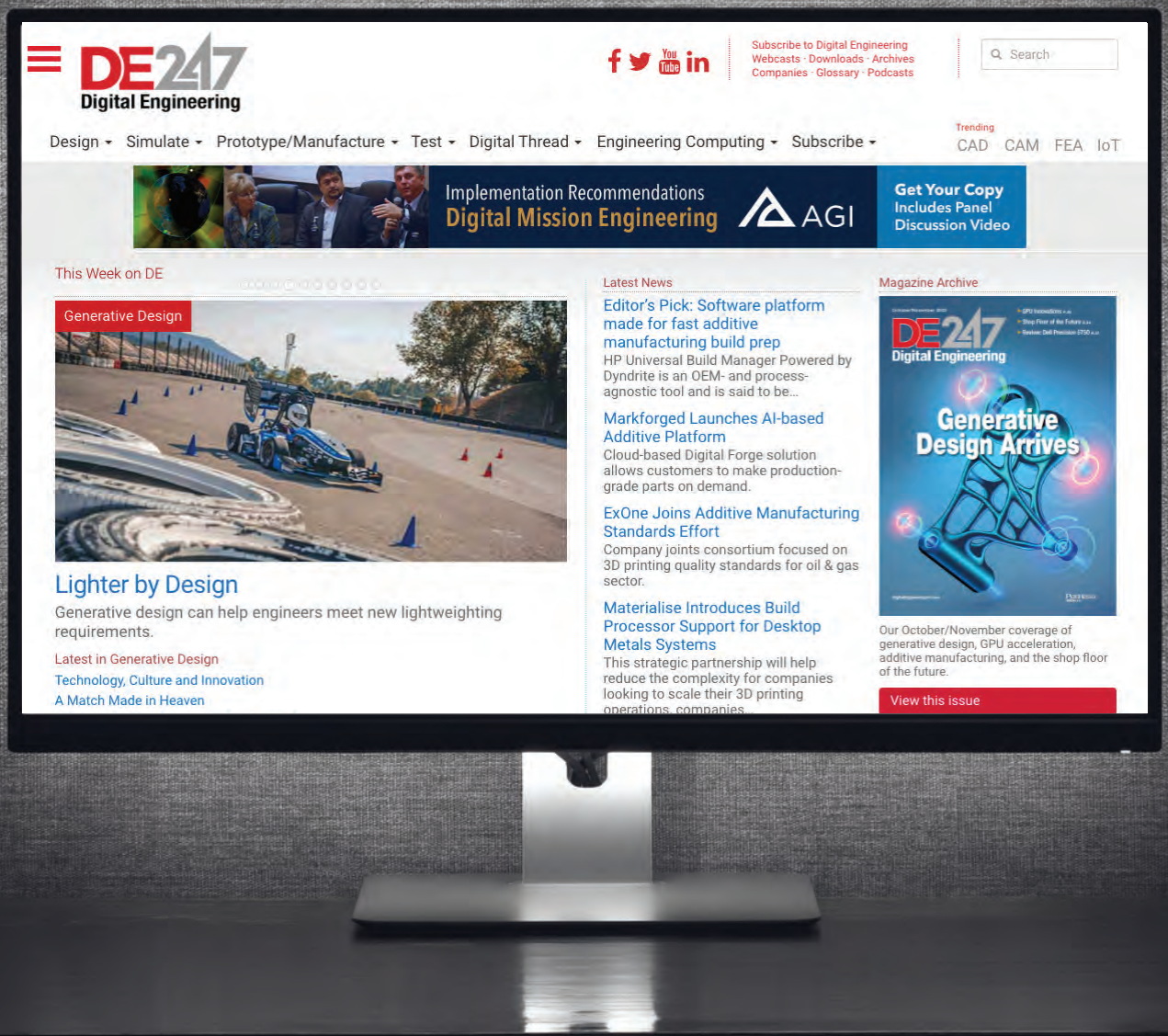


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# Digital Transformation in Turbulent Times

The pandemic has prompted the increased use of design and simulation technologies to prepare for an uncertain future.

**BY JIM ROMEO**

Turbulent times are, perhaps, the greatest catalyst for technological change and growth. Simulation for design has taken center stage during the pandemic to aid engineers, workers and public health officials as they solve problems and strive to be best prepared to combat the spread of COVID-19.

Design and simulation software is in the spotlight more than ever, as it's an instrumental way to create solutions and help many overcome obstacles, problems and challenges that have arisen due to the coronavirus and all that goes with it.

"Engineering simulation software technology has been able to address critical issues at the personal, societal and business levels. Engineering simulation software is being used in a variety of ways as part of the pandemic, used to model both the protection of the general public as well as patient treatments," says Marc Horner, senior principal engineer, healthcare, Ansys.

The utility of engineering software and modeling has flexed its muscles best during the pandemic, providing data and information to public health officials in an unprecedented way. Simulation technology is applicable to health

**Comparison of particle spread by someone coughing at a distance of 3 feet (left) and 6 feet (right).**
*Image courtesy of Ansys.*

issues and to influencing better decisions and pathways to best practices and behaviors.

Horner says that from a public health perspective, engineering simulation software has helped establish the underlying reasons for following the recommended best practices for social distancing and wearing of personal protection equipment (PPEs).

"Computational fluid dynamics simulations of breathing, sneezing and coughing clearly illustrated how the droplets that leave our mouth can travel long distances before falling to the ground," notes Horner. "We are not able to see aerosol particles with the naked eye; therefore, these simulations were quite valuable when establishing the need for complying with WHO (and other health agency) recommendations."

**Firefighters use powered air-purifying particulate respirators (PAPR); 3D printed versions help first responders sanitize their gear without single-use masks.** *Image courtesy of Michigan Technological University.*

Another public safety concern Horner addresses is virus transmission via contaminated surfaces in public spaces, such as airplanes or hospital rooms.

"Proper cleaning and disinfection are required because the virus can live on surfaces for an extended period of time," he adds. "This resulted in significant interest in designing automated UV-C light systems that could rapidly and efficiently decontaminate exposed surfaces, allowing for that airplane, train or hospital room to be returned to service as quickly as possible. In this case, light simulation modeling using Ansys SPEOS helps to ensure sufficient doses of UV light are delivered to deactivate virus particles on surfaces."

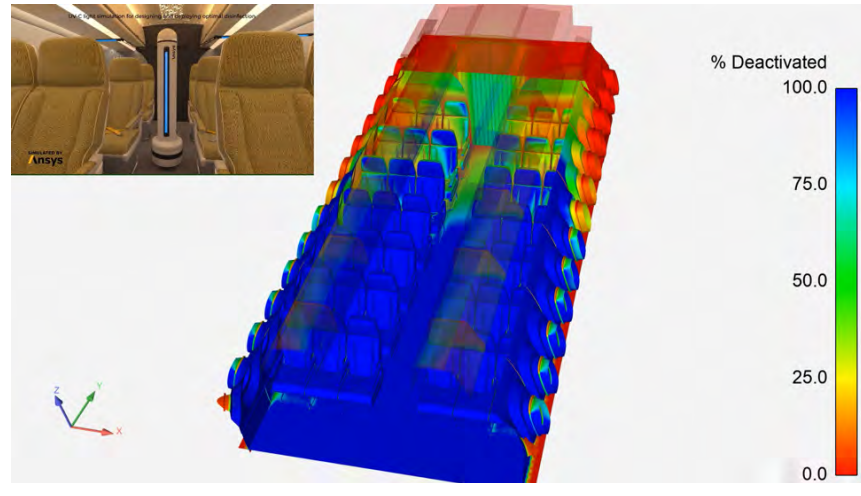
Regarding the dangers of the pandemic, simulation is presenting a new venue to mitigate, control and aid the population who is so vulnerable to its danger.

Paweł Chadzynski, senior director of product marketing at Aras, says simulation allows us to explore and probe various medical and behavioral approaches to mitigate, control and help resolve the pandemic.

"Much of the investigation and prediction around the nature and spread of a virus can be conducted safely using validated scientific numerical methods and physics-based simulations," advises Chadzynski. "While the process for developing a vaccine requires human clinical trials towards the end, the path to the trials does not. This is a role for simulation technology and the pandemic simply highlighted the importance of it."

Chadzynski says that while simulations approximate reality, they also provide a sense of direction.

"The approximation aspect opens the door to questioning the predictions," he says. "The direction aspect opens the door to overplaying the potential risks. These often create tension between scientists and politicians, and that is exactly what is at play when simulation is used to mitigate, control and help resolve the pandemic. The process becomes confusing to all when used in support of conflicting objectives, as




**Automated robots emitting UV-C light (inset) are being used to decontaminate exposed surfaces in public spaces. This image shows the results of an Ansys SPEOS simulation that predicts the efficiency of the decontamination.** *Image courtesy of Ansys.*


**At Interplay Learning, customers can leverage our platform to train new techs, refresh experienced techs and/or assess any techs skills to be able to place them in a job—all done virtually, online.**
*Image courtesy of Interplay Learning.*

in the case of the current situation. This is not a problem of technology but rather a question of what role technology should have in making fundamental life-and-death decisions."

## From Simulation to Finished Product

The role of technology in such decisions has made its way into many products, devices and objects that help keep people safe. Safety is a primary goal at organizations as well as communities everywhere throughout the world. Simulation and designs that are rapidly transformed through fabrication into useful forms and objects is a key benefit they provide.

"Employees' health and safety were the number one goal at most organizations," says Gurvinder Singh, global product director for injection molding for Protolabs. "Engineers were forced to figure out a way to collaborate, design and bring products to market while social distancing and in most cases working remotely from home."

Singh adds that what further complicated things was that supply chains were completely disrupted, impacting sourcing and distribution logistics; engineers had to figure out which suppliers were agile and reliable to deliver during those uncertain times.

"The pandemic was growing at an exponential pace so speed to market was the number one objective of the engineers and executives stepping up to respond to the virus," says Singh. "Engineers didn't have the time to iterate. They need to get designs right the first time and required partners that would help them get there."

Singh explains that the impetus of Protolabs is built on speed, agility and flexibility. By using on-demand tools, engineers could order a range of COVID-related components, such as testing kits, PPE, ventilators and cleaning/sanitizing solutions. Suppliers were required to be onshore due to the uncertainty of overseas suppliers. Additionally, they had to be vertically integrated to ensure transparency and fit Protolabs' requirements.

"We have tools that virtually manufacture the part to create a digital twin as part of the quoting process," notes Singh. "This ensures that we clearly communicate exactly what the customer will receive if they order. This digital process saves time and production costs, and improves part quality before the actual production begins. These tools helped the engineers get their part right the first time."

Bringing products that are in short, as well as large, supply is a key benefit of producing via 3D printing nowadays. Labs now make things with locally sourced materials in record time, and it's making a difference.

"There is a desperate need for low-cost hardware to deal with COVID-19 all over the world," says Joshua Pearce, a professor of materials science and engineering at Michigan Technological University.

"Today, with the evolution of digital manufacturing technologies such as 3D printers and circuit milling systems, humanity can share designs with others who can then replicate medical-grade devices for the cost of locally sourced materials," Pearce says.

Pearce adds that the pandemic "has taught us that massive distributed manufacturing is possible by sharing open-source designs. This is most clear with the success of PPE manufacturing. Next time we will be ready with far more sophisticated digital designs."

## Using Simulation to Create Reality

Outside of the design aspect, the use of virtual reality and environment simulation for training humans is another useful application of simulation. Its primary advantage, relevant to a pandemic environment, is that it may be used effectively, mostly without human contact or being near others.

"The pandemic has brought safety to the forefront for most corporations," says Doug Donovan, CEO and co-founder of Interplay Learning. "As such, our firm, Interplay Learning, has seen a surge during the pandemic in the implementation of our online training for the skilled trades with our digital experiential learning platform. This means we create an immersive learning environment online that simulates in-person learning utilizing 3D simulations and virtual reality, while keeping our users safer and socially distanced."

Donovan adds that their customers leverage a virtual platform to train new techs, refresh experienced techs or assess technical skills to hire an individual in a job. This is all done online, virtually. Donovan points out that the days of in-person classroom learning are becoming unnecessary with technology using 3D simulation and virtual reality.

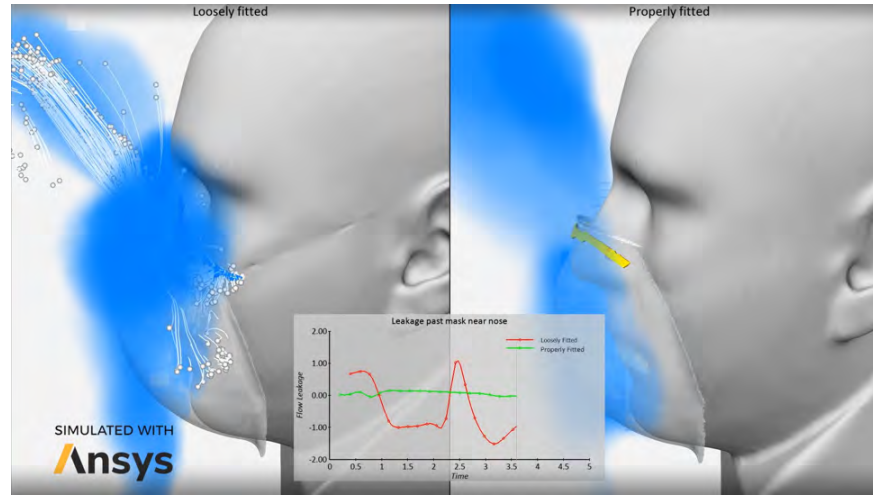
"We hope this will keep our customers safer, while still enabling them to train to be job-ready," he says.

## Balancing Simulation and Digital Design

But the introduction and embrace of simulation and digital design must be met with careful balance with the way we've always done business, and what we can do now. The results that design and simulations provide must fit and apply where and when needed.

"The adoption of digital technologies has varied greatly across industries and company sizes," says Singh. He believes traditional organizations have been struggling to find a balance between existing operations and digital transformation of the entire value chain.

With digital design and simulation, more tools allow organizations to create products and build practices that represent the agility needed to meet the demands of a world that fears havoc.




**CFD simulations using Ansys Fluent highlight particle escape that occurs around the upper edges of the mask when not using the nasal clip (left) and the significant reduction in particle escape when properly applying the nasal clip (right).** *Image courtesy of Ansys.*

Underlying a product's design and simulation, or even a practice, is a flexible, speedy means of problem-solving. These approaches help organizations do things such as reduce risks to the supply chain, accelerate the speed and timing that goods and solutions meet markets and reduce product cost, which makes it easier for products to reach the users that need them.

"We believe technology is going to play a key role in helping us rethink manufacturing in the U.S. to reduce supply chain risks and cost while improving agility, speed to market and transparency," says Singh. "We are sitting at an inflection point where thanks to Moore's law, computing and storage are accessible at minimal cost. Additionally, we continue to make leaps in automation and artificial intelligence that will help us navigate cost in the region." DE

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**MORE INFO**

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- **Aras:** Aras.com
- **Interplay Learning:** InterplayLearning.com
- **Michigan Technological University:** MTU.edu
- **Protolabs:** Protolabs.com

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# Digital Twins Form Building Blocks for Smart Cities

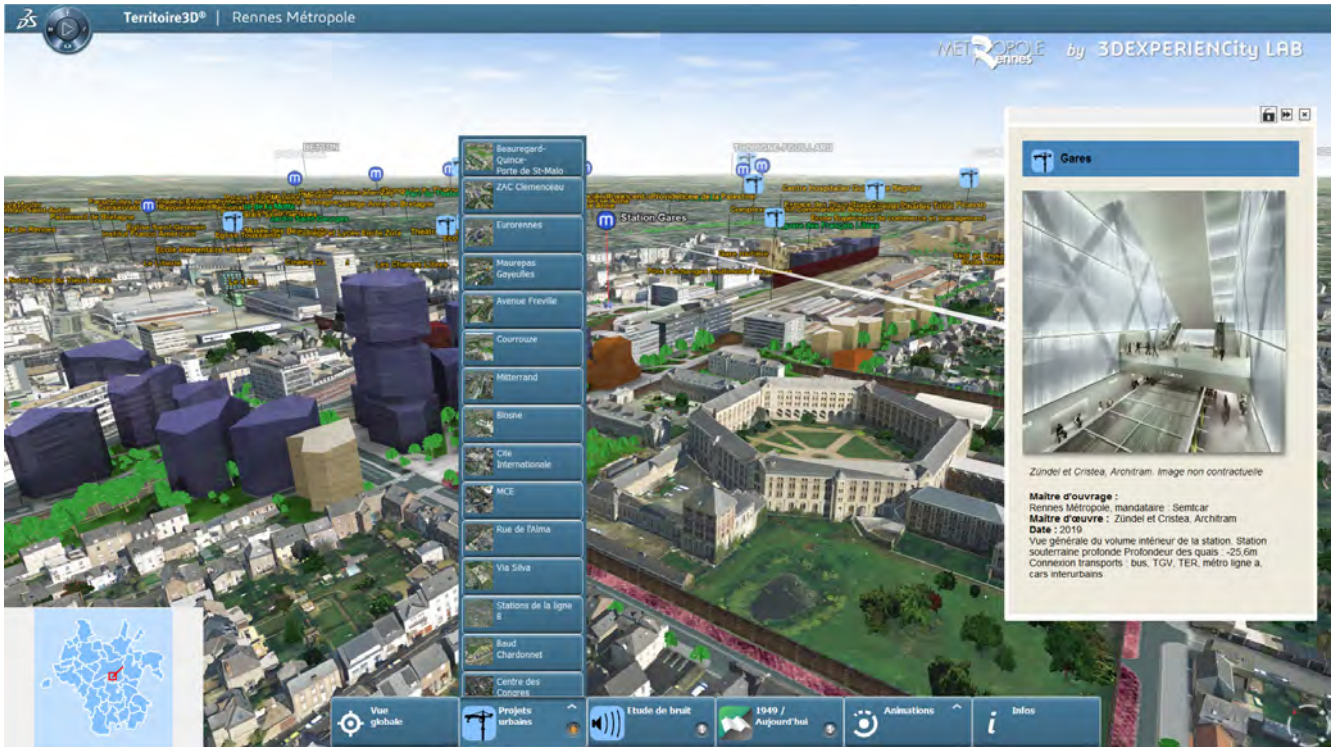
The combination of 3D models, simulations and real-time IoT data means smart city digital twins are being tapped to optimize everything from traffic patterns to energy efficiency.

**BY BETH STACKPOLE**

Digital twins, a concept rapidly gaining traction as a way to improve product design, create proactive maintenance services and optimize performance of industrial assets, are starting to take shape on an entirely different scale as they become the building blocks for futuristic smart cities.

In a smart city design context, digital twins function as a virtual replica of a city's assets; think buildings, roads, traffic patterns, lighting systems, mobility solutions, energy and grid capabilities. But it's not enough to create a 3D representation of these resources.

Just like a product digital twin, a digital twin of a smart city pairs 3D information, spatial modeling of a built environment, simulations and mathematical models of electric and mechanical systems with real-time data feeds from Internet of Things (IoT) platforms such as sensor-integrated buildings and equipment. Smart city digital twins also incorporate other private and public data sources to deliver a




**3DEXPERIENCity Virtual Rennes is a digital twin of the city based on geometric and topographical elements used to develop effective public policies.** *Image courtesy of Dassault Systèmes.*

living, breathing representation of an urban space.

With a smart city digital twin in hand, utility companies can optimize and create self-sustaining and renewable energy grids, first responders could run what-if scenarios to prepare for emergency scenarios such as fires or floods, and city planners could map out and manage traffic patterns to circumvent congestion and counter the effects of urban sprawl with well-placed vegetation and parks.

Melding the physical and virtual worlds together in a digital twin can help city planners and administrators make better decisions, keep citizens informed and engaged, and be a mechanism for addressing major public health, safety and environmental issues.

For engineers designing components for municipalities of the future—autonomous vehicles, public transit fleets, smart lighting systems or buildings—the smart city digital twin becomes a key part of the development cycle, to inform design requirements and for feedback on how that asset operates under real-world conditions. As smart city architects delve deeper into design and planning, digital twins of core assets will become a requisite as they aim to create a holistic picture.

"[Urban planning clients] are increasingly demanding a digital twin at the design stage that can be connected to the information sources to be used downstream," explains Michael Jansen, chairman and CEO of Cityzenith, maker of the SmartWorldPro digital twin platform.

"They want a digital twin because they want to explore their energy costs over 10 years—it's not enough to say we're going to deliver a good product. They want answers and to be able to run scenarios," Jansen says. "There's an ability for the design community to provide evidence-based results using a digital twin and it will be a game changer for the ones that do it better."

**Cityzenith's SmartWorldPro digital twin technology aggregates, integrates, analyzes and visualizes smart city project data on a single 3D platform.** *Image courtesy of Cityzenith.*

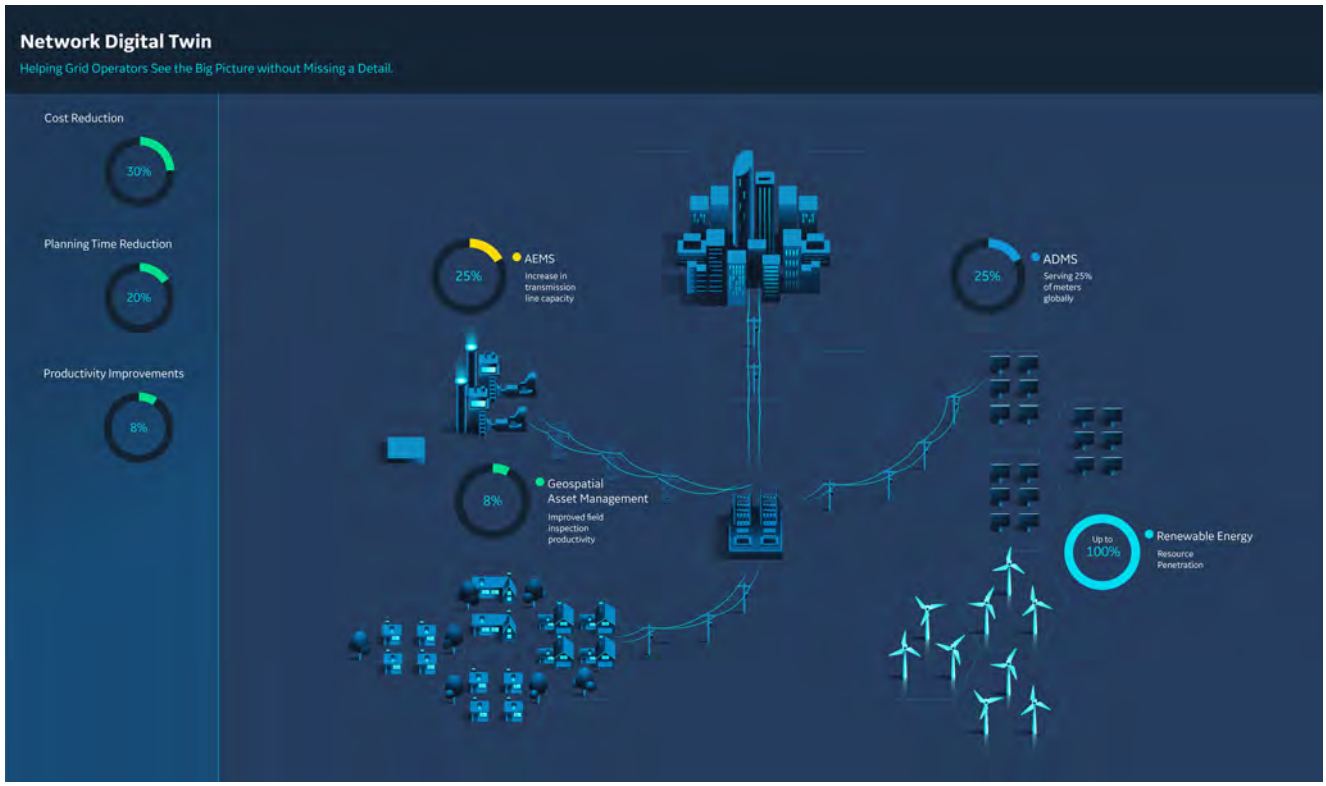
## Twinning on the Rise

Whether playing a role in the design of smart cities or smart products, use of digital twin technologies is expanding. The digital twin market is projected to surge from its current market value of approximately $4 billon to over $35 billion by 2026, according to a recent study by market research firm Global Market Insights. Gartner Research estimates that three-quarters of organizations implementing IoT projects already use or plan to use digital twins within a year.

As the concept evolves, Gartner expects organizations to integrate multiple digital twins. For example, as in a power plant where digital twins of each piece of equipment are synced for a composite picture used to analyze overall operations. Similarly, myriad design twins could be connected to create a composite of smart city infrastructure.

Gartner says 61% of companies implementing digital twins have already integrated at least one pair of individual digital twins, and 74% plan to execute on that approach over the next five years.

"The biggest thing we're looking for with smart cities is how to get systems to interconnect and convert the city into a system of systems," explains Sean Moser, senior vice presi-




**Through digital twin technology and AI and machine learning techniques, GE Digital is helping customers manage and optimize a modern and resilient energy grid.** *Image courtesy of GE Digital.*

dent for digital product management for GE Digital's Grid Software team. Unlike a typical product digital twin, which is focused on mimicking the physics of materials or product behavior, a digital twin in the context of a smart city is about simulating a dynamic system.

"Think of a digital twin simulating the physics of a part or a component, and then a digital representation of a full machine," Moser says. "The aggregation of these things continues to catenate and becomes encapsulated into a digital twin of a smart city."

Dassault Systèmes has been actively immersed in a number of pioneering smart city projects. Its 3DEXPERIENCity platform is being used to create Virtual Singapore, a $73 million project to design a 3D city model and collaborative data platform for building a more resilient and sustainable city.

Using tools such as CATIA and SIMULIA, Singapore planners are creating a unified 3D data model that all public agencies, businesses and researchers can leverage for various use cases, from determining the best place to install solar panels, to analyzing pedestrian patterns, to planning buildings with an eye toward minimizing wind tunnels, according to Simon Huffeteau, Dassault's vice president of Construction, Cities and Territories.

The Dassault tools suite is also helping build the 3DEXPERIENCity Virtual Rennes project, including one use case involving a large-scale visualization aimed at helping planners in the French city optimize green spaces. By capturing detail such as the quantity, type, age and location of trees, the city is creating a virtual twin of the urban canopy.

"A digital twin of a city is not a pure physical digital mockup," Huffeteau says. "A virtual twin allows you to simulate and represent the complexities of the real world the way it operates on a daily basis."

## Twinning Smart Cities

As interest in digital twins—and digital twins for smart city design, in particular—grows, various vendors are stepping up, in addition to Dassault Systèmes.

Bentley Systems and Microsoft recently announced an expanded alliance to combine Microsoft's Azure IoT Digital Twins and Azure Maps with Bentley Systems' iTwins platform, enabling engineers, architects and city planners to work within a city-scale digital twin.

As part of their collaboration, the companies are offering ProjectWise 365, an Azure cloud-based solution for increasing the speed and quality of infrastructure design collaboration. They are also working on integrations that ensure the Bentley iTwins platform can leverage Azure Digital Twins, Azure IoT Hub and Azure Time Series Insights for storing and processing operational data.

Other use cases and smart city digital twin tool sets include:

Climate change and resiliency. Cityzenith is one of the

leaders in this space with its SmartWorldPro Version 2 digital twin technology, which aggregates, integrates, analyzes and visualizes smart city project data on a single 3D platform. The platform, currently underpinning more than two dozen building and smart city initiatives around the world, is primarily being adopted to help cities and urban planners deal with the effects of climate change, Jansen says.

"The ability to aggregate data at scale helps them develop climate-resilient strategies at scale," he says.

For example, as part of New Mexico's new "smart infrastructure" and its carbon-neutral energy initiative, SmartWorldPro will model the replacement smart energy infrastructure. The country's fifth largest fossil fuel power is driving a multi-billion-dollar project that includes solar and wind arrays to power the state while generating surplus for trading on energy markets.

Cityzenith's SmartWorldPro platform is also the information model foundation for Amaravati, a new $6.5 billion smart city capital being developed for the Indian state of Andhra Pradesh. The digital twin platform will accelerate the development of advanced mobility and traffic monitoring solutions and advanced microclimate and climate change monitoring systems. Multi-nodal IoT sensors, in conjunction with Smart World Pro, provide real-time construction monitoring and environmental and wellness monitoring.

Autonomous vehicles and mobility solutions. Traffic patterns and mobility solutions are big issues in smart city design, and simulations and digital twins can play a significant role. Whether mapping out where smart traffic lights should be installed or creating the safest intersections, digital twins get city planners and mobility solutions designers closer to how things actually look as new technologies and infrastructure come on board, according to Karen Giese, Smart Cities program management for Siemens Mobility and Intelligent Traffic Systems.

Unlike traditional simulation models, which assume perfection in vehicle design and behavior, a digital twin is dynamic, taking in real-time information from sensors, LiDAR and cameras to capture a vehicle's perspective and providing a level of granularity that hasn't been seen before.

"The more you can create a digital twin of the environment in which a vehicle ultimately is going to operate, the better you know you're designing that vehicle to be successful," Giese says. "You need a digital twin from the chips in the controller to the mechanical and electrical systems to the digital twin of traffic and the city."

One effort that provides a glimpse of where Siemens is going is its partnership with the Fédération Internationale de l'Automobile (FIA) and Bentley Systems to improve the safety of spectators and drivers at Rally events. Connected vehicle technology, 3D models and simulations created in Simcenter Amesim, artificial intelligence (AI) image classification and sensor networks from Siemens Intelligent Traffic Systems and Siemens PLM Software groups will create a digital twin of select Rally stages and to help detect dangerous locations for spectators. The concepts and lessons learned will eventually be evolved for the next phase: to help improve pedestrian safety in cities, officials say.

Smart utilities and the grid. Another big digital twin application for smart cities involves energy efficiency and optimizing management of the electricity grid. This is an area GE Digital has staked out with a variety of its products and services; as of 2018, the company had 1.2 million digital twins for 300,000 assets ranging from individual pieces of equipment to entire power plants.

In one specific example, GE just released an AI-driven Visual Intelligence platform for utilities that ingests all forms of visual inspection data and executes automated analysis to contextualize data into a digital twin of a utility network. That twin then helps facilitate asset inspection and vegetation management, and allows utility companies to do predictive maintenance to trees and other vegetation that could cause power failures during high winds and storms.

Though much about the smart city digital twins impact urban planners, construction companies and architects, participation from design engineers will eventually become an imperative.

"When you're an engineer working in a given framework and set of requirements for your product, you are not isolated—there is always a multi-scale element to it," says Dassault's Huffeteau. "Being able to connect these elements is clearly part of the vision and future of all virtual twins." DE

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**MORE INFO**

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- **Cityzenith:** Cityzenith.com
- **Dassault Systèmes:** 3DS.com
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- **Microsoft:** Microsoft.com

**Siemens Digital Industries Software:** sw.siemens.com

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# 3D Printing in a Post-COVID-19 World

Mass customization and flexibility ensure AM's role in the post-COVID world.

**BY KENNETH WONG**

This March, as coronavirus-induced travel restrictions and supply chain disruptions wreaked havoc around the world, additive manufacturing (AM) or 3D printing found itself in an envious position—a position of advantage.

Particularly in personal protective equipment (PPE) production, 3D printing attracted headlines and media spotlights. Without the need to set up tooling or create molds, 3D printers, from hobbyists to professional houses, were able to swiftly make and deliver PPEs to hospitals and clinics facing short supply. (For more, read the related stories listed at the end.)

"There was the recognition that 3D printing is a viable manufacturing technology for medical devices. Previously, there were still lots of questions. But because the industry came together and put new products into the market in weeks, not years, it showed it could be done," observes Luis Baldez, senior manager of market development, HP 3D Printing.

During the shutdown, Greg Paulsen, director of Application Engineering for on-demand manufacturing service provider, Xometry, says he saw among his customers, "the willingness to explore 3D printing as a way to make end-use products." He adds, "Some customers found that the lead time to move to molding or casting just didn't fit their deadline. We made a lot of them believers in AM."

The pandemic is not over yet, but manufacturers are finding ways to reopen and resume production while adhering to social distancing and safety requirements. In this article, we explore the role of 3D printing and on-demand manufacturing service providers in preparing for the post-COVID future.


**Personalized face shields, printed in HP Jet Fusion systems, point to mass customization enabled by enterprise-scale AM.** *Image courtesy of HP.*

## Onshoring and Diversification

For many U.S. manufacturers, the pandemic was a wakeup call. The tried-and-true formula to make products at low cost overseas and ship them to the target markets began to break down. The supply chain that had stood the test of time began to slip. Onshoring—bringing production closer to home—was already occurring before the pandemic, but the latest turn of events may be accelerating it.

U.S.-based on-demand manufacturing service providers found themselves in greater demand, swarmed by calls from manufacturers who needed to make up for the delays from suppliers in virus-affected Asia.

"When everything shut down, we were in full

**Fictiv's factory floor in Guangzhou, China, with CNC machines. On-demand manufacturing service providers like Fictiv are expected to help create redundant supply chains to counter the risk of future shutdowns.** *Image courtesy of Fictiv.*

gear," recalls Paulsen. "We were working with established businesses that still had to make parts but found their supply chains shut down."

Xometry's network is made up of more than 5,000 shops. Of them Paulsen estimates about 3,000 are based in the U.S., 2,000 are in Europe and a smaller number are in Asia and other locations. Thus, at the peak of the pandemic when Chinese manufacturers were under lockdown, Xometry's U.S.-based partners had sufficient capacity to pick up the orders.

"During COVID-19, we saw a drop in users who were individuals and hobbyists, [and] those who were doing personal projects, but we were discovered by people who have not used us before," recalls Paulsen.

Headquartered in San Francisco, Fictiv also relies on its network and automated quoting system to offer on-demand manufacturing service.

"Businesses that could adapt fast and were digitally enabled could survive the disruptions and even thrive by supporting the need for test swabs and other rapid response solutions for the frontline fight against COVID," says Dave Evans, co-founder and CEO of Fictiv. "It has been a chance for both 3D printing and digital manufacturing ecosystems to show why they are so important to the future of manufacturing and [the] supply chain."

Eventually the danger of the pandemic will fade with the development and availability of affordable vaccines. However, warfare and political turmoil will continue to disrupt manufacturing from time to time. So a wholesale transfer of production from one region to another (say, from Asia back to the U.S.) is not necessarily the best strategy.

"As digitally enabled manufacturing systems deliver consistently from any printer in any location, then perhaps manufacturing geography and all the incumbent issues like politics, tariffs etc., become less important or even irrelevant," says Evans. "It is easy to see how you can upload a design, select the best process, the best location, the best delivery method and the best price for every part within every product."

"There have always been supply chain challenges, but we hadn't seen a case where the entire country shut down. So even if you had multiple fabricators in that country, you were out of luck," says Paulsen. "After this, people will start thinking of having redundant supply chains, more flexible supply chains."

In other words, distributed supply chain is a safer bet.

## Beyond PPE

HP estimates that its community of partners and customers have produced more than 5 million 3D-printed parts using HP's Multi Jet Fusion technology to help health care workers on the front lines. Initially, the almost-instantaneous AM capacity was the best way to answer the urgent call for PPE production, but as the need for PPE evolves, traditional manufacturers are catching up too.

"Now that all the countries are trying to open up and people are going back to work, you need PPE not just in hospitals but also in schools, office buildings, military, retail and any other places where people might gather. So the need is going beyond health care," points out Baldez.

"For the first couple of weeks, 3D printing helped as a stop-gap measure," says Paulsen. "But additive is just one form of manufacturing. For scale, to hit the volume of PPE needed per day at a reasonable cost, moving to a more traditional mass-production method makes sense."

In April, Fictiv began devoting some of its production capacity to the fight against COVID-19. It announced hos-

pitals and health care providers can order "face shields in batches of up to 10,000 per order at cost for shipment as fast as one day."

"It isn't as simple as 3D printing or CNC, or any other process. The ideal solution is to be able to explore many manufacturing technologies for each part and to pick the best one in each case," cautions Evans.

3D printing has also altered the commodity PPEs with fresh innovations—customizable masks, for example. WASP, a startup that developed versatile 3D printing and milling machines, launched the My Face Mask project, allowing users to print custom-fitted masks with replaceable filters.

The company uses open-source technology to develop a way to obtain the target user's face geometry using photogrammetry. It employs its Delta WASP 4070 printer to produce the mask in warp-resistant polycaprolactone materials or the more flexible F1 Skin Contact Flex materials.

In a similar project called MyMask, physicians and technologists came together to launch a custom-fitted mask creation portal. It uses the depth-sensing camera in iPhone 10 and newer models to let users to easily scan and upload their face geometry. The project is supported by simulation software maker MSC Software, part of Hexagon.

"Some physicians found that they like the 3D-printed face shields more than the traditional ones; they are lighter and have better fit. If the pandemic hadn't happened, they might not have discovered that," says Baldez.

## Adapting to Market Demands

As a result of the impact of the COVID-19 pandemic, many companies with AM capacity decided to pitch in to offer relief to the overtaxed medical equipment manufacturing sector. Others saw a drop in demands for their usual products, so they shifted to medical supplies that were in higher demand for pure survival. No matter the reason, these experiments revealed one of AM's greatest benefits—flexibility.

U.S.-based Superfeet usually uses its HP Jet Fusion printers to make custom insoles based on buyers' feet scans. The company has already secured a partnership with New Balance to provide 3D-printed insoles for New Balance shoe buyers. But in March, when the pandemic took a toll and business was on a pause, the company announced, "We're opening up capacity on our HP Jet Fusion printers and setting up a manufacturing line for producing life-saving medical equipment."

With 3D printing, "one day you can produce face shields, another day nasal swabs, then another day go back to automotive parts," says Baldez.

Ad hoc use of AM to produce something originally meant for machining or molding is quite common, but that is not the best use of the technology.

"To get the most out of AM, you really have to start thinking about it in the design phase," says Paulsen. "Lattice structures, for example, are designed for AM. So are multipart assemblies that can be consolidated into one. You need to have AM in your design intent."

With its sights set on large-scale adoption of AM in enterprises, HP in October announced it is sprucing up its software for automating and managing complex print workflows, dubbed HP Universal Build Manager Powered by Dyndrite. The news came out in advance of the Formnext Connect, a virtual conference for the AM community.

"Automation, software and data are key to delivering mass-customization of parts and unlocking the full potential of large-scale AM," says Ramon Pastor, GM and global head of 3D Printing and Digital Manufacturing, HP.

HP's COVID-related projects involved mostly the HP Jet Fusion printers capable of printing in polymer. The company also offers metal 3D printing via its HP Metal Jet technology, working closely with production partners such as Germany-based GKN and the San Francisco Bay Area-based Parmatech. 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.*

## Related stories:

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**MORE INFO**

- **Fictiv:** Fictiv.com
- **HP:** www8.hp.com/us/en/printers/3d-printers.html
- **MyMask:** MyMaskMovement.org
- **WASP:** 3DWasp.com
- **Xometry:** Xometry.com

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# Optimize your CFD workloads on AWS


On AWS we've helped customers remove bottlenecks from running computational fluid dynamics (CFD) simulations in the cloud. From popular commercial codes like Simcenter STAR-CCM+ and ANSYS Fluent to open-source products like OpenFOAM and SU2, we are helping customers run faster and more cost-efficiently every day.

One of the key benefits of moving to AWS for CFD is simulation time. We typically see customers benefiting from reduced simulation times because AWS has the latest generations hardware (which is being regularly refreshed) compared to their current on-premises system. In addition, the scale of AWS typically means customers can run larger models and meshes to gain improved accuracy that may not be available on limited on-premises capacity. Just look at how we helped Formula 1 to reduce their simulation times from days to just hours.

The second benefit is to scale out jobs horizontally and run tens of thousands of jobs at the same time. On-premises capacity can limit the number of simultaneous jobs, resulting in users waiting in queues. On AWS, customers aren't capacity constrained and can therefore run multiple jobs all at once using the optimum number of compute resources for each job. Just look at how we helped INEOS Team UK to do this.

The third benefit is that the optimum hardware can be used for each CFD solver (e.g higher memory nodes for pre-processing solvers and stages, and then compute optimized for solver sections). Finally, you can launch GPUs to optimize the post-processing stages. This is a key advantage over on-premises configurations that are typically not elastic and flexible. Finally, with NICE DCV you can securely connect to any remote servers and run CFD remotely from your home or office. Find more about how you can optimize your CFD workloads for cost and performance on AWS here.

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**AWS**
Seattle, WA
https://aws.amazon.com/hpc/cfd/

# NEERE – Making Remote Collaborative Product Development Happen

Today's unprecedented circumstances push the limits of remote communication and collaboration solutions, as organizations strive to ensure business continuity.

Especially in the field of engineering simulation the evolution of analysis models and the evaluation of results, on different design stages and centers, requires time-efficient and effective mediums of collaboration.

At the same time, working and communicating from distance, with non-reliable and not secure platforms add risk and reservations.

Addressing those needs, BETA CAE Systems brings forth NEERE, a new software, with the aim to meet existing needs and take remote work and collaboration to new levels.

## Access your office work-station from anywhere

With NEERE you can gain full access to your corporate workstation and work remotely allowing you to mobilize your data and information stored in corporate systems and run your software from anywhere.

## Join your colleagues in the world of your models

On top of the standard communication tools such as messages, voice, live videos, NEERE offers an easy to learn and work on Virtual environment in which you will dive into the world of your virtual simulation models. Integrated with ANSA, META, and META VR, NEERE provides a complete collaboration platform that makes sharing of knowledge and exchange of ideas effortless.

## On-premises, private and secure

As an on-premises, web-based tele-collaboration platform NEERE will let you boost productivity in an enterprise-ready, multi-OS web platform that ensures security and trustworthiness. All interprocess network, server-client, HTTP, and WebRTC traffic is encrypted and secure, while all data are transferred via your organization's own network only.

BETA
SIMULATION SOLUTIONS

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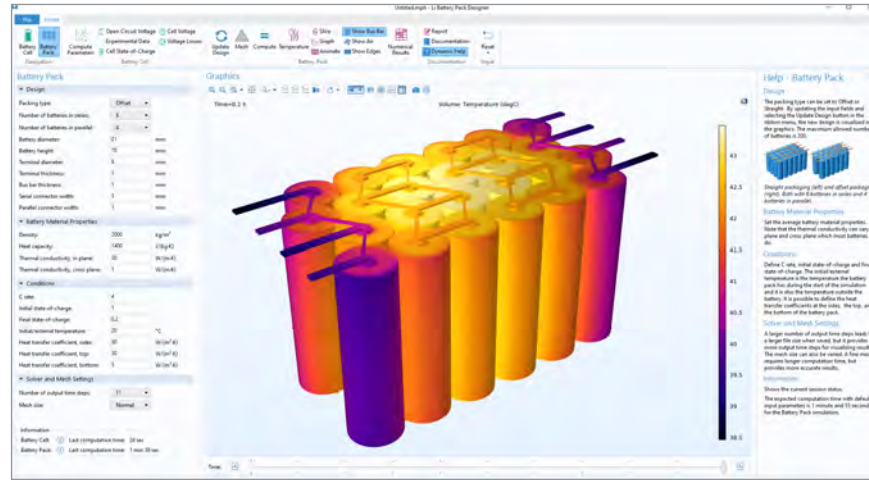
# Simulation Applications Bring the Future of Modeling into the Present

Simulation applications and the tools used to distribute them are ushering in a new era of product development to organizations around the world. By democratizing simulation, companies can develop better products faster, using the specialized expertise of each team member involved.

Mathematical modeling and numerical simulation are widely accepted methods for product development, which makes sense: They have been around for more than half a century. As long as these tools have been available, their use has been restricted to simulation engineers. This creates a bottleneck in the development process, as design engineers wait for analyses and results. COMSOL provides the tools to sidestep this bottleneck by creating easy-to-use simulation applications and distributing them companywide.

Simulation engineers create specialized applications based on the computational models they develop in the COMSOL Multiphysics® software. The applications enable anyone to test parameters and run repeated analyses without the simulation engineer, who can then focus on solving complex problems, developing innovative products, and building more applications.

For instance, Samsung Research America — a leading worldwide audio company — designs high-quality loudspeakers using simulation and applications. Get an inside look at their workflow in this blog post: comsol.blog/loudspeaker-design. Another example is Cornell Dubilier, a leader in manufacturing high-quality capacitors, which creates several applications for electrical



**Simulation of battery pack temperature distribution using the Lithium Battery Pack Designer App.**

optimization. "[We] create applications for other departments to let them test different configurations for their particular requirements and pick the best design." says Research Director Sam Parler.

Collaborators are provided access to applications through two methods: compiling them into standalone executable files using COMSOL Compiler™ or distributing them via the application management tool COMSOL Server™. COMSOL Compiler™ is used to create compiled applications that can be run without a COMSOL® software license. COMSOL Server™ helps those who want to upload and manage applications for an organization and enable application users to run simulations via a web browser or desktop client — on any hardware, including phones and tablets.

Numerical simulation has changed since it first came about some 50 years ago. Through the use and distribution of applications, it has become even more powerful.



**COMSOL, Inc.**
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www.comsol.com

# Optimizing Design for Additive Manufacturing

By Fabian Alefeld, EOS

As more organizations explore additive manufacturing (AM) solutions such as industrial 3D printing, design optimization for AM has become a top priority. As manager of the Additive Minds consulting group at EOS North America, I'm on the front lines of helping organizations explore their AM design capabilities.

Organizations in many industries now understand how AM can enable new material efficiencies, reduced cost-per-part, and advantages in product performance and sustainability. Now, they want to know *how* to do it: Best practices that make AM success come to life.

For many companies, that journey begins with design optimization for AM. I help organizations unlock creativity, adopt an AM mindset, and navigate their big opportunities for success. My work involves in-depth training and guidance for companies at every stage of AM exploration and adoption. That includes helping design engineering teams explore the opportunities AM provides for performance, material efficiency, and sustainability.

EOS is unique because we provide mature end-to-end AM solutions that create long-term success for businesses. From start to part, we help organizations strategize, develop, deploy, and optimize successful AM programs. Our exceptional 31-year legacy is evident in our diverse technology portfolio, which was founded on our mastery of laser, material, and process. Our extensive sister organizations and industry alliances make our tribal knowledge unique in the industrial 3D printing world.

Here's one real-world example of our impact: We worked with a company in the aerospace industry to explore AM applications in their parts portfolio. The result was a 3D printed latch – which may not seem like the most exciting application. However, that latch was significantly cheaper to produce via AM and lighter in weight. When you measure its impact across an airline fleet, it saved the customer around $20 million while reducing CO2 emissions by 8,000 lbs. per plane annually.

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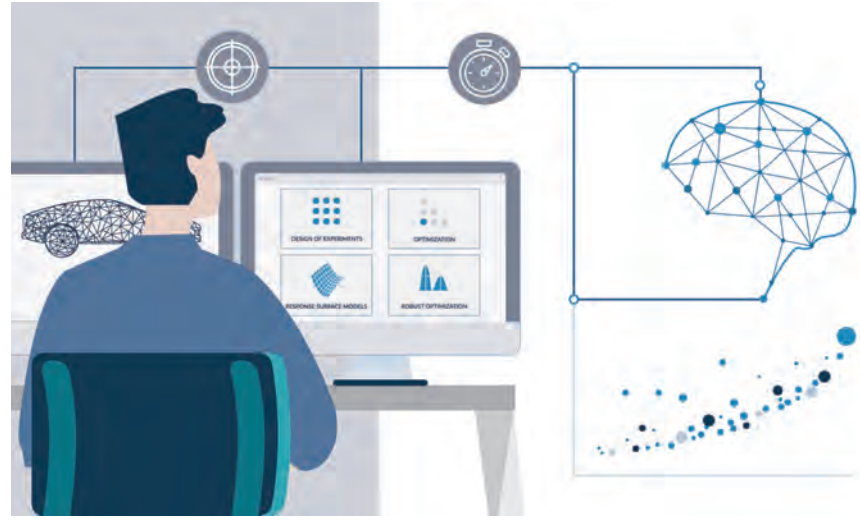
# Where Autonomous Matters: Design Space Exploration Made Easy

## ESTECO VOLTA expedites the decision making and design space exploration phases, freeing up time and human resources

Usability is a key issue for many working with automated solutions. Regardless of their level of expertise, individuals are faced with complex algorithms and must identify the right optimization strategies to get the best result, while taking into account the time and human resources available. Such manual tasks are not only time-consuming but highly repetitive, where the design and engineering expertise of specialist staff is not used to its full potential.

This is where ESTECO's advanced process automation and optimization driven design technology can help. It allows to automate every sort of simulation process, integrate any solvers, run intelligent algorithms, and pick the right design. What's more, this capability frees design and engineering experts, allowing them to focus on value-added tasks instead. It can also be used by non-expert users democratizing the design space exploration and accelerating the decision making processes.

Effective design space exploration is a complex issue, where users must often balance the time to reach a solution with the quality of that solution. This is where ESTECO Autonomous Optimization capabilities step in, minimizing the time from the first model to the first result.



Compared to the self-Initializing mode, which uses as a single parameter the number of design evaluation, to reduce some of the complexity of the optimization strategy, ESTECO Autonomous mode takes things to the next level. It is an intelligent solution, which allows expert and non-expert users to balance the time to find the optimal solution with the number of design iterations.

The algorithms featured use information gathered from the problem analysis stage to drive optimization in the right direction, available in a reasonable time window. Users simply press Play to start the system working.

ESTECO VOLTA simulation and product data management platform simplifies the simulation process, enabling teams to concurrently compare, validate and collaboratively decide on design solutions with advanced data intelligence tools. Within VOLTA you can find a complete set of numerical tools covering deterministic, stochastic and heuristic methods for both single and multi-objective problems, all available in the Autonomous mode.

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# Reliable, On-Demand Manufacturing


One of the key challenges facing design teams today is accesss: This pertains to accessing data, technical knowledge, and physical resources such as equipment and materials. Historical data, good record keeping, and access to multiple departments within a product development company can bridge the gap to efficiency. Too often, companies perform in silos and those lines need to be removed to improve efficiency. One hand does not necessarily talk to the other. The same goes for technical expertise and access to resources. Manufacturers with multiple locations are unfamiliar with the capabilities that their partner facilities may have. Eliminating those barriers and identifying your own strengths and weaknesses will ultimately lead to better outcomes.

Being a service manufacturer means that we work with countless engineers, designers and researchers on a variety of projects. Not only do we have the technical knowledge, equipment and materials to solve many product development problems... we often work with companies with multiple facilities so we provide a consultative approach to identify strengths and weaknesses. We've done this many times, it's what we call our manufacturing plan process.

## Why customers choose us

There is so much competition in our marketplace and we rely heavily on referrals. Because of this, we never sacrifice customer satisfaction and use our expertise to provide the best outcome possible for our clients. We are constantly growing, building new relationships, and adding the right equipment, and people, to further serve the industry.

Speed is critical. It makes such a difference to provide quality parts quickly and our clients appreciate our approach to immediate solutions. They can keep their ideation momentum when we deliver.

Due to the nature of our business, our clients request the ultimate in confidentiality. It's because of this that we remain a trusted source for many in key industries such as automotive, healthcare, aerospace and device. But ask around, we've touched many, many companies and we feel that our work speaks for itself.

FORECAST 3D

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# End-to-End Innovation

A lack of standardization is a challenge for many manufacturers. Until recently, there was little opportunity to standardize on technology that effectively manages the full range of manufacturing workflows from concept to production.

This standardization gap leads to challenges with technology compatibility as well as employee development and on-boarding. As a result, effective collaboration is often stifled and creativity or R&D initiatives are compromised.

Manufacturers have an opportunity to mitigate many problematic internal processes with an end-to-end technology partner like IMAGINiT Technologies who can look at ALL phases of your go-to-market strategy holistically from conceptualization and design engineering to digital prototyping and, finally, to production.

IMAGINiT provides not only the best-in-class technology to support today's modern workflows and engineering requirements, but also the education and support to utilize your technology investment to the fullest. Our team of experts provides software development services to further enhance design productivity and also help bridge the gap with consulting services for design simulation and process automation.

Very simply put, our clients understand that global competition in every sector of manufacturing demands a more agile and creative manufacturing environment. New materials are replacing traditional every day, new equipment and emerging techniques for manufacturing are being put in process every day, and new markets with new demands are emerging every day. Design and manufacturing strategies that used to be considered long-term goals have been reduced to ASAP timeframes. Manufacturers need to focus on reacting to tomorrow's growth strategy without the burden and drag of poorly integrated or automated design technology, or inefficient processes.

IMAGINiT helps clients to accelerate innovation while improving project quality and profitability with a focus on people, process, and technology, the cornerstones of why leading companies choose to do business with us.

• **People** – IMAGINiT continues to grow and add the most remarkable talent. With decades of experience, knowledge, and expertise, our team will help you achieve your business objectives.

• **Technology Partnerships** – Get the best training and support for top technologies, including those from Autodesk and Leica Geosystems.

• **Process** – Trust IMAGINiT's proven and configurable methodologies for services such as Data Management, Product Lifecycle Management (PLM), Computer Aided Manufacturing (CAM), Reality Capture, Process Automation, and design simulation.

With more than 40 locations across the United States and Canada our clients get the local support they need, but also have the opportunity to leverage the knowledge and experience of dozens of other professionals with specialties that your team may require.

IMAGINiT TECHNOLOGIES
A RAND Worldwide Company

**IMAGINiT Technologies**
**800.356.9050**
www.imaginit.com

# Particle-Based CFD Offers Engineers New Simulation Capabilities

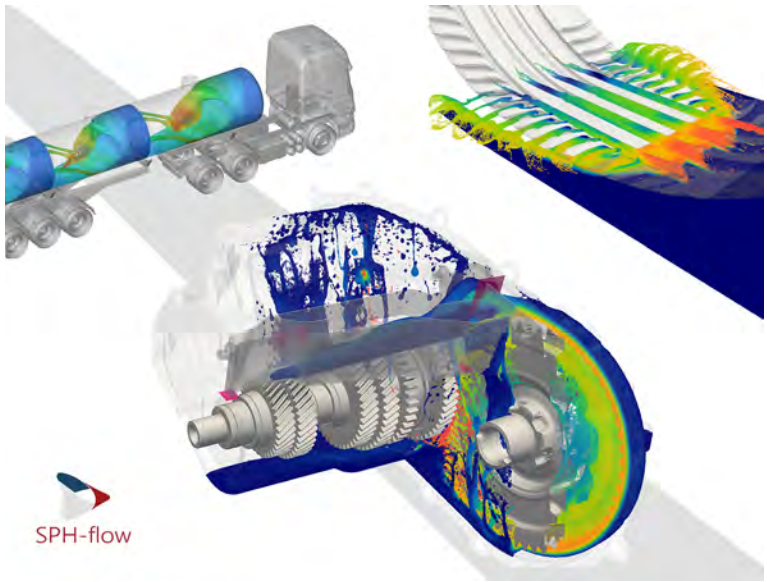
## When traditional CFD shows its limitations, SPH can deliver fast and accurate results

In most cases, Computational Fluid Dynamics (CFD) simulation can be achieved using the industry-proven body-fitted Finite Volume (FV) method. After more than 20 years of research, particle-based methods, and especially Smoothed Particle Hydrodynamics (SPH), have reached industrial maturity. Today, SPH can complement established CFD solutions where FV shows its limitations, either in its capability to simulate correctly the fluid flows, or in terms of lengthy computation time.

Thanks to Nextflow Software and other actors, the SPH method has been moving from academic labs to industrial engineering offices. SPH is being significantly adopted by automotive manufacturers and tier-1 providers for key applications like powertrain and transmission system lubrication and cooling (including e-motors), or vehicle river crossing (a.k.a. fording or wading) studies. Still, many other industries are adopting SPH for other applications in aerospace, marine & offshore, environment & energy, industrial process/machinery and manufacturing, etc.

The main characteristics of the SPH method are:

• SPH solves the Navier-Stokes equations (like FV) but represents fluid flows with moving particles. It is especially well adapted for simulations involving *complex solid interfaces* (body motion, deformation, contact…) and *fluid interfaces* (multiphase, atomization, coalescence…). Traditional FV methods are often limited by their mesh-based nature and cannot simulate effectively such interfaces.




• SPH does not rely on manual meshing and allows engineers to launch fluid flow simulations *few minutes* after getting their CAD files ready. Traditional mesh-based FV methods require tedious and user-dependent manual meshing operations, taking hours or even days of highly skilled engineers.

Nextflow Software's SPH-flow solver offers compressible and incompressible formulations to accurately target all fluid flows:

• SPH-flow incompressible formulation is best-suited for highly fragmented flows, where the fluid is atomized into droplets or jets, and for long-duration flows.

• SPH-flow compressible formulation is best-suited for fluid flows involving complex physics and brief dynamics, such as shocks and impacts. This formulation is especially recommended when local pressure field and free-surface accuracy matter.

SPH-flow can be 5 to 100 times faster than FV solvers on specific applications that best fit with the SPH method, meaning that 1 week of computation may now shrink to few hours, with often better simulation results compared to FV on such applications. These capabilities open up for new uses of fast 3D CFD in the design-simulate-update loop, either as standalone simulation tool or embedded in design tools (whether 3D or not).

Nextflow Software

**NEXTFLOW SOFTWARE**
contact@nextflow-sofware.com
www.nextflow-software.com

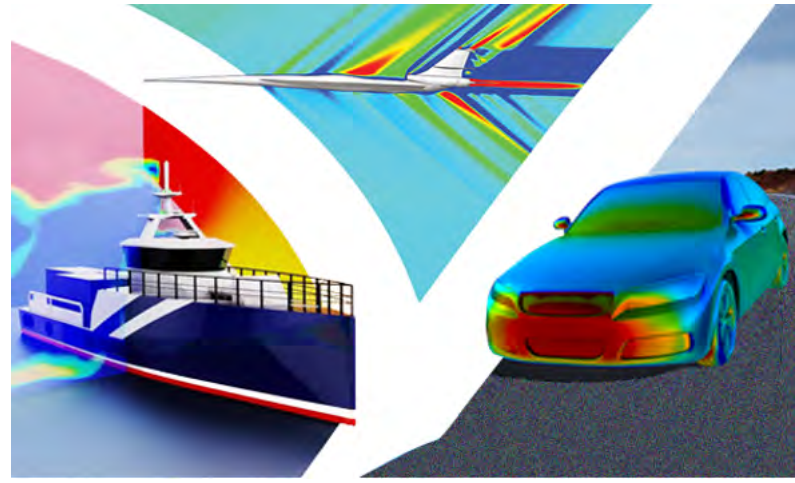
We push the limits of numerical design.
Contact us !

# NUMECA Announces Expanded Suite of Simulation Solutions for CFD & Design Engineers

Perhaps now more than ever it is critical for engineering teams to be adaptive and efficient as they design products that respond to greater competitive pressures in the market, meet higher performance demands from management, and comply with changing regulatory standards. Accomplishing all of this while containing R&D costs can be a real challenge.

Delivering on our promise to '*Ensure your competitive advantage*,' NUMECA has continued to expand the capabilities of our suite of specialty CFD & Meshing software solutions. A tuned and efficient simulation configuration from NUMECA can be designed to meet your reliability, speed, and cost targets. Users have collectively saved millions thanks to the productivity increases gained from unparalleled processing speed, reduced hardware demands, and flexible licensing plans.

At NUMECA, we don't believe in general purpose tools because they can so often fail to deliver on the increased accuracy and performance demands necessary to create cutting-edge designs. We believe in solutions that are reliable and fast with dedicated workflows and smart user interfaces. Of course, this means something different depending on your industry and specific project, so we ensure that the optimal technology is available for every step of the simulation process with an array of meshing and solver technologies optimized for various industry applications. All of this functionality is accessible within a unified interface and backed by powerful computation algorithms.



## LATEST RELEASE HIGHLIGHTS:

### AutoSeal:
is a truly unique CAD/STL preparation tool that delivers watertight & clean geometries in minutes (or less) compared to the days/weeks of engineering time typically required when manually preparing complex geometries.

### OMNIS™/Open-PBS:
offers a new fully coupled pressure-based simulation approach with built-in highly efficient Conjugate Heat Transfer capability.

### OMNIS™/Mpacts:
incorporates DEM (Discrete Element Method) simulations into our range of solvers, and offers great flexibility in the ability to represent all possible shapes and particle interaction mechanics since no mesh is needed.

### Cloud/HPC:
NUMECA's on-demand software & hardware cloud offering continues to expand in functionality, and now includes access to OMNIS™ products available in both CPU & GPU configurations. Whether you have a small power or supercomputing request, our flexible model allows you to select the resources and software you need when you need them.

### And more to come:
Stay tuned for 2021, when Numeca will introduce a brand new solution that steps into uncharted territory in the CFD landscape. Accuracy-to-demand will be accomplished with an ease of set-up which is yet to be seen, while offering turnaround time within the day, *no matter the complexity*.

**NUMECA International**
www.numeca.com

# The Freedom to Collaborate from Anywhere

Onshape's cloud product development platform rapidly accelerates your design process

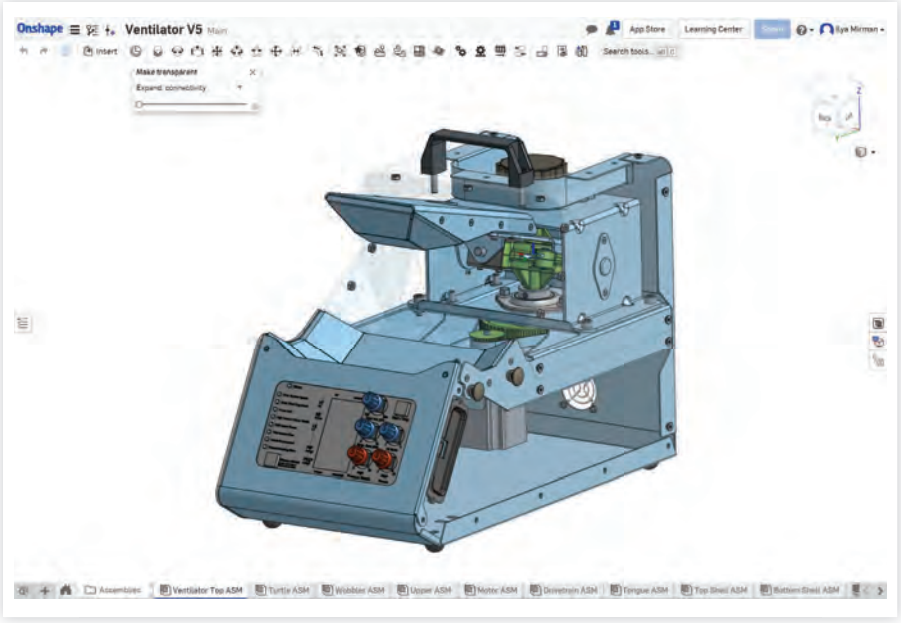
An alarming 8 out of 10 engineering teams sometimes cannot either locate or access the correct design data when they need it.

That's one of the key findings of *The State of Product Development and Hardware Design 2020*, an independent research report that surveyed nearly 1,000 executives, project managers and engineers around the world to determine the most urgent priorities for today's manufacturers.

Data management headaches and the need to minimize time on non-design related activities was ranked as the top time-waster, scoring higher than "unproductive meetings" (73%), "work lost due to crashes and data loss" (71%) and "technology maintenance" (70%).

PTC's Onshape Software-as-a-Service (SaaS) platform speeds up product development by eliminating the most common obstacles that slow companies down. Onshape is the only cloud-native product design platform that combines powerful CAD tools with built-in data management, real-time collaboration and business analytics.

Onshape gives distributed product design teams the flexibility and freedom to simultaneously work together from any location on any computer, tablet or phone. Whenever one engineer makes a design change, everyone else on the team can instantly see it.




*Product development teams using PTC's Onshape SaaS design platform benefit from built-in version control without the need for an external PDM system.*

Meter, a Boston industrial hardware startup, recently designed, built and clinically tested the Rise Emergency Ventilator in only 21 days using Onshape's real-time collaboration tools – a process that normally would have taken many months. The accelerated timetable was achieved despite the fact their core design team was forced to work remotely during the early days of the COVID-19 pandemic.

"Onshape was just incredibly valuable for us," says Meter CEO Eduardo Torrealba. "We were moving way too fast to deal with emailing files around or setting up servers and a lot of the other things that we would need to do to have that same level of collaboration if we had been using other CAD packages."

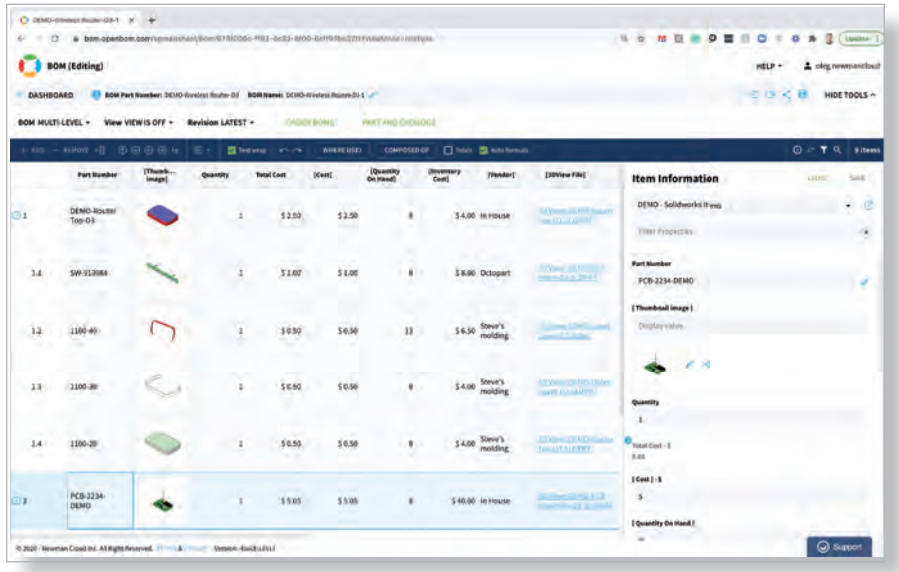
onshape®

**Onshape, a PTC Business**
Boston, Massachusetts
www.Onshape.com

# OpenBOM™ - Manage Parts, Bill of Materials, Vendors, and Purchases

A digital network platform to manage product data and to connect manufacturers and their supply chain networks.

Engineering and manufacturing companies are facing increased product complexity, aggressive timelines, and budget constraints. The teams are distributed, located across the globe, and work around the clock, which leads to a high demand for information and details needed to complete their goals. The problems and errors found too late cost a fortune, mistakes in communication with contractors and suppliers lead to product delays and increased cost. .




### Unique User Experience and Integrations

OpenBOM is focused on helping engineering and design teams to organize their product information in a single source of truth, accurately create the Bill of Materials, manage changes, and share the data instantly thanks to OpenBOM cloud nature. OpenBOM user experience paradigm allows users to manage information in a manner consistent with the realities of design and manufacturing. OpenBOM seamlessly integrates with all CAD systems allowing one-click data extraction and updates.

### Streamlined Processes and Design To Purchase Data Handover

Traditional PLM and data management systems never built for this new model of distributed work. The old system takes a long time to install, configure, and set up, and after all, engineers are turning to Excels. Small and medium-sized companies are at an extreme disadvantage experiencing a high level of complexity combined with the lack of resources and fierce competition. Companies are moving from the world of single computers and files into a world of data and cloud services.

### Connected Multi-Tenant SaaS PLM

OpenBOM developed unique data management and collaboration platform capable to connect engineers and manufacturing companies to work together in a seamless and connected way. OpenBOM intuitive user experience is using a familiar spreadsheet-like paradigm by hiding the complexity of data management and communication using cloud and SaaS technologies. OpenBOM integrations with CAD systems are second to none providing easy data handover between engineers and other users.

### Don't Be Chief Excel Officer - Use OpenBOM!

OpenBOM provides a new digital experience to the customers coming online and starts using it immediately. Customers are saying that "By starting to use OpenBOM there is a great relief [to me] as it saves a lot of time to keep track of components." The first time experience is extremely important. As one of our customers said, "With OpenBOM, I clicked and it worked! It was nice to see all information already filed in CAD come to my BOM. Material, for example, is very important and it came right to the BOM." Users are relying on OpenBOM to share information and check how the selection of components, materials, suppliers and contractors.

**OpenBOM**
Contact info: oleg@openbom.com
www.openbom.com

# Engineer a Better Tomorrow with Simcenter

Your engineering team is faced with increasing complexity across several dimensions: integrating mechanical, electrical, and controls behaviors, new materials and manufacturing methods, and opportunities from cloud and IoT.

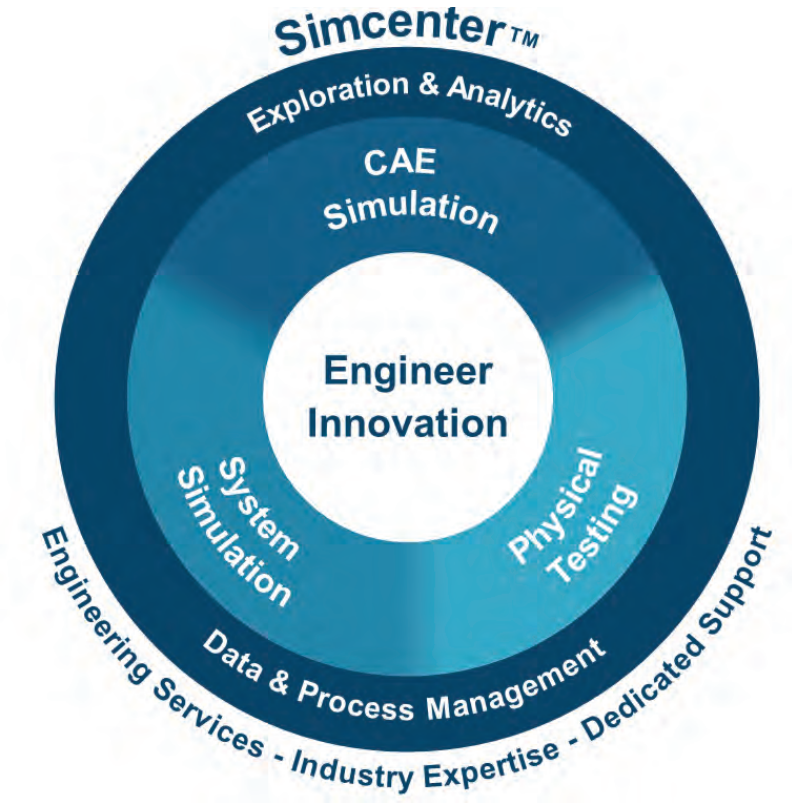
Turn this complexity into a competitive advantage.

Siemens Digital Industries Software can help you harness complexity and accelerate your firm's digital transformation. The comprehensive digital twin is a key enabler for this transformation. It covers the entire product and production lifecycle. Simulation and test are the beating heart of this digital twin. Simcenter allows you to predict every aspect of product performance, which enables the digital twin to evolve throughout every challenge a product faces in its operational lifetime. A key solution within the larger Xcelerator portfolio for digitalization, Simcenter helps you:

- model the complexity to ensure decision confidence
- explore the possibilities by enabling insight earlier
- stay integrated by connecting all activities for full traceability and alignment
- achieve speed and agility through streamlined processes
- maximize return on your simulation and test investments

Siemens is a world leader in digitalization. A partnership with Siemens can help you transform your company and turn complexity into a competitive advantage.

Simcenter puts the key to engineering innovation into your hand today so that you can create a better tomorrow.




"OEMs are really satisfied with the input that we deliver using Simcenter tools. Thanks to Simcenter solutions, we are able to release our new products three times faster than was previously the case."

*—DENSO*

"But what we value the most about Siemens is that each kind of software we acquire for a specific question is part of a large suite of software that communicates very easily with each other."

*—IDIADA Automotive Technology*

"Thanks to the use of Simcenter solutions from Siemens Digital Industries Software, we cut costs during the development of the commercial truck by 20 million rmb."

*—China FAW*

SIEMENS
Ingenuity for life

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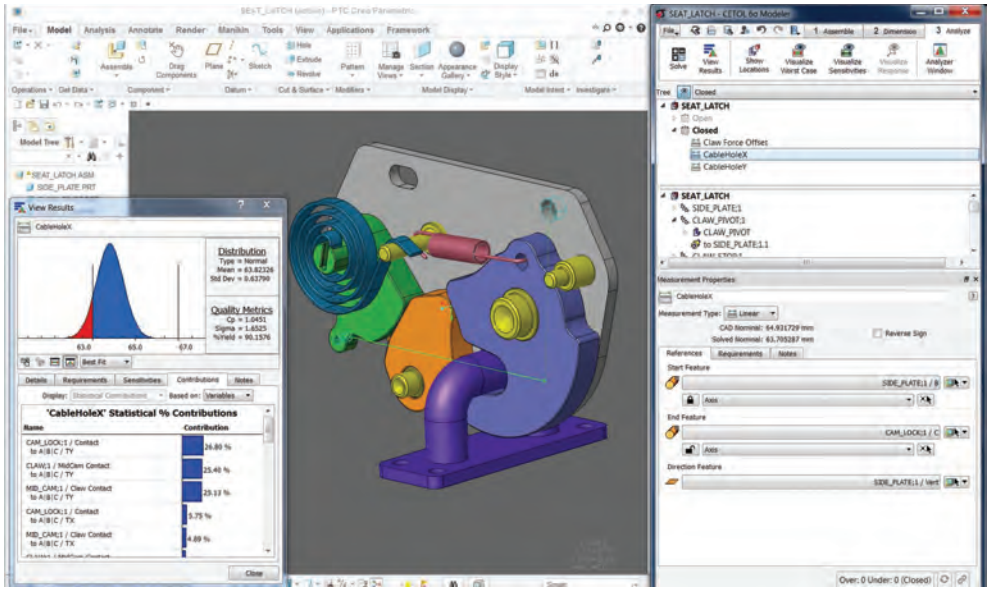
Plano, TX 75024 | +1 (972) 987 3000
http://www.siemens.com/simcenter

# Achieving faster time to market with advanced tolerance analysis software



With the ever-increasing need to produce better products more quickly and at a lower cost, product design teams demand innovative simulation technologies to understand how a product will perform in before parts are made. The Computer-Aided Engineering industry is therefore one of the fastest going segments, but these tools also fall under the same scrutiny – they must be fast and easy to use. Engineers can't wait days or even weeks for analyses to be performed before receiving the information they need. For example, tolerance analyses can provide valuable information about the probability of having designs that work using existing manufacturing capabilities as well as help evaluate different design options. But as tasks typically performed near the end of the design cycle with the aid of spreadsheets, their value is too limiting.

Sigmetrix, a company dedicated to helping customers produce better products through mechanical variation management, offers software tools that work directly with the design models, including embedded tolerance data when available, to provide design teams necessary information early in the design process. Sigmetrix has emphasized speed and ease-of-use in their tools, and they supplement them with a strong portfolio of training courses in both concepts and software, ensuring their customers have what they need to use them effectively. In the space of mechanical variation management, their training and software solutions span from addressing the most basic designs to the complex.

Their approach is working. When Hilliard Corporation identified shortcomings and inefficiencies of their traditional methods for managing variation – spreadsheets manually populated from drawings, they used CETOL 6σ to evaluate a legacy field issue caused by complex angular tolerances not captured by their traditional approach. Their conclusion? Not only did the software identify the problem much more quickly, but had it been used during development, the problem would have never occurred.

**Sigmetrix**
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CAE simulation engineers are facing increased pressure to perform higher fidelity simulations, using additional physics, for faster decision making in an ever-shrinking design cycle. These trends have increased the interest in adopting High Performance Computing (HPC) to help reduce the simulation run time and enable more complex simulations to be performed.

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# GPUs Give **Simulation** and **Analysis** a Turbo Boost

More CAD, CAE vendors decide to leverage GPUs in product offerings.

**BY RANDALL S. NEWTON**

When Ansys developed Discovery Live for real-time early design exploration, it brought together three separate technologies. The first was SpaceClaim, a direct editing CAD tool used for faster 3D modeling. Next, it borrowed heavily from its portfolio finite element analysis (FEA) and computational fluid dynamics (CFD) solutions. Finally, it wrote new code to capitalize on the observation that graphics processing unit (GPU)-based computation was increasing in speed at a much faster rate than CPU computation.

"Five years ago we were noticing Moore's law was declining on CPUs but accelerating on GPUs," says Mark Hindsbo, vice president and general manager for the Design Business Unit at Ansys. "We got a speed boost of up to 1000x on our algorithms," when they integrated GPU support into the Ansys Discovery Live prototype. "It allowed a real-time paradigm" for simulation as part of the initial design exploration.

"Whenever customers experience a real-time simulation for the first time they scarcely believe it is real," adds Greg Brown, product management fellow at PTC. "But they dig in and see it has actually solved the problem they are used to waiting minutes or more for."

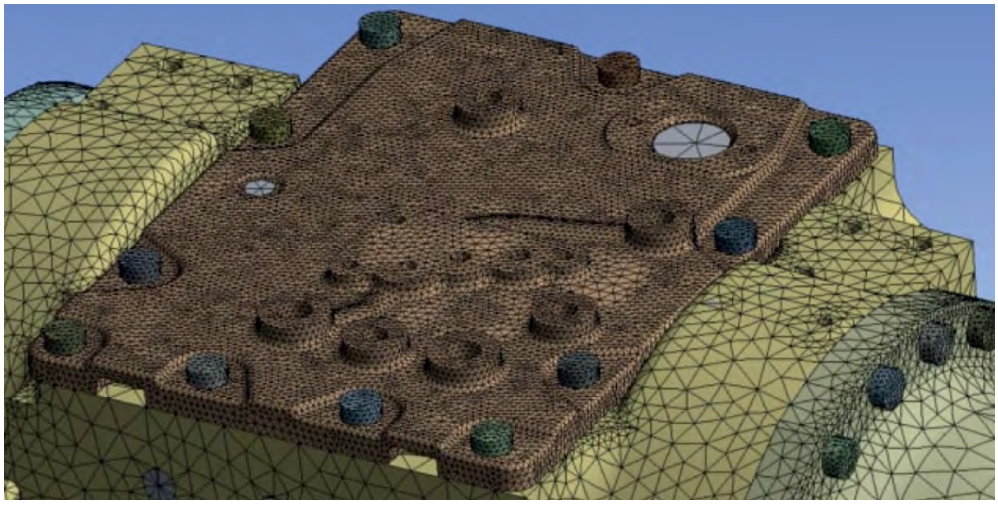
Ansys Discovery Live was a breakthrough for the industry when it first shipped in 2017. Today various simulation and analysis products from several vendors support the use of GPU technology. PTC, for example, sells a version of Discovery Live and has also adapted parts of its existing CAE portfolio to take advantage of GPU acceleration. The switch is breaking down the traditional analysis workflow of one model analysis at a time.

"Now we have an iterative approach, where one question leads to another," notes Hindsbo.

The GPU was originally designed to provide a performance boost for technical software. In the days of the PC, there were a wide variety of graphics cards, some of which only worked in monochrome. Each graphics card required a unique software driver for each software product it worked with.

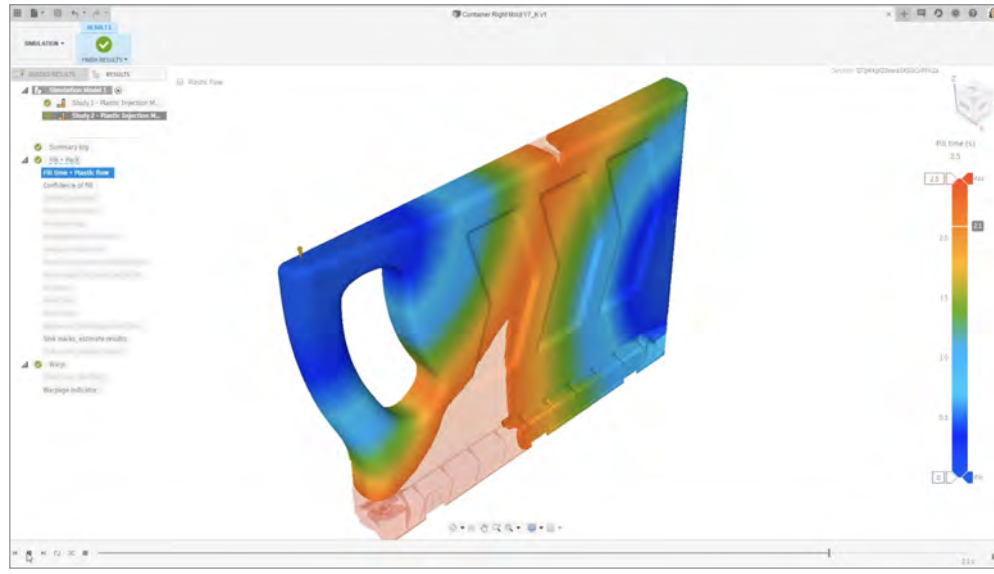
When the industry standardized on Windows as the de facto operating system, hardware companies were free to focus on performance. NVIDIA and AMD became the two main survivors of an industry shakeout.

As the market consolidated, GPU vendors started adding end-user programmability. When NVIDIA held its first



**The more compute power available to an engineer, the less need there is for defeaturing, or the practice of simplifying or removing elements of a model from the simulation.** *Image courtesy of Ansys.*

developers conference, there were presentations from a wide range of scientific, technical and entertainment domains, all focused on the ability to run graphics-intensive applications faster. But for the past three years, NVIDIA developer conferences have been dominated by applications for artificial intelligence (AI), machine learning use cases and advanced simulation and analysis, where fast graphics are only one part of the benefit.



**The use of both local and cloud-based GPUs help Autodesk Fusion 360 run common simulations with near real-time results.** *Image courtesy of Autodesk.*

Today, GPUs contribute far more than visualization and rendering capabilities. Though CAD engines are based on single-threaded serial processing, most CAD vendors are finding ways to use GPU power to improve overall performance.

"Naturally, graphics and visualization is the area where users will benefit from having a GPU—large model rendering is greatly enhanced," says PTC's Brown. "Today it is safe to say GPU-enabled solvers have opened the door to real-time simulation."

Not all simulations can be formulated to fully leverage a GPU-based process, Brown notes. But with the rise of voxel-based solvers, "suddenly real-time, or at least 'interactive time' is within reach."

Brown says his work laptop, equipped with an NVIDIA RTX 2080 is able to "power generative designs that are basically interactive. I can easily watch the progression and make necessary adjustments to get the desired outcome. Compared to the hardware and software of just 10 years ago this is a quantum leap forward."

GPUs provide an outlet for algorithms to run orders of magnitude faster in some cases, but they can only do this with the right kinds of problems.

"[These are] things that are 'data parallel' as opposed to 'task parallel,'" Brown says. "If things are inherently sequential then GPUs offer little or no benefit over a CPU." He says a "few specific operations" in PTC Creo are currently multi-threaded, "but this typically leverages a relatively small number of threads, which can be executed using multi-core CPUs rather than the massive parallel capabilities of a GPU."

PTC's Onshape, the first pure-cloud CAD solution, renders the screen using WebGL, which can use the GPU.

"Certainly there are other areas of research we are actively pursuing, and we do expect there will be more areas of our products that get the GPU treatment," Brown adds.

## A One-Two Punch

Today's GPUs offer fast parallel calculation and an abundance of memory. Sometimes the memory boost is as important as the thousands of small processor cores. This one-two punch will serve GPUs well as computation becomes even more distributed.

"I'm a big believer [that] computing will be on the edge and in the cloud," notes Ansys' Hindsbo. To not be perceived as slow, distributed systems must have response times of 50 ms or less. "It is hard to go back and forth to a data center in less than 50 ms," says Hindsbo. "A high-speed train or a self-driving car needs to answer the bell to 'Shall I brake?' in real time. To make decisions faster than 200 ms becomes tough with a cloud-based approach."

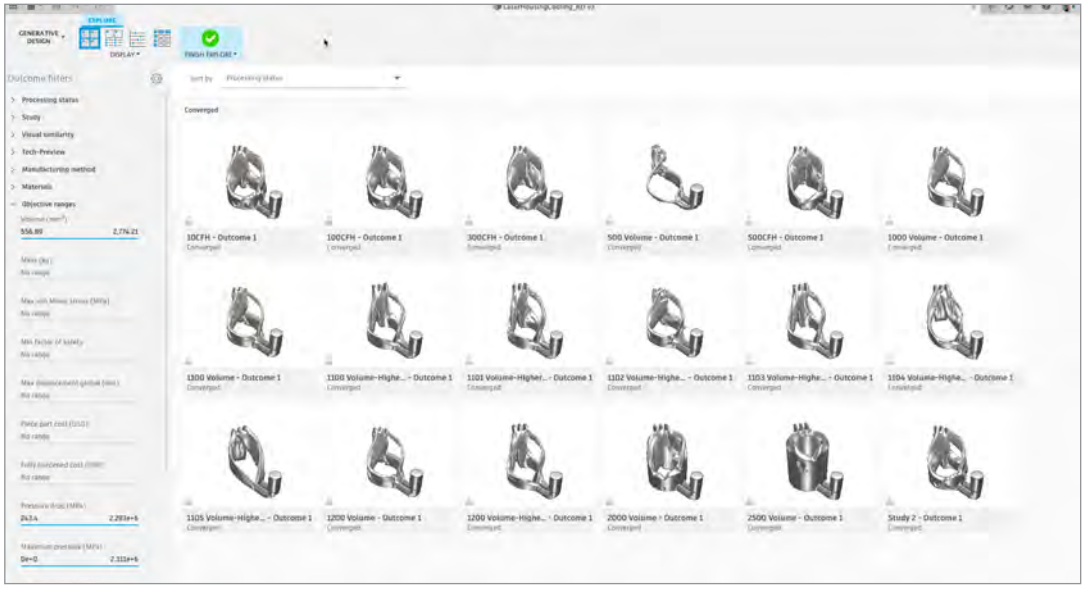
CAD vendors are increasingly taking advantage of artificial intelligence code alongside traditional deterministic code, Hindsbo notes.

"An AI algorithm will use the CPU to set up a specific simulation," and the GPU runs the problem.

One unexpected benefit of using GPUs for engineering analysis is the cost of running the software. It is common for CAE products to charge for usage based on how many CPUs are running the software.

"They charge by the CPU core but not on the GPU, so from a licensing perspective it is a free speed boost," notes Rod Mach, principal at TotalCAE, an IT consulting service that specializes in engineering applications. "So our customers use GPU for speed-up without a licensing penalty on their very large models."

"Not every model or application will benefit" from moving the computation to GPUs, adds Mach. "But it is definitely becoming more common in the implicit realm." Dassault Systèmes Abaqus, for example, "needs a teraflop and



Some software vendors have added generative design algorithms to their CAE software. The highly iterative process is an ideal use for GPU computation. *Image courtesy of Autodesk.*

several million degrees of freedom before it is worthwhile to pack up the problem for the GPU."

TotalCAE runs high-performance computing (HPC) clusters for some clients, and also uses cloud services as needed. But even single-workstation simulation runs can benefit from the GPU boost. "If you only have a few cores—eight or less—adding GPU is a turbo boost," notes Mach. "It will make a difference on smaller jobs. Every hour counts."

Autodesk is using GPU compute in the cloud for its generative design functionality in Fusion 360. "Generative design is a high-compute workload," says Brian Frank, a senior product manager at Autodesk. "To make it efficient—for both the customer and for Autodesk—we use a large-scale computer."

When Fusion 360 sends a job to the cloud it can be either CPU-only or take advantage of GPUs. "When using GPUs, we are talking about a 30 percent to 50 percent speed-up per outcome," says Frank. "Scale that across hundreds of outcomes, and it is a really significant difference. It is the difference between a couple of hours per outcome versus days" for non-GPU compute outcomes.

## Democratization Dividend

Frank says Autodesk customers appreciate the democratization effect GPU use has on simulation, which provides access to large-scale compute resources in affordable small segments.

"Leveraging the power of the GPU is really freeing," Frank says. "We get to match the right technology to the job. We don't have to wait for our customers to purchase the latest hardware. Instead of only 5 percent of our customers having high-end resources, they all have access to it." Whether the user is on an older Mac or Windows computer, a tablet or the latest workstation, "they still get the benefit" of GPUs in the cloud.

Frank says Autodesk is working to extend the value of GPU-based analysis beyond generative design, which is a FEA problem.

"We are working on a new electronics cooling module leveraging the GPU," as well as other analysis problems that lend themselves to the kind of heavy parallel computation best suited to GPUs, Frank explains.

Looking ahead, software vendors know demand for GPU-based analysis will continue to grow. The question becomes where to focus development efforts.

"Some apps need it more than others," says Hindsbo. "It might be in some cases that we write for both GPU and CPU. A fluid algorithm might work better in the GPU, while a related set of algorithms for turbulence work better on a CPU. One can accelerate the other." DE

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**MORE INFO**

- **Ansys:** Ansys.com
- **Autodesk:** Autodesk.com
- **PTC:** PTC.com
- **TotalCAE:** TotalCAE.com

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

# Digital Twins Coming Into Focus

Augmented and virtual reality can help users better understand complex digital twin data.

**BY TOM KEVAN**

Digital twin technology conjures up visions of many benefits, promising dramatic improvements in the design, manufacture and maintenance of products and processes. Look closer, factor in the impact of the Internet of Things (IoT) and the increasing complexity of assets, and you begin to realize that twin innovation brings a new set of challenges.

Ironically, these challenges are based as much on human shortcomings as they are on technical issues.

The problem lies at the core of a digital twin. These virtual replicas are by definition vessels that hold huge amounts of data, enough at least to represent a complete record of an asset. To complicate things further, this record must be constantly updated to ensure real-time accuracy throughout the asset's lifecycle. All this translates into mountains of data, even after artificial intelligence (AI) data filters out data of little value.

Here's the rub: How do you present data in such a way that users can easily digest and understand large amounts of complex data that come into play with digital twins? Increasingly, the engineering community's answer is: virtual reality (VR) and augmented reality (AR).

## Context Complications and Opportunities

Most technologists would agree that VR has the potential to enhance the use of digital twins (Fig. 1), but this doesn't open the door for blanket implementation of VR technology. Certain elements must come into play before the visualization technology delivers its full value.

One factor is context. In this case, context represents the combination of digital twin configurations and operating conditions in which the asset must operate. For example, a configuration element might be the viscosity of the gear box oil in a wind turbine. Operating conditions, on the other hand, might be ambient temperature, terrain or wind conditions.

Context is important in digital twin projects because it introduces a level of variability that can complicate design or design refinement processes. The variability springs from the fact that a digital twin's configuration can vary significantly depending on the operating conditions.

"You can have two 'like' assets, right next to each other, each having its own unique configuration and product data history," says Jason Kasper, product marketing manager at Aras.

This variability precludes using a one-size-fits-all design approach. For most VR use cases, the designer wants the exact representation of conditions in the field, in its environment. The greater the fidelity, the greater the accuracy and the greater the design efficiency. As fidelity decreases, VR's value declines.

**Fig. 1: The sensory nature of VR takes design reviews to an experiential dimension. These immersive, interactive environments have a cognitive and emotional aspect that helps users more easily digest the complex data that makes up the digital replicas.** *Image courtesy of Siemens Digital Industries Software.*

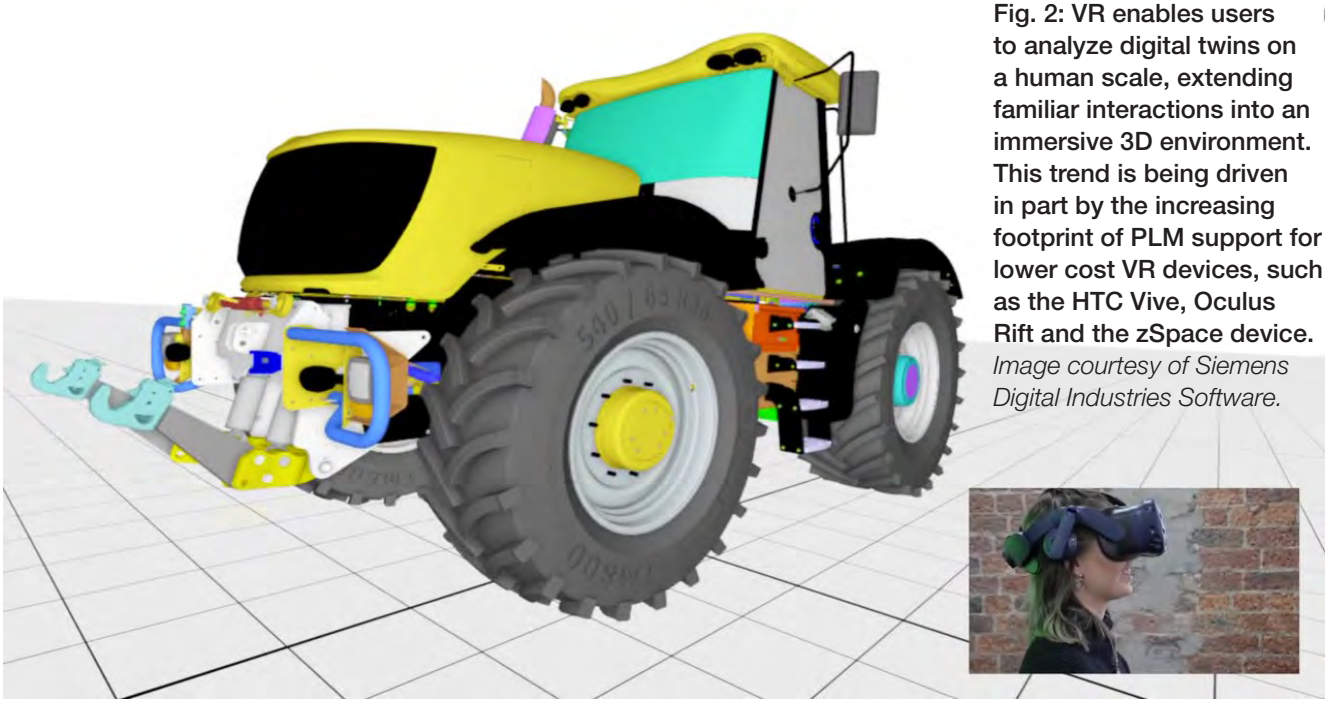

**Fig. 2: VR enables users to analyze digital twins on a human scale, extending familiar interactions into an immersive 3D environment. This trend is being driven in part by the increasing footprint of PLM support for lower cost VR devices, such as the HTC Vive, Oculus Rift and the zSpace device.** *Image courtesy of Siemens Digital Industries Software.*

As a result, the designer must include all relevant product data for each asset configuration. Skip this process, and the development team is exploring a conceptual model, not the reality in the field.

On the plus side, the same variability created by context also presents designers with an opportunity to leverage one of VR's strengths to make significant improvements to design efficiency. For instance, VR-assisted design evaluation moves the process from a flat screen to a virtual 3D environment, which overcomes distortions and limitations of 2D screens and allowing the engineers to more intuitively evaluate the asset's design.

VR also allows design evaluations to transcend certain physical limitations. With a slight change on the controller, a designer can alter the asset's material, texture, color and parts to review the impact of design changes. The virtual asset can also be placed in any given environment or time to evaluate the effects of the operating conditions.

All this speeds up the evaluation process—where the real costs and time-consuming tasks are— and allow design teams to simultaneously bring dozens of design proposals into the VR environment, review them in any arrangement or from any orientation, and weigh the impact of each configuration or design change early on.

## A New Digital Twin Perspective

Part of the enhanced efficiency brought by VR to digital twin springs from the fundamental nature of the visualization technology. In VR's immersive environment, engineers can view and analyze the twin, at scale, engaging human sensory perception—such as touch, spatial awareness and depth perception—which is often impossible in a 2D environment.

Through interactive simulations, based on real proportions and body measurements, more effective products can be created. Further, VR can ensure easier maintenance using a haptics interface, navigation and manipulation through interactive touch.

These features allow design teams to assess ergonomic factors such as sight lines, reachability and clearances, resolving design conflicts earlier in the asset's lifecycle. They also make traditional design processes such as digital mockup functions—such as interference and clearance analyses, sectioning and positioning—more intuitive.

"There are processes that significantly benefit from a VR experience, such as being able to mount or dismount components, where you can use a controller to pick up a part and get haptic feedback when the part touches another one," says Kilian Knoll, product manager for Teamcenter Visualization, Siemens Digital Industries Software. "So, we are combining the strengths of VR input devices with a real-time collision and path planning capability, which allows the user to get their job done faster."

VR also enables a personal connection to data. The immersive paradigm has a cognitive and emotional aspect to it that is not experienced by looking at digital twin representations on a flat screen. When a user is volumetrically surrounded by data, it provides a level of correlation to the digital twin that is intuitive (Fig. 2).

## Making Design Experiential

All these factors help the engineer to overcome one of the greatest challenges encountered in the design process: clearly conveying an idea when relying on models and drawings. Even with today's 3D renderings, non-designer stakeholders often find it difficult to grasp all of a design's components and implications.

Using an immersive VR environment, both designer and client can experience walking around a space, viewing


**Fig. 3: AR helps engineers and service technicians more efficiently install, maintain and repair machinery by overlaying up-to-date, contextually relevant information on real-time images of the actual equipment. AR visualizations can be viewed on commercial mobile devices and hands-free headsets.** *Image courtesy of PTC.*

details from any angle and understanding its composition. The immersive technology builds common ground that facilitates better understanding of the issues that arise during the design, development and redesign processes.

"Combining the extended realities with other forms of digital and physical assessments results in experiential problem-solving," says Elizabeth Baron, enterprise solutions executive at Unity Technologies. "Because immersion is a holistic paradigm, as the digital twin is as well, a user can represent a problem from many points of view. Immersion brings things to a common understanding of the product."

## Making Digital Twins More Collaborative

VR's experiential nature points to two of the visualization technology's greatest strengths: enabling new levels of collaboration and facilitating easier understanding of complex design data.

At its core, immersive VR is a social paradigm that functions on a global scale. The technology allows users to amplify meaningful communications and create scalable, connected spaces, where all users, regardless of their location, can relate and evaluate digital twins.

"When a cross-functional, globally connected team meets in an immersive environment, it creates a forum where every discipline is properly represented in context, and complex stories are told amongst the multidisciplinary teams," says Baron.

This is seen when VR is used to perform design reviews. Here, stakeholders of varied disciplines, using a common data set, can visualize, analyze and mark up the twin-based designs. Some platforms even save the data created during VR design reviews back to the design structure, including markups and annotations, making the data visible to all stakeholders.

"Performing virtual design reviews in real time is a key enabler," says Siemen's Knoll. "Supporting virtual conferences reduces ambiguity and speeds up the decision-making process significantly. As an example, pointing to an issue in real time and redlining it is like a whiteboard on steroids."

## Cutting Collaboration Costs

To maximize the technology's benefit for digital twin users, VR platforms should work with low-cost, mainstream VR devices, such as Oculus Rift and HTC Vive. This trend has been driven by the cost reductions witnessed by the market over the past couple of years.

"One of the barriers to adoption has been significantly lowered by the price reductions," says Knoll. "For example, a Cave that used to cost up to a six-digit investment with dedicated rooms and custom hardware can now be replaced with low-cost VR headsets, controllers and trackers that can be purchased online."

Some product lifecycle management (PLM) based VR platforms extend collaboration services to users who do not have access to specialized VR hardware. This allows desktop users to see the avatars of immersed conference participants.

"Bringing multiple data sources into context that can be experienced on any platform is the hallmark of a successful deployment of digital twin," says Baron. "It is important, therefore, that all platforms are supported."

## AR—Right Data at the Right Time

In addition to enhancing digital twin applications with VR technology, today's engineers can also avail themselves of another visualization technology—AR. Unlike VR, which completely immerses the user in a computer-generated reality, AR overlays contextually relevant images, text and other digital information over real-world images.

Distinctly different from its virtual cousin, AR brings its own benefits to digital twin applications and carves out a unique set of use cases. Engineers can use AR to overlay the digital twin of a piece of equipment to visualize the machine's inner workings and understand its data flows; to assist technicians deploying or maintaining the system; or to help automation engineers see how a piece of equipment best fits in a manufacturing workflow (Fig. 3).

AR capabilities help users better digest digital twin information, leveraging its ability to contextualize information. In this case, context means showing the right amount of information, for the right job and right skill set, empowering users


**Fig. 4: In this example of AR, the yellow circle and the hands represent the user and how their device will visualize the digital twin—in this case on a tablet. The popout window appearing on the right side of the screen (Engine Pre-heater Torque Screws) visualizes the workflow initiated when a user selects the wrench icon (top of the screen). The popout window shows the four screws, with directions indicating which way to turn the drill to tighten the screws.** *Image courtesy of PTC.*

to make the most appropriate decisions because they have everything they need, when they need it (Fig. 4).

"Historically, technicians were required to flip through a 1,000-page manual while conducting very complicated repairs," says Marc Schuetz, vice president of augmented reality product management at PTC. "With the emergence and adoption of AR, technicians can now leverage the digital twin in an easier way to visually walk them through any potential repairs. Being able to overlay such information provides the context to help technicians understand why the repair is necessary and how to perform it fast and safe."

AR promises to enable design and development teams to transcend diverse differences of expertise and functional concerns. This translates into making data more accessible to all stakeholders.

"AR gives stakeholders across all disciplines greater access to digital twin data," says Schuetz. "While previously someone could have gone back to their desk to look something up or review a manual, now using the devices they already have on them, they can access the right guidance, based on the context of what they're looking to accomplish. The ease of getting the right information, in the right way, for the right context results in the data being more accessible to users."

## Moving Forward

Though the convergence of digital twin, AR and VR is still in the early days of the evolution, signs do point to a path the trend will follow.

Visualization and PLM tools supporting digital twin appear to be evolving from stand-alone platforms to interconnected suites of tools. The complete representation of an asset required by digital twin, consisting of multiple data sources available at any time, requires an integration of technologies for communication and content distribution.

"Data visualizations with CAD tools or AR or VR systems do not inherently need to be distinctly different from the user's standpoint," says Baron. "The goal is to have the digital twin process deliver the visualization platform requested by the user. This would realize efficiency improvements in having a single source of truth in data to resolve system-to-system interfaces for product and process issues."

The need for data integrity will play a leading role in shaping the architectures of digital twin-visualization suites.

"Integrating PLM with other software tools helps to ensure all around data integrity, allowing for the correct view of the digital twin and ensuring all stakeholders can participate in the product lifecycle," says Knoll. "We are seeing a significant uptick of customers extending the usage of VR with desktop applications tightly integrated to the PLM system, as well as establishing processes that allow the use of AR driven by the PLM system." DE

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**➜ MORE INFO**

- **Aras:** Aras.com
- **PTC:** PTC.com
- **Siemens Digital Industries Software:** SW.Siemens.com
- **Unity Technologies:** Unity.com

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

# A **Winning** Partnership

Team Penske and Stratasys collaborate to make racecar design and manufacturing faster, safer and more economical.

**BY KIP HANSON**

In 2017, motorsports champion Team Penske joined forces with 3D printing solution provider Stratasys. The companies entered into a formal agreement in which the race car builder would use Stratasys equipment to produce tooling and end-use components, and Stratasys would provide them with the design, application and product support. The partnership is still profitable and rewarding for those involved.

They renewed that three-year agreement earlier this year, although they withheld the news due to the 2020 racing season's pandemic-related delay.

"Nobody was racing," says Patrick Stewart, marketing services manager at Team Penske. "I suppose we could have announced it along with the launch of virtual racing, but all of us wanted to see real cars on real tracks before breaking the news. We're delighted to announce it now."

Team Penske already had extensive manufacturing capabilities at its Mooresville, NC, headquarters, such as state-of-the-art machine tools, welders, and fabricating equipment. Starting with a large-format F900 fused deposition modeling (FDM) and J750 PolyJet printer, followed by a Fortus 450mc production system and "plug-and-play" F370, they've taken their capabilities over the top in terms of design speed and flexibility.

## Keeping Cool

One example of its manufacturing capabilities comes from an event at the Indianapolis Motor Speedway, where summer temperatures combined with a new protective device raised concerns over driver comfort, and ironically, their safety. That's according to Team Penske production manager Matt Gimbel, who explains that the Aeroscreen was designed to shield drivers from road debris and other flying objects.

It was a great idea, except for one problem: The unexpected rise in temperature within an Aeroscreen-equipped cockpit; temperatures high enough to cause heat exhaustion, as seen during the July 4th IndyCar event.

"No one was arguing over the Aeroscreen's value, but we had to do something about the excess heat, especially with the Iowa 250s coming up later that month," says Gimbel.

Designers at Team Penske worked with team members from Arrow McLaren SP, Andretti Autosport and IndyCar, and quickly developed a cooling duct that would channel air to the driver's cockpit. The problem was then how to manufacture these ducts with less than one week until the next race. Knowing that 3D printing was the only viable solution, Team Penske reached out to IndyCar, who tapped Stratasys for help.

"We received the final design the Saturday before the race, and everyone was scheduled to be in Iowa that upcoming Thursday," says Pat Carey, senior vice president of the Americas at Stratasys. "We had to jam pretty hard, but once we validated the build process, we just reached out to a few of our internal departments for help. Between their printers and the available capacity at our sister company, Stratasys Direct, we were able to make


**The Fortus 450mc 3D printer is designed for FDM Nylon 12CF (carbon fiber), ULTEM, PEKK-based Antero and other high-performance materials, according to Stratasys.** *Images courtesy of Stratasys.*

Shown here: the 3D-printed ductwork assembly that helps keep the drivers of Aeroscreen-equipped racecars cool.


Ready access to a 3D printer such as the Stratasys F370 helps streamline the design process and shorten development cycles.

24 cooling ducts, enough for all of the teams competing that weekend. It was fun to see it all come together so quickly. Best of all, Team Penske won both races."

## The Biggest Fan

The design challenge was fun, but not unexpected.

"That's the great thing about additive," Gimbel notes. "If we'd had to make the ducts via traditional methods, it would have taken at least two weeks, probably much more, not to mention the tooling costs and lack of design freedom. 3D printing just lets you get to the finished product more quickly. Because of this capability, it's become an integral part of our design and manufacturing processes."

Stewart agrees, and having worked for six years in Team Penske's IndyCar pit crew, has firsthand experience with the opportunities that 3D printing presents.

"When it comes to working on the car, whether in the shop or at the track, there are big differences in the equipment each team uses," he says. "You can stand at the end of the pit and see who has the best solutions; in our case, these are often designed and 3D-printed in-house."

This could be something as simple as a fan to cool the brakes down during practice sessions, Stewart adds, shaking his head at some of the homegrown solutions he's seen over the years.

"Some teams will use corrugated tubing that's been duct-taped to a leaf blower," Stewart says. "It sounds crazy, I know, but finding a more effective way to accomplish simple things like that can make the difference between winning and losing."

To address this particular problem, Team Penske 3D-printed a special fan that quickly reduces brake temperature by 30 degrees Fahrenheit or more compared to the competition. They also made a carbon fiber fuel handle using 3D-printed tooling that allows the pit crew to more easily fill the racecar; a handle made to Stewart's exacting specifications.

"Not only did it look sexy, but it was the lightest, most ergonomic handle I've ever used," Stewart laughs. "We even embedded it with timing lights."

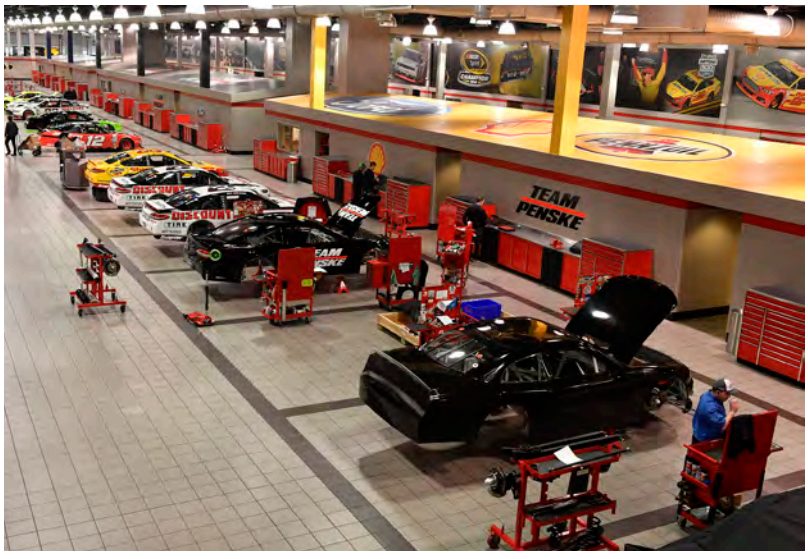
## Perusing Polymers

Carbon fiber-reinforced material might be a game changer, but it's not the only one. Between their four 3D printing platforms, Team Penske designers have access to dozens of engineering-grade polymers, the FDM Nylon 12CF (carbon fiber) among them.

These include acrylonitrile styrene acrylate (ASA), polycarbonate (PC), acrylonitrile butadiene styrene (ABS), ULTEM and thermoplastic polyurethane (TPU 92A), a flexible, rubber-like material "good for making bellows and boots," says Gimbel.

"TPU is a great material," he adds. "So is Diran, a tough, Nylon-based thermoplastic specific to Stratasys 3D printers. We just started playing with that one fairly recently and find that it's excellent for use in jigs and fixtures. You can bang on it all day long and you won't leave a mark."

There's also ST-130, a soluble designed for sacrificial tooling like that used to produce tanks, ductwork and shrouds. Such tooling is a critical component of racecar man-




A bird's-eye view of the shop floor at Team Penske's Mooresville, NC, headquarters.

ufacturing, Gimbel notes, and the team that builds it most quickly and cost-effectively is best equipped to bring home the championship.

Here again, 3D printing provides Team Penske with a competitive edge; where it might take weeks or even months to machine a mold for the bellows or tanks just described, Gimbel and his crew can often 3D print one overnight.

## Speed Isn't Everything

"The rate at which we can iterate different designs has made a big difference in the way we do things, especially when you talk about PolyJet," Gimbel says. "When we first got it, the engineering department was blown away by how fast we were turning parts around. Between that and the different material options, it gives us capabilities we didn't have before."

Stewart agrees. "Having the Stratasys equipment on-site greatly speeds up the development process," he says. "It means we don't have to rely on outside resources for anything. More importantly, it allows you to do four or five iterations in the time it would normally take to do just one. This can make the difference between a winning design and one that's not."


With a build envelope measuring nearly 1 cubic yard, the Stratasys F900 ranks as one of the largest high-performance FDM printers available.

These benefits came at a cost, however. Both Team Penske members note the learning curve that comes with 3D printing, but were quick to point out that the partnership with Stratasys eased this particular pain significantly. So did the company's GrabCAD Print software, which is said to guide the user through the build process via an obstacle-free workflow. It also simplifies machine monitoring, and allows operators to check in on print jobs from anywhere with internet access.

"GrabCAD Print runs across all of our printers and played a role in our ability to turn around the Aeroscreen ducts so quickly," says Stratasys' Carey. "It has numerous functions that make common 3D printing tasks easier, features like geometry optimization, color matching and automatic support generation. There are also several advanced tooling controls that let an engineer build up around a boss, for example, or fill in certain areas with a mesh structure for weight reduction, something that's obviously critical to racing vehicles."

For the members of Team Penske, the ready access to Stratasys' 3D printing technology boils down to one thing: continuous improvement.

"It means iterating faster, producing more design options and figuring out which one's going to work best, and that means getting to the racetrack with our latest and greatest designs," he says. "If we can do all that more quickly than the competition, then we're going to win the race. That's what 3D printing does for us." DE

**Kip Hanson** *writes about all things manufacturing. You can reach him at kip@kahmco.net*

**MORE INFO**

- **Stratasys:** Stratasys.com
- **Team Penske:** TeamPenske.com

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

# A Perfect Portable: MSI WS66 10TMT-207 Mobile Workstation

MSI continues to prove it is serious about CAD.

**BY DAVID COHN**

MSI recently launched its next generation of mobile workstations and it delivered one to us for a hands-on evaluation. It has been more than a year since we last reviewed a mobile workstation from the Taiwan-based company (*DE*, October 2019; digitalengineering247.com/r/23448), we have reviewed other MSI-built systems branded by other system integrators, notably the GoBOXX SLM 17 (a rebranded MSI WS75).

Why get excited about a new system from MSI? MSI has proven over the past several years that it was very serious about the CAD industry. Before the pandemic shut things down, MSI had a significant presence at most conferences and tradeshows.

It also joined the ranks of companies like Dell, HP and Lenovo in securing independent software vendor (ISV) certification from Autodesk, Siemens, Ansys and Dassault Systèmes, which ensures that the hardware and software are fully stable and compatible for a professional experience. MSI was also the first company to ship a mobile workstation that included an NVIDIA Quadro RTX graphics board.

Outwardly, the new MSI WS66 mobile workstation is similar to the WS65, but it is a fraction larger and no longer sports bronze accents. The WS66 comes housed in a very attractive brushed black aluminum case measuring 14.17x9.75x0.96-in. (WxDxH) and weighs 4.97 lbs.

Fig. 1: The new, powerful MSI WS66 10TMT-207 15.6-in. mobile workstation is equipped with the NVIDIA Quadro RTX 5000 GPU.

MSI sells four WS66 configurations. We received the top-of-the-line WS66 10TMT-207, which included an NVIDIA Quadro RTX 5000 graphics processing unit (GPU). Systems incorporating that or the RTX 4000 GPU come with a 230-watt power supply (6.06x2.87x1.12-in.), adding an additional 1.95 lbs. Models equipped with an RTX 3000 graphic board come with a 180-watt power supply. Interestingly, the power supply we received was the same Chicony part included with the recently reviewed Eurocom Nightsky ARX15.

## Four Variations

Unlike many other OEMs, MSI does not offer custom configurations. Instead, the company sells preconfigured systems based on specific component combinations. There are currently four configurations for the WS66, all based on various models of eight-core Intel 10th-generation Comet Lake CPUs.

All four MSI WS66 systems use an MH470 chipset, feature a 15.6-in. 1920x1080 touch-enabled display capable of reproducing 72% of the NTSC gamut that in turn is powered by an NVIDIA Quadro RTX graphics board, and include an 84-key backlit keyboard, a 1TB M.2 NVMe solid-state drive (SSD), Wi-Fi and Bluetooth, an SD card reader, an IR 720p HD webcam and a four-cell 99.9Whr lithium-ion battery. All four WS66 models are virtual reality (VR) ready, with the only differences being the specific CPU, GPU and the amount of memory.

At $2,499, the least expensive configuration (the WS66 10TKT-080) includes a 2.3GHz Intel Core i7-10875H CPU, an NVIDIA Quadro RTX 3000 GPU with 6GB of discrete graphics memory and 32GB of RAM. Next in the lineup is the

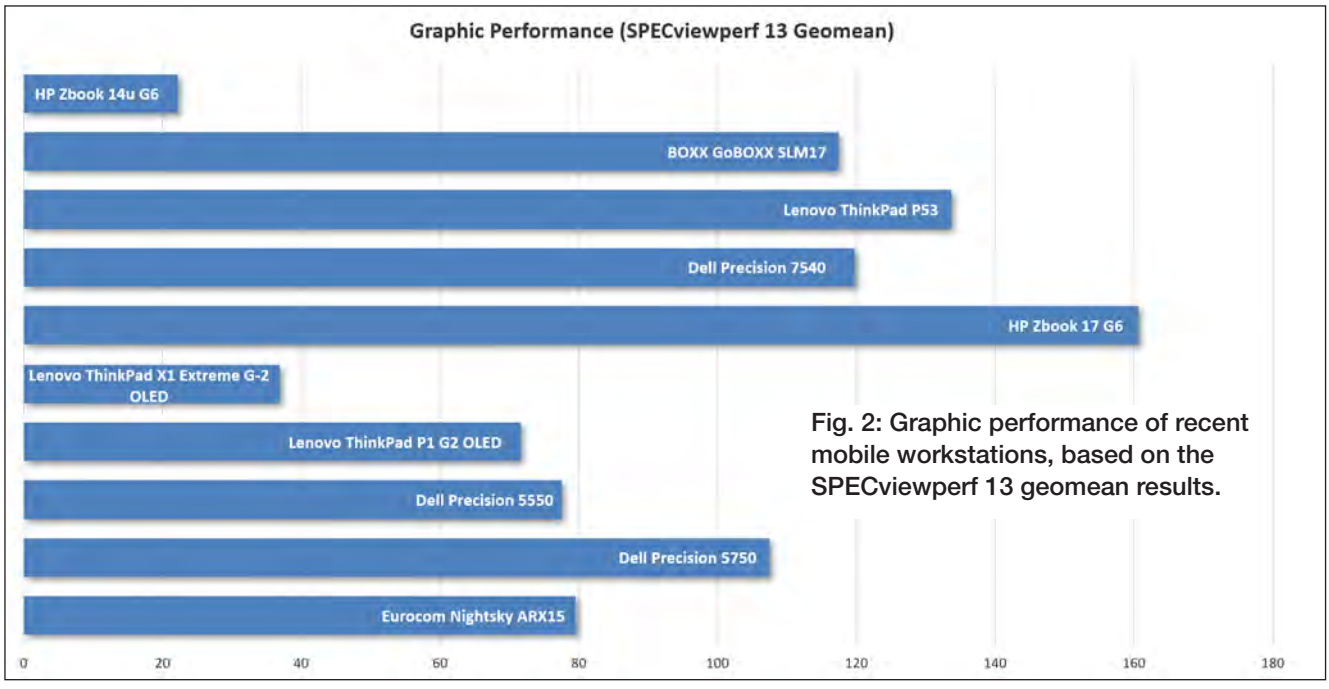



Fig. 2: Graphic performance of recent mobile workstations, based on the SPECviewperf 13 geomean results.

WS66 10TKT-081 ($2,999), which uses a 2.4GHz Intel Core i9-10980HK CPU, an RTX 3000 and it comes with 64GB of memory. The WS66 10TLT-079 ($3,299) is based on the Core i7-10875H processor but includes an NVIDIA Quadro RTX 4000 GPU with 8GB of discrete memory, and 32GB of RAM.

But for our review, MSI sent us the WS66 10TMT-207, a system built around the 2.4GHz Intel Core i9-10980HK processor. This CPU has a 5.3GHz maximum turbo frequency, a 16MB cache and integrated Intel UHD graphic, while boasting a thermal design power (TDP) rating of just 65 watts.

With a suggested retail price of $3,999, our evaluation unit also included an NVIDIA Quadro RTX 5000 graphics board, a GPU with 16GB of discrete GDDR6 memory and featuring 3,072 CUDA cores, 384 Tensor cores and 48RT cores. Its 256-bit interface yields a 448 GB/second bandwidth while consuming a maximum of 110 watts.

As we have noted in previous reviews, MSI only sells its systems through authorized resellers who can set their own prices, so your cost may vary.

## Almost Enough Ports

Lifting the lid reveals the 15.6-in. display and an excellent backlit keyboard with a standard layout. The power button is actually the key in the upper-right corner of the keyboard. An LED in that key glows white when the system is powered on and using the Intel graphics and amber when the discrete NVIDIA GPU is in use. There are also small LEDs on the Caps Lock and several function keys used to control sound and other settings.

An infrared webcam is centered above the display, flanked by a pair of microphones, and can be used with Windows Hello Face to sign into the computer. A gesture-enabled 5.5x2.63-in. touchpad is centered below the spacebar. Although the touchpad lacks dedicated buttons, you can click in the lower-right corner to access right-click shortcut menus. A fingerprint reader is located in the upper-left corner of the touchpad.

MSI appears to be following the trend of reducing the number of ports on its latest system, but the WS66 still offers some features its competitors have eliminated. For example, the right side of the case provides a USB 3.2 Gen 2 Type-C port, an SD-card reader, a 3.5-mm combo audio jack, and a full-size RJ-45 network port.

Though the left side of the case includes just a single USB 3.2 Gen 2 Type-A port, it also contains a Thunderbolt (Type-C) port, an HDMI port, a connection for the AC adapter and a battery status light. There are no other ports—so you may need to factor in a hub, docking station or USB Type-C to Type-A adapter—and the system does not provide an attachment point for a security lock.

Like most modern thin, light-weight systems, the battery is not removable. But that battery managed to keep our system running for 9 hours and 50 minutes in our battery rundown test, just 40 minutes short of the record.

The MSI WS 66 10TMT-207 remained cool and quiet throughout our tests. At a maximum sound pressure of just 45dB, its internal fans were seldom audible above the 35dB ambient background level in our test lab. We measured a maximum temperature of 114°F on the bottom of the system during our tests.

## Plenty of Power

The MSI WS66 10TMT-207 mobile workstation performed flawlessly throughout our tests. On the SPECviewperf test, which is a measure of pure graphic performance, the WS66 finished a close second to the HP ZBook 17 G6, a 17-in. Xeon-based system priced more than $1,600 higher. On the SPECapc SolidWorks tests, the results were even more im-

# Mobile Workstations Compared

| | MSI WS66 10TMT 15.6-inch mobile workstation (2.4GHz Intel Core i9-10980HK 8-core CPU, NVIDIA Quadro RTX 5000, 64GB RAM, 1TB NVMe PCIe SSD) | Eurocom Nightsky ARX 15 15.6-inch mobile workstation (3.5GHz AMD Ryzen 9 3950X 16-core CPU, NVIDIA GeForce RTX 2070, 64GB RAM, 2x 4TB NVMe PCIe SSD) | Dell Precision 5750 17.3-in. mobile workstation (2.40GHz Intel Xeon W-10885M 8-core CPU, NVIDIA Quadro RTX 3000 w/Max-Q Design, 32GB RAM, 1TB NVMe PCIe SSD) | Dell Precision 5550 15.6-in. mobile workstation (2.30GHz Intel Core i7-10875H 8-core CPU, NVIDIA Quadro T2000, 32GB RAM, 1TB NVMe PCIe SSD) | Lenovo ThinkPad P1 G2 OLED 15.6-in. 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-in. mobile workstation (2.60GHz Intel Core i7-9850H 6-core CPU, NVIDIA GeForce GTX 1650, 32GB RAM, 1TGB NVMe PCIe SSD) |
|---|---|---|---|---|---|---|
| Price as tested | $3,999.00 | $8,512.00 | $5,219 | $4,355 | $3,133 | $2,794 |
| Date tested | 10/1/20 | 9/2/20 | 8/28/20 | 6/24/20 | 2/16/20 | 2/16/20 |
| 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 | 174.60 | 183.08 | 132.73 | 91.74 | 76.32 | 85.73 |
| catia-05 | 256.00 | 109.70 | 173.75 | 147.96 | 126.46 | 56.36 |
| creo-02 | 233.21 | 178.81 | 159.58 | 116.59 | 101.20 | 75.12 |
| energy-02 | 40.50 | 19.94 | 29.78 | 17.31 | 17.11 | 6.37 |
| maya-05 | 228.70 | 249.96 | 153.66 | 112.25 | 102.12 | 100.62 |
| medical-02 | 103.67 | 53.19 | 73.08 | 51.11 | 47.95 | 24.57 |
| showcase-02 | 95.62 | 101.02 | 74.54 | 43.99 | 36.50 | 36.83 |
| snx-03 | 291.91 | 15.25 | 189.01 | 144.50 | 191.81 | 11.29 |
| sw-04 | 156.49 | 87.13 | 110.18 | 100.81 | 86.57 | 53.45 |
| **SPECapc SolidWorks 2015 (higher is better)** | | | | | | |
| Graphics Composite | 5.43 | n/a | 3.82 | 3.43 | 2.81 | n/a |
| Shaded Graphics Sub-Composite | 3.36 | n/a | 1.94 | 1.77 | 1.41 | n/a |
| Shaded w/Edges Graphics Sub-Composite | 4.25 | n/a | 2.88 | 2.67 | 2.03 | n/a |
| Shaded using RealView Sub-Composite | 3.92 | n/a | 2.62 | 2.42 | 1.91 | n/a |
| Shaded w/Edges using RealView Sub-Composite | 4.69 | n/a | 3.47 | 3.28 | 2.60 | n/a |
| Shaded using RealView and Shadows Sub-Composite | 4.49 | n/a | 3.04 | 2.85 | 2.23 | n/a |
| Shaded with Edges using RealView and Shadows Graphics Sub-Composite | 4.94 | n/a | 3.67 | 3.45 | 2.76 | n/a |
| Shaded using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite | 15.06 | n/a | 9.86 | 7.51 | 6.92 | n/a |
| Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite | 14.68 | n/a | 10.68 | 8.64 | 7.79 | n/a |
| Wireframe Graphics Sub-Composite | 4.08 | n/a | 3.85 | 3.53 | 3.13 | n/a |
| CPU Composite | 7.13 | n/a | 3.55 | 3.09 | 3.19 | n/a |
| **SPEC Workstation v3 (higher is better)** | | | | | | |
| Media and Entertainment | 2.33 | 3.43 | 2.20 | 1.93 | 1.63 | 1.70 |
| Product Development | 2.38 | 1.56 | 2.29 | 2.09 | 1.62 | 1.57 |
| Life Sciences | 2.35 | 2.91 | 2.15 | 1.59 | 1.54 | 1.31 |
| Financial Services | 1.76 | 4.72 | 2.13 | 1.54 | 1.53 | 1.17 |
| Energy | 1.50 | 2.33 | 1.43 | 1.30 | 0.99 | 0.99 |
| General Operations | 2.07 | 2.15 | 1.92 | 1.96 | 1.90 | 1.84 |
| GPU Compute | 3.61 | 3.77 | 3.09 | 1.91 | 1.79 | 1.84 |
| **Time** | | | | | | |
| AutoCAD Render Test (in seconds, lower is better) | 28.70 | 27.10 | 35.60 | 38.9 | 49.00 | 44.10 |
| Battery Life (in hours:minutes, higher is better) | 9:50 | 0:55 | 10:30 | 10:22 | 7:14 | 6:45 |

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

**MORE INFO**

- **Micro-Star International:** MSI.com
- **MSI WS66 10TMT-207**

**Price:** $3,499 as tested ($2,499 base price)

**Size:** 14.17x9.75x0.96-in. (WxHxD) notebook

**Weight:** 4.97 lbs. plus 1.94-lb. 230-watt power supply

**CPU:** Eight-core 2.4GHz Intel Core i9-10980HK w/16MB Smart Cache

**Memory:** 64GB DDR4 at 2666MHz

**Graphics:** NVIDIA Quadro RTX 5000 w/16GB GDDR6 memory

**LCD:** 15.6-in. FHD (1920x1080) IPS w/touch

**Camera:** 720p RGB/Infrared webcam

**Storage:** 1TB Samsung M.2 PCIe NVMe

**Audio:** Realtec built-in speakers, combo audio jack (microphone/headphone), built-in microphone

**Network:** Intel/I225 and Intel Wi-Fi 6 AX201 plus Bluetooth 5.1

**Ports:** one USB 3.2 Gen 2 Type-A, one USB 3.2 Gen 2 Type-C, one Thunderbolt 3 (USB Type-C), HDMI, RJ-45 LAN

**Other:** SD-card reader

**Keyboard:** Integrated 83-key backlit keyboard

**Pointing device:** Integrated touchpad with fingerprint reader

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

pressive, with the MSI WS66 yielding some of the best scores we have ever recorded for a mobile workstation.

On the very demanding SPEC workstation performance benchmark, the MSI WS66 10TMT-207 also performed exceedingly well, earning top scores on both the Product Development and storage subsystem portions of the test.

On our own AutoCAD rendering test, a multi-threaded process where fast CPUs with multiple cores have a clear advantage, the 28.7-second average rendering time was just 1.6 seconds behind the record set by the Eurocom Nightsky ARX15, which was based on a much faster CPU (3.5GHz versus the MSI's 2.4GHz) with twice the number of cores.

MSI preloads Windows 10 Professional 64-bit on all of its WS66 mobile workstations and backs them with a 3-year warranty, two years longer than what now comes standard from major vendors like Dell and Lenovo.

MSI also preinstalls a free copy of its Creator Center software, which optimizes the system for use with various programs (similar to performance tuning software from Dell, HP and Lenovo). In addition to ISV certification, most MSI mobile workstations now also meet MIL-STD-810G standards.

MSI continues to prove that it is serious about being a major player in the mobile workstation market. The new MSI WS66 10TMT-207 is a great, thin, lightweight, VR-capable system that delivers amazing performance at a very attractive price point—a mobile workstation that any engineer would be proud to own. DE

**David Cohn** *is the senior content manager at 4D Technologies. He also consults and does 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.*

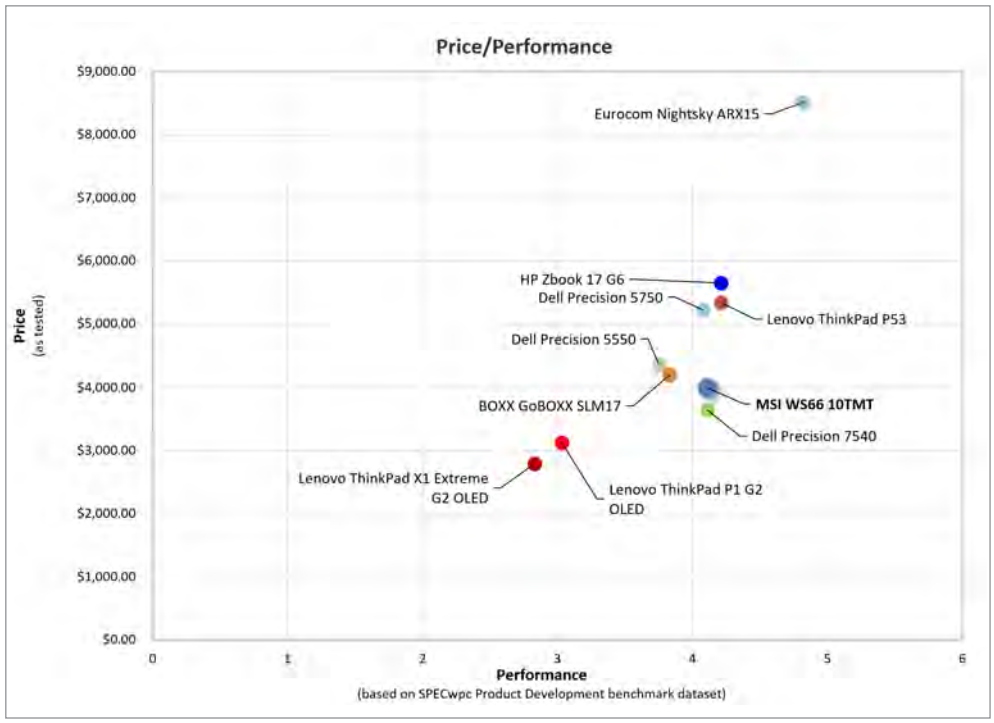


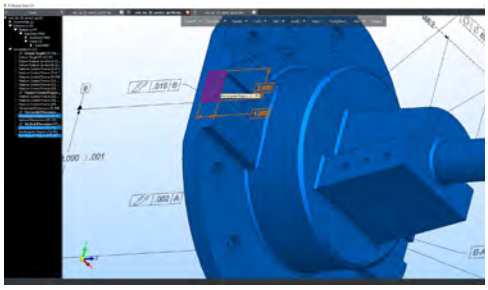

**Fig. 3: Price/performance chart of recent mobile workstations, based on SPECwpc Product Development benchmark dataset.**

# 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.*

## Improved CAD interoperability

New releases of the K-Compare and K-Display lines are now available for download.



Kubotek3D introduces the 3.0 update of K-Compare and K-Display, tools for CAD interoperability. The company says this major release provides updates to its STEP and CAD file readers, several improvements to user interface elements, and new functions specific to each product. Each product consists of two modules. There is K-Compare Revision and K-Compare Validate; K-Display View and K-Display Convert. All updated products are enhanced with support for STEP AP 242.

**MORE** ➜ digitalengineering247.com/r/24469

## Micron-resolution production 3D printing

3D printer increases build volume, speed and material capacity over older model.

Boston Micro Fabrication introduces the microArch S240, a micro-precision 3D printer suitable for industrial production. The printer is based on BMF's Projection Micro Stereolithography technology, a technique that allows for rapid photopolymerization of a layer of liquid polymer using a flash of UV light at micro-scale resolution.

The company says the microArch S240 sports a larger build volume and up to 10 times faster print speeds than its previous model.

**MORE** ➜ digitalengineering247.com/r/24447

## Explore wide-format printer line from tech leader

Series to support creative process for engineering and other graphics-based pros.

Canon USA launched its updated ColorWave and PlotWave wide-format digital printers. There are two updated ColorWave models and five updated monochromatic PlotWave models.

ColorWave models use advanced CrystalPoint digital imaging technology. PlotWave large-format printers operate with internally developed controller, print and scan technologies. A tablet-style interface is standard on all models. Both printer lines are compatible with a range of stackers and folders.

**MORE** ➜ digitalengineering247.com/r/24418

## Experience faster graphics even in 4K

This edition features a new utility when working with referenced files.

ZWSOFT introduces ZWCAD 2021, a popular drafting solution. ZWCAD 2021 sports an upgraded graphics engine. Speed, stability and display quality are not compromised even when working on a 4K monitor. The company says working with external references is faster, due to new preview and check-file features in a single panel.

Users may specify transparency of objects individually or collectively if in the same layer. ZWCAD also allows organizing viewports as layers.

**MORE** ➜ digitalengineering247.com/r/24391

# Next-Gen Engineers

Student Competition Profile: Innovate for Impact Challenge

## Sustainable Design Suited for Socially Minded Engineer

**BY JIM ROMEO**

The Innovate for Impact challenge began in February 2020 as a call to action for socially minded engineers and hardware innovators to address two United Nations sustainable development goals: zero hunger and clean water. This spirit of open innovation is at the heart of the Innovate for Impact: Siemens Design Challenge, an initiative created by Siemens, in collaboration with The American Society of Mechanical Engineers (ASME) and Engineering for Change (E4C).

Over the course of the challenge phases, participants were required to submit their project research, CAD drawings and simulation results (above). The Innovate for Impact challenge began in February of 2020 and was a call to action for socially minded engineers and hardware innovators to address two of the United Nations sustainable development goals (below). *Images courtesy of E4C.*

John Miller is the senior vice president of mainstream engineering software for Siemens Digital Industries Software. Miller worked with Iana Aranda, director of engineering global development programs for the ASME and president of E4C. We spoke to them to learn about how the competition works.

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

**John Miller:** Participants made up of engineering students, practicing engineers, faculty, Siemens employees, entrepreneurs and global development practitioners from 34 countries, representing 43 universities, took part in the challenge and proposed more than 220 solutions addressing the quality of life in underserved communities.

E4C, a platform and community from the ASME, architected the application and evaluation process, educated participants on human-centered design principles and provided a variety of other tools and resources. Siemens provided free access and training on cutting-edge technology tools for digital design and engineering from its Xcelerator portfolio.

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

**Miller:** For the Zero Hunger Track, finalists are:

- EcoLife Cold Room: Hadijah Nantambi, Ian Williams and Kyle Gaiser, Uganda and U.S.; a cold room for fresh produce that prioritizes cooperative design, affordability, sustainability and technological innovation to benefit rural produce farmers in central and southern Uganda.
- Hybrid Multi-Crop Greenhouse Dryer: Mobolaji Oluyimika Omobowale, Nigeria; solar drying at a large scale that mitigates post-harvest loss of grains, fruit and vegetables among sub-Saharan African farmers.
- OnlyFresh: Chuma Asuzu, Canada; a standalone refrigerated unit for transporting fresh vegetables that will assist farmers, distributors and retailers in Nigeria.
- Solar Thermal Absorptive Refrigerator (STAR): Angelica Errigo, Brianna Dooley, Sergio Andre Jordan Villena, Sandra Vergara Davila and Dr. Amy Ciric, U.S. and Peru; a reliable, sustainable charcoal and ethanol refrigeration unit that increases food safety for rural farmers and consumers in Peru.

The Clean Water Track finalists are:

- Apu uya Wuin: The Guardian of Water: Jhonn Aguilar, Manuel Mejia, Monica Gutierrez, Aliex Trujillo, Colombia; a ready-to-assemble device for solar water desalination augmented with an education strategy to assure social appropriation of the technology for the Parenskat-Wayuu ethnic community in the arid region of La Guajira, Colombia.
- Desalination Battery for Electro-

chemical Brackish Water Treatment: Lukas Hackl and Bilen Akuzum, U.S. and Germany; an electrochemical desalination system with significant energy efficiency and system scalability advantages over reverse osmosis and distillation methods that help almond and cashew farmers in California's Central Valley and globally.

• Desalination for Santa Elena Communities, El Real—Francisco X. Plaza, Ecuador Humidification and dehumidification technology that will provide a steady supply of potable water to reactivate the economy of drought impacted coastal communities in the Santa Elena province of Ecuador.

• Water Water Everywhere—Daniel Hodges, U.S.; a wind-powered vacuum distillation system to help water-stressed coastal small families around the world.

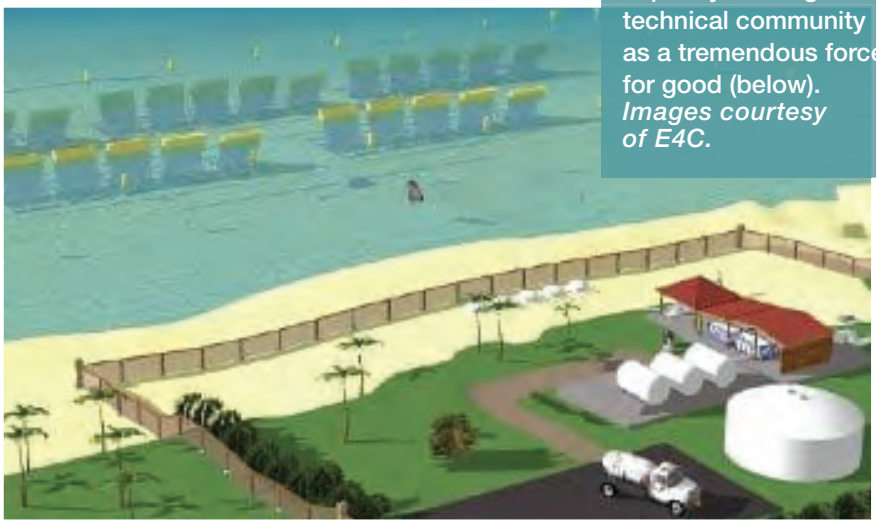
Individuals as well as newly formed teams collaborated in the development and design of new ideas to address these two important sustainable development goals (SDGs). Over the course of the challenge phases participants were required to submit their project research, CAD drawings and simulation results. In the third and final phase of the challenge finalists will be required to submit their final design files, a presentation summary of their project and a pitch video.

Inspirations for the designs ranged from wanting to create sustainable solutions for society, to ensuring no community goes without access to clean water.

***DE:*** **Can you provide some examples of what the event has produced or what you expect it to produce?**

**Miller:** There were more than 220 applications submitted from 34 countries, representing 43 universities. Winners were to be announced in September 2020.

Winners will meet the CEO at Siemens and be featured in an innovation event where they can interact with corporate leaders and present the teams' design. Finalists and winners will be promoted globally via the E4C platform, social channels and affiliate media channels.



In the third and final phase of the challenge, finalists are required to submit final design files, a presentation summary of their project and a pitch video (right). The design challenge demonstrated capacity of the global technical community as a tremendous force for good (below). *Images courtesy of E4C.*

***DE:*** **Are there any academic partners/universities involved in this design competition?**

**Miller:** In addition to the faculty and student participants from more than 43 universities, our judging process integrates academic institutions from the E4C Research Fellows (many of whom are graduate students) and judges (faculty from leading universities):

• Julie Korak, assistant professor, University of Colorado, Boulder. Expertise: Desalination Technologies;

• Natasha Wright, mechanical engineer, assistant professor, University of Minnesota—expertise: desalination technologies;

• Laura MacDonald, managing director, Mortenson Center of Global Engineering—expertise: water and sanitation.

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

**Iana Aranda:** The diverse teams and unique solutions assembled through the Innovate for Impact: Siemens Design Challenge demonstrate the capacity of the global technical community as a tremendous force for good. While the COVID-19 pandemic has imposed limits around the globe, this digital challenge shows us that there are no limits to the social innovation drive of our community. DE

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

**MORE INFO ➜**

• **Innovate for Impact: Siemens Design Challenge:** www.engineeringforchange.org/siemenschallenge