DigitalEngineering247.com

DE Digital Engineering

January/February 2020

VR

- VIRTUAL REALITY AND DESIGN
- PROTOTYPING
- VIRTUAL CAD
- VR-READY WORKSTATIONS

Peerless MEDIA, LLC

| DEGREES OF FREEDOM |

By Brian Albright

How Real is VR for Design?

THE USE OF EXTENDED REALITY (XR) PRODUCTS—incorporating either virtual (VR) or augmented reality (AR) solutions—has become an increasingly hot topic in the design space, at least in theory. AR/VR capabilities are cropping up in a number of software tools for design review and other applications, and workstation manufacturers are touting more units as VR-ready.

As I write this, a host of AR/VR products are being rolled out at the annual CES show in Las Vegas. More than 330 companies had AR/VR products on display at the show, including stand-alone headsets and new HDR-capable VR glasses from Panasonic.

According to IDTechEx's "Augmented, Mixed and Virtual Reality 2020-2030" report, the industry is attracting increased levels of investment and interest, particularly as remote assistance and training applications expand. Technology improvements are also helping increase investment. According to IDTechEx:

"There have been great advancements in resolution, for example, in the past decade. This creates a more immersive experience for the user. Although this experience is far from perfect, as some users still experience motion sickness, it shows that in the future this field will continue to grow as there is continued update of these devices in the future."

The Virtual Design World

What does this mean for design and engineering users? So far, the data is mixed. Interest is increasing, but actual usage remains relatively low.

In our own annual Technology Outlook Survey (published in our December 2019 issue), we found that 32% of respondents believed that AR/VR would have a big impact on product design in the next five years, and 33% agreed that AR/VR will revolutionize the design engineering process. Just over a quarter of respondents (29%) indicated they had plans to incorporate AR/VR tools in the future. However, just 11% reported they were currently using or developing products for AR/VR.

The technology was cited as "very familiar" to just 13% of respondents, while 49% reported being somewhat familiar with it.

PwC research from a few years ago does indicate that among companies already using the technology, product design and development topped the list of applications. According to their 2015 numbers, nearly 40% of companies using AR/VR were doing so for design and development, and another 18% used it for virtual assembly and improved design processes.

In this issue of *Digital Engineering*, we've asked our team of experts and editors to take a look at the multiple facets of XR/VR/AR use in our industry. Senior Editor Kenneth Wong surveyed industry analysts and researchers to see how they thought the use of AR/VR would unfold over the next few years, and also provided us with an overview of how the technology could affect CAD tools.

We've also included coverage of AR/VR training and simulation workflows, as well as the use of the technology to help reduce or eliminate the cost of building physical prototypes. What will the incorporation of AR/VR mean for the engineering workstation? We've provided some insight into how those computers will need to be configured as well.

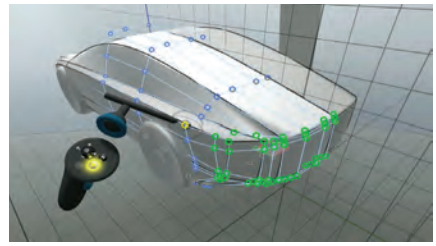
We hope this issue can provide you with some guidance and inspiration when it comes to AR/VR. We also welcome your input and opinions on how the technology could be used to enhance the design process, and when you think that might actually be practical. You can send your thoughts or AR/VR experiences to de-editors@digitaleng.news. DE

Brian Albright *is editorial director of* Digital Engineering. *Contact him via balbright@digitaleng.news.*

DE
Digital Engineering
TECHNOLOGY FOR OPTIMAL ENGINEERING DESIGN
January/February 2020
Vol.26 • No.1

INSIDE

FOCUS ON VR



DigitalEngineering247.com

ON THE COVER:
Collage, Getty Images

FEATURES

REVIEW

DEPARTMENTS

Editor's Pick, Page 44

PUBLISHER
Tom Cooney

EDITORIAL
Brian Albright | Editorial Director
Kenneth Wong | Senior Editor
Stephanie Skernivitz | Associate Editor
Jess Lulka | Copy Editor

CONTRIBUTING EDITORS
Tony Abbey, David S. Cohn, Kip Hanson, Tom Kevan, Randall Newton, Beth Stackpole

ADVERTISING SALES
Len Pettek | Western U.S. Regional Sales Manager
Phone: 805-493-8297
lpettek@digitaleng.news

Tom Cooney | Eastern U.S. and International Sales Manager
Phone: 973-214-6798
tcooney@digitaleng.news

CREATIVE SERVICES
Wendy DelCampo | Senior Art Director
Polly Chevalier | Art Director
Kelly Jones | Production Director

A PEERLESS MEDIA, LLC PUBLICATION
Brian Ceraolo | President & CEO

EDITORIAL OFFICES
Peerless Media, LLC
111 Speen St., Suite 200,
Framingham, MA 01701
Phone: 508-663-1500
de-editors@digitaleng.news
www.DigitalEngineering247.com

SUBSCRIBER CUSTOMER SERVICE
***Digital Engineering*® magazine**
PO Box 677
Northbrook, IL 60065-0677
Phone: 847-559-7581
Fax: 847-564-9453
E-mail: den@omeda.com

Peerless MEDIA, LLC
peerlessmedia.com

Digital Engineering*®** (ISSN 1085-0422) is published monthly by Peerless Media, LLC, a division of EH Media 111 Speen St., Suite 200 Framingham, MA 01701. Periodicals postage paid at Framingham, MA and additional mailing offices. *Digital Engineering*® is distributed free to qualified U.S. subscribers. **SUBSCRIPTION RATES:** for non-qualified; U.S. $108 one year; Canada and Mexico $126 one year; all other countries $195 one year. Send all subscription inquiries to MeritDirect, *Digital Engineering*®, PO Box 677, Northbrook, IL 60065-0677. ***Postmaster: Send all address changes to MeritDirect, *Digital Engineering*, PO Box 677, Northbrook, IL 60065-0677.

Address all editorial correspondence to the Editor, *Digital Engineering*. Opinions expressed by the authors are not necessarily those of *Digital Engineering*. Unaccepted manuscripts will be returned if accompanied by a self-addressed envelope with sufficient first-class postage. Not responsible for lost manuscripts or photos.

Virtual and Augmented Reality

75% of workers have never used AR/VR headsets or similar devices on the job.

78% say they are open to using the technology if asked by their employers.

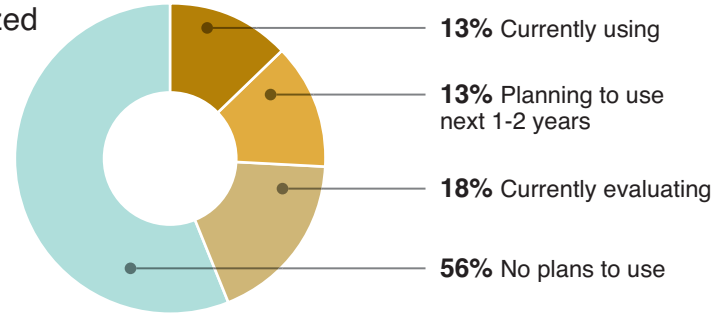
55% believe that AR/VR headsets or similar devices will be as common as smartphones in the workplace within the next decade.

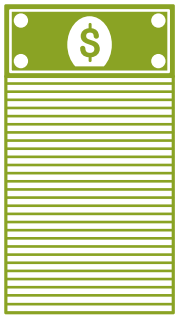
Source: "Tomorrow's Workplace Technology: What Happens When Things Get Personal", Mojo Vision, December 2019.

SMBs Plan for Virtual Reality

Up to **46%** of U.S. small and medium-sized businesses (SMBs) could be leveraging VR in the next two years, according to the 2018 Capterra survey on Top Technology Trends.

Source: Capterra, 2018.





$1.5 Trillion

The amount of revenue that PwC predicts VR and AR could add to the global GDP by 2030.

Source: "Seeing is Believing," PwC, November 2019.

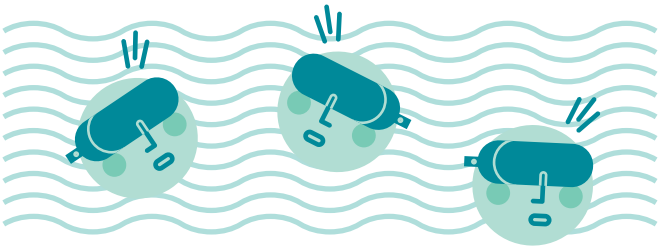
$167.89 Billion

Size of the global AR/VR market in 2026 according to Research and Markets. The firm expects the market to grow at a CAGR of **34.7%** from 2016 to 2019.

25% to 40%

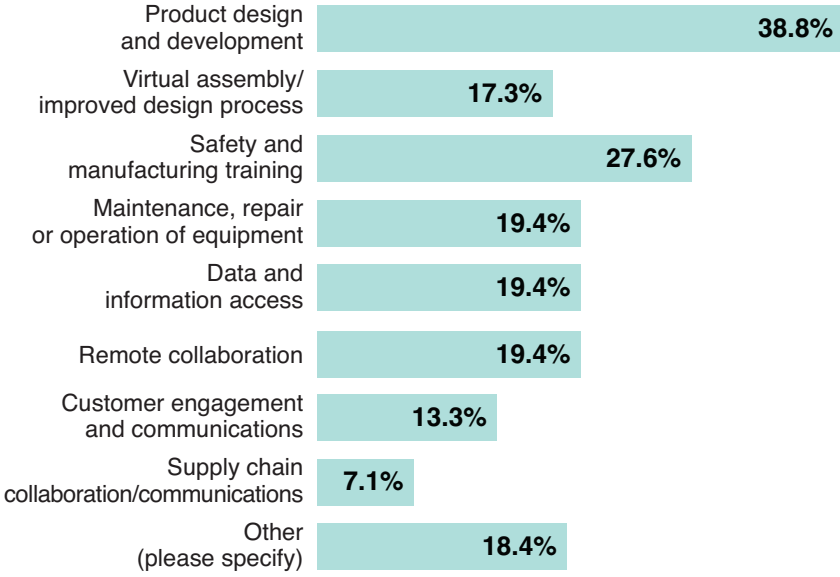
Percentage of people who experience motion sickness when using VR headsets.

Source: "Virtual Reality has a Motion Sickness Problem," Science News, March 2017.



Product Design, Worker Safety and Training are Most Popular AR/VR Applications Among Manufacturers

How is your company using virtual and/or augmented reality technology? Please select all that apply.



Source: "2015 Disruptive Manufacturing Innovations Survey," PwC, 2016

$258.6 billion

North American addressable market value for AR/VR technologies

Source: Research and Markets, December 2019

$4.57 billion to $50.55 billion

Growth trajectory of the European AR/VR market

Source: Research and Markets, December 2019

$1.59 billion to $6.09 billion

Visiongain expects the military AR market to experience a CAGR of **14.4%,** growing from $1.59 billion in 2019 to $6.09 billion in 2029.

Source: "Military Augmented Reality Technologies Market Report," Visiongain, December 2019

NEWS

CAASE20 PREVIEW

CAASE20 Will Feature Simulation Training, IndyCar Night

NAFEMS Americas, *Digital Engineering* present CAASE20 Conference in June.

BY BRIAN ALBRIGHT

While the temperatures are dropping outside, the teams at NAFEMS Americas and *Digital Engineering* (*DE*) are gearing up for the summer, when simulation experts from around the country will converge for CAASE20 (the Conference on Advancing Analysis & Simulation in Engineering) in Indianapolis, June 16-18. The event will be held at the Indiana Convention Center.

CAASE20 will bring together the leading visionaries, developers and practitioners of CAE-related technologies in an open forum, unlike any other, to share experiences, discuss relevant trends, discover common themes and explore future issues.

This conference will cover a wide range of topics, addressing every aspect of engineering analysis and simulation during a 2.5-day program. The four key themes this conference will address:

- Driving the Design of Physical Systems, Components & Products
- Implementing Simulation Governance & Democratization
- Advancing Manufacturing Processes & Additive Manufacturing
- Addressing Business Strategies & Challenges

The final conference schedule is due to be announced on Feb. 1, but NAFEMS has already lined up an impressive lineup of keynote speakers. They include:

- **Geoffrey Moore,** consultant and author of "Crossing the Chasm." Moore is an author, speaker and advisor who splits consulting time between start-up companies in the Mohr Davidow and Wildcat Venture Partners portfolios and established high-tech enterprises, most recently including Salesforce, Microsoft, Autodesk, F5 Networks, Gainsight, Google and Splunk.

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

- **Amir Husain**, inventor and author of "The Sentient Machine," as well as the CEO of AI company SparkCognition and founding CEO of SkyGrid, a Boeing-SparkCognition joint venture. He has been named Austin's Top Technology Entrepreneur of the Year, listed as an Onalytica Top 100 Artificial Intelligence Influencer and received the Austin Under 40 Technology and Science Award. He also is a member of the Council on Foreign Relations and the Center for a New American Security Task Force on Artificial Intelligence and National Security.
- **Dr. Maria Klawe**, president of Harvey Mudd College, who will discuss increasing diversity in the STEM workforce. A computer scientist and scholar, Klawe is the first woman to lead the College since its founding in 1955. Prior to joining HMC, she served as dean of engineering and professor of computer science at Princeton University. Klawe is the recipient of the 2014 Women of Vision ABIE Award for Leadership and was ranked 17th on Fortune's 2014 list of the World's 50 Greatest Leaders.
- **Monica Schnitger,** president and principal analyst at Schnitger Corp. and occasional *DE* columnist, who will discuss the evolution of simulation technology in the modern enterprise. Schnitger has developed industry forecasts, market models and market statistics for the CAD/CAM,CAE, PLM, GIS, infrastructure, AEC and plant design software markets since 1999.
- **Scott Leemans**, creative engineering generalist at X (The Moonshot Factory), who will discuss democratizing technology at the K-12 and college levels. Leemans has a broad background in design, analysis and simulation, and has received awards for nine Small Business Innovative Research (SBIR) projects related to Advanced Composites Simulation and Design Space Exploration. He also participates in the working groups for the Composite Materials Handbook (CMH-17) and ASTM D30 Committee, as well as COFES and ASSESS.
- **Bill Pappas**, VP of competition & engineering at IndyCar, will present "Simulation: The 21st Century Tool for IndyCar Racing." Pappas has been in the racing industry for more than 30 years, and is a two-time winner at Indy 2 championships. He oversees IndyCar's technical department.

In addition to conference sessions, there will be a variety of NAFEMS training sessions available to attendees. Those include pre-conference sessions on composites and postprocessing of structural analyses. During the conference, training sessions will include nonlinear analysis, structural optimization, fatigue analysis, CFD for structural engineers, elements of turbulence modeling and several other courses.

Attendees will also have a chance to visit the local Dallara IndyCar Factory, which is the exclusive Chassis supplier to the NTT IndyCar series. The event will include full-car racing simulators, rides in a street-legal IndyCar, an interactive tour, as well as dinner and drinks.

You can register for CAASE20 on the NAFEMS website at www.nafems.org.

In October, NAFEMS Americas and *DE* launched their inaugural CAASE19 Virtual Conference. The online sessions are available on-demand on the CAASE19 registration page (tinyurl.com/suv78x6). DE

AMUG PREVIEW

AMUG 2020 Returns to Chicago

The Additive Manufacturing Users Group (AMUG) Conference is set to take place this year in Chicago, March 22-26 at the Hilton Chicago. AMUG is unique in the additive space in that the event is organized by users and targeted at users to help increase the value of AM across industries.

The 2020 program will once again feature a Sunday evening (March 22) reception for first-time attendees. In addition, new for the 2020 event are first-timer gatherings throughout the week where newcomers will regroup, get answers to their questions and have an opportunity to connect with long-time AM users.

Innovator, Scholarship Awards

The conference officially opens on March 23, and will feature presentations that include extended discussions of insights and highlights with a focus on the tools/companies supporting the conference.

In addition, Hans Langer, founder of EOS, will receive the annual Innovators Award and engage in a "fireside chat" that will provide insight into his background, interests, trials/tribulations, successes and thoughts on how to succeed in AM and what the future holds. AMUG will announce its annual scholarship winners on Monday, March 23, as well as the winners of the Distinguished Innovator Operators (DINO) awards, and board and officer elections.

The AMUG conference sessions, which are active throughout the week except during meals and expo hours, will feature sessions organized by AMUG's Track Leader Committee. The vast majority of these presentations and panels are conducted by AMUG members. The sponsor conference sessions, which run throughout the week but primarily in the afternoons, are conducted by AMUG's Diamond and Platinum Sponsors. These sessions run concurrently with the AMUG sessions.

By popular demand, AMUG is incorporating many more panel discussions (and other sessions that invite engagement) into the conference agenda. The conference will also include more than 160 speaker, panel and training sessions throughout the week. This includes AMUG track sessions for:

- Aerospace/Transportation/Defense/Military
- AM Metal Technologies
- AM Technologies—Non-Metal
- Casting
- Education and Training
- Materials
- Medical & Dental
- Scanning & Metrology
- Software

EOS Founder Hans Langer will receive the Innovators Award.
Image courtesy of AMUG.

This year's event will have expanded expo hours, running from 4 p.m. to 10 p.m. on March 22; and from 10 a.m. to 2:30 p.m. and 6 p.m. to 10 p.m. on March 23. The keynote speakers have not yet been announced, but the keynote sessions will be held on March 23 and March 26.

As in previous years, AMUG will once again hold a Technical Competition for additive manufacturing (AM) users to present their noteworthy use cases and applications. The event offers two recognitions: Advanced Concepts and Advanced Finishing. Winners will be announced on March 25.

There will also be off-site evening events on Tuesday and Wednesday during the conference, as well as a closing "Family Dinner" on Thursday evening.

Attendance is limited to those who use/operate/own AM technology used in a professional setting. Registration includes all meals.

To register, go to the event homepage at www.amug.com/attendee-registration. DE

Jay Leno's Garage Gets 3D Printing Part Boost

The ability to churn out on-demand 3D custom parts helps keep classic cars on the road.

BY BETH STACKPOLE

It's a well-known fact Jay Leno is car-obsessed—and not just by any car, but by exotic, hard-to-find models that often lack an available inventory of parts.

So what's Leno and his car enthusiast television show to do when they can't find replacement gear to get their starring vehicles back on the road? They turn to 3D printing through a partnership with Stratasys to build out a digital inventory of parts that can help the Leno crew road test, refurbish and retrofit the classic cars that are part of the entertainment mogul's expansive collection.

"Jay Leno's Garage," a show that conducts reviews of vintage and restored cars (as well as Leno's own Big Dog Garage, which houses his more than 200 cars and 150 motorcycles) is now using a Stratasys Fortus 450mc 3D printer to produce prototypes and custom parts for the collection, valued at over $50 million. The on-site Fortus 450mc printer complements the group's already expansive use of the Stratasys on-demand manufacturing service to recreate parts that are no longer on the market or that would be too time-consuming and expensive to manufacture using conventional methods. Stratasys owns and helps man the Fortus 450mc on-site at the Leno production facility while also providing 3D printing consulting expertise as part of the partnership arrangement.

"You can't procure many of these parts the old-fashioned way—they simply don't exist," says Pat Carey, senior vice president of strategic growth at Stratasys. "[Leno] sees 3D printing as a huge advantage as a car collector and cut nut."

To date, Leno has leaned on 3D printing to create a timing belt cover for a 1960s Pontiac Firebird and a set of valve cover breather tubes and carburetor spacers for a 1934 Rolls Royce Merlin 12, among other projects. The design flexibility of 3D printing also allowed his engineering team to create a new air intake plenum that allowed for more air flow and didn't require changes to the hood when adding a 7-liter Roush V8 engine to a 1966 Ford Galaxie 500, Stratasys officials say.

Materials advances for 3D printers, including carbon fiber-filled nylon and aluminum and steel, along with higher performing 3D design tools like CAD and 3D scanning, have fueled the rise of additive manufacturing as a tool for producing on-demand and custom parts. The ability to do so fills a need for exotic car enthusiasts like Leno, but it also showcases a new manufacturing workflow that can benefit an array of industries from aerospace companies to motorsport race teams. To that end, Stratasys has launched its Performance Partner Program, currently at 11 partners, including Leno's Big Dog Productions, which is dedicated to advancing use of AM for production purposes across these high-performance sectors. Boom Supersonic, using Stratasys AM technology to produce flight hardware, and Arrow Schmidt Peterson, a race team competing in the NTT IndyCar Series, are among the collaborators participating in the Stratasys program.

"We are partnering with people who use our technology to achieve competitive advantage," Carey says. "They're not just building prototypes or printing cute little things. They are printing parts or using tools made from printed parts to drive competitive advantage." **DE**

CAASE20

The Conference on Advancing Analysis & Simulation in Engineering

June 16th - 18th, Indianapolis

Co-Hosted by: DE Digital Engineering, NAFEMS

NAFEMS Americas and **Digital Engineering** (**DE**) are teaming up (once again) to present CAASE, the Conference on Advancing Analysis & Simulation in Engineering, June 16-18 in Indianapolis!

CAASE20 will bring together the leading visionaries, developers, and practitioners of CAE-related technologies in an open forum, unlike any other, to share experiences, discuss relevant trends, discover common themes, and explore future issues.

Presentations at this event will be centered on four key themes:

1. Simulation-Driven Design
2. Implementing Simulation Governance & Democratization
3. Advancing Manufacturing Processes & Additive Manufacturing
4. Addressing Business Strategies, Challenges & Advanced Technologies

Visit nafems.org/CAASE20 for more information

Platinum Sponsors:

HEXAGON, MSC Software, SIEMENS, SIMULIA, Front End Analytics (FEA) Delivering Business Advantage, Altair Innovation Intelligence, ANSYS, cadence

Event Sponsors:

TotalCAE, ISTECO, Endurica Get Durability Right, VOLUME GRAPHICS, Wolf Star Technologies, VCOLLAB Actionable Simulation Insights, RECURDYN, msi, BETA Simulation Solutions, DEP MeshWorks, kineticvision Excellence in Product and Process Development, SYNOPSYS, ROCKY, nTopology, ceetron understanding by visualization, PENGUIN COMPUTING, ASSESS, ASME Setting the Standard, Revolution in simulation, engineering.com

600+	265+	200+
Attendees	**Companies**	**Presentations**

40+	30+
Exhibitors	**Courses & Workshops**

KEYNOTE PRESENTERS

Geoffrey Moore
Advisor, Speaker and
Author of *Crossing the Chasm*

Amir Husain
Serial Entrepreneur, Inventor,
Technologist and
Author of *The Sentient Machine*

Maria Klawe
President
Harvey Mudd College

Monica Schnitger
President and Principal Analyst
Schnitger Corporation

Scott Leemans
Creative Engineering Generalist
The Moonshot Factory

Bill Pappas
Vice President of Competition & Engineering
IndyCar

ROAD TRIP

Simulation Revolution on Track

ASSESS 2019 Congress Marked Progress in the Expansion of Simulation Across the Value Chain.

BY BRIAN ALBRIGHT

The ASSESS Initiative held its by-invitation-only conference (the ASSESS 2019 Congress) in Georgia in October. The fourth annual event is structured to enable strategies and relationships related to increasing the use and benefit of engineering simulation. The theme for the 2019 event was "Advancing the Engineering Simulation Revolution."

Kicking off the event, ASSESS CEO and co-founder Joe Walsh provided an overview of the group's accomplishments over the past year, including publication of positioning papers on all seven of the key themes the association has identified that are associated with greater adoption of simulation. ASSESS has also published strategic insight papers on generative design and an engineering simulation risk model.

According to Walsh, a massive increase in demand for simulation is imminent. "The business drivers for this include the need to be more competitive, to reduce risk and to reduce time to market, which are going to raise the priority of simulation not only in groups currently using it, but also in groups that are not using it. The business drivers are really forcing a revolution in simulation."

That revolution will require simulation to be model-based, fit-for-purpose, integrated, smart, transparent and generative, according to Walsh. "There will be near-real-time simulations, near-real-time physics capabilities, and more things are being done to enable this. It will require a culture change," Walsh says. "The idea of analysis being limited to the guys in the back room is going to go away."

According to market data from Cambashi, the CAE market is expected to be worth more than $10 billion in 2022, with growth rates ranging from 10 to 12% annually.

Ralf Hartmann, vice president of digital product continuity at Airbus Defense & Space, outlined how Airbus is incorporating the concept of the digital twin and simulation to enable a "digital revolution for product development, where simulation plays a significant role," he says. The company's target is to have an end-to-end digital twin across the value chain that can provide double-digit reductions in lead time, non-recurring costs and overall total cost of ownership of the aircraft.

Andreas Vlahinos, CTO of Advanced Engineering Solutions, spoke about generative design tools at the 2019 ASSESS Congress. *Image courtesy of ASSESS.*

According to Hartmann, this will require changes in culture as well as changes in the available tools. "Today, we have configuration management on different models and documents, but it is not consistent. In the future we need to have an approach that covers all the data and models in a consistent way."

"We also need to decouple engineering capabilities," he adds. "Today, engineering tools and analysis are very much in the early design domain. We will need them to also be available in later phases of the life cycle."

Hartmann also identified raw data storage, maintaining a connection between the real and virtual world, and advanced data exploration as critical components of this type of model. "There will need to be automation at all levels so workflows can be executed efficiently, and we will need the user experience to be efficient in order to interact with these complex systems," he added.

He also noted that the building blocks of the digital twin will not work without an integrated conceptual data model that

he described as the "most challenging item in the whole story."

In terms of making this a reality at Airbus, Hartmann said that half of the allocated budget goes into re-engineering processes that can be adapted to enabling the benefits of this new approach, while 40% goes into the IT infrastructure. Another 10% is required for change management. "This is a human problem and a change management problem to get the whole company and all of our employees to embrace these new processes," Hartmann says.

He says that the next phase of this evolution is digital continuity. "That means interaction between all of the domains: the various phases of design, manufacturing and service," he says. "I believe that is the phase we are entering."

Hartmann also said that the company is streamlining its set of technology tools. "In the past we picked tools, and then customized them to death," he says. "We are suffering from that today. It's a huge effort to maintain, and impossible to get new versions of those tools.

"The tools are getting better, and we want solutions we can use out of the box," Hartmann adds. "We will end up with an ecosystem of out-of-the-box tools."

The annual ASSESS Congress was organized around the theme of "Advancing the Engineering Simulation Revolution." *Image courtesy of ASSESS.*

Generative Design Value

Andreas Vlahinos, CTO of Advanced Engineering Solutions, also gave a presentation on the opening day of the Congress entitled, "Are the Real Time Simulation and Lattice Structure Generation Tools a Game Changer?" In that session, Vlahinos described the value of real-time generative design tools, as well as the use of artificial intelligence to generate lattice structures and help accelerate design iterations.

Lattice structures were previously difficult to use because existing tools couldn't create them, and manufacturers couldn't make them. Now, mature topology optimization codes can use the element mesh to generate lattice structures. Combining lattices and real-time simulation can improve performance.

"These are exciting times," Vlahinos says. "You can do crazy things and generate really high-performance products in the area of lightweighting and energy absorption, acoustics and medical implants. Metal 3D printing has improved, so we can print these amazing structures."

Positioning Papers

ASSESS is organized around seven key themes, and has published positioning papers outlining each. The first two were released in 2018 (covering alignment of commercial and research efforts, and the democratization of engineering simulation). In 2019, the organization published additional papers on business challenges, engineering simulation credibility, digital twins, generative design and the integration of system/sub-system simulations. All are publicly available.

In addition, ASSESS members have access to a series of strategic insight papers on related topics. The most recent looks at generative design-enabled process paradigm shifts.

"Generative design could be a transformative technology," Walsh says. "The key part of that is 'could be.' It shows promise, but the industry is not quite ready for that transformation yet. How can we make it so that generative design really is transformative?"

Walsh said ASSESS will publish two additional papers in 2020.

The ASSESS Congress also included presentations from INCOSE, Siemens, Eastern Virginia Medical School, the NASA Glenn Research Center, NAFEMS, Sandia National Laboratories and others. DE

ASSESS Initiative Resources

ASSESS Initiative members can download the full slate of ASSESS 2019 Congress presentations along with the recently published Strategic Insight Papers at the group's website. Visit **www.assessinitiative.com/resources/**.

The seven theme positioning papers and other introductory documents can also be downloaded at: **www.assessinitiative.com/resources/#documents.**

ROAD TRIP

AU 2019: Partnership with ANSYS, Free Generative Design Tools

CAD and Simulation Leaders Cement Partnership at Autodesk University

BY KENNETH WONG

At Autodesk University (AU 2019) last November, an unlikely guest made an appearance. On day two, during the Product Design and Manufacturing Keynote, Autodesk CEO Andrew Anagnost stepped up to the stage, followed by Ajei Gopal, CEO of ANSYS.

As the two leading developers of well-known software titles in design and simulation, Autodesk and ANSYS are competitors in certain areas. Both offer simulation solutions; both seek dominance in the automotive sector.

Yet, the two are also software partners, due to the common practice among engineers to create designs in Autodesk's software, then conduct analysis in ANSYS' offerings.

Gopal's cameo at the annual Autodesk user event was the outcome of a partnership announced in September, signaling Autodesk and ANSYS' plan to jointly pursue opportunities in the automotive sector.

Sitting side by side for a chat moderated by Greg Fallon, VP of Business Strategy, Autodesk, the two CEOs explained why the corporate handshake makes sense.

"Simulation is key to understanding what better design is," said Anagnost. "I'm excited about our partnership. We're going to bring more powerful simulation so people can make better choices. And that's the future. Everything's a simulation problem."

"We'll enable our customers to build these seamless workflows that will allow them to develop these next-generation products faster and more efficiently than ever before," said Gopal.

Autodesk CEO Andrew Anagnost (left) and ANSYS CEO Ajei Gopal (center), in a chat moderated by Greg Fallon, VP of Business Strategy, Autodesk (right). *Image courtesy of Autodesk.*

Cementing the ANSYS-Autodesk Partnership

In the initial announcement of the partnership, Autodesk and ANSYS emphasized their plan to "connect Autodesk's automotive 3D visualization and virtual prototyping software [VRED] with ANSYS' physics-based lighting simulation solutions, enabling automakers to complement hyperrealistic visualizations of vehicle interiors and exteriors with highly accurate lighting simulation."

During AU, Fallon revealed the partnership would also enable interoperability between Autodesk Fusion 360 and ANSYS Mechanical. The connection was built on Autodesk Forge, the development platform from Autodesk available for licensing.

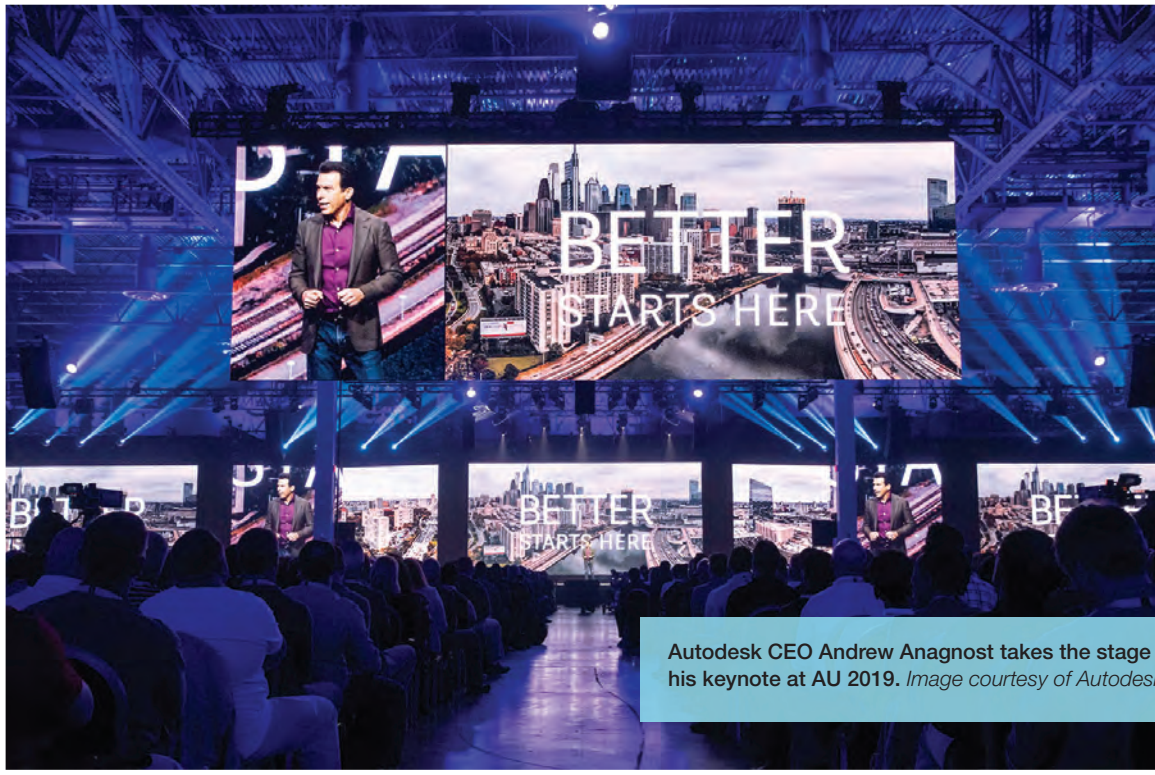
Autodesk and ANSYS have been building cloud-hosted design and simulation features, recognizing the industry's steady shift to the cloud. With Autodesk rival PTC's recent acquisition of the cloud-hosted CAD startup Onshape, claiming cloud territories take on greater urgency.

"Autodesk has been exploring and automating on the cloud. One of the things the cloud is really good at is connecting data from different disciplines, different ecosystems. Better does start with data," said Gopal.

Free Generative Design Tools

For Autodesk software subscribers, Stephen Hooper, VP and GM, Autodesk Fusion, had an early Christmas present. "We're granting every subscriber free unlimited of generative design until the end of this year," he announced.

Under the campaign to drum up interest in its generative design technology, Autodesk announced its offering the tools free until 2020. The offer was made possible by Autodesk's partnership with AWS and GPU maker NVIDIA. Generative design tools are integrated in the Autodesk Product



Autodesk CEO Andrew Anagnost takes the stage for his keynote at AU 2019. *Image courtesy of Autodesk.*

Design & Manufacturing Collection and Fusion 360.

Because of Autodesk's partnership with aPriori, Autodesk Fusion users can consider cost as a parameter in generative design and topology analysis sessions.

Autodesk Fusion 360, Autodesk's integrated CAD-CAM-CAE program with cloud-powered features, now includes PCB (printed circuit board) design tools, a result of Autodesk's acquisition of the ECAD software developer EAGLE.

Getting Involved in the Virgin Hyperloop

In the partners' expo, AU attendees saw a model of the Virgin Hyperloop, the airplane maker's project to bring a high-speed passenger train to the U.S. During the conference, Autodesk announced, "an alliance [with Virgin Hyperloop] to explore new opportunities in extending the value of Building Information Modeling (BIM) for transportation route optimization and improved digital engineering and construction workflows."

The centerpiece of Autodesk's BIM solution is Autodesk Revit, a 3D modeling program for the AEC (architecture, engineering, construction) industry.

The Changing Face of Manufacturing

During his general keynote on day one, Autodesk CEO Anagnost observed, "We all know that automation is changing jobs, but it's also creating an opportunity for more meaningful work, better work. Together we have the opportunity to create a more sustainable, equitable and more prosperous future."

The emergence of robotic service workers and self-driving cars are but two examples of the radical automation trends, seemingly threatening traditional manufacturing practices and many associated jobs.

At the same time, it has also become more difficult to attract a new generation of skilled workers. "Half of the U.S. construction workers are now over 45. And the job is seen as just too dirty, dangerous and dull to many younger workers. This lack of skilled labor, over the last decade, is why the average U.S. hotel has taken longer and longer to build," added Anagnost.

IMAGINiT, an Autodesk authorized training and service provider, took note of the changes among its clients as well. "There are people who can do high-level calculations, but a lot of the shortage is in the day-to-day operations where you need to get your hands dirty," noted Caleb Funk, IMAGINiT.

"We used to do mostly in-class training, but it's now moving to virtual classrooms. Previously, the classes used to be general software skills, like 'I want to learn Autodesk Inventor.' Now, it's much more specific. For example, they might say, 'Teach us to use Inventor iLogic to automate this process.' Whatever it is, we cater to our clients," he added. DE

Graebert to CAD Vendors: We Can Take You to the Cloud

BY RANDALL S. NEWTON

Big news rippled through the CAD industry when PTC announced it was buying Onshape, the cloud-based mechanical design system (see "PTC Snatches Up Cloud CAD Pioneer Onshape;" digitalengineering247.com/r/23250). PTC is not the only company that sees its future in the cloud.

At the recent Graebert Annual Conference, Graebert presented its expanded vision for the cloud-based CAD technology it already sells as an original equipment manufacturer (OEM) to several vendors including Onshape. Graebert used the Berlin, Germany-based conference to encourage CAD vendors to leverage its years of experience to create their own cloud tools.

"We are not shy to say that Graebert's ARES Kudo technology is years ahead of any competition," says Wilfried Graebert, CEO and founder of Graebert GmbH. "Graebert took a head start in this technology by investing very early and attracting early partners such as Onshape."

Graebert has been shipping cloud-active CAD for more than a year as part of its ARES series of CAD products. Now, Graebert is sharing the results of its years of work with end users and other vendors who wish to jumpstart their cloud/CAD development.

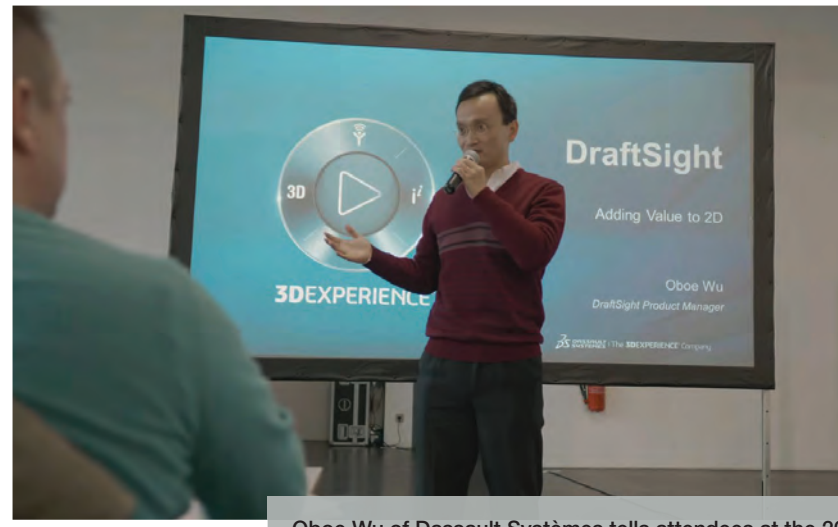
The larger world of IT has already significantly invested in the software-as-a-service (SaaS) model, but with few exceptions, the engineering software industry has been lagging behind.

According to an IDC survey quoted by Graebert, 72% of IT managers give preference to cloud-based solutions. A report from Zuora called the Subscription Economy Index (also quoted by Graebert) indicates that SaaS companies are growing three times faster in sales than the non-SaaS software companies in the S&P 500 index.

"The CAD industry is facing the challenge to start immediately investing in Cloud without neglecting their existing on-premises solutions," says Cedric Desbordes, director of marketing and business development for Graebert. "The SaaS transformation will inevitably take several years, most likely more than 10 years."

Graebert shared with current and potential OEM clients how the existing Graebert line—the ARES Trinity of interconnected desktop, mobile and browser CAD tools—already use cloud technology to provide benefits such as file synchronization and commenting tools. New markup features introduced at the conference extend annotation by making it easier for non-CAD users to collaborate without prior CAD experience.

ARES Kudo is the browser version of Graebert's CAD line; it includes a C++ API that allows developers to use the same core code for desktop and cloud. The company also launched CLOUDify Pack for ARES Commander OEM;ARES Commander is the desktop version of Graebert's "Trinity of CAD." This optional development kit enables software vendors or motivated end users to add cloud utility to their existing on-premises solutions.



Oboe Wu of Dassault Systèmes tells attendees at the 2019 Graebert Annual Meeting how DraftSight complements SolidWorks in the manufacturing workflow. DraftSight uses technology from Graebert. *Image courtesy of Graebert GmbH.*

Graebert presented its expanded vision for cloud-based CAD solutions at its annual conference. *Image courtesy of Graebert.*

Features include:

- a Cloud Storage Palette that works with leading commercial solutions;
- a Commenting Palette to create discussion threads; and
- a Share View-Only Links feature which generates a URL from the Cloud Storage Palette to share live updates of drawings.

Graebert says this combination of drawing access and commenting options allows CAD professionals to edit and annotate drawings, and non-CAD users to review and comment—with voice memos and photos—without the ability to modify geometry, all in the same workflow.

DWG in a Model World

Graebert is a small company that is the second-largest CAD company by seats of its technology in use. This anomaly exists because Graebert is primarily a developer for other CAD vendors, including Dassault Systèmes, Corel Corporation, Onshape (now PTC), Esri and a variety of regional CAD vendors around the globe. Dassault Systèmes has been a Graebert client for 10 years, and recently signed a new long-term deal.

"The future of design is integration," notes Oboe Wu, DraftSight product manager for Dassault. The company is best known for SolidWorks and CATIA, yet DraftSight has almost as many users as both 3D products combined.

Wu cited a recent study on model-based manufacturing that claims a model-based manufacturing design workflow is must faster than a strictly drawings-based workflow. However, two challenges remain. Firstly, there is still the need to pull drawings from the model. Secondly, there are still 2 billion legacy files in DWG that often must be consulted and the data integrated into new models.

The latest edition of DraftSight has new features that integrate DWG drawings with SolidWorks models, including visualization and augmented reality views of product views within DraftSight. The new version also allows someone sketching a new part in 2D to extend it into 3D for handoff to SolidWorks.

Onshape added Graebert's cloud-based 2D drafting technology based on continued customer request for sketching tools. Today, Onshape uses Graebert's Kudo cloud-based drafting technology to offer drawing capabilities inside the cloud-based modeler. "Onshape's largest customer uses Kudo inside Onshape, and they also buy more Kudo," notes Wilfried Graebert. "So this means we are the leader in cloud CAD."

To put a point of emphasis on the leadership claim, Graebert started the conference by announcing the publication of a white paper claiming Graebert ARES Kudo significantly outperforms Autodesk AutoCAD Web in head-to-head independent testing. The white paper, "Comparing Cloud-based CAD Systems from Autodesk and Graebert (Graebert.com/compare-areskudo)," is written by well-known CAD expert Ralph Grabowski. The paper described the results of testing and details the two products feature by feature.

Both products are designed to be "use-anywhere" products, capable of opening and editing DWG-based drawings or starting new drawings on any device with a supported browser. Few other CAD vendors have web-based versions of their products; most are view-only. DE

Randall S. Newton *is principal analyst at Consilia Vektor, covering engineering technology. He has been part of the computer graphics industry in a variety of roles since 1985. Contact him at DE-Editors@digitaleng.news.*

Mixed Reality Moves Beyond the Cool Factor

As hype subsides, practical use cases emerge.

BY KENNETH WONG

As the 2019 Christmas season approached, the VRX Conference in San Francisco kicked off at the Hyatt Regency. One panel tackled the question, "Are investors done with XR [extended reality]?"

The panelists' pragmatic approach to investment assessment suggests the industry is no longer enamored by augmented reality and virtual reality (AR/VR) as novelty items. For better or worse, the hype is beginning to wear off. The technology must now face difficult questions about its own sustainability, scalability and the value it offers.

"We want to make sure [the firm we invest in] has a first-generation product, something tangible to test, so we know they have the technical prowess to make a product and understand the problem they're trying to solve," says Amy LaMeyer, partner, WXR Fund.

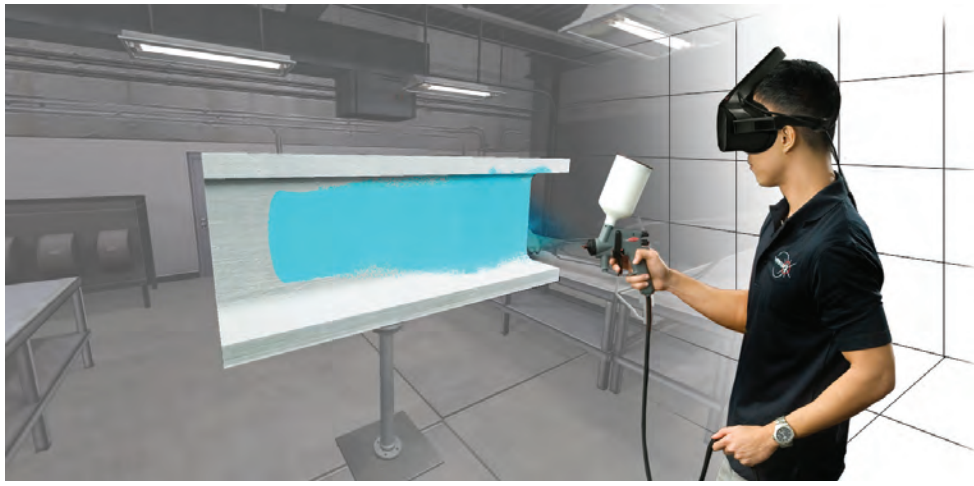
"Ideas are a dime a dozen; it's all about execution," says Tipatat Chennavasin, co-founder and general partner, The VR Fund. "We also ask if the idea is venture-scalable. There are some companies with great ideas, but they're not venture-scalable. In that case, we say they're better off bootstrapping or looking for angel investors."

"Take VR out of your pitch. What problem are you solving? VR is just one of the mechanisms to solve that problem; you don't need to define yourself as a VR company," notes Maddie Callander, VR Accelerator & Portfolio, Boost VC.

Cordless XR on 5G

A week before the VRX Conference, Qualcomm announced its Snapdragon 765 mobile processors that support 5G connectivity and artificial intelligence workloads. This has some implications in the development of untethered or cordless XR devices.

It's not yet feasible to fit workstation-class CPUs and graphics processing units (GPUs) into a head-mounted display (HMD), along with the necessary power source to



Developer Sixense uses a mix of replica equipment and VR helmets to build VR-based training systems. Shown here is Sim Spray, a vehicle spray painting training application. *Image courtesy of Sixense.*

GPU maker NVIDIA and other hardware makers identify collaboration as a key area where VR can add value. Shown here is NVIDIA Holodeck, a VR environment for engineering collaboration. *Image courtesy of NVIDIA.*

support them; doing so would increase the device's weight significantly, discouraging users from wearing it for long periods. Therefore, many XR devices are powered by an external source, usually a workstation, via a cord. The less-than-perfect solution introduces navigation issues, such as wire entanglement and risk of tripping.

However, Snapdragon and similar mobile processors can overcome these issues by streaming graphics. The cordless Microsoft HoloLens 2, powered by Snapdragon 850, has shown that streaming graphics via Wi-Fi gives a much better user experience. In the case of devices powered by Snapdragon 765, 5G remote connectivity serves the same purpose.

"There are some use cases that will always necessitate super high-fidelity content that requires high-end PC/workstation performance that mobile silicon can't compete with, but at the same time there's significant usage that sits below that processing requirement," says Eric Abbruzzese, research director of AR/VR, ABI Research.

"Of course, one caveat is [original equipment manufacturers] need to actually adopt and leverage the new silicon to reap the benefits. New devices often lag a couple generations behind the latest chipsets, and in the AR-VR space some have opted to leverage the standard Snapdragon line rather than the XR line," he adds.

Different Strategies for AR and VR

The fundamental difference between AR and VR is that in AR, digital objects coexist with reality. In VR, the world is completely virtual. For this reason, they are positioned to address different problems.

"VR is a great way for engineers to clearly visualize designs at scale. The value increases when you use VR for a collaborative project review with globally dispersed participants. You gain unique visualization perspectives," notes Chad Jackson, chief analyst and CEO, Lifecycle Insights.

GPU maker NVIDIA has developed a VR-based collaborative environment called the NVIDIA Holodeck, targeting engineers and designers. One of its appeals is the ability to ingest detailed CAD models and display them in real-time raytraced mode.

"AR is uniquely applicable to the redesign of existing products. Engineers can overlay new designs onto physical products, visualizing fit, aesthetics, analysis results and a lot more. There's nothing quite like seeing a new design on the top of an existing design in real, physical space," Jackson adds.

Traditionally, engineers and design firms have turned to VR for a more virtual design process. AR is bringing new capabilities to end users. "AR is the newer kid on the block. Solution providers like PTC and AVEVA have been pushing

AR for several years, and the big enterprise players have taken note and include it in their digital twin strategies," observes Stan Przybylinski, vice president, CIMdata.

"When I think of AR, I think more of overlaying [Internet of Things] or other enterprise data on things that exist in the real world. Engineering can benefit from that as well, by seeing their designs in action while displaying key process indicators in real time. But the largest benefits to date have been in service and manufacturing," Przybylinski also notes.

In VR training, while wearing a headset and sitting in a small cubicle, you can virtually be in an immersive airplane cockpit, surrounded by responsive real-time raytraced visuals that depict all the intricate dials and knobs. On the other hand, in AR-based maintenance and installation, you can see the real object that needs to be repaired, with an animated sequence showing the procedure.

Decoding Reality: AR, VR, MR, XR

The acronyms for AR and VR, often used interchangeably by many outside the industry, may be confusing. They warrant some differentiation.

AR means augmented reality. In an AR system, you do not lose sight of the real world around you. Your reality is merely enhanced with a layer of digital data. In other words, you can still see the tables, chairs, and walls around you, but you may also see a virtual vehicle that's not really there.

VR means virtual reality. When using a VR system, you enter an immersive virtual world. Therefore, you can no longer see the physical objects around you. VR head-mounted displays (HMDs) generally do not come with see-through glasses; they block off your eyesight completely.

XR and MR (extended reality and mixed reality) have now become general terms that encompass AR and VR. However, some argue the terms should more narrowly be applied to AR because they suggest mixing or fusing reality with digital data. In this article, they refer to the collective industry that includes AR as well as VR.

The Hype Cycle

Adoption during the hype cycle's early phase is fraught with risks. In this phase, the technology remains unstable and mergers and acquisitions that will identify the leaders have not yet occurred. On the other hand, adoption during the later phase forces one to catch up.

"The hype cycle is mostly through on the enterprise side, now moving into scaling implementations," says Abbruzzese. "The consumer market in regards to head-worn AR is (subjectively) pre-hype cycle and as a result very immature and so not really viable as an alternative for enterprises at this point; this is something that is guaranteed to change in the next few years, potentially as early as next year. Mobile AR is farther along and has helped spur some knowledge share and user understanding around AR before a possible head-worn growth spurt."

"The technologies continue to evolve, with price points continually decreasing. There are no clear winners yet, but I do not think that companies can sit on the sideline waiting for a dominant player to emerge. Companies can pilot the technologies without making a huge commitment," advises Przybylinski.

With a significant price difference between consumer units (usually around $400 to $1,500) and professional devices (usually around $1,500 to $5,000), enterprises should consider different strategies.

One option is to experiment with low-cost consumer devices until a clear use case is established. Another is to look for operations where high-fidelity VR can replace high-cost physical spaces (such as training facilities and equipment).

"If VR or AR solves a problem in a short period of time, then implement it. However, be very clear about the value you expect to reap from the investment. It is easy to get lost in the cool factor of these new technologies," notes Jackson. 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

- **ABI Research:** ABIResearch.com
- **CIMdata:** CIMdata.com
- **Lifecycle Insights:** LifecycleInsights.com
- **NVIDIA:** NVIDIA.com
- **Qualcomm:** Qualcomm.com
- **VRX: Events.** VR-Intellignence.com/VRX

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

Redesigning CAD for Mixed Reality

Break old habits while inventing new practices at the same time.

BY KENNETH WONG

Have you ever heard the story of a piano teacher with a strange pricing policy? Her rate for complete beginners is quite reasonable, but she doubles the rate for students who have taken lessons elsewhere. The justification? It takes a lot more work to untrain the habits someone has already picked up.

In bringing engineering applications to augmented reality (AR) or virtual reality (VR), pioneering developers face the same uphill battle recognized by this piano teacher. Due to decades of parametric and NURBS modeling experience in desktop software, users have learned to employ specific steps to create and edit geometric shapes. They learned to draw 2D sketches and add depth to create solids, to select edges and surfaces to add chamfers and holes to them, to pull on dynamic points in splines to morph surfaces and so on.

These operations were invented to overcome the limitations of the mouse, keyboard and 2D monitor that did not provide a way to directly interact with the CAD model. You cannot, for example, reach through the 2D monitor to rotate a CAD component, or pull out a pin with your real fingers.

With mixed reality (MR), the previous input limitations no longer exist. Yet, the modeling paradigm persists, because it's part of the user's collective understanding of 3D objects.

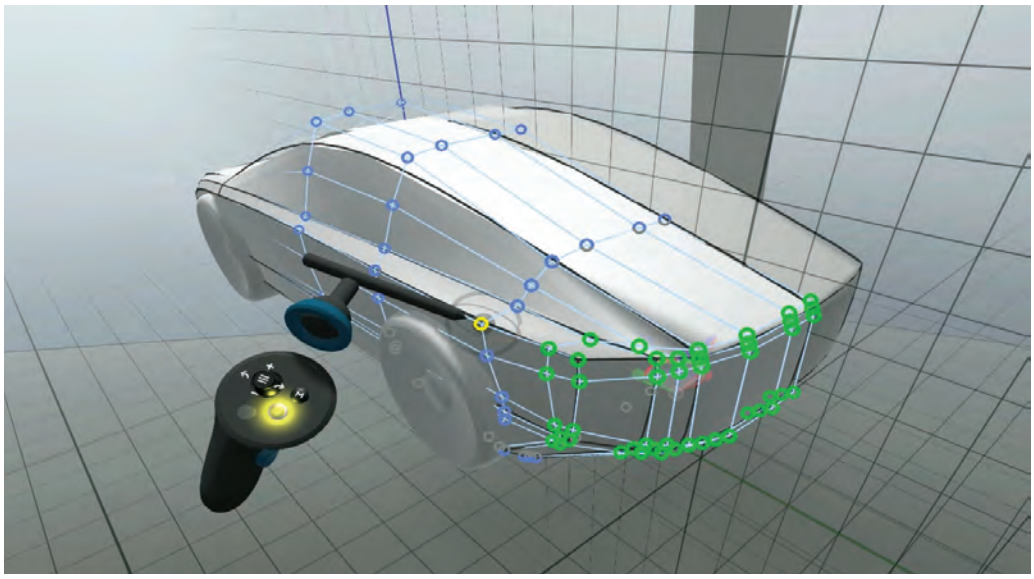
How should 3D modeling be re-engineered for MR? Get rid of the mouse-based geometry selection and editing methods altogether? If so, replace them with what? The developers' challenge is quite similar to the apocryphal piano teacher's. Not only must they undo the deep-rooted modeling methods in the software user's mind, they must also invent a whole new way of modeling for AR and VR.

Autodesk developed a version of its surface modeling software Alias for VR. *Image courtesy of Autodesk.*

Pushing Pixels

In October, Autodesk released Alias Create VR, a VR-ready version of its industrial design software Alias. The software is widely used by automotive designers to create complex and elegant surfaces.

"One of our key goals is to enable our customers to leverage immersive technology within our products in a way that offers a unique benefit for them. This thinking was the driver to add VR creation workflows to Autodesk Alias. Our automotive customers in particular were open to exploring how to bring concept designers into the 3D space early in the process, and VR made this



flyingshapes reimagines surfacing modeling inside VR using controllers. The company is also a software partner for Logitech's VR Ink Pilot Edition, a stylus for VR. *Image courtesy of flyingshapes.*

possible," notes Thomas Heermann, senior director, Autodesk design products.

In the desktop version of Alias, you use the mouse pointer to push and pull on control points in splines to shape and edit surfaces. By contrast, in Alias Create VR edition, you use VR controllers with a two-handed approach to push and pull on control points. You may also pull on surfaces as if there were cloth to cover certain regions. With hand-tracking in certain VR systems, there's also a possibility that soon you might just use your fingers instead of controllers.

"We are working very closely with our hardware partners, as well as observing technology trends to better understand how our users are working in VR. The biggest hurdles reside in user comforts: how it feels, whether users can do what's needed in VR without getting fatigued. For us, the hardware is still in the early stages, but we expect there will be a lot more technology leaps in this space to come," says Heermann.

Stylus or Fingers

Though flyingshapes is described as "CAD for VR," Dr. Johannes Mattmann, co-founder of flyingshapes, admits he doesn't have a strong CAD background, which actually may have helped in this case.

"When we started developing flyingshapes, we focused primarily on how modeling should work inside VR; we didn't think about how other desktop CAD tools work," says Mattmann.

In the markets that flyingshapes wants to target, surfacing software such as Autodesk Alias and Rhino are the dominant brands. The company's founders and some developers came from the automotive sector, where such programs are the standard; this may explain flyingshapes' similarity to these packages.

"The VR nature of the software opens it up for users who shy away from the effort of mastering one of today's CAD tools," says Mattmann.

Recently, computer peripheral device maker Logitech unveiled a pen-like device for VR, dubbed VR Ink. When deployed inside VR, the Logitech device's top button triggers virtual ink for drawing operations. Its side buttons allow you to select and position surfaces and solids. flyingshapes is one of the application partners for the VR Ink.

With HoloLens 2's finger tracking technology, developers like flyingshapes also have the option to allow users to draw with fingertips, the way a child might dip their finger into a paint bottle and draw on a piece of paper.

"There are pros and cons for using a stylus in VR and also for using fingers. We definitely want to support both," notes Mattmann. "Currently, devices with finger tracking are more expensive because it adds complexity. But soon, it could be the opposite."

Mattmann and his colleagues believe, as adoption picks up momentum, even consumer-class AR/VR devices could start implementing finger tracking. His rationale is, ultimately, a device with fewer hardware pieces costs less to manufacture and can be sold at a lower price point. And finger tracking offers the opportunity to eliminate the need for controllers altogether, leading to a more compact device.

Waiting for Better Hand Tracking

For moving and positioning objects, for example, the human hand offers a much more natural interface. Imagine being able to grab machine components and snap them together to form an assembly. However, for sketching 2D profiles or splines to mark trimming regions, the stylus is a more natural device with greater precision. Whether to support one or the other, or both, is a decision AR/VR modeling app developers must confront.

"Hand recognition has to get better. Right now, it's not possible to recognize really subtle movements, so it's not possible to implement, for example, virtual sliders to adjust dimensions in VR. With HoloLens 2 making it possible, you will see in the next year user interfaces adopting it and rapidly changing," observes Greg Jones, senior manager, global business development, NVIDIA.

GPU maker NVIDIA developed a VR-based collaborative design space called the NVIDIA Holodeck. In the Holodeck's virtual environment, users appear as avatars to interact with 3D models in true scale.

"With the current 3D hand-tracking technologies, precision is not enough for designing details (CAD scenario), but in many cases provides enough precision to sketch and sculpt in 3D where lower precision is acceptable," notes Shahrouz Yousefi, CTO and founder of ManoMotion. ManoMotion provides a hand-recognition software developer kit to AR/VR developers working on mobile applications in iOS and Android OS.

"However, for natural interaction and manipulation of the design, hand tracking can bring a big value. In my opinion, controllers are reliable inputs for high precision design and hand tracking for interaction with the design. One option is to use both for these two different purposes until the hand tracking can provide the required precision level," adds Yousefi.

Start off With Collaboration

SolidWorks, part of Dassault Systèmes, offers you an easy way to export VR-viewable models with a few clicks from its popular mechanical modeler SolidWorks. Its viewing and markup program eDrawings also offers VR and AR functions.

"Initially people find value in collaborating around VR models and decision making, so we thought eDrawings is the right vehicle because it's much more lightweight," notes David Randle, senior manager, strategy and business development, SolidWorks.

"A one-to-one true scale perspective possible in VR is not something you can get with the desktop app. That's a new way to inspect and interrogate 3D assets. You get a better understanding of how some components may need to be accessed [in maintenance and repair]," he adds.

For a design-creation application for VR, Randle points to a SolidWorks software partner, Gravity Sketch, as one good direction. Gravity Sketch supports Oculus, Vive and Windows MR devices. The controller's user experience for editing and manipulating surfaces and solids shows some resemblance to flyingshapes and Autodesk Create Alias VR.

Designing the Virtual Workspace

AR/VR developer Varjo has been developing a new design user interface (UI) for AR/VR. Codenamed "Virtual Workspace," the UI was unveiled last December. It includes a library of virtual furniture and interior items for you to drag and drop into the VR environment. It also allows you to import Windows programs into VR, so you can, for example, access your file folders inside the VR workspace.

The new UI is meant for the company's latest generation developer kit, the XR-1 Developer Edition. The headset's built-in front-facing cameras track the user's hands and recreate the same movements and gestures inside VR. In early demos, the author was able to employ a virtual hand (not a controller) to interact with 3D CAD assembly models in VR; however, some pixelation around the virtual hand suggests the software is still a work in progress.

"Varjo Workspace shows how professionals will use and interact with computers in the future. Unlike other immersive computing UIs, Varjo Workspace is not built on 'hand-waving' Hollywood UIs with no practical basis in reality, but instead integrates the way we work today using professional 2D applications—all enhanced by the capabilities of Varjo's XR-1 Developer Edition," says Urho Konttori, co-founder and chief product officer at Varjo.

Don't Lose Sight of Reality

When you enter a virtual world, you also temporarily turn a blind eye to the real world, in a manner of speaking. By contrast, in AR, you see your real world enhanced with a layer of digital information. For example, when you look at an engine block before you, you may also see its installation date, service record and available replacement parts digitally overlaid on top of it.

"I'm much more a fan of AR, because when you design, you still need to design for the real world," says Jon Hirschtick, founder and CEO of Onshape. "We view AR as a rich design platform, just like mobile devices are. Think of AR like a second monitor, another way to co-design."

In October 2019, the software-as-a-service (SaaS), cloud-hosted CAD provider Onshape was acquired by PTC, which already owns an AR technology portfolio under its Vuforia brand. As part of PTC, Onshape could integrate Vuforia components to deliver Onshape for AR, for instance.

"We've already announced that we are developing an Onshape AR client. We haven't released it yet, but it's in prototype now," says Hirschtick. "Modern AR devices support hand recognition, so you can imagine simply reaching out, grabbing objects and moving them around kinematically

in assembly mode. You could also imagine shaping surfaces via control points using your hand, or adjusting dimensions using hand gestures. For example, thumbs up for increasing the dimension and thumbs down for decreasing."

Cloud is Critical

For now, Hirschtick believes partial CAD tools for AR make more sense than a full CAD application for AR. "We also believe with AR, embracing cloud and SaaS technology is part of the vision. We can't imagine on-premise file-based systems becoming popular among AR users," he says.

As people have begun purchasing multiple devices and integrating them into their workspaces, the notion of a CAD session is rapidly changing. "We should be aware of multidevice usage. People log in and use multiple devices to interact with the same 3D model," notes Hirschtick.

In a single modeling session, you might use a tablet to sketch out a 2D profile, edit the resulting solid model on your desktop then put on an AR display to review the design. This will likely come in conflict with traditional seat-based or node-locked CAD licensing that prevents users from launching multiple instances of the software without penalty.

How Real Should it be?

Generally, desktop CAD users do not work in true scale inside CAD software. A 350 cubic-in. engine appears as a fist-size SolidWorks assembly onscreen; a Boeing 747 with a 211-ft. wingspan appears as a 1-ft.-long 3D model on the monitor. The scaling makes it possible to work on large assemblies within the confines of a 2D monitor using mouse-driven rotation. But with MR, the limitation of the 2D screen disappears.

"We don't have to worry about screen space budgeting, since in AR, screen is unlimited," notes Hirschtick. "The advantage in VR is, you can move anywhere within the virtual space—no space limitation," notes Mattmann. That means, in design review, you can look at the proposed concepts in true scale to better understand comfort and ergonomics.

Would you really want to travel 211 virtual feet to go from one end to the other of your Boeing 747's digital twin in VR? Would you really want to stretch your arms wide enough to rotate a 350 cubic-in. engine in AR? For sure, most engineers would choose an easier way to execute such operations. How much realism is too much; how much is just right? How should scaling work in MR? These are open questions.

Comfortable and Cordless

One hurdle inhibiting movement in VR is the cord. Because the head-mounted display (HMD) needs to borrow computing power from a workstation-class system, many invariably come with cords. That means, even if the virtual world is unlimited, the user's ability to roam is limited. The risk of tripping and entanglement is also a challenge.

"I think cordless solutions are the future, so the app has to be a cloud app. Most likely you won't install the entire CAD system onto the hard disc in the head-mounted display; it'll have to run in a client app—something Onshape is already architected to do," notes Hirschtick.

"Cutting the cord is the key. Everybody wants to cut the cord," says Randle. HoloLens 2 removes the cord by connecting the device to the powering system via Wi-Fi. Other devices have also begun adopting a portable powering system, no bigger than a hockey puck or a mobile phone, that the user can carry around.

"Cords and power stations are not limiting the quality of the modeling but certainly affect the comfort of the designer, especially the experience in VR, where immersion is a big factor," says Yousefi. "This is obviously more important together with positional tracking technology where the designer needs to move within the physical space and might be even more limiting in collaborative VR with multiple users. The impact might be lower in AR since users see the physical space."

The weight of the HMD is an inhibitor. Heavier devices prevent users from working with it for long periods; therefore, the most likely scenario for the present is, the user will only put on the HMD when viewing the design in AR/VR.

Dedicated design and modeling applications for AR/VR are still in the experimental phase. However, the UI similarities in the early programs suggest some standard modeling protocols are already emerging. 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

- **Autodesk:** Autodesk.com
- **flyingshapes:** flyingshapes.com
- **Gravity Sketch:** GravitySketch.com
- **Logitech:** Logitech.com
- **ManoMotion:** ManoMotion.com
- **NVIDIA:** NVIDIA.com
- **SolidWorks:** SolidWorks.com
- **Varjo:** Varjo.com

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

Mixed **Experiences** Ring in **New Era** of Design **Collaboration**

AR/VR brings enhanced visual context to design collaboration, reducing time-to-delivery cycles and resulting in better products.

BY BETH STACKPOLE

Augmented reality (AR) catapulted into mainstream consciousness a few years ago with the release of Pokémon Go, a widely hyped consumer game. The technology is carving out a role transforming plant floor operations and in-field product maintenance and support by creating a platform to deliver more intuitive and informative forms of work instructions and training.

More recently, AR, and its close counterpart virtual reality (VR), are taking root in design workflows. The dynamic duo are ushering in mixed-reality experiences that are helping far-flung engineering teams to collaborate more effectively on early concept ideation and during extensive design reviews.

The technologies are also providing a more efficient, effective way for engineers to share ideas and orchestrate design changes with customers and non-technical stakeholders. The models deliver a level of visualization and context not possible with traditional 3D modeling tools like CAD and simulation.

"The best use of AR in the design process is for collaboration," contends Brian Thompson, senior vice president, Creo product management, at PTC. "What AR helps customers do is change their point of view of what the product is and how the product presents itself by reducing the cognitive load that you have to endure when you see a design sitting on a flat screen in 3D. You get a much better feel for the reality of a product when you see it at scale in front of you before you see on a table top or on the factory floor."

Bringing Realism to Design

PTC, a leading provider of CAD and PLM that has made major investments in AR, is seeing a significant uptick in interest among its base of Creo CAD and Windchill PLM users wanting to leverage the technology as part of their design workflows, Thompson says. Creo and Windchill have long had robust collaboration, digital mockup and visualization capabilities via Creo View, software that lets design teams easily access a range of engineering data, including 3D CAD models, 2D drawings and electrical schematics.

ANSYS VRXPERIENCE is used to simulate interior lighting in a car as part of the design workflow. *Image courtesy of ANSYS.*

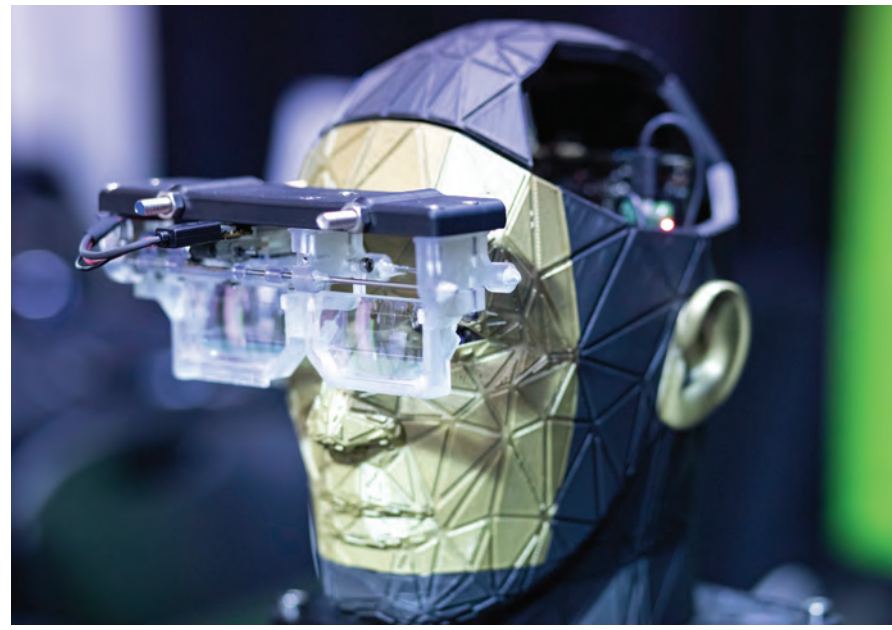
AR Design Share, now integrated into Creo View, takes design collaboration and visualization to the next level, Thompson says. Designers can explore work-in-progress concepts by bringing them to life in full-scale and in the context of real-world environments.

For example, consider customers that are already using the Creo Manikin extension to explore the ergonomics of plane cockpits or vehicle consoles using the software's range of anthropometrically-correct manikins. By putting on a Micro-

soft HoloLens or another AR headset, teams can go beyond Creo Manikin's 3D-based human-centric simulation and fully explore a design at scale, which provides far more realism and context for making design choices.

"The ability to walk into a cockpit or around a piece of equipment is critical," Thompson says. "[With AR], you can see how big an opening is for a worker's hands or what it's like for someone to walk through an opening [in a cockpit or building]."

AR's potential to establish context and real-world scale when evaluating designs is important not just for engineering collaborators, but also for customers who must evaluate work in progress, especially when components or surfaces are customized to their specific needs. In the typical workflow, the engineering team sends around a 2D PDF drawing and spends time walking the customer through the changes or any other areas of the work product they want to highlight, says Thompson.



NVIDIA demos Prescription AR, a project that melds AR capabilities into prescription glasses. *Image courtesy of NVIDIA.*

The visual rendering of the product is often shared in a 2D PDF file instead of a fully featured 3D CAD file because most non-technical stakeholders don't know or have access to CAD, in addition to concerns about intellectual property.

Sharing design intent in this manner opens the door to miscommunication. "Even if you've engineered what the customer needs or wanted, you run the risk of the customer not being able to interpret that properly," Thompson says.

An immersive AR experience minimizes the need to interpret 2D drawings and circle or mark areas you want to change, Thompson adds. AR Design Share, which can attach an AR experience to a specific modification or component as opposed to the whole product design, serves as a more natural and streamlined approach to managing design changes with customers, he says.

AR/VR and mixed reality experiences can also be instrumental for letting the designer view the product through the customer's perspective, according to Prashanth Mysore, director for global strategy business development at Dassault Systèmes.

Although traditional CAD and PLM allow for a digital design mockup, including form and function, a mixed reality experience allows the designer to literally get into the driver's seat of a car and explore the accessibility of the dashboard controls, for example, or how the clutch feels when shifting.

"The innovation process is increasingly about adopting the customer experience as part of the design," Mysore explains. "AR for designers really helps the way they innovate in terms of having the end customer in mind at the early design stage."

AR can also help engineers communicate complex systems such as buildings or aircraft. One of the hurdles to systems-level design is visualization, given that complex systems have layers of engineering data that is spread across multiple systems and global design centers, Mysore says.

"When you have so many layers of engineering data, you require a good amount of visualization for design reviews," Mysore says, explaining that extended reality experiences are increasingly able to fill that role and help communicate design intent for cars, aircraft, even industrial plant floor equipment and operations.

To make mixed reality experiences more accessible to its customers, Dassault Systèmes has included extended-reality capabilities in SolidWorks 2019. With the new capability, which publishes CAD scene data into AR/VR tools or web browsers, product development teams can capture more accurate digital representations of a design and partake in interactive experiences to improve design reviews and sales engagement, as well as a vehicle for training product users.

AR/VR's ability to boost visual collaboration in a design context also has an impact when design responsibilities are spread across a broad chain of partners. As engineers go through the iterative process of optimizing design goals (specifications) and constraints (cost or manufacturability), they typically move through the process sequentially, which makes it harder to reconcile and optimize conflicting goals and constraints across the different disciplines of engineer-

SolidWorks customers can view 3D CAD models in an immersive AR environment, helping to improve collaboration by evaluating designs within context. *Image courtesy of Dassault Systèmes.*

ing, manufacturing and supply chain, notes Joe Barkai, an independent consultant, speaker and author specializing in the engineering and manufacturing space.

That's where tools like AR/VR and mixed reality experiences come in. "Complex design decisions can be biased whether intended or not," he explains. "Visualization and simulation level the playing field and allow each to see it from their 'discipline's' point of view and show the outcome of their decisions using terms of the other participants. Visual information provides more of a common language."

Virtual Reality Gets Real

Although AR is beginning to make waves, VR, historically limited by cost and complexity, is also starting to surface in engineering and design workflows. ANSYS, for example, offers VRX OPTIS, an immersive simulation experience that helps engineers explore the driving environment and lighting systems exactly how a driver would experience the car.

Startup flyingshapes recently announced its new application, which introduces a VR CAD workflow for 3D spatial modeling in a fully immersive virtual environment complete with haptic controls and interactive tools for sketching, surfacing and collaborating with teams on the cloud.

Aimed at the early concept stage of the design workflow, the tool's VR capabilities help design professionals by improving communications, reducing discrepancies between the prototype and final model, and shortening iteration cycles, according to Dr. Johannes Mattmann, co-founder.

Using a VR headset, engineers sketch and shape CAD models and can use hand gestures to position the objects with exact lines, curves and surfaces in a 360° workspace. The software, powered by Unity real-time rendering capabilities and leveraging high-end NVIDIA or AMD GPUs, functions as the digital equivalent of a clay model with the added benefit of easy access to the full stack of CAD data.

In a typical workflow, engineers start with sketches, go to CAD and then build clay models, but they have to go back and forth to CAD data to get measurements to be precise about changes, says Jonas Kunze, co-founder, flyingshapes.

"At some point, you need the data, and with flyingshapes, you never lose the data," he says.

The Road Ahead

Although AR and VR are certainly making inroads into design processes, the technology is still in the early stages, and a variety of challenges remain. For one, much of the hardware is either still very expensive and out of reach for mainstream customers or not nearly precise enough for professional design and development use. Field of vision is one of the key hurdles, especially for glasses-based systems that are essential for enabling hands-free design work, notes David Weinstein, director of professional virtual reality for NVIDIA.

To address some of the issues, NVIDIA has a pair of projects underway: one is prescription AR glasses, which will have a user's prescription built in and make for a more comfortable viewing experience. There are also plans for a "foveated AR" headset, which combines gaze tracking and deep learning technologies to adjust image resolution to match where a user is looking. "You have to be extremely precise with AR, which presents opportunity and problems," Weinstein says.

Beyond the technology challenges, there's also the cultural hurdle of getting people to work differently and for product engineers to embrace different design workflows.

Emphasizing the value that new kinds of visual collaboration can bring to the design process is one way to get engineers on board. "Move the conversation away from AR or VR and focus on visual collaboration," Barkai says. "Identify where poor collaboration has led to mistakes, delays or rework. That's where AR and VR can be really helpful." DE

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

MORE INFO

- **ANSYS:** ANSYS.com
- **Dassault Systèmes:** 3ds.com
- **Flyingshapes:** flyingshapes.com
- **NVIDIA:** NVIDIA.com
- **PTC:** PTC.com

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

Virtually **Trained**

Still using textbooks and whiteboards? AR/VR-assisted learning is faster, more effective and less expensive.

BY KIP HANSON

Virtual reality (VR) is nothing new. In 1838, scientist Charles Wheatstone positioned two photographs opposite one another with a set of perpendicular mirrors in between, thereby inventing the first three-dimensional images. He dubbed his invention "stereoscopy."

A century later, pharmacist and photo-finishing entrepreneur Edwin Mayer and two business partners capitalized on Wheatstone's idea with the View-Master, a stereoscopic device that many of us played with as children and that is still sold today. With it, users learned about dinosaurs, toured the Hoover Dam and viewed photorealistic—but static—scenes from "Star Trek" and other favorite TV shows.

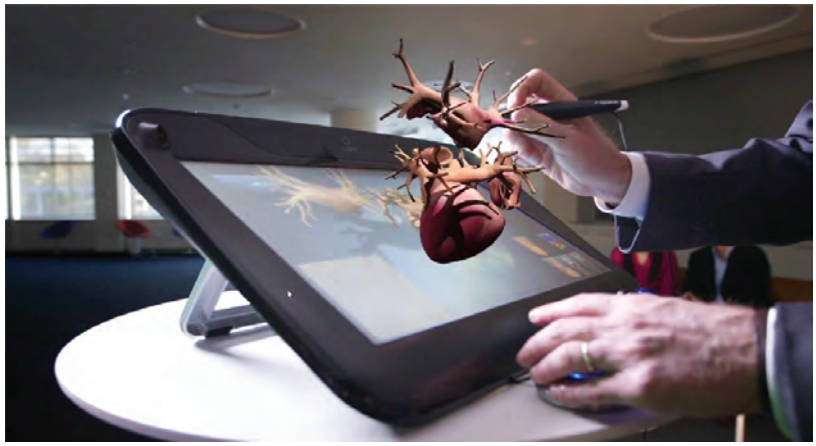
Get Real

Since then, the virtual world has become positively real. Surgeons use VR headsets and haptic gloves to practice on anatomically accurate models of their patients. Jurors visit virtual crime scenes, shoppers tour virtual department stores and astronauts fly through virtual space in virtual spacecraft. And if you're a product designer or manufacturing engineer, chances are excellent that you're already collaborating on projects and visiting the production floor via VR.

In fact, the virtual world has become so important that Joel Breton, president of Sixense Studios, the software development studio of immersive computing solution provider Sixense Enterprises, can list off dozens of industrial applications for augmented reality, VR and mixed reality technology, each of which makes a strong argument for its use.

"We conducted a market survey recently and discovered that there are at least 10 and potentially up to 15 different verticals that can benefit from immersive computing applications," he says. "When you consider that we're still in the early days of the adoption curve, I like to think of it as a big blue ocean of opportunities."

VRSim, one of Sixense's partners, is a virtual reality



Dassault Systèmes' Living Heart project represents an important use of AR/VR technology, providing surgeons with unprecedented training and learning opportunities. *Image courtesy of Dassault Systèmes.*

AR allows virtual objects to be placed atop the real-world environment, as shown in this example.
Image courtesy of Siemens Digital Industries Software.

and simulation training company that uses Sixense's "full presence" technology in its products. SimSpray, for example, is a VR spray paint and coating simulation tool that is said to cut training costs in half, while VRTEX 360—a welding simulator developed in partnership with Lincoln Electric—promises to teach even advanced welding processes in 23% less time and with certification levels 41% higher than traditional methods.

Sixense has also worked with industrial robot manufacturer Sisu on its VUDU product, a training tool that uses advanced motion tracking to significantly streamline the programming process.

Closing the Loop

The potential for VR training extends well beyond factory applications, however. Breton says the technology is suitable for use cases such as healthcare, consumer sales, data protection and human resources. "I could probably stay busy for the rest of my life creating immersive training applications," he laughs.

But the setup isn't just a fancy pair of glasses and some cool video. VR/AR training environments work because they allow the user to immerse themselves in a wholly realistic—but artificial—world; one that responds to their hand gestures and body movements with accurate feedback.

"Research has shown that our memory processes spatial information better than it does verbal or written," Breton explains. "You might struggle to recall the name of someone you met this morning, but you can easily remember the layout of a room you visited last year. VR training leverages this phenomenon by physically immersing someone in the subject matter. This not only gives them the visual stimuli needed to remember certain activities and tasks, but helps them to develop the necessary muscle memory as well."

VR training also gives people a chance to gain skills that might otherwise be learned the hard way. Guillaume Donval, senior innovation lab architect for SIMULIA at Dassault Systèmes, suggests that future

automobile simulators would allow students to navigate a flat tire at highway speeds, drive through inclement weather or even experience a crash.

Though scenarios like these offer tremendous learning opportunities to those who survive them virtually, they also give product designers and engineers the chance to see how end users react under certain conditions.

Have a Virtual Heart

"This sort of immersive review is a great tool to understand the complete user experience, and improve product designs based on that information," says Donval. "That's why we've integrated VR and AR into the design process as a whole, from the initial concept stage through to manufacturing, product testing, deployment and even marketing. The technology allows us to close the design loop, going from the virtual world to the real one and then back to the virtual again."

It's also a great tool to connect each of these processes, Donval notes, and improve communication between team members. Rather than attempt to describe a problem area within a mechanical component or brainstorm how to best layout a production line, team members can simply don AR/VR headgear and take a virtual stroll.

Once there, they might disassemble the digital twin of an automobile chassis, look inside a gas turbine engine while it's under power or move heavy machine tools around with alacrity. These learning and sharing activities can be done from anywhere in the world, bringing together disparate design teams, maintenance crews, production workers, customers and investors like never before possible.

Dassault Systèmes is quite active in the medical field as well, where AR/VR technology does more than reduce training costs and improve communications; it saves lives. In collaboration with the U.S. Food and Drug Administration and leading hospitals and universities, the company plays a significant role in the Living Heart project, creating virtual replicas of the human heart that can be used in many ways, but especially for training.

"The Living Heart project builds on Dassault's 3DEXPERIENCE twin concept, allowing cardiovascular physicians to test surgical procedures, evaluate novel devices, train interns and far more, often using a digital replica of the patient's actual heart," says Donval.

In the Field

Ian Fisher isn't analyzing any virtual hearts, but he agrees on the importance of an accurate digital twin. A senior technical architect at Siemens Digital Industries Software, Fisher says that digital twins give people the ability to make informed and data-driven decisions. It also allows them to learn and adapt from the digital twin, and to enhance and improve it in the process, thereby anchoring the digital twin to the real world.

"The value of any digital twin is determined by the quality of interaction between the people who are using it and the digital twin itself," he says. "And in terms of training, that interaction is probably best expressed with augmented reality, where a user can see virtual objects—a schematic, for example, or an assembly diagram—laid on top of the real-world environment. Here, even an inexperienced technician can take this technology onto the shop floor or into the field and effectively engage with [their] physical surroundings and the virtual model at the same time."

Considering the challenges that the manufacturing industry faces with finding, training and retaining skilled employees, the ability to guide technicians through an assembly or setup procedure via AR is invaluable. Just as important, though, is what Dassault Systèmes' Donval mentioned earlier—the ability to close the loop.

In the case of a maintenance application, for instance, an AR-equipped technician can be guided through the steps needed to service a piece of equipment, in some cases following the bouncing ball or highlighted parts on their headset until the repair is complete.

Though that may sound cool, what's even more cool is the opportunity to provide real-time feedback on the observations or challenges encountered during said procedure. In a cloud-based AR/VR environment, this information is automatically routed to the manufacturer or product designer, providing endless opportunities for continuous improvement.

"Augmented reality allows us to show virtual objects in a physical context," Fisher says. "This is especially relevant to field support, where you can bring spatial and location-based information into the digital twin. I think that's huge. I think that's where a lot of businesses really want to be." DE

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

MORE INFO

- **Dassault Systèmes:** 3DS.com
- **Siemens Digital Industries Software:** SW.Siemens.com
- **Sixense:** Sixense.com
- **VRSim:** VRSim.com

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

Workstation Vendors See **Tool Chain Emerging** for VR Applications

As more engineering firms decide to use VR, workstation vendors must address performance concerns and hardware capabilities.

BY RANDALL S. NEWTON

Increased access to virtual reality (VR) is creating new opportunities for product design and manufacturing, from initial design concepts to sales. An ad hoc "tool chain" is emerging as leading manufacturers and small engineering teams bring VR into their workflow. Some uses of VR are extensions of existing use cases, while others are completely new.

Engineering challenges for VR are more complicated than bringing VR to consumers. VR for consuming content or playing games is more of a passive, easily predicted experience. Engineering needs a robust, interactive environment for collaborative design review, virtual product testing or interactive sales configuration. Engineering use cases need a faster graphics processing pipeline to overcome the inherent issues surrounding interactive VR use including latency, frame rate and image definition.

Some high-volume workstation customers are looking to vendors to help sort out what technologies are required to create virtual design review sessions, training simulations and showroom experiences. Others are sharing with their preferred workstation vendor how they want to create and use VR, looking for the vendor to put together the right combination of hardware and software.

"The affordability and accessibility of VR is opening greater commercial applications for the technology," notes Gary Radburn, director of virtual and augmented reality for Dell. Radburn quotes a Gartner study that claims AR, VR and mixed reality immersion offerings will be adopted by 20% of large enterprises as part of their digital transformation strategy by 2020. A similar growth prediction comes from Goldman Sachs, which predicts engineering will be a $4.7 billion market for VR by 2025.

"It is common to see individual components like headsets and graphics cards say they are VR ready, but you can have the best chip in the world for VR rendered moot if your system is underpowered in other areas," adds Radburn. "A quality VR experience needs all those components to align." In the case of Dell, it is certifying entire hardware systems—including software—as ready for VR.

Radburn says the Dell VR certification process includes a full perception test, "where we sit and engineer inside the headset for 30 to 40 minutes. An automated benchmark test will not catch all the glitches attached to VR-powered engineering work. Personal vetting of the system and putting it through the paces of simulated workloads ensures that it can do what it promises."

Rise of VRED

Industry contacts consistently mentioned Autodesk VRED as a key technology for creating VR applications. VRED (pronounced "Fred") is 3D visualization and virtual prototyping software originally designed for automotive designers. It is a hub for transforming and serving digital design and engineering data as a holistic 3D model.

VRED comes in two versions. VRED Design is for review and evaluation of design ideas and viewing in VR. VRED Professional is a superset of VRED Design for creating high-end virtual prototypes and visualizations that supports NURBS data.

Industry newcomer Varjo (Finnish for "shadow") is gaining attention in engineering for its enterprise-class mixed reality headsets that offer the industry's lowest latency rate and highest resolution. *Image courtesy of Varjo.*

Fujitsu Workstations is seeing increased demand for VRED-based VR workstations.

"VRED is excellent," says Marcus Hartmann, a business development manager for Fujitsu Celsius Workstations in Augsburg, Germany. It allows users to import CAD data from all the leading solutions and host the data in a single environment. "VR is just a tool for visualization," he adds. "Users need to always rely on raw data sets."

Fujitsu cooperates with Autodesk in a VR Center of Excellence in Munich for its customers in automotive and other large manufacturing industries.

For users creating interactive applications, Hartmann says Fujitsu equips a workstation with two RTX-class NVIDIA graphics processing units (GPUs), connected using NVIDIA VR SLI—Virtual Reality Scalable Link Interface. Using two GPUs allows VR data to be created for each eye at the same time, running the two GPUs in parallel.

"There is a great performance benefit to run simultaneously," says Hartmann. "It nearly doubles performance. Performance in VR means frame rate—you want high frame rate to prevent motion sickness."

Virtual Sales Floor

Koenigsegg is a boutique sports car manufacturer in Sweden building the world's fastest production automobiles, for between $2 million and $4 million apiece. More than half of a recent production run was sold using VR, says Greg Jones, a senior manager for XR global business development at NVIDIA. The workflow "exemplifies the path from ideation to design to marketing and sales," he says.

Looking at a fancy car in VR doesn't need the highest level performance from a workstation or the GPU, but developing the full model does. Koenigsegg creates VR content using workstations equipped with two NVIDIA RTX 8000 GPUs, bridged with VR SLI to run in tandem.

"It is a great use of VR, shopping for scarce goods," notes Jones. "The only shopping experience available might be VR."

Jones says NVIDIA is also seeing a rise in the use of VR for product testing and training. Such uses take advantage of digital twins to test and train, even while the product is still in development.

Bell Helicopter recently put a pilot in a VR simulator before a prototype was built for a new model. Feedback from the testing was incorporated into the design. Jones says design time for the new model dropped from three years to six months as a result. "Training is not just for people; it is also for refining the system you put the people into," notes Jones.

Volkswagen is a leading user of virtual reality in engineering and manufacturing. *Image courtesy of Volkswagen.*

VR 3.0 for Enterprise

"We are now into VR 3.0 for enterprise," says Mike Leach, a workstations solutions portfolio manager at Lenovo. Leach says VR 2.0 was attempting to use consumer-class VR technology. Today, "there is no one-hardware-fits-all; there are multiple ways" to create and use engineering content, he explains.

Automotive remains the leading industrial user of VR, Leach says, but other industries are ready to take advantage. "People want virtual prototypes because pixels are cheaper than bricks," he adds.

Lenovo is unique among workstation vendors because they also manufacture VR headsets in partnerships. They built the Oculus Rift S and now have a manufacturing partnership with Varjo, the Finnish startup creating photorealistic VR headsets with eye tracking and ultra-low latency suitable for mixed reality applications as well as VR. Leach says the Oculus model ($600) is good for entry-level engineering uses such as product review and design iteration, while the Varjo ($6,500 to $9,995, depending on model) is "unsurpassed in the market" and suitable for collaboration, training and other high-throughput uses of engineering data.

As a hardware vendor, "experience is king" for Lenovo, Leach says. "The computer has to understand headset movement, send it to the GPU and output pixels. Motion to photon has to happen in less than 20 milliseconds or latency and frame issues happen." Lenovo now ships its Lenovo Performance Tuner, which can optimize hardware performance settings based on customer needs. DE

Randall S. Newton *is principal analyst at Consilia Vektor, covering engineering technology. He has been part of the computer graphics industry in a variety of roles since 1985. Contact him at DE-Editors@digitaleng.news.*

MORE INFO

- **Dell:** Dell.com
- **Fujitsu Workstations:** Fujitsu.com/global
- **Lenovo:** Lenovo.com
- **NVIDIA:** NVIDIA.com
- **Varjo:** Varjo.com

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

Pushing the **Design** Envelope **On the Go**

With a new generation of visual designers, working anywhere in the world, CAD in the Cloud is emerging as a solution for mobile workers to build the future.

BY JIM ROMEO

With 20 World Championships and 182 Grand Prix victories under his belt, Bruce McLaren built a behemoth of automotive design. His creative engineering design team continues to work with the very best tools, showcasing their engineering ingenuity.

With the magic of virtual design, engineers can easily remove a frame supports, reroute exhaust piping, move one component from one side of the car to the other—or change their whole idea and come up with a different configuration altogether. Using CAD solutions on different devices, users can change a nose shape for a formula race car, tweak the details of its cape, making it aerodynamically perfect, a masterpiece—with the least drag—that may race at unimaginable speed and come across the finish line, checkered flags waving.

At McLaren, designers in many different locations use the portability of Dell's 15-in. workstations, loaded with Autodesk applications that allow them to design without archaic clay models like in the past. It is all part of the team's "digital transformation," that their principal digital architect says can simulate, model and integrate data to "bring their designs to life."

But today's high-caliber designers, like McLaren's, need the cloud—to design anywhere, anytime on any premise. This may explain the strategic thinking behind the recent acquisition by PTC of Onshape—a pure software-as-a-service (SaaS) platform that links CAD with powerful data management and collaboration tools via the cloud.

Feeding A New Market Ecosystem

The utility of CAD, when offered via the cloud, is ratcheting up its functionality to be not only a business tool, but one that

More companies are leveraging mobile and cloud-based CAD functionality.
Image courtesy of Chetu.

Software company Chetu sees CAD via SaaS to be a logical next step that allows design collaboration, regardless of location. *Image courtesy of Chetu.*

mobile engineers using tablets, compact workstations and other devices use for generative design (the use of a design program that generates finite outputs with given constraints). It allows on-the-spot design changes, without the need for complete CAD remodeling.

"In a large way CAD is evolving into a business management tool through SaaS," says Jesse Coors-Blankenship, senior vice president of advanced development, PTC. "The more business functions that can access shared data and collaborate on shared data, the more effective a business can be. Not just in engineering and design but in procurement and sales, for instance. The more mobile CAD can be, the more effective a business network and market ecosystem can be."

Blankenship highlights the business value that such a newfound network and market ecosystem can be.

"Generative design is a great example for how sharing data in a collaborative way in SaaS CAD can drive business value," Blankenship says. "With generative design, design requirement changes result in immediate regeneration of designs without the need for timely CAD remodeling. In these ways, teams can utilize concurrent engineering to realize generative models that persist throughout product development cycles."

Tom Schell is the national account manager for Chetu software in Atlanta. He considers CAD via SaaS to be a logical step for designers. It follows a line of disruption in the development of products that not only serve their designs, but also the presence of designers from anywhere, to anyone, whenever design tweaks are to be made. It brings efficiency and a whole new expectation of designers, by designers.

"People can now access and share designs through the provision of a simple link from anywhere with an internet connection," Schell says. "More recently, some programs even facilitate multi-user simultaneous viewing and interacting with drawings, models and information. This ability to virtually immerse multiple people, such as design team members and other stakeholders from around the globe, creates the opportunity for collaboration that occurs on a near real-time basis."

Ease-of-Access Generation

Mitch Hughes, CEO of ViZZ, a software company that enables physical design visualization for the architect-engineer community, says the chronology of CAD, going back decades began in the drawing board culture where engineers, detailers and artists worked pen to paper, alongside their cohorts, creating what he calls a "tactile" relationship.

About 30 years or so ago, the accuracy and speed of CAD became a new expectation and allowed file sharing. Today, many people have a hand in a design, and come from all layers of a project team. From the corner office to the engineer in the field, designers are still tactile—but not only with the proverbial crew that they're used to working with. Now they're working with non-CAD folks as well.

"CAD started as a computer program for the experts, but that too is changing," Hughes explains. "As the most recent generations of people entering the design field bring with them the experiences of gaming, so too are the expectations of ease of use

McClaren Racing engineers use mobile workstations to improve the design process as part of their digital transformation initiative. *Image courtesy of McClaren Racing.*

and multi-player experiences.

"This transition from the expensive, difficult-to-use, specialized programs built for the 'professional,' to the realization of value for all the stakeholders, whether a person is in the field, on the shop floor or in an office or home, is becoming a reality," Hughes continues. "Part of this ease-of-access transition includes moving from the historical outlay of thousands of dollars, to a more financially attainable product that allows access and collaboration with non-CAD experts. Thus, the subscription-based SaaS model of product delivery further enables a broader audience to participate in the CAD revolution."

Chetu's Schell says the largest obstacle that mobile CAD platforms have to overcome is the industry's ability to integrate new technological innovations.

"Many companies are fully committed to modernizing the workflow process, but many others are just now embracing new solutions. The more mainstream cloud computing, mobile application use and other modern tech solutions become in the industry, the more effective the software can be as a whole," Schell says.

He adds that integration has been a challenge, but such a challenge can be overcome when the compatibility is customized and made to fit.

"Firms may be having difficulties with the latest CAD software initiatives due to some incompatibilities with their current software," he says. "Custom software solutions have been proven to alleviate these issues and drastically improve workflow and productivity."

Schell says that the development of CAD software's move to mobile devices has sparked a considerable change in the engineering field, with more engineers and architects turning to the beautiful outcomes of engineering software applications like AutoCAD and putting it to work to streamline and modernize the design and engineering process.

"Cloud computing and mobile app development have allowed the entire design process to be conducted on the go, with users being able to create, edit and share their work instantly with other members of their team, which allows for greater collaboration and removes the whole process from a data silo.

"Also, it provides greater insights than traditional paper blueprints, ensuring that on-site construction managers and contractors know exactly what is needed, which can help maintain or even speed up the overall building time," Schell continues.

Keeping Engineers and Designers On Track

Schell sees the proliferation of cloud computing and mobile devices as a change that continues to modernize the design community with firms tackling larger projects all over the world.

"We are seeing a greater demand for tech innovations that can keep their engineers and project managers on track in a global, connected business environment," Schell says.

For McLaren Racing and McLaren Automotive, the race is on. Mark Roberts, head of design operations for McLaren Automotive, says they use virtual reality to pull in, as he calls it, "engineering hardpoints." "Millimeters do matter," he says. "You could literally bring in an engine, bring in a radiator position, bring in vision lines and [all necessary components]."

What used to be 30 hours of detailed modeling, now takes about 15 minutes, according to Roberts.

And things may get even easier if a cloud-based CAD solution is used. The promise of perfect design never looked so good. DE

Jim Romeo *(www.JimRomeo.net) is a technology writer based in Chesapeake, VA.*

MORE INFO

- **Chetu Software:** Chetu.com
- **McLaren Automotive:** Cars.mclaren.com/us-en
- **PTC:** PTC.com
- **Vizz:** ViZZ3d.com

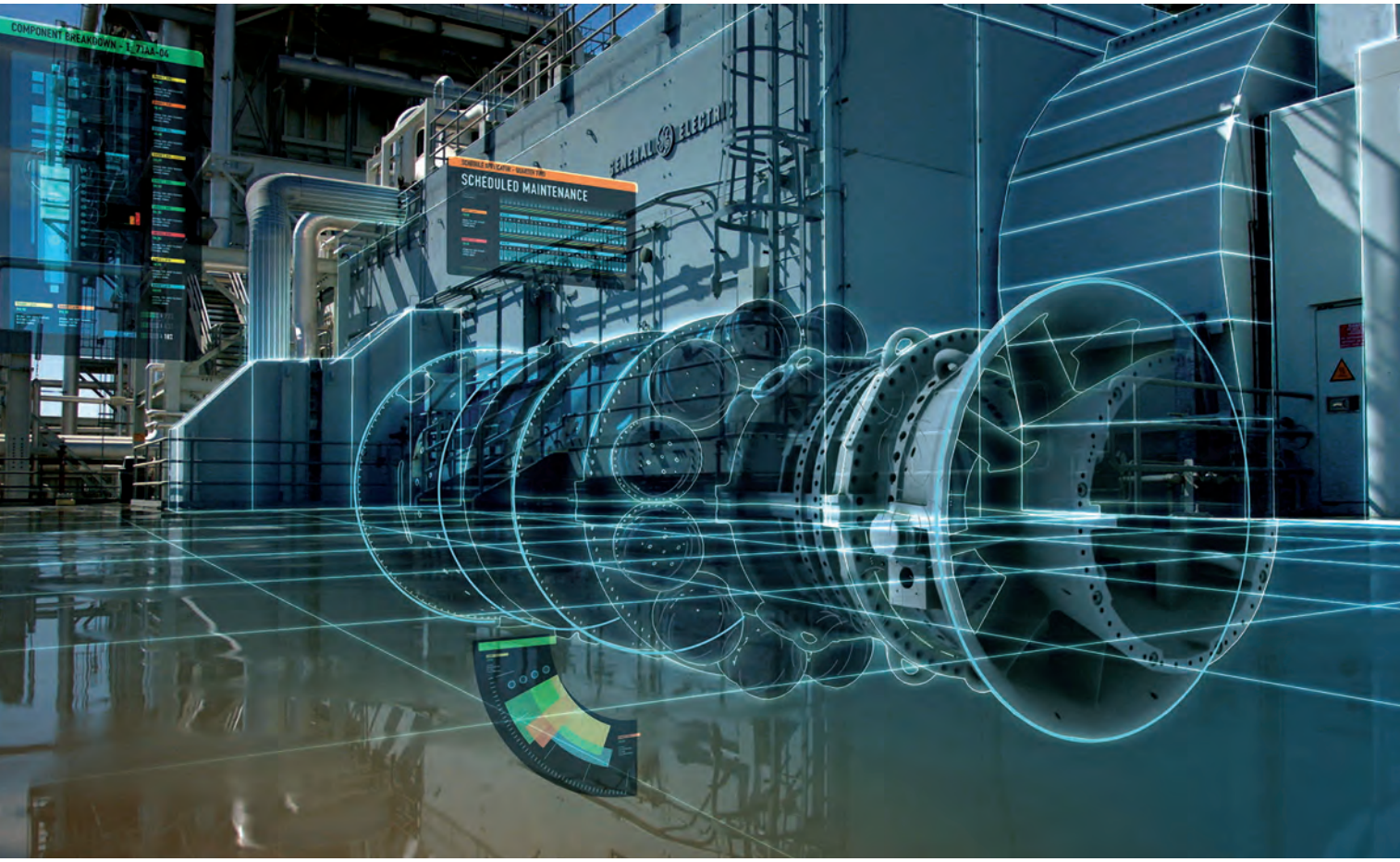
For more information on this topic, visit DigitalEngineering247.com.

AI Rewrites the Possibilities of Digital Twin

Developers of the virtual design tool see AI as providing the catalyst for a major shift in product development.

BY TOM KEVAN

Digital twin technology promises to transform design and give product developers, manufacturers and businesses a 360-degree view of products and systems throughout the entire lifecycle (Fig. 1). Armed with an enriched pool of data provided by the Internet of Things (IoT), the design technology stands poised to deliver previously impossible opportunities. But, there's a catch: A key capability is missing from conventional modeling and simulation tools.



For the technology to deliver on its promise, it must be able to run analytics in real time or faster, provide a high degree of prediction accuracy and integrate data from a collection of disparate and often incompatible sources.

Unfortunately, meeting these goals lies beyond the reach of traditional design technologies. To address the new demands, designers are turning to artificial intelligence (AI), the missing element in the engineer's toolbox.

But even with the current crop of AI technologies, developers and analysts have to perform a number of balancing acts. For instance, they have to find algorithms that can achieve the right balance of speed and accuracy. They must also acknowledge that the size of the data pool sometimes matters less than the quality of the data in it.

Furthermore—and this may make or break the technology's success—digital twin software providers will have to find a way to reduce implementation demands so that more users can enjoy the benefits of the technology.

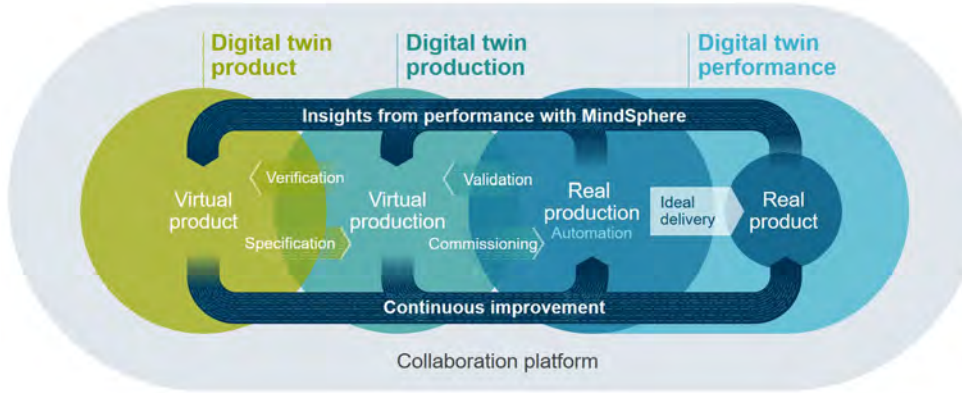


Fig. 2: Digital twins provide manufacturers with the data they require to make near-real-time production optimization decisions. The twin captures and retrieves live, in situ production line and product performance data. *Image courtesy of Siemens.*

What Is AI's Contribution?

How can AI help to fulfill the promise of the digital twin? Developers of the virtual design tool see AI as providing the catalyst for a major shift in product development.

"With machine learning (ML), we can create models based on observed behavior and historical data rather than just the design information," says Bhagat Nainani, group vice president of IoT and blockchain application development at Oracle. "We can also use historical asset data and real-time sensor readings from multiple assets to help detect anomalies and make failure predictions, preventing unplanned downtime."

Technology developers see AI as a way to accelerate design processes, allowing engineers to quickly evaluate many possible design alternatives. By changing design parameters and running AI algorithms, digital twin design software providers contend that engineers could quickly evaluate possible best fits based on the results of the algorithms.

They also claim that designers will be able to run AI solutions on existing designs to uncover properties not considered during the initial design phase and then use the findings to improve the product or system (Fig. 2).

The use of AI in this context is still in the early stages. Most successful digital twin technologies use AI systems to make predictions of situations where data is abundant and where the processes being evaluated are relatively simple. But this is changing.

"We are in the midst of a second wave of digital twin technologies, which has truly game-changing attributes," says Juan Betts, managing director of Front End Analytics. "In this new framework, the digital twin is not just predicting overall product performance based on user preferences, but it is also adapting and predicting the performance and state of key individual components of the system to achieve user-specific individualized performance enhancements."

A good way to see how these benefits are delivered is by viewing the various stages of a digital twin implementation. This examination begins with conventional computer design tools and migrates to more cutting-edge AI-based processes.

The typical starting point for implementing one of these virtual designs is with an existing 3D simulation model, created using a product lifecycle management (PLM) platform or CAD tool. These models typically describe what the physical entity will look like and provide dimensions and possibly descriptions of materials to be used in construction.

In Pursuit of Simplicity and Speed

The engineer—or sometimes the analyst—then begins to create a digital twin of the physical product by overlaying the existing 3D simulation model with real-time data from associated sensors, deployment details and operational conditions.

At this point, the engineer encounters a major challenge. Conventional design software often takes hours or even days to complete simulations using the operational and sensory inputs required to create the digital twin. As a result, tasks such as design optimization, design space exploration and what-if

Fig. 1: Engineers can build digital twins of complex physical assets using design, manufacture, inspection, sensor and operational data. The accuracy of the digital twin increases over time as more data refines the AI model. *Image courtesy of GE Global Research.*

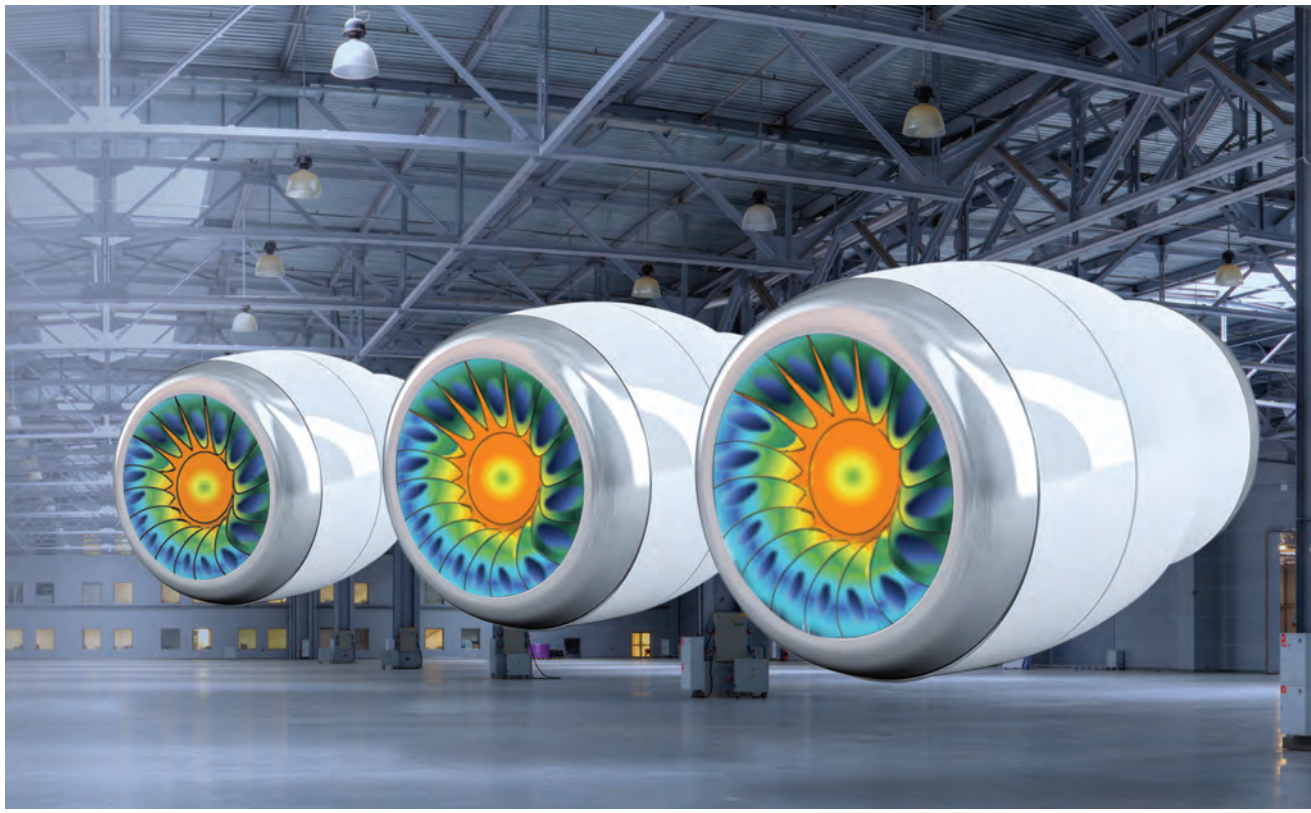


Fig. 3: Phoenix Contact Electronics developed a digital twin of its safety relays using a variety of AI techniques, integrating simulation results with physical measurements from the relay to accurately predict the remaining life of each device. *Image courtesy of ANSYS.*

analyses become impractical because they simply require too many simulations.

To bypass this obstacle, digital twin developers implement an AI-driven process called surrogate modeling—also known as reduced order modeling—which mimics the behavior of complex simulation models as closely as possible in a less computationally intensive way.

The analyst constructs surrogate models using a data-driven, bottom-up approach, taking the critical aspects of a detailed model and reducing them to simpler algorithms that are executed in real time or faster.

Multiple techniques can come into play here, with the engineer combining computations from online and offline phases and using decomposition methods. The surrogate model can use truncation, subspace and response surface methodologies, neural networks and ensemble-based heuristics.

The analyst trains each of the models with one or a combination of data types, including simulation, experimentation, field-test and product-operational data (Fig. 3). Model training calibrates the simulation outputs so that their predictions are more accurate.

These techniques help the engineer to generate a surrogate model, which delivers a number of important advantages.

"Due to that acceleration enabled by surrogate models, development teams can explore many architectural implementations and verify the results in the same amount of time it would have taken for one original simulation run," says Martin Witte, senior principal key expert, system engineering and simulation at Siemens Digital Industries Software.

The goal is to reduce the computational complexity of the mathematical models while still emulating complex full-order models or processes, capturing essential features of the phenomena, often without calculating all full-order modeling details.

Surrogate models use real-world data to optimize design parameters, predict behavior changes—such as those caused by aging—and update the digital twin accordingly. Engineers can use this approach to sense and interpret the real-world conditions and operating parameters of the physical device and feed their insights back into the digital twin.

After these steps are completed, the engineer links the surrogate models, algorithms and other physical data into a product model. The digital twin is updated based on new real-time data and usage data from deployed assets. To ensure

this model doesn't get stale, engineers execute AI algorithms periodically to update the digital twin operational model.

Digital Twin's Tower of Babel

A digital twin simulates many different models, representing all aspects of the asset, ranging from CAD and model simulation to flow-dynamics and electrical-circuit simulations. The processes that create digital twins make it crucial that the various data and model formats interact as seamlessly as possible.

"The output of one design analysis is used by other design analysis," says Achalesh Pandey, technology director for artificial intelligence at GE Research. "The key challenge is in stitching together the various high-fidelity simulation models, and finally, creating stitched reduced-order models [surrogate models] to perform system-level design optimization. The other challenge is to run these compute-intensive simulations in a scalable manner using optimal compute architecture."

A number of design tools, such as ANSYS' Twin Builder, claim to support these processes. Engineers, however, also use other technologies. For example, compiling simulations into lightweight runtime modules that can interact with each other is essential.

That said, challenges remain. "The ability to combine the models from all the authoring tools in the digital twin flow is limited by the lack of standards," says Witte. "Even when there are standards, they do not completely specify the semantics required for these tools to all behave the same. For example, functional mockup units for simulation and Step formats for CAD lack the requisite semantic richness."

When There's Not Enough Data

Designers and analysts have the greatest success in applying AI in the creation and enhancement of digital twins when they have access to abundant data and when the processes of interest are relatively simple. Unfortunately, these two components do not always exist.

Several data-driven approaches—such as neural networks and radial basis functions—are used to build surrogate models. To create a good-quality model, AI technology requires large quantities of trusted data to train models to accurately identify expected behavior and properties. The catch is that this volume and quality of data are often difficult to acquire and verify.

"The digital twin brings real-world physical experience to the simulation," says Ed Cuoco, vice president, AI and analytics, at PTC. "Acquiring such data, however, can be a challenge, particularly when the model to be simulated isn't a fielded product yet."

In another instance, complex issues pose real problems for the designer. "The more complex the system, the more complex the AI framework, and the more data is required if using conventional [AI] techniques," says Betts. "Thus, training AI has typically been the principal barrier to its use."

One Solution to the Data Problem

To overcome these challenges, one company has developed a new approach to surrogate modeling that promises to help engineers build models with significantly smaller training data sets while still achieving high predictive accuracy.

The technique developed by Front End Analytics called Physics Informed Machine Learning (PIML) incorporates physics into the AI framework, which establishes the governing shape of the surrogate model.

PIML translates inputs from the geometry space—such as data from simulations and prototype testing—into inputs for the physics space, ranking the data based on its importance to the results. This allows the engineer to train the AI system within a physics framework and create a multi-stage physics-based model via machine learning techniques.

The model provides a proxy or approximate prediction of the product's performance. According to Front End Analytics, engineers can tweak the results using conventional AI techniques to further reduce prediction error.

One of the main features differentiating this methodology from other data-driven approaches lies in the fact that the empirical models that fit the training data set are based on the underlying physics of the engineering problem.

"These techniques have shown great promise," says Betts. "Example cases have dramatically diminished the amount of data required to predict performance outputs while maintaining very high levels of accuracy. The predictive nature of the solution is also more robust than conventional AI, enabling us to extrapolate results beyond the range of data used for training while maintaining accuracy. The PIML models run faster than real time and are computationally simple." DE

Tom Kevan *is a freelance writer/editor specializing in engineering and communications technology. Contact him via de-editors@digitaleng.news.*

MORE INFO

- **Front End Analytics:** Feasol.com
- **GE Research:** GE.com/research
- **Oracle:** Oracle.com
- **PTC:** PTC.com
- **Siemens Digital Industries Software:** SW.Siemens.com

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

BOXX GoBOXX SLM 17: VR-Ready Power to Go

This new lightweight mobile workstation performs great, but for a price.

BY DAVID COHN

BOXX Technologies has developed a well-deserved reputation for building high-quality, high-performing workstations for 24 years. The Austin, TX-based company also sells mobile systems, which are typically rebranded versions of computers built by other original equipment manufacturers.

The GoBOXX SLM 17 we recently received continues that tradition. A quick check confirmed that the SLM 17 was indeed the same system as MSI's recently introduced WS75 system.

First announced in August at SIGGRAPH 2019 in Los Angeles, the new BOXX GoBOXX SLM 17 is a thin, lightweight 17.3-in. mobile workstation based on a 9th-generation Intel Core i9-9880H processor and a discrete NVIDIA Quadro RTX graphics board; it's dubbed an RTX Studio laptop.

Fig. 1: The GoBOXX SLM 17 mobile workstation from BOXX Technologies delivers great performance in a thin, lightweight package. Image courtesy of David Cohn.

The GoBOXX SLM 17 measures 15.63x10.25x1.0-in. (WxDxH) with an attractive brushed black aluminum case and bronze accents on the side air grilles. Despite its larger size, it weighs just a bit more than its smaller sibling—4.89 lbs.—plus an additional 1.41 lbs. for the 180-watt power supply (5.75x3.0x0.87-in.).

Unlike some of the mobile systems from BOXX we have previously reviewed, however, BOXX does not have many customization options. Instead, the company sells three different pre-configured versions of the GoBOXX SLM 17.

All come with the same CPU, 32GB of RAM and the same 1920x1080 HD display. The only difference is the specific graphics processing unit (GPU) and the capacity of its solid-state hard drive.

For this review, BOXX sent us its least expensive configuration, a $3,850 system equipped with a virtual reality-ready NVIDIA Quadro RTX 3000 graphics board and a 512GB solid-state drive (SSD).

A similar system with a 1TB SSD costs just $119 more ($3,969), while systems equipped with the more powerful RTX 4000 GPU and a 1TB SSD sell for $4,923.

Well Equipped

Raising the lid on the GoBOXX SLM 17 reveals a 102-key backlit keyboard with a separate numeric keypad. Although the key tops are flat, the keyboard has a good feel with adequate travel.

A multi-touch enabled 5.5x2.5-in. touchpad with built-in fingerprint reader is centered in the palm rest, which means it is not centered on the spacebar. Although the touchpad lacks dedicated buttons, you can still right-click by tapping the lower-right corner of the touchpad.

A perforated grille above the keyboard conceals the built-in stereo speakers. A small power button, centered above this grille, is nearly invisible.

A 720p webcam, flanked by microphones and an LED, is

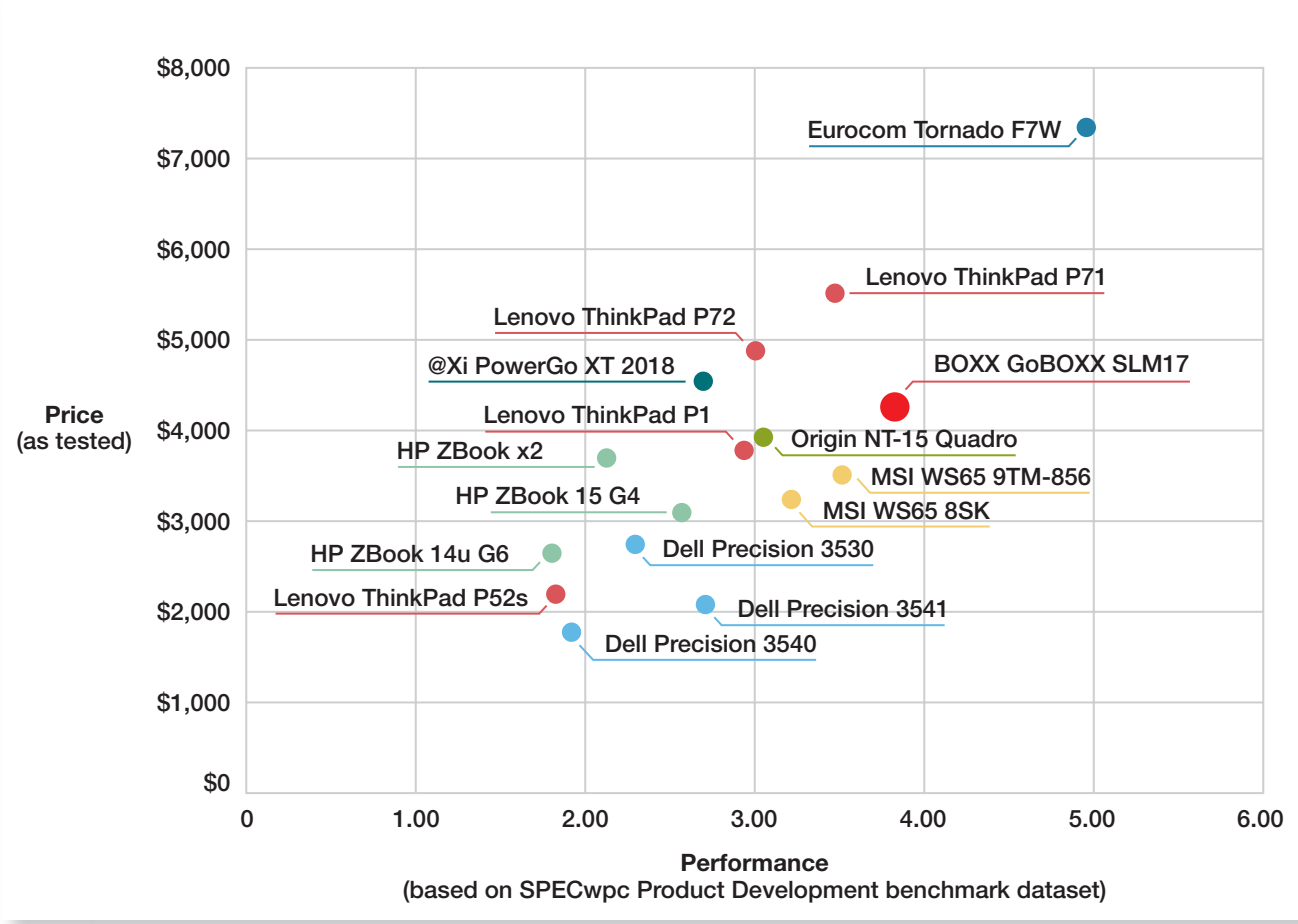


Fig. 2: Price/Performance chart based on SPECwpc Product Development benchmark dataset.

centered above the 17.3-in. 1920x1080 ISP display. A small LED to the left of the keyboard indicates the Caps Lock status, but unlike most other laptops, there is nothing else to indicate when you have engaged the Number Lock or other keyboard-enabled functions.

In fact, other than a small light to the left of the power button—which glows white when the system is on and using the Intel graphics, and amber when the discrete NVIDIA GPU is in use—the only other light of any kind on the SLM 17 is a battery status indicator near the front right edge of the case that blinks if the battery fails.

The SLM 17 also uses the same somewhat awkward keyboard layout found on similar laptops, though it certainly doesn't take long to get used to the odd location of some keys.

The GoBOXX SLM 17 includes an excellent selection of ports. Along the left side is an air vent, the power connector, an RJ-45 network jack, a USB 3.2 port, a card reader and a pair of audio jacks (headphone and microphone) for the built-in Realtek high-definition audio. The right side has a security cable slot, another air vent, HDMI port, a USB 3.2 Type-C/Thunderbolt port, two additional USB 3.2 ports and a second USB 3.2 Type-C port. There are no other ports on the rear of the system. Additional speakers, a large ventilation grille and a battery reset hole are located on the underside of the system.

Few Choices

All three versions of the GoBOXX SLM 17 are powered by a 2.3GHz Intel Core i9-9880H eight-core Coffee Lake CPU with a 4.8GHz maximum turbo boost. This processor, which has a 45-watt thermal design power rating, features a 16MB cache and integrated Intel UHD Graphic 630.

All SLM 17 systems also include a discrete NVIDIA Quadro RTX GPU. The RTX 3000 included in our evaluation unit has 6GB of dedicated GDDR6 memory, 1920 CUDA cores, 30 RT cores and 240 Tensor cores while consuming a frugal 80 watts. Coupled with its 192-bit interface, the RTX 3000 delivers a maximum bandwidth of 336 GB/second.

All three versions of the SLM 17 include 32GB of DDR4 2666MHz memory, installed as two 16GB small outline dual-inline memory modules. Our evaluation unit also came with a 512GB Samsung NVMe M.2 SSD installed in the single M.2 slot.

Excellent Performance

With its relatively fast CPU and powerful GPU, we expected this BOXX mobile workstation to perform extremely well, and the BOXX GoBOXX SLM 17 delivered.

On the SPECviewperf tests, it turned in excellent results on every dataset, outperformed only by systems equipped with even more powerful NVIDIA graphics boards. The

Mobile Workstations Compared

	BOXX GoBOXX SLM17 17.0-inch mobile workstation (2.30GHz Intel Core i9-9880H 8-core CPU, NVIDIA Quadro RTX 3000, 32GB RAM, 512GB NVMe PCIe SSD)	HP ZBook 14u G6 14.0-inch mobile workstation (1.90GHz Intel Core i7-8665U 4-core CPU, AMD Radeon Pro WX3200, 32GB RAM, 512GB NVMe PCIe SSD)	MSI WS65 9TM-856 15.6-inch 2.60GHz Intel Core i7-9750H 6-core CPU, NVIDIA Quadro RTX 5000, 32GB RAM, 512GB NVMe PCIe SSD	Dell Precision 3541 15.6-inch 2.60GHz Intel Core i7-9750H 6-core CPU, NVIDIA Quadro P620, 16GB RAM, 512GB NVMe PCIe SSD	Dell Precision 3540 15.6-inch 1.80GHz Intel Core i7-8565U 4-core CPU, AMD Radeon Pro WX 2100, 16GB RAM, 512GB NVMe PCIe SSD	Lenovo ThinkPad P72 17.3-inch 2.90GHz Intel Xeon E-2186M 6-core CPU, NVIDIA Quadro P5200, 16GB RAM, 500GB NVMe PCIe SSD, 1TB 5400rpm SATA HD
Price as tested	$4,200.00	$2,649.00	$3,499	$2,0687	$1,782	$4,887
Date tested	**10/23/2019**	8/8/19	7/12/19	7/3/19	7/3/19	3/26/19
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	148.65	36.42	169.25	47.53	16.54	143.97
catia-05	200.15	35.60	213.02	53.63	31.56	247.85
creo-02	185.52	34.17	210.09	52.16	15.27	213.88
energy-02	29.94	2.61	39.87	8.25	0.42	36.33
maya-05	187.67	34.17	206.74	56.88	35.19	223.95
medical-02	63.59	9.73	80.88	12.63	8.52	51.37
showcase-02	79.50	13.93	92.57	21.87	11.20	69.64
snx-03	218.39	52.78	288.08	71.37	41.00	303.66
sw-04	123.98	46.04	123.16	60.95	49.00	150.18
SPECapc SolidWorks 2015 (higher is better)						
Graphics Composite	5.03	2.27	3.73	4.16	4.14	4.86
Shaded Graphics Sub-Composite	3.01	1.39	2.23	2.69	2.28	3.18
Shaded w/Edges Graphics Sub-Composite	3.89	2.06	2.96	3.51	3.09	4.01
Shaded using RealView Sub-Composite	3.57	1.63	2.63	3.05	2.87	3.62
Shaded w/Edges using RealView Sub-Composite	4.35	2.98	3.12	3.50	4.87	4.11
Shaded using RealView and Shadows Sub-Composite	4.11	1.45	3.04	3.48	3.02	4.15
Shaded with Edges using RealView and Shadows Graphics Sub-Composite	4.56	2.47	3.30	3.66	4.83	4.34
Shaded using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	13.54	3.01	10.06	10.13	7.75	12.14
Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	13.35	4.58	9.59	9.73	11.27	11.69
Wireframe Graphics Sub-Composite	4.34	2.76	3.50	3.69	3.50	3.95
CPU Composite	5.33	1.85	2.71	4.17	3.37	3.06
SPEC Workstation v3 (higher is better)						
Media and Entertainment	1.98	0.8	1.82	1.37	0.92	1.73
Product Development	2.07	1.04	2.01	1.57	1.21	1.57
Life Sciences	1.99	0.87	1.97	1.00	0.94	1.44
Financial Services	2.16	0.7	1.49	1.41	0.80	1.59
Energy	1.32	0.54	1.28	0.95	0.50	1.11
General Operations	1.79	1.13	1.75	1.67	1.52	1.45
GPU Compute	3.09	0.6	3.41	1.00	0.35	2.76
Time						
AutoCAD Render Test (in seconds, lower is better)	45.90	140.40	43.80	59.70	77.50	42.80
Battery Life (in hours:minutes, higher is better)	8:37	5:30	6:07	15:28	15:17	5:38

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

Fig. 3: Graphic performance chart based on SPECviewperf 13 Geomean.

The BOXX Difference

We reached out to BOXX regarding the price difference between this BOXX mobile workstation and the MSI-branded version of this same system we found online. Matt Priest, GoBOXX Product Manager, responded:

"Unlike our APEXX desktop workstations and RAXX servers, GoBOXX mobile workstations are manufactured and branded for BOXX by MSI. But just like our workstations and servers, these laptops are then subjected to rigorous BOXXlabs testing to ensure that they are indeed certified to run specific software applications. In some instances, configurations are modified to ensure that each GoBOXX delivers maximum performance and is qualified to wear the BOXX mantle of 'purpose built.' To ensure rapid repair or replacement, we stock spare parts and back GoBOXX laptops with U.S.-based, legendary BOXX Technical Support."

"The MSI laptop price, as found on Newegg, Amazon or other retail sites is commonly referred to as a 'street price' and is the final price whereas the GoBOXX price on box.com is an MSRP or starting price required by government, GSA and other entities. BOXX offers discounts on this MSRP—especially with bulk corporate purchases. Therefore, comparing the two system prices is not an 'apples-to-apples' comparison. In addition, BOXX only serves the professional market, not consumers, and as such, we provide professional services (loading a corporate image, system validation, etc.) under the mantle BOXX for Enterprise. We also offer terms so business customers can purchase through an account and not just via credit card."

SLM 17 delivered equally impressive results on the SPECapc SolidWorks tests. On the demanding SPEC workstation performance benchmark, the BOXX GoBOXX SLM 17 led the pack among mobile workstations we have tested recently.

On our own AutoCAD rendering test, the 45.9-second average rendering time was one of the fastest we've ever recorded for a mobile workstation. Despite its performance, the GoBOXX SLM's four-cell 82-WattHour battery still managed to keep the system running for 8 hours and 37 minutes. The system remained cool and quiet throughout our tests.

BOXX preloads Windows 10 Professional Edition or you can opt for Windows 10 Professional Workstation Edition for $84 more. Our only complaint was that BOXX only backs the system with a one-year warranty though essentially the same system from MSI comes with a three-year warranty.

Since most workstation-class systems typically include a three-year warranty, our as-tested price includes the $350 BOXX charges for the longer warranty, which brought the total price to $4,200.

The BOXX GoBOXX SLM 17 is clearly a great choice for any engineer or designer who needs a thin, lightweight VR-ready system they can depend on whether they're in the office or on the road.

But potential buyers should also consider the MSI-branded version of this same system, which we found online for $1,000 less. DE

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

➜ MORE INFO

BOXX Technologies: BOXXTech.com

BOXX GoBOXX SLM 17

- **Price:** $4,200 as tested ($3,850 base price)
- **Size:** 15.63x10.25x1.00-in. (WxDxH) laptop
- **Weight:** 4.89 lbs. plus 1.41 for 180W power supply
- **CPU:** Intel Core i9-9880H 2.3GHz eight-core w/ 16MB cache
- **Memory:** 32GB DDR4 at 2666MHz
- **Graphics:** NVIDIA Quadro RTX 3000
- **Storage:** Samsung 512GB SSD M.2 PCIe drive
- **Floppy:** None
- **Optical:** None
- **Audio:** Realtek High-Definition audio with stereo speakers and build-in microphone, headphone-out and microphone-in
- **Network:** Integrated 10/100/1000 Intel Dual-Band Wireless-AC 9560 with Bluetooth and RJ45 jack
- **Modem:** None
- **Other:** Three USB 3.2, USB 3.2 Type-C/Thunderbolt, USB 3.2 Type-C, HDMI, card reader
- **Keyboard:** 102-key backlit keyboard with numeric keypad
- **Pointing device:** Integrated touchpad with multi-touch and fingerprint reader

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

EDITOR'S PICKS

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

Removing Bottlenecks From Sharing Simulations

VCollab merges information from multiple CAE and CAD sources into a single 3D file.

VCollab is designed to overcome the organizational and performance challenges inherent in how simulation results are shared. The data is vendor-neutral and compact, making it easy to share.

New in VCollab V19 is an enhanced Python API, a powerful tool for intelligently extracting and processing simulation insights. Python is an easy-to-learn scripting tool for engineers who want as much control as possible over automation processes.

MORE ➜ digitalengineering247.com/r/23304

500,000 Colors Produced From One 3D Printer

The latest generation of a printer line popular for creative design prototyping.

Stratasys unveils the next generation of its full-color, multi-material PolyJet line, the J850 3D printer. Stratasys says the J850 can print up to twice as fast as previous J-Series printers, thanks to a new Super High Speed mode. Another key to speed is found outside the printer, in model preparation. The J850 uses GrabCAD Print technology, which allows the user to select a CAD model from the GrabCAD repository and send it straight to the 3D printer without intermediate translation to STL.

MORE ➜ digitalengineering247.com/r/23272

Fresh Take on Industrial Design Software

Altair Inspire Studio is part of Altair's Inspire Platform, a set of contemporary tools.

Industrial design (ID) requires CAD tools that differ from most engineering disciplines. Altair used its existing product Evolve as the foundation for Inspire Studio. Inspire Studio combines immediate visual capabilities with a modern user interface for sketching, freeform design, solids modeling and PolyNURBS parametric modeling. Included is Inspire Render for turning models into photorealistic 3D animation and rendering using physically based lighting.

MORE ➜ digitalengineering247.com/r/23243

Thermoplastic Masters Long Production Runs

Figure 4 PRO-BLK 10 3D printing material ideal for variety of use cases.

3D Systems extends the capabilities of the Figure 4 modular 3D printer with a new material, Figure 4 Production Black 10 (PRO-BLK 10). The big draw of the Figure 4 System is its ability to directly produce end-use plastic parts in high volume without tooling.

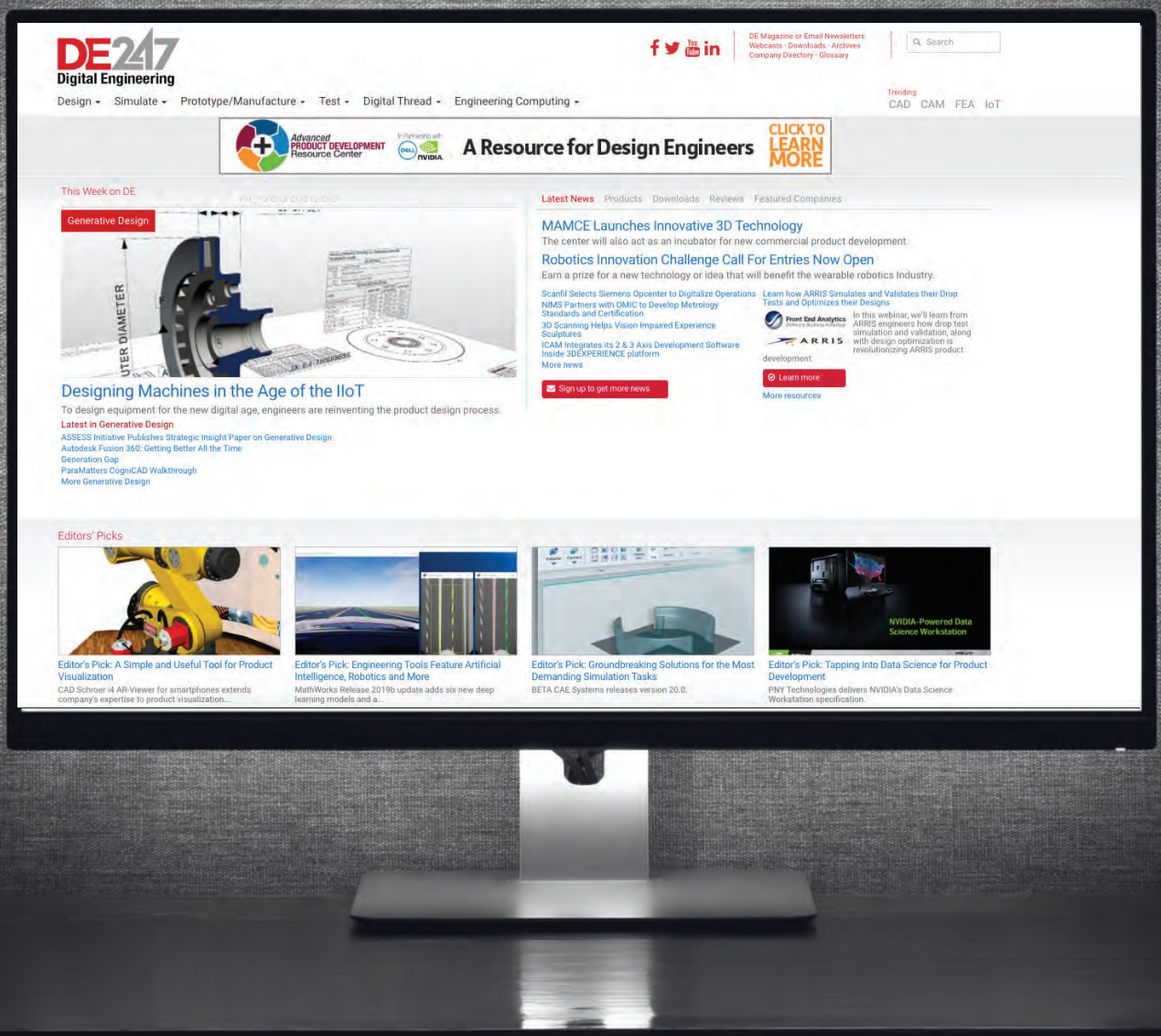
Figure 4 PRO-BLK 10 offers a fast throughput and a simple post-processing of a single curing cycle and a single solvent cleaning. The result is a smooth surface and sidewall finish.

MORE ➜ digitalengineering247.com/r/23223

NEWS, TRENDS & INSIGHTS

MORE CONTENT, MORE RESOURCES, MORE SOLUTIONS

DIGITAL ENGINEERING WEBSITE



DE247
Digital Engineering

DigitalEngineering247.com

Next-Gen Engineers

Student Competition Profile: NASA Human Exploration Rover Challenge

Students Master the Drive Train Technology Challenge

BY JIM ROMEO

The Blue Ridge–University of Arizona 4-H Fab Lab is a partnership between Blue Ridge Unified School District, the University of Arizona and the 4-H youth development program. This past year, students participated in the NASA Human Exploration Rover Challenge and the team took first place for High Schools in the "Drive Train Technology Challenge" competition.

Kevin Woolridge teaches math, physics and engineering, as well as Fab Lab classes, at Blue Ridge Unified School District. Following is a conversation with Woolridge, the teacher and mentor who led students from Blue Ridge to first place in the competition.

Students created a two-speed transmission for the competition. *Image courtesy of Blue Ridge Unified School District.*

Digital Engineering: **Can you provide an overview of your competition, how it came to be and the program's intent? Who will be participating or who has participated? How many participants have you had or do you expect? Do you have any demographics of participants?**

Kevin Woolridge: Nearly 100 student teams from high school, colleges and universities worldwide took part in the NASA Human Exploration Rover Challenge. The competition, organized by NASA's Marshall Space Flight Center in Huntsville, AL, and hosted by the nearby U.S. Space & Rocket Center, honors a half-century of historic engineering ingenuity—and today's ongoing pursuit of bold new discovery missions to the Moon, Mars and beyond.

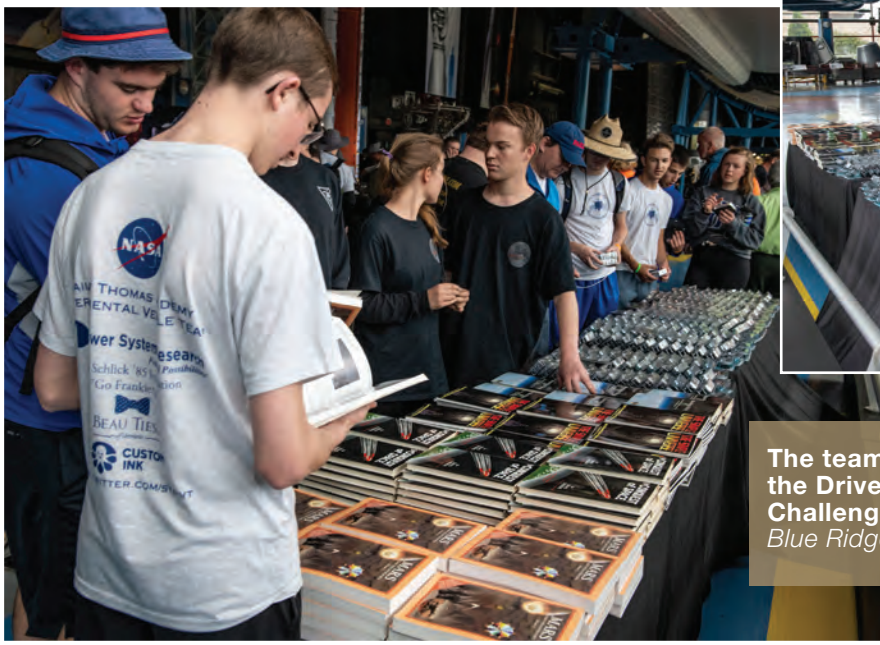
The Rover Challenge integrates the nation's ambitious, multi-decade plans for solar system exploration with practical engineering skills, innovative design techniques and real-time strategy and decision-making complementing students' classroom STEM curricula—science, technology, engineering and mathematics courses. The Blue Ridge Physics and Engineering Class and Club chose to participate in the event as part of their class capstone project.

The team consisted of 14 students (six girls and eight boys) ranging from 9th to 11th grade. Although several of the students have already decided to go into engineering and other STEM-related professions, many are yet undecided. Participation in this competition allowed for the students to have opportunities they never realized were available. This exposure lit a fire in them and moved them a little closer to making STEM a future career choice.

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

Woolridge: The Blue Ridge team created a two-speed transmission with a dog clutch with a gear ratio of 3/1 or 1/3, depending on high versus low gear. One of the event organizer's major pushes is to have teams move away from less-reliable bicycle type chain drive trains and towards a rigid drive.

The Blue Ridge team used the MDX40a to prototype a 1/10th scale model of the transmission as well as their wheel design. Part of the engi-



The team took top honors in the Drive Train Technology Challenge. *Image courtesy of Blue Ridge Unified School District.*

neering design process requires the students to prototype and test prior to creating the finished product. The team used Roland DGA equipment to create scale models of their concepts, test and modify their designs then create the actual product to be installed on the rover.

This process allowed us to significantly decrease the cost and eliminate wasted time and trial and error. Roland SP300i was used to create promotional and fundraising materials, and the LEF12 UV flatbed printer was used to print the team logo on their T-shirts.

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

Woolridge: I think that this is best summarized by the NASA mission statement and description for the competition. "This student design challenge looks to the next generation of scientists and engineers to aid in the design process by providing innovative designs and unique perspectives."

Essentially, in addition to being a STEM opportunity for high school, college and university students, this competition brings new ideas to the NASA scientist. It harnesses the brainpower and creativeness of thousands instead of relying on a limited few to solve mission-critical challenges. By bringing in new perspectives and solutions to design problems, the NASA engineers are better able to solve existing mission-critical problems.

DE: **Is there anything else you'd like to tell us about the event?**

Woolridge: Blue Ridge School District is a majority-minority school district located in rural eastern Arizona in the town of Pinetop-Lakeside. As a small rural school in a town with a population of just over 4,000 residents, our team faced many unique challenges, most specifically project funding. Unlike a majority of the teams participating in the competition, our team had very little money or resources to draw from. Our greatest challenge was not in building the rover, but rather in raising the money for travel, food, lodging and shipping.

While most of the teams at the NASA Human Exploration Rover Challenge had significant budgets for building their rovers as well as travel costs, the Blue Ridge team had to first raise the funding required for competing as well as travel. They also needed to creatively solve design problems using what was available and could be repurposed. Our team built its rover for less than $200 using discarded fitness equipment and donated materials.

Competing in the competition also wouldn't have been possible without Roland DGA's sponsorship. As important as the Modela MDX-40A benchtop milling machine, 3D printers, laser cutters and CNC routers are in the engineering and digital fabrication process, the VersaCAMM SP-300i 30-in. Eco-Solvent inkjet printer/cutter and LEF-12 benchtop UV flatbed printer were equally important.

Without the ability to create promotional materials and posters to solicit donations as well as materials for sale as a team fundraiser, we would not have been able to participate in this competition. By combining the traditional engineering and prototyping tools with the digital media tools, we were able to both build and test our concepts and raise the funding necessary to travel and compete. **DE**

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

For more info, visit NASA.gov/stem/roverchallenge/home/index.html

| COMMENTARY |

By Jamie Howard

Unexpected Supply Chain Benefits of 3D Printing

The same flexibility that 3D printing brings to design can also improve manufacturing and logistics.

Not all products can be, nor should be, 3D printed. 3D printing will never rival the economies of scale found in mass-produced commodities, though the technology is becoming more capable and reliable.

According to Gartner (Gartner.com/doc/3845863), 47% of supply chain managers plan to use 3D printing in the next two years. This creates five unexpected benefits of bringing 3D printing into supply chain processes.

Avoid Negative Outsourcing Effects

Businesses have outsourced to other companies for decades because it made economic sense. However, global logistics is becoming riskier and more expensive. Things only get more complex when you add the time required to negotiate with multiple suppliers, and navigate several time zones and different languages in the mix. More fragmented than ever, outsourced supply chains are losing their luster.

There is huge potential for 3D-printed spare part creation, which, according to one DHL report (bit.ly/35VK0Fu), can account for more than 20% of a company's unused or excess stock. Many automotive manufacturers are required to stock spare parts for seven to 10 years (bit.ly/387taWq) for every vehicle they make. The end-to-end process that 3D printing offers serves as a fully fledged production method, cutting down on excess stock and wait times for parts.

Simplify Supply Chain Costs and Save Time

Compared to outsourcing, 3D printing typically has a higher ROI, but supply chain simplification provides other savings as well. Three examples of how 3D printing can generate even more ROI include:

Transport Costs

The logistical nightmare of producing and shipping spare parts from overseas offers an opportunity for easy savings. By simply installing a 3D printer to meet on-demand part manufacture, research (bit.ly/2LlpdTZ) suggests companies could save up to 85% on shipping costs.

Wider Profit Margins

Based on public data sets from the Bureau of Labor Statistics and manufacturing industry economic data (bit.ly/2YcCT92), it can be estimated (bit.ly/2OME3W0) that cost of operating in the manufacturing industry in the United States is $4,258,341 per minute, with a profit margin of only $22,480 each minute.

3D printing can impact a large industry if it can save time in gained productivity. Although the cost savings for printing one prototype part in-house may not seem

significant, each opportunity to save time or money adds up quickly, especially for large-scale manufacturing facilities.

Reduced Labor

Typically, overseas labor rates were cheaper than U.S. rates, so many manufacturers outsourced that cost. 3D printing reduces dependence on this variable because one trained worker can operate a small spare parts production facility at a workstation. This is due to increased printer uptime and reliability, with network-enabled machines controlled via intuitive printer management software.

Create a More Agile Value Chain

Traditional supply chains are not known for their responsiveness and are only getting more complex. By reducing the manufacturing duration and cutting out overseas transportation, 3D printing almost negates lead times.

Depending on their complexity, most printed parts are produced in hours, not weeks; organizations can easily scale production output with multiple machines to meet demand.

Benefit from 3D Printing's Unique Product Performance

3D printing offers small-batch manufacturing with a significant advantage: geometric freedom. Traditional production methods, like injection molding, can be restrictive and follow design-for-manufacturing rules.

With 3D printing, more exotic and efficient geometries can be printed with generative design (bit.ly/2qh1kFR)—leading to improved structural performance, material savings and a shorter design-to-manufacturing cycle.

Differentiate Services with On-Demand Part Production

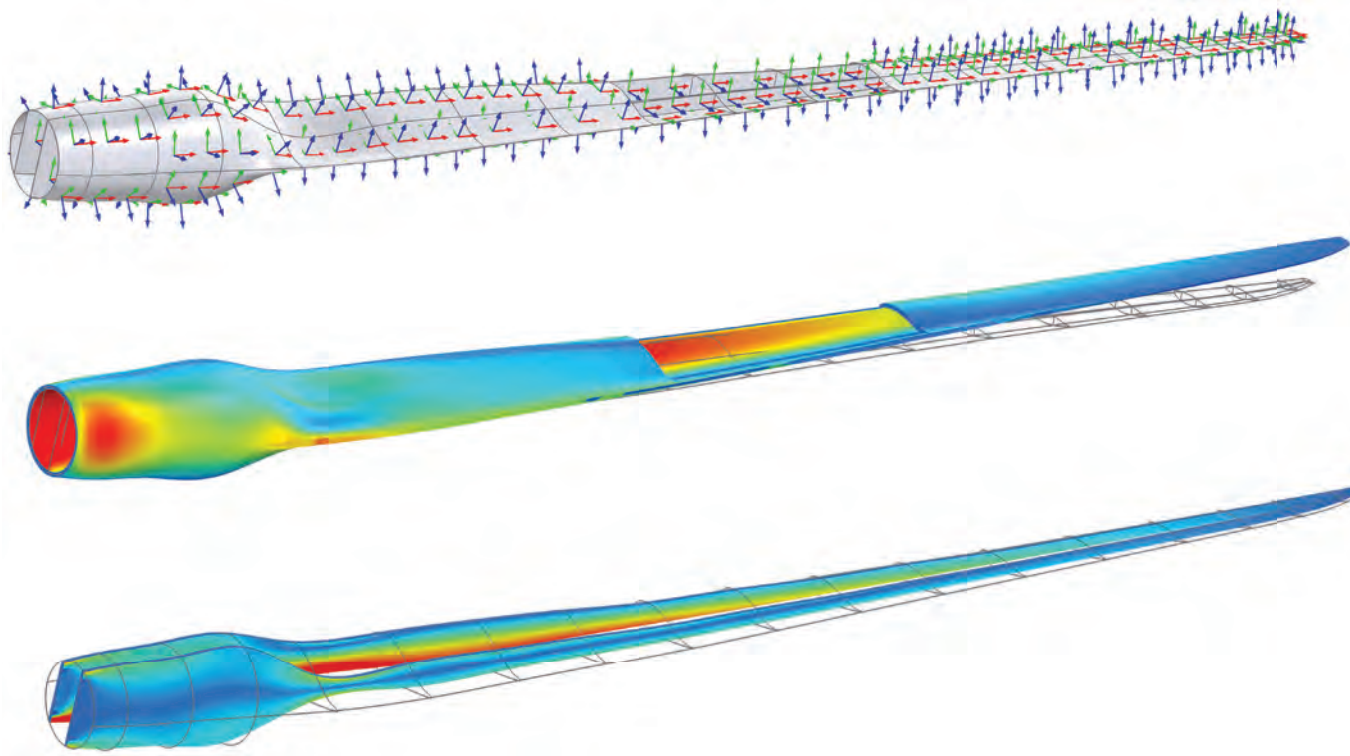
As digitization fuels the "demand economy," 3D printing synergizes perfectly with connected manufacturing. This on-demand part production enables greater levels of personalization for finished or almost-finished goods. Parts can be individualized, such as manufacturing tools with ergonomics specific to the worker.

Essentially, 3D printers can replace your just-in-time inventory. Already a reality, virtual warehouses can send 3D model files digitally to the nearest 3D printer. Logistics companies like DHL and UPS are already using 3D printing to supplement their "end-of-runway" services when specific parts are needed in the fastest time possible.

Not everything should be 3D printed. But with its multiple benefits, 3D printing technology can improve the supply chain in ways that shouldn't be overlooked. DE

Jamie Howard *is president of Ultimaker Americas, where he is responsible for the company's commercial strategy and business execution in the Americas region. He has more than 25 years of GM, engineering and technology management experience. He holds a B.A. from California State University, Long Beach, and M.A. from Fuller Theological Seminary.*

Develop composite material designs that last.



Stress and modal analysis of a wind turbine blade made of composite materials.

When designing a structure that is made up of composite materials, such as a wind turbine blade, you need to be able to analyze composite layer stacks with different thicknesses, material properties, and fiber orientations in each layer. Simulation can be used to analyze composite structures for different material types and stacking sequence by performing modal and stress analyses for different types of loads.

The COMSOL Multiphysics® software is used for simulating designs, devices, and processes in all fields of engineering, manufacturing, and scientific research. See how you can apply it for analyzing composite materials.

comsol.blog/composite-turbine-blade

COMSOL