DigitalEngineering247.com

DE

Digital Engineering

September 2019

Software Bundles P.14

Path to Simulation P.19

Budget Workstations P.28

FOCUS ON: Democratization P.10

Unlocking Simulation

REVIEWS:

DELL PRECISION 3540 & 3541 P.30

PARAMATTERS COGNICAD P.36

AUTODESK FUSION P.42

PERVASIVE ENGINEERING MEANS TWIN-TWIN PROPOSITIONS

With ANSYS Twin Builder, you can build, validate and deploy a digital twin for unparalleled insight into your asset's performance — and cut maintenance costs by up to 20 percent.

Learn more: **ansys.com/twin-builder**

ANSYS®

DE Digital Engineering

NAFEMS

Digital Engineering and NAFEMS Americas are teaming up to present CAASE19, a one-day Virtual Conference on Advancing Analysis & Simulation in Engineering

CAASE19

Virtual Conference

October 8, 2019

TRACK 1: Simulation-Driven Design
TRACK 2: Simulation Governance & Democratization
TRACK 3: Manufacturing Processes & Additive Manufacturing
TRACK 4: Addressing Business Strategies & Challenges

Go to: **digitalengineering247.com/joincaase19** to view the presentations from Ford Motor Co., Embraer, Procter & Gamble and others, and register for this great day of learning.

Sign Up Today!

| DEGREES OF FREEDOM |

By Brian Albright

A More Open, Accessible Future

IF YOU HAD TOLD ME A YEAR AGO that I'd soon be overseeing my first issue of *Digital Engineering* at its editorial director, I would have quickly dismissed the notion. Jamie Gooch has been the "face" of *DE* for as long as I've been a contributor. I was surprised when the post suddenly became available, and also thrilled at the opportunity to dive into the work that this magazine has been doing so well for so long.

I have some big shoes to fill. My predecessor spent the past decade guiding *Digital Engineering* through tremendous changes, both in the design and engineering market at large and within the magazine itself. I'm approaching the challenge with a mix of trepidation and excitement.

This is a highly dynamic space to write about, and new innovations in high-performance computing, cloud-based applications, simulation-driven design, additive manufacturing, and other technologies are going to lead to a rapid evolution in how designers and engineers develop, test and build new products across nearly every sector of manufacturing.

It is serendipitous that my first issue at the helm keys in on democratization. During the past 20-odd years that I've been writing about technology, the trend lines have been the same in almost every industry and every market: a sometimes slow but continuous push to open up technology both to new users and new use cases. To put more data in the hands of people who can make use of it, and to expand their numbers. Our focus on democratization in this issue is pointing to the future, but also telling an old story.

Democratizing Technology

I've seen it again and again. In the healthcare sector, it has manifested in digital healthcare approaches that make it easier for physicians to collaborate and for patients to access their own health records. In the logistics industry, supply chain visibility has been pushed down to the mobile devices carried by everyone from the CEO to the truck driver, and the advanced technology that helped behemoths like FedEx and UPS innovate is now available to anyone with a few trucks and some ambition. Complex demand forecasting techniques pioneered by Walmart are now within the grasp of any small retailer.

The process is rarely easy, and often messy. Ask any doctor how they feel about electronic health records, and you're likely to get an earful. Kmart tried to mimic Walmart's fulfillment model, failed to properly prepare and fell into a hole from which it was never able to fully emerge. Our goal in putting this issue together is to help illuminate opportunities and challenges that lie ahead, and point our readers in the direction of the successful strategies and useful tools as they navigate this new territory.

A Wide Open Future

Throughout this issue, you'll see examples of how this steady expansion of data, of application reach, of end user communities, affects every aspect of design. You'll hear from visionaries that want to see designers gain access to easier-to-use simulation tools, and see how subscription-based software can help smaller companies leverage advanced design and simulation. We even take a look at lower-cost workstation options that put more computing power in the hands of entry-level users.

In preparing for this issue, I also read through a 2017 Aberdeen report on simulation-driven design that showed how best-in-class firms are applying simulation earlier in the design process, and giving access to simulation tools to a growing number of non-experts. These firms are able to capture the expertise of computer-aided engineering (CAE) staff and share it with non-engineers, while also encouraging collaboration. As a result, 73% of those firms verified the product design earlier in the process, shortened development time by an average of 29%, and built 27% fewer prototypes.

The cost savings, accelerated time to market, and productivity boost enabled by this approach could be enormous. Beyond those return-on-investment (ROI) figures, the potential to accelerate innovation could be even more staggering.

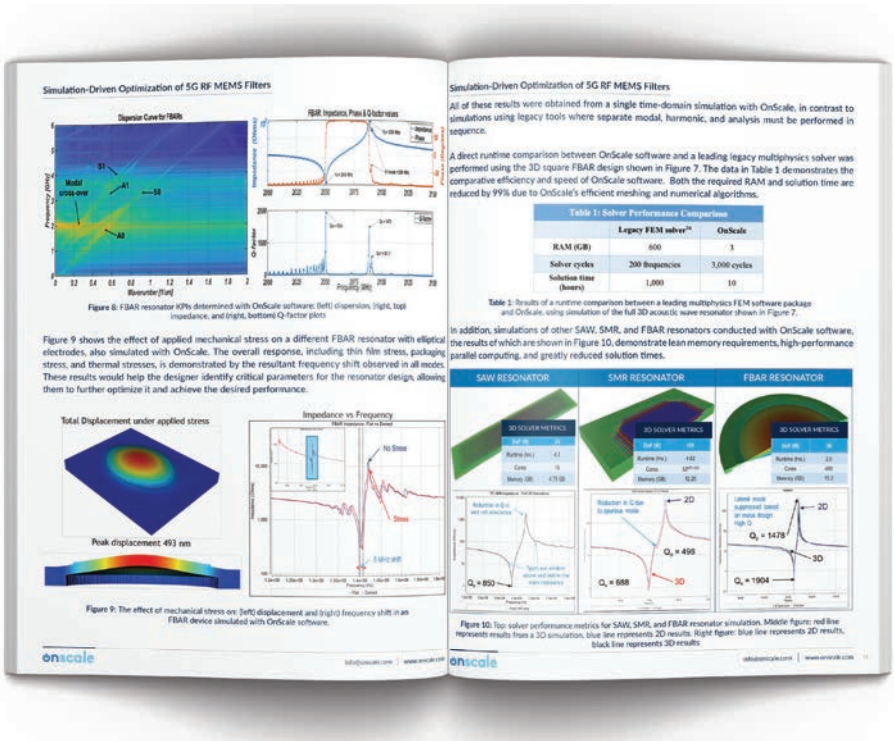
The future envisioned by the champions of democratization in this space will be exciting for me to learn and write about, and even more exciting to experience for the designers and engineers who will use these tools in the future.

I'm looking forward to seeing what that future will hold for all of us, and I hope that you readers will reach out and share your own concerns, predictions and experiences as we move forward together. DE

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

Explore the Full Design Space of 5G Communication Devices

Accelerate design cycles with Cloud Engineering Simulation.



DOWNLOAD WHITEPAPER

onscale.com/whitepapers

onscale

DE
Digital Engineering

TECHNOLOGY FOR OPTIMAL ENGINEERING DESIGN

INSIDE

DigitalEngineering247.com

September 2019
Vol.25 • No.1

ON THE COVER:
Images courtesy of Getty Images/ jgroup and Getty Images/ jagsandrew.

FOCUS ON DEMOCRATIZATION

10 Subscription Pricing Meets the Design World

The desire for increased flexibility and an ongoing relationship with vendors is fueling a shift toward subscription-based pricing models.

By Beth Stackpole

14 Pick and Choose Purpose-built Bundles

Vendors assemble curated collections of engineering software to attract SMBs.

By Kenneth Wong

16 Generation Gap

Bye bye, baby boomers. Move over millennials. Engineering software gears up for Gen Z.

By Kip Hanson

19 The Path to Simulation

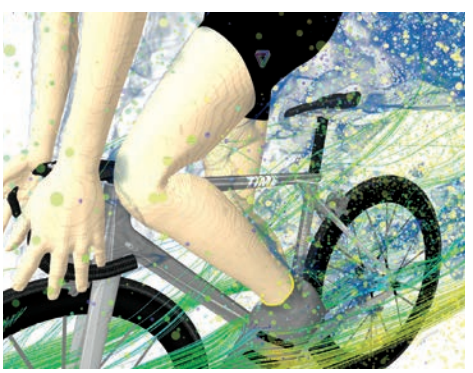
Industry veterans weigh in on how to make engineering simulation more accessible to a larger user base.

By Brian Albright

24 Consumer vs. Professional Tug of War

Can consumer hardware be adapted for professional usage?

By Kenneth Wong



FEATURES

|| ENGINEERING COMPUTING

28 **Budget Workstations for Engineers**
Tasks, not price, define today's entry-level engineering workstation offerings.
By Randall S. Newton

|| ENGINEERING COMPUTING

30 **Affordable Power: A Tale of Two Dells**
We evaluate Dell's Precision 3540 and 3541 mobile workstations.
By David Cohn

|| PROTOTYPE & MANUFACTURE

34 **Manufacturing-as-a-Service: Dawn of a New Horizon?**
Engineers are using online manufacturing services to meet design deadlines.
By Jim Romeo

|| SIMULATION

36 **ParaMatters CogniCAD Walkthrough**
Setting up topology optimization problems is clear-cut in CogniCAD.
By Tony Abbey

|| DESIGN

42 **Autodesk Fusion 360: Getting Better All the Time**
Autodesk consolidates Fusion 360 into a single, more powerful package.
By David Cohn

|| DESIGN

45 **progeCAD Professional 2020: Low-Cost CAD**
This affordable CAD program looks a lot like AutoCAD, but brings functionality at an affordable price.
By David Cohn

DEPARTMENTS

2 Degrees of Freedom
A More Open, Accessible Future
By Brian Albright

6 By the Numbers:
Democratization

8 Editor's Picks
Products that have grabbed the editors' attention.

9 Road Trip
DE travels to Los Angeles to explore highlights of SIGGRAPH 2019.

48 Next-Gen Engineers
Robotics Engineering Takes to the Seas
By Jim Romeo

48 Advertising Index

|| SPECIAL SECTION

22 **Simulation Democratization Q&A**
Leading vendors weigh in on new approaches to make simulation more accessible to non-expert users.

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, Tom Kevan, Randall Newton, Beth Stackpole

ADVERTISING SALES
Tim Kasperovich | Eastern and Midwest Regional Sales Manager
Phone: 440-532-1360
tkasperovich@digitaleng.news

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

Michele Mittenzwei | Advertising Support Specialist
Phone: 908-209-0599
mmittenzwei@digitaleng.news

ART & PRODUCTION
Darlene Sweeney | Director
darlene@digitaleng.news

ADVERTISING, BUSINESS, & EDITORIAL OFFICES
***Digital Engineering*® Magazine**

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

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

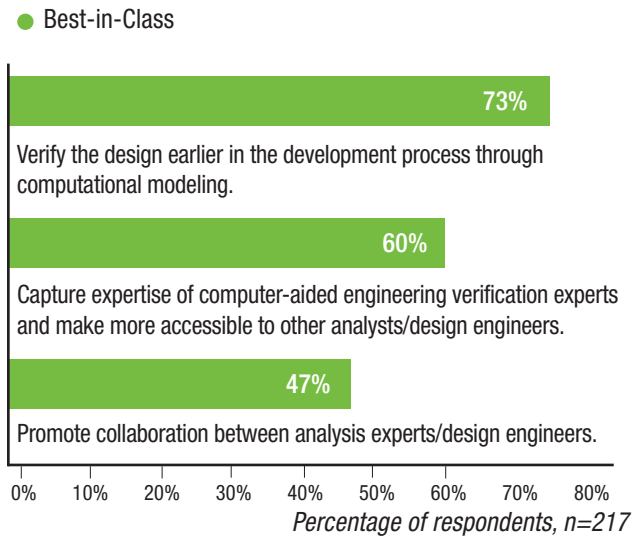
Peerless MEDIA, LLC

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.

Simulation-Driven 87% Leaders Using Simulation

Best-in-Class Promote Simulation by Non-Experts

The Shift to Simulation in Design Among the Best-in-Class

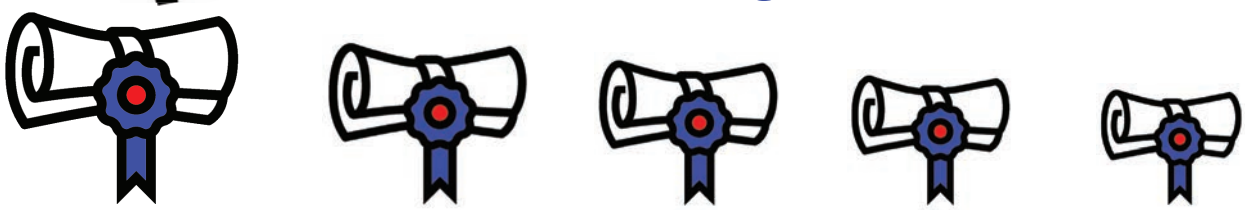


Percentage of respondents, n=217

Among best-in-class design organizations, 87% used simulation, and were 2.5 times more likely to deploy simulation with non-experts. These firms also built 27% fewer prototypes, and shortened development time by 29%.

— "The Benefits of Simulation-Driven Design," Aberdeen Group, 2017

Top 5 Bachelor's Degrees Awarded



31,936 Mechanical

19,092 Computer Science

13,767 Electrical

12,221 Civil

11,586 Chemical

In 2018, 393 U.S. institutions reported that enrollment in undergraduate engineering degrees reached 622,502 full-time students. Institutions awarded 136,233 degrees. Mechanical engineering was by far the largest of that group, followed by computer science, electrical, civil and chemical.

— "Engineering by the Numbers," American Society for Engineering Education, 2018

New Software Models

80% by 2020

According to market research firm Gartner, all-new software providers and 80% of existing vendors will offer some version of subscription-based business models, both in the cloud and for on-premise software systems.

— "Moving to a Software Subscription Model," Gartner, May 30, 2018.

$85B by 2019

Software-as-a-Service (SaaS) offerings will reach revenues of $85 billion by the end of 2019, a 17.8% increase over previous years. This represents the majority of public cloud revenues, which will reach $278 billion by 2021.

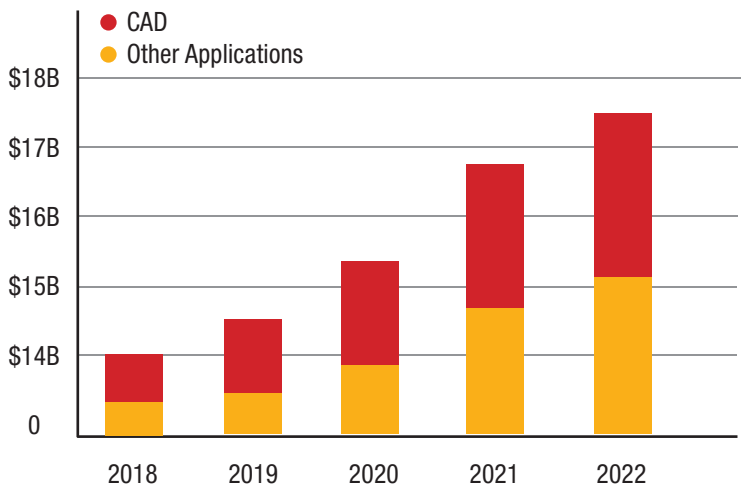
— "Forecast: Public Cloud Services, Worldwide, 2016-2022," Gartner, April 2019.

$4.1B by 2030

Driven in part by the availability of cloud-based platforms that encourage collaboration among different stakeholders, the factory simulation software market will grow 11% to reach $4.1 billion in 2030.

— "Industrial Virtualization, Visualization and Simulation Market Tracker," ABI Research, May 2019.

$17.25B 2022 Revenues

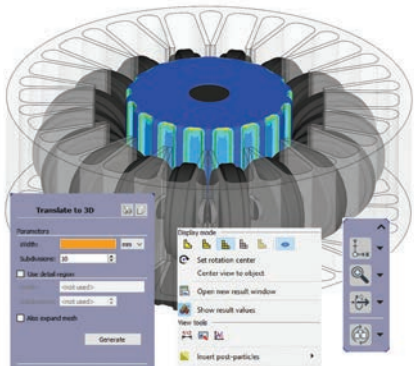


In 2018, the market for computer graphics software was worth $14 billion (not counting services and maintenance) and is expected to grow to $17.3 billion by 2022 as the industry shifts to the cloud and subscriber systems. CAD/CAM dominates the market.

— "Computer Graphics Software Market" Jon Peddie Research, July 28, 2019

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.



Simulation to Find Factory Process Imperfections

MSC Simufact introduces Simufact Forming Version 16.

MSC Software offers simulation and analysis for manufacturing machines and forming processes. It rewrites through the product to increase speed and usability. Geometry data processing can identify errors and send them back to CAD. This process also allows users to retrace any corrections, maintaining data trail credibility.

One-click Best-Fit technology compares simulations and reference models. Optional modules offer increased functionality for specific forming processes.

MORE ➜ digitalengineering247.com/r/22888

Stacking up Sand for the Digital Industrial Foundry

ExOne introduces a production-level sand casting 3D printer.

ExOne, maker of sand mold 3D printers, debuts a model that brings new power to the process of making prototypes and industrial series production.

The S-MAX Pro can achieve printing speeds of up to 135 layers per hour and can print two full 1,800x1,000x700 (mm) job boxes, each with a volume of 1,260 liters, in just 24 hours. The S-MAX Pro features an efficient printhead and fully automated recoater. Molding material also can be replaced quickly.

MORE ➜ digitalengineering247.com/r/22867

Tensor Cores and Real-time Ray Tracing Go Mobile

Lenovo introduces high-end versatility in a 15-in. mobile workstation.

Lenovo has released a new 15-in. model of its popular ThinkPad P Series. Lenovo is offering the latest NVIDIA mobile GPU, Quadro RTX 5000, in a 15-in. mobile form factor. It brings power, allowing the P53 to run artificial intelligence research, deep learning routines and real-time ray tracing.

The RTX 5000 offers RT Cores for ray tracing at the blink of an eye, and Tensor Cores to make quick work of the matrix-based calculations common in AI, and machine learning.

MORE ➜ digitalengineering247.com/r/22830

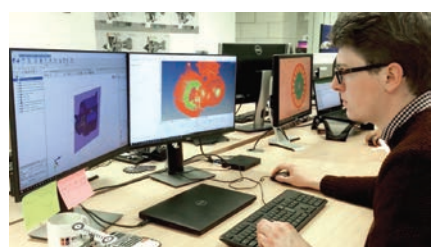
Tools for Drivetrain Simulation Get Updated

Romax Technology introduces integrated suite Romax Nexus.

The new suite is solution-oriented, designed for collaborative simulation in a world where the discrete elements of engineering must be solved as a unified whole. Now these six toolsets—previously separate products—are integrated into Romax Nexus.

Each title works separately, or it can be used as a set of related tools as needed. One person can be the only user of the suite, or separate users can collaborate. This level of flexibility did not exist previously.

MORE ➜ digitalengineering247.com/r/22795



SIGGRAPH 2019: AI-Driven Denoising Comes to the Forefront

BY KENNETH WONG

At SIGGRAPH 2019 (s2019.siggraph.org), special effects artists, visualization specialists and digital wizards from near and far converged on Los Angeles to share tips and find new ways to advance the art and craft of computer graphics.

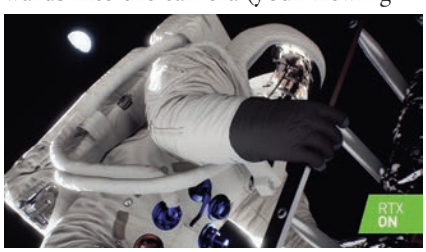
The event also coincided with the 50th anniversary of the Apollo 11's moon landing. To commemorate the event, GPU maker NVIDIA (digitalengineering247.com/company/nvidia-corporation) released newly rendered footage of the landing, created with RTX GPUs.

The virtual recreation adds details that weren't visible in the original grainy footage.

Moon Landing Recreated in RTX GPUs

RTX, part of NVIDIA GPUs, is a technology that makes real-time raytracing possible, making rendered images physically accurate. It does so with a speed that's near instantaneous, enabling designers to visualize changes on the fly.

"With RTX, each pixel on the screen is generated by tracing, in real time, the path of a beam of light backwards into the camera (your viewing point), picking up details from the objects it interacts with," wrote Rev Lebaredian, vice president of simulation, NVIDIA (cutt.ly/CwyLMs5).



NVIDIA uses RTX GPUs to render the moon landing of the Apollo 11. ***Image courtesy of NVIDIA.***

At SIGGRAPH, NVIDIA to let attendees become part of the moon landing. Against a backdrop with a mockup spacecraft, attendees struck poses, which were instantly translated into the posture of an astronaut via a virtual camera.

The technology may be applicable in developing affordable ways to conduct ergonomics studies for automotive, aerospace and manufacturing.

KeyShot Joins GPU Computing

Luxion's (digitalengineering247.com/company/luxion) CAD-friendly renderer KeyShot has remained exclusively CPU-based since its launch, but this is about to change. Starting with KeyShot 9, the program will support GPU rendering, the company announced (cutt.ly/dwyL8TP).

"Luxion has evaluated GPU rendering for several years," said Henrik Wann Jensen, co-founder and chief scientist at Luxion. "With NVIDIA's RTX technology, GPU-accelerated hardware raytracing and AI denoising, gigaray performance, GPUs with over 8GB of memory, and the free OptiX SDK, now is the time to do it."

AI-powered denoising or accelerated rendering will be part of KeyShot 9 when running on the GPU. When rendering on the CPU, the Intel Open Image Denoising steps in.

One of KeyShot's rivals, the GPU-renderer Bunkspeed SHOT, was acquired by Dassault Systèmes and incorporated into SolidWorks. The renderer is now the engine behind the SolidWorks Visualize rendering environment.

Long-time CPU-only renderer KeyShot plans to add GPU rendering in its upcoming release, KeyShot 9. ***Image courtesy of KeyShot.***

AMD Showcases ProRender Denoising

NVIDIA's rival AMD (digitalengineering247.com/company/amd) was also at SIGGRAPH, highlighting its free rendering program ProRender (amd.com/en/technologies/radeon-prorender).

AMD recently added AI-powered denoising into select plug-ins and partner products, including Blender 2.80 Beta, Autodesk 3ds Max and Maya plug-ins.

Without the need for licensing free, ProRender is expected to attract developers who need to integrate a rendering engine into their applications. AMD offers the AMD ProRender Developer Suite (amd.com/en/technologies/radeon-prorender-developers) for those who want to implement raytraced rendering. It works for CPU, GPU or hybrid rendering.

With many leading renderers adding or supporting AI-powered denoising, it'll likely become a standard feature in rendering in the near future. 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 ➜ digitalengineering247.com/r/22988

SUBSCRIPTION PRICING MEETS THE DESIGN WORLD

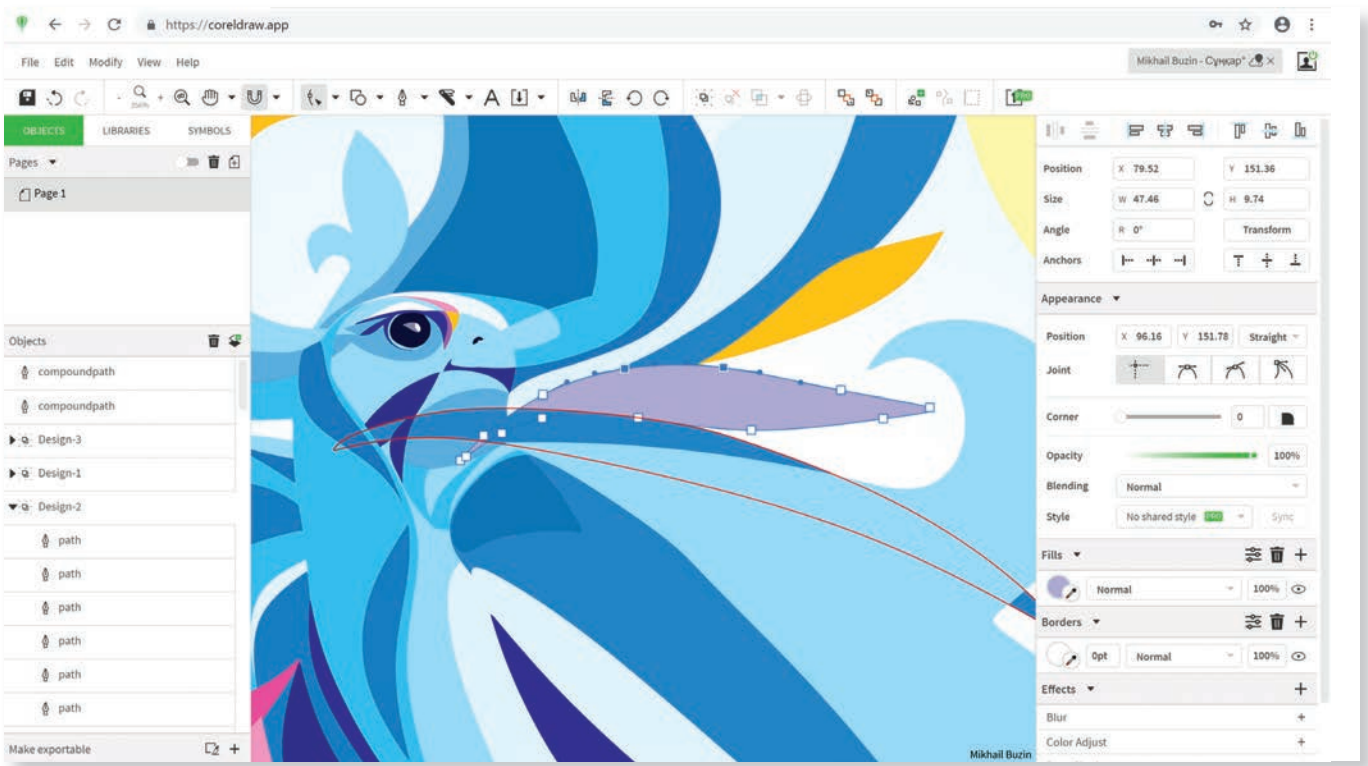
The desire for increased flexibility and an ongoing relationship with vendors is fueling a shift toward subscription-based pricing models.

BY BETH STACKPOLE

DESPITE ENGINEERS' PENCHANT FOR consistency regarding their core design tools, there have been a handful of tectonic shifts these last few years. Among the more prominent is the ongoing transition away from traditional licensing models to subscription pricing, which is sometimes accompanied by cloud deployment.

Subscription pricing is fast becoming the de facto standard for many enterprise applications, most notably customer relationship management, HR-related platforms and various collaboration tools. Market research firm Gartner predicts that by 2020, all new software providers and 80% of existing vendors will offer some flavor of subscription-based business models regardless of whether the application is deployed on-premises or in the cloud.

Consumers of software and other products are leaning in to subscription-based pricing models for varied reasons. Some favor a move away from big, upfront capital expenditures (CapEx) to a more consistent and manageable operating cost (OpEx) model. Others are taken in

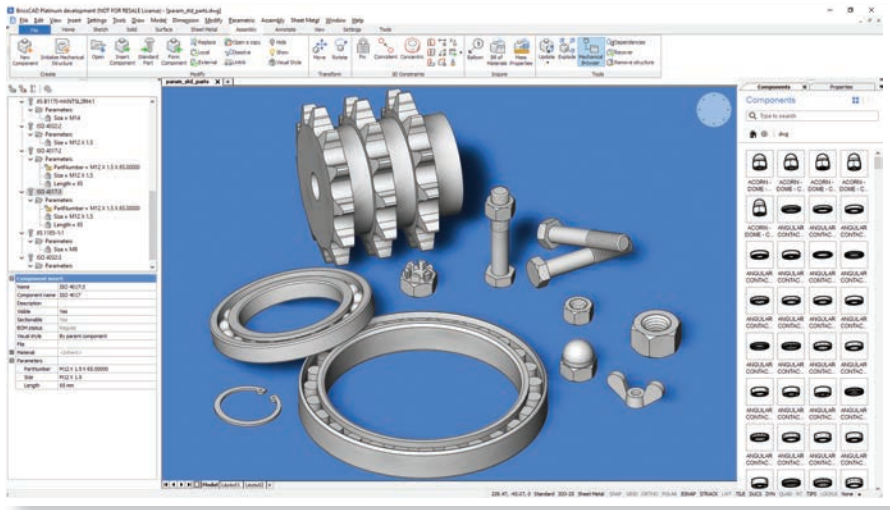


One benefit to subscription- or maintenance-based pricing is easy access to additional functionality such as the web-based CorelDRAW app available to CorelDRAW Graphics Suite users. *Image courtesy of Corel.*

by the flexibility of a subscription model, specifically the ability to scale up software licenses to meet seasonal demands or to accommodate temporary contract workers during peak periods and to dial back licenses when they are no longer needed.

Beyond those apparent upsides, a growing number of customers are pushing for subscription-based pricing models for software and other types of goods because there is now an interest in buying services, not physical products, contends Gian Paolo Bassi, CEO of Dassault Systèmes' SolidWorks. At the same time, companies are placing a priority on outsourcing key activities to a set of partners that can deliver in a continuous value stream, he adds.

"Switching from perpetual licenses to subscription pricing is not what customers are talking about—the topic of conversation is about helping them be more innovative through a continuous relationship that keeps them current with the latest technology trends, provides updates and delivers best practices," he explains. "More and more customers are asking us to provide expertise and knowledge that is conducive to a continuous value stream. In financial terms, that is subscriptions."



Most BricsCAD customers have shown a preference to remain on perpetual-based pricing. ***Image courtesy of Bricsys.***

The New Lineup

In the CAD community, Autodesk was a pioneer of subscription pricing, embracing the model in a big way nearly a decade ago and underscoring its commitment through its Fusion 360 portfolio of cloud-based CAD/CAM/CAE offerings sold exclusively through subscription. The company has been refining and iterating the model over the last nine years and is seeing a clear preference among its existing and new customer base for subscription pricing even for its non-cloud applications, according to Amy Bunszel, Autodesk's senior vice president of design and creation products.

Bunszel says Autodesk's perpetual license, offered with a maintenance option that allows for staying current on software upgrades, is a stepping stone for customers to acclimate to the subscription model and has been essential for driving the transition. Currently, Autodesk derives less than 20% of its revenue from legacy perpetual licenses with a maintenance add-on, and on average, one-third of its maintenance renewal opportunities migrate to a subscription model every quarter, Autodesk officials say. Autodesk also continues to offer a perpetual license with maintenance as a hybrid solution for those customers who are still balking at a full-blown subscription arrangement.

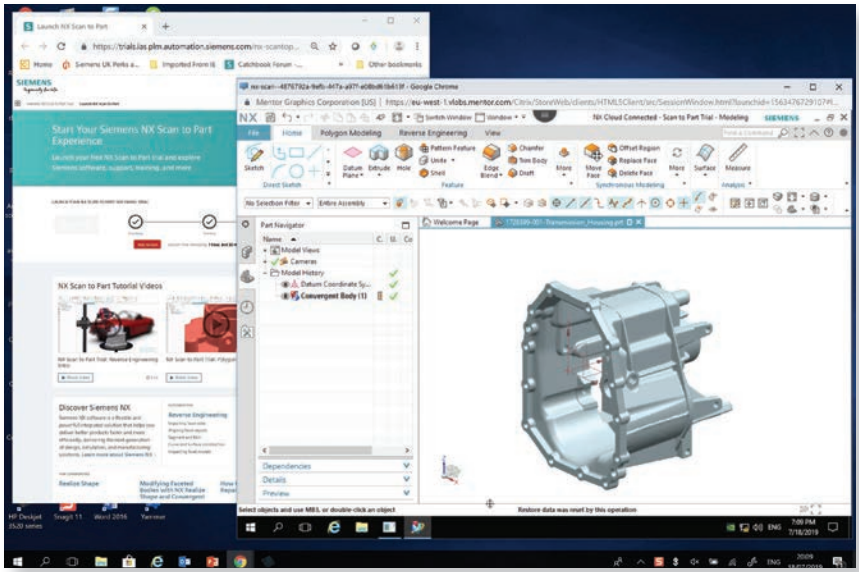
"We took a very deliberate, multi-year approach moving people into subscription," Bunszel says. "We wanted customers to have advanced notice that changes were coming and we gave them a long runway to plan for when we wouldn't be selling any more enterprise licenses."

To accelerate the transition, Autodesk has a number of efforts underway to incentivize customers to move to subscription-based pricing while also doing its part to allay fears about unexpected costs. To that end, Autodesk offers a variety of tools and guidance to provide transparency into its subscription pricing over a 10-year period. In one such example, the company published its extended renewal pricing guidance (autode.sk/2uegATD) through 2028 for customers of the Move to Subscription offer, which specifies no more than a 5% increase in 2021, 2023, 2025 and 2027 with no changes to the cost during the even years during the same time frame.

Siemens PLM Software is also seeing an increased appetite for subscription-based pricing from its customer base, although there are discrepancies between industries and more specifically, among different size firms, says Grant Rochelle, the company's vice president of business models and portfolio management. "Industries subject to a rapid rate of change and that are driven more by new product innovation are looking for every edge they can get," he explains. "We see this as an and, not an or—we are not looking to take people off of perpetual licenses. Through detailed discussions with customers of all sizes, we see some are ready to go now while others need a couple of years or even longer. We will respect that and provide maximum flexibility going forward."

That flexibility is delivered in the following ways: Any software from a Siemens acquisition or any newly-developed internal application will now be offered through subscription as the de facto pricing model. In addition, most of the Siemens portfolio is already available as subscription in addition to traditional perpetual licenses, including Solid Edge, NX, MindSphere, Polarion, Teamcenter, Simcenter and Tecnomatix. Niche solutions like Analog Mixed Signal, Catapult, Calibre, Pads, IES Embedded, FLoEFD, FloMASTER and Camstar, among others, can also be served up in a subscription flavor.

In addition to the subscription pricing option, Siemens is offering its software in various ways for added flexibility—for example, NX Cloud Connected products, featured on the Siemens store, can be purchased and run as a flexible cloud-based subscription, including automatic updates. Siemens also has a managed services offering, which is available through perpetual license, but is owned and maintained in someone else's infrastructure. Going forward, the company is considering enhancing subscriptions by breaking capabilities down into microservices (for example,



The NX Scan to Part trial, available in the cloud, looks nearly identical to the desktop experience and is available via subscription. ***Image courtesy of Siemens PLM Software.***

paying for data storage) as well as a consumption-based model for greater flexibility and customization, Rochelle says.

At Dassault, 92% of existing SolidWorks on perpetual licenses also pay for an additional maintenance layer, which, Bassi claims, is fairly similar to subscription pricing. Customers can choose the traditional SolidWorks desktop offering through perpetual license with or without maintenance, can purchase a term option, which delivers the desktop version on subscription, or can buy SolidWorks in the cloud, which by definition is a subscription offering, he explains. Dassault is looking to evolve its subscriptions with new capabilities like allowing an initiation fee to be paid upfront (Bassi likened it to paying points on a mortgage) to lower monthly costs in addition to a token-based model, which would charge users based on consumption. Dassault's SIMULIA simulation suite is already offered with a token-based subscription pricing scheme.

PTC, which as of January 1, 2019 no longer offers perpetual licenses for new software sales (with the exception of Kepware), still supports the model if existing customers don't want to make the break, says Bruce Reed, senior vice president pricing and licensing. As of now, the company has done 1,300 transitions away from perpetual licenses to subscription, and new license sales are in the neighborhood of 95% subscription-based as of the end of this year, Reed says.

Yet Reed cautions companies not to confuse subscription pricing with cloud or software as a service (SaaS) deployment—they can be, but are not always, one and the same. "There is as much on-premises subscription going on as there are SaaS subscriptions," he says. "CAD customers are not pushing that fast [to go to SaaS]. The issues around data management, file transfer and the graphics nature of CAD packages suggest that sometimes it's better done locally at the desktop."

Pros and Cons

One of the less talked about upsides to software by subscription is gaining access to additional products and capabilities not available under traditional licenses. In addition, the subscription model makes it easy for customers to run pilots and experiment with new software without buying additional expensive licenses.

Subscription also transfers risk to the vendor, some contend, as it's incumbent on the software provider to continuously prove its value by releasing new capabilities designed to keep users engaged. At Corel, for example, users on subscription for CorelDraw Technical Suite recently gained access to a new web-based app that lets them access work remotely.

"Having an ongoing relationship between the software vendor and the user enables us to provide additional functionality that would be difficult to do if it were a one-off transaction," notes Gérard Métrailler, Corel's executive vice president of global products. "It helps keep the customer base engaged and adds pressure on software vendors to continue to add value to customers every renewal cycle."

For Autodesk, subscriptions allow it to offer customers easy access to pilot new capabilities and in the future, better access to analytics that will help administrators optimize their investments and understand how the software is used internally. "There is a foundation of trust that we will use their data responsibly to deliver value back to them," Bunszel says.

In the end, however, there are just some engineers and design tool users that aren't interested in making the leap from perpetual licenses to subscription. Bricsys, maker of BricsCAD, offers both options, but claims it's winning lots of new business simply because of its perpetual option, which still constitutes 95% of its licensing sales today.

"Among small- to medium-size businesses, there is still a great demand for perpetual licenses," says Don Strimbu Jr., Bricsys' vice president of communications. "If they have burst needs or are working on specific short-term things, they may use subscription, but customers are coming to us expressly to buy perpetual licenses and they are happy." DE

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

INFO ➜ **Autodesk:** Autodesk.com

➜ **Bricsys:** Bricsys.com

➜ **Corel:** Corel.com

➜ **Dassault Systèmes:** 3ds.com

➜ **PTC:** PTC.com

➜ **Siemens PLM Software:** PLM.Automation.Siemens.com

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

DE Digital Engineering

DE EDITORIAL WEBCAST DISCUSSION SERIES — INSIGHTS, INSPIRATION AND INFORMATION

HOT SEAT

Next Gen Engineers

LIVE Webcast!
September 18, 2019
2 PM ET / 11 AM PT

Is design software prepared for next-gen engineers?

The Snapchat and YouTube generation raised on mobile devices, cloud-hosted apps, self-paced tutorials and touch-responsive screens have radically different ideas about how design concepts should be created, shared and tested.

Are engineering software makers keeping up with these socio-technological changes to accommodate the next generation?

In this **LIVE** webcast, panelists join *DE* to tackle the following questions:

- What are the developers doing to simplify complex CAD, simulation and PLM tools?
- What are they doing to make sure new tools don't get in the way of your creativity?
- How do they plan to evolve the user experience for the next generation without isolating current users?

Moderated by
Kenneth Wong
DE's Senior Editor

IN THE HOT SEAT

Matt Heying
Product Strategy
Vertex

vertex

Register for FREE Today!

digitalengineering247.com/UXhotseat

Pick and Choose Purpose-built Bundles

Vendors assemble curated collections of engineering software to attract SMBs.

BY KENNETH WONG

HIDDEN IN MANY DESIGN and data management bundles is a brief history of the design software industry's consolidations. As larger product lifecycle management (PLM) vendors swallowed up independent CAD developers, the CAD-and-PLM combo became the standard. The pairing of SolidWorks with collaboration products from Dassault Systèmes is the natural result of Dassault's acquisition of SolidWorks in 1997. Likewise, the pairing of Siemens PLM Software's Teamcenter with Solid Edge resulted from the double acquisition, first of UGS' acquisition of Solid Edge in 1998; later of Siemens AG's acquisition of UGS in 2007.

Over time, some of these pairings proved to be less than ideal. The larger PLM firms historically catered to the aerospace and automotive giants. The smaller CAD vendors counted five- to 10-person design and engineer shops as their core clients. The former's hefty enterprise solutions are often a poor fit for the latter's needs—too much software for the tight-knit workgroups.

A correction seems to be taking place, triggering a shift in the pairings to suit the needs of manufacturers of different sizes.

Announcing 3DEXPERIENCE.WORKS

This February, as he delivered his keynote at SolidWorks World (in February 2019 in Dallas), SolidWorks CEO Gian Paolo Bassi revealed a new offering, dubbed 3DEXPERIENCE.WORKS "Platform is the new thinking. The entire world is heading in that direction. We want to offer you this amazing concentration of knowledge, technology and know-how," he said. "We call this 3DEXPERIENCE.WORKS ."

The collection is made possible in large part by the company's acquisition of IQMS, which describes its flagship product as "manufacturing-specific ERP [enterprise resource management]." Not only is the software tailor-made for manufacturing, but it also targets small and midsized businesses (SMBs). These two characteristics make IQMS a good fit for the SolidWorks crowd. IQMS is now rebranded as DELMIAWORKS, after the DELMIA collaboration platform from Dassault Systèmes.

Generative design and additive manufacturing design are part of Autodesk Inventor, part of the Product Design and Manufacturing Collection. ***Image courtesy of Autodesk.***

Bassi further clarified that 3DEXPERIENCE.WORKS is a suite of software to plan, design, simulate and manufacture. "The idea behind 3DEXPERIENCE.WORKS is to connect the SolidWorks desktop users to other products from Dassault Systèmes through the Dot-Works platform," explains Stephen Endersby, director of product portfolio, SolidWorks. "The point is, we won't shoehorn an Airbus-type solution into a small company's workflow. We're coming up with something that fits their needs."

That acknowledgment is significant. Although similar in nature, the scope and functions of a data management system for long-time customer Airbus, for example, may be overkill for a discrete manufacturing shop with five to 10 employees.

The company hasn't released a lot of details about 3DEXPERIENCE.WORKS, but the four executives who introduced the product at the show offered some clues to the areas covered

by the collection: Gary Nemmers, CEO of DELMIAWORKS (formerly CEO of IQMS); Stephane Declee, CEO of ENOVIA; David Holman, SIMULIA brand lead; and Florence Hu-Aubigny, senior VP, platform and marketplace. The lineup represents ERP, PLM, simulation and marketplace for on-demand services.

The 3DEXPERIENCE.WORKS collection is expected to augment SolidWorks CAD software users' workflow. It also requires a separate license in addition to the SolidWorks license.

The Latest Rental Option

The price for SolidWorks has remained consistent. Standard SolidWorks is $3,995, as listed by reseller Computer Aided Technology. The software usually comes with an annual subscription (for access to support and upgrade), priced at $1,295.

The software also comes as Pro and Premium versions, with additional simulation, data management and parts libraries. Computed Aided Technology offers three options for the CAD package with annual support bundles:

- SolidWorks Standard and one-year subscription: $5,290
- SolidWorks Professional and one-year subscription: $6,985
- SolidWorks Premium and one-year subscription: $9,990

The software is traditionally offered under perpetual licenses, but two years ago, SolidWorks began testing the waters with the introduction of short-term contract options, as well.

The Multi-tiered Approach

Solid Edge (SE) is the mainstream CAD software from Siemens PLM Software. SE subscriptions range from $75 to $230 a month, and are billed annually. Subscriptions such as SE Design and Drafting and SE Foundation cover the basic 2D and 3D modeling features. SE Classic comes with generative design, standard parts library, basic simulation and rendering. SE Premium comes with electrical routing, thermal simulation, optimization, collaboration and built-in data management.

For those with more comprehensive data management demands, the company offers Teamcenter integration, a direct link to Siemens PLM Software's Teamcenter PLM through a SE-embedded client.

In contrast to Siemens NX, the higher end CAD-CAM-CAE suite, Solid Edge is a better fit for SMBs. The multi-tiered subscription structure allows budget-conscious SMBs to pick and choose the level of design, simulation and data management suitable to them without paying for a one-size-fits-all bundle.

Verticalized Collections

With a dizzying array of software titles in its collection, Autodesk offers three distinct bundles for the major sectors it serves: the Architecture, Engineering and Construction (AEC) Collection ($2,825 per year); Product Design Collection ($2,590 per year); and Media and Entertainment Collection ($2,145 per year).

The AEC Collection revolves around the building information modeling software Revit; the Product Design and Manufacturing Collection revolves around the mechanical modeling and simulation package Inventor; and the Media and Entertainment Collection revolves around 3DS Max and Maya.

The AutoCAD version included in each collection is slightly different. The AEC collection comes with architecture-specific AutoCAD tools for creating windows, doors and walls. By contrast, the Product Design Collection comes with AutoCAD with tools for easy factory layout creation.

At SolidWorks World 2019 (February 2019), Dassault Systèmes executives discuss the upcoming offering, 3DEXPERIENCE.WORKS. *Image courtesy of Dassault Systèmes*.

Single-product Option Remains

The collections, Autodesk argues, offer more software for the subscribers' dollars. However, for those who feel they only need specific titles without any other complementary software, Autodesk continues to offer single-title subscriptions. For example, AutoCAD on its own is $1,288 per year. Inventor by itself is $1,985 per year. 3DS Max by itself is $1,545 per year.

The company also offers Fusion 360, an integrated CAD-CAM-CAE package targeting SMBs, for $60 per month, $495 per year or $1,335 per three years. The license includes a mix of generative design, collaboration, data management and rapid prototyping in addition to the core modeling and simulation functions (prices as of July 2019, per Autodesk online catalog.)

Bundles, which usually sell for more than single titles, are the revenue engines for many firms. A good argument can be made that purchasing the design and data management combo costs less than assembling the required pieces separately. But many vendors also realize an unwanted bundle, no matter how comprehensive, is pointless. This is reflected in the fact that most of them continue to offer the single-title licensing option for their top-selling products. 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.*

INFO ➜ **Autodesk:** Autodesk.com

➜ **Computer Aided Technology:** CATI.com

➜ **Solid Edge, Siemens PLM Software:** SolidEdge.Siemens.com

➜ **SolidWorks:** SolidWorks.com

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

Generation Gap

Bye bye, baby boomers. Move over millennials. Engineering software gears up for Gen Z.

BY KIP HANSON

DO YOU HAVE A SNAPCHAT ACCOUNT? Post regularly on Instagram? How about a YouTube subscription? If the answers are no, no, and no, and you fondly remember the oohs and aahs when the next-door neighbors brought home their first color TV, you might want to gulp down some Geritol before reading further. That's because the next generation of designers is about to enter the workforce, and they have some different ideas about product design.

And Now, for This Commercial Break

"My teenaged kids don't even understand TV commercials," says Sam Sattel, senior marketing manager for Fusion 360 at Autodesk Inc. "They're used to Netflix. They're used to Hulu and Vudu. They want to watch what they want, when they want it, and for them, cable television is about as old-fashioned as using a mouse."

Yes, you heard that right. A mouse. According to Sattel, Autodesk recently introduced a group of elementary school students to the company's Tinkercad program, and every one of them ignored the traditional keyboard and mouse and reached for the computer screen, thinking it was a giant iPad.

Granted, today's current design workforce hasn't yet embraced this level of hands-on computer use, but rest assured, the upcoming touch-screen generation will demand it, just as they'll demand social media integration, virtual reality tools, self-paced training, Google-like search capabilities and other

ABOVE: Autodesk recently collaborated with automaker Volkswagen, using generative design to give this iconic vehicle a more modern look. ***Image courtesy of Autodesk.***

advanced user interface (UI) capabilities.

The good news is that much of this sociotechnical wizardry is already here. Each of the companies interviewed rattled off a host of recent software enhancements, from augmented reality (AR) to artificial intelligence (AI), some of which have been around longer than today's grade schoolers.

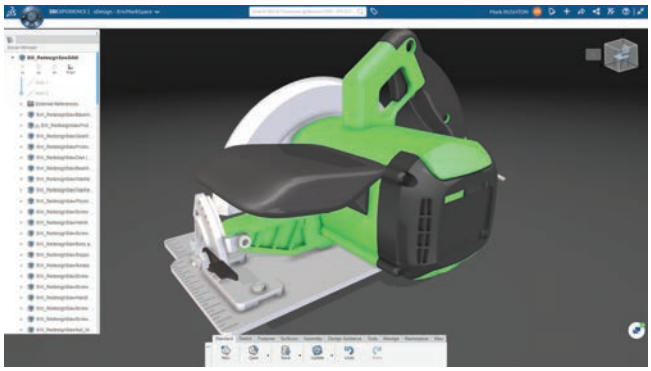
Many of these advancements are geared toward social media, also known as Web 2.0, or online participation. "The younger generation is all about sharing, from telling their friends what food they eat to showing them the clothes they wear," Sattel says. "For those who've taken on a design role, they want to share their latest product models, their engineering data, their thought processes. Sharing's part of the vernacular these days."

Let's go Tubing

Dan Staples, vice president of mainstream engineering at Siemens PLM Software, explains that the social media generation wants to link with Facebook and software-specific communities, as well as post videos of their latest creations. "That's a feature we introduced to Solid Edge a while back," he says. "A user can record a screen session and upload it directly to YouTube. Not only does this give them a chance to show off their work, but it allows them to see how other people are approaching engineering challenges."

According to Siemens, augmented reality systems like the one shown here "help companies design better, while communicating more effectively and efficiently." ***Image courtesy of Siemens.***

Anyone concerned about intellectual property loss might raise their hand at this point, concerned that an overly eager designer may inadvertently give away the corporate farm, but Staples is quick to point out that this and other social media sharing functions are equipped with plenty of warning and safe-



Although graphical user interfaces are becoming easier to navigate, 3D design software is growing ever more capable. ***Image courtesy of Dassault Systèmes.***

guards, and are set to private mode by default.

While design software is becoming more social, it's also getting smarter. AI is making it easier for young design engineers to get up to speed quickly, while at the same time making even experienced users more efficient. "For example, our NX product has the ability to identify user patterns and determine which functions are used more frequently," says Staples. "Over time, it develops a command palette based on your interactions with the system."

AI is the engine behind generative design in Fusion 360, adds Autodesk's Sattel, a tool that changes the age-old question of "How do I solve the problems with this product design?" to "What are the problems I want to solve, and how can I design a product around them?" Virtual reality (VR) and AR also play a role in this space, tools that are helping designers young and old alike develop better products. "VR and AR, together with generative design technology, basically reverses software's role—instead of a user driving the software, the software can now assist and in some ways drive the user," he says.

Back to School

No matter how user-friendly the software, however, training is still required. Mark Rushton, SolidWorks' product portfolio manager for Dassault Systèmes, suggests that Generation Z learns differently than their parents and grandparents. This helps explains why Dassault Systèmes and other software makers are offering far more online and self-paced training, rather than relying solely on the traditional classroom setting.

"We've offered video tutorials through my.solidworks.com for some time now, and have had pretty extensive training coverage on YouTube, not just from Dassault Systèmes and our value-added resellers but from the SolidWorks community in general, thanks in large part to the fact that a lot of our users like to share their content," he says.

There's also Gen Z's love of mobile devices and app-based software to consider. Aside from their ability to watch training videos on their cellphones, Rushton points to Dassault Systèmes' xDesign and xShape as ways to "design on the go," as both are browser-based and designed with touch-screen devices in mind. "The younger generation in particular wants the ability to design on tablets, laptops and other touchscreen devices," he says. "This is our way to support that desire."

The Digital Transformation

The cloud helps. That's because sharing, training and collaboration are made easier when software and its data is deployed from and stored in the cloud. On the 3DEXPERIENCE platform, says Rushton, users no longer need to send emails to one another, but can instead post an image or 3D model, or ask a question on a cloud-based 3DSwYm Community. "It's just like any other social media feed," he adds. "It even has a 'Like' button."

There's more driving this transformation than a socially-aware design community, though. As software becomes easier to operate, it's becoming much more capable as well, an attribute that's necessary to meet today's complex design and engineering needs, says Marc Lind, senior vice president of strategy at Aras.

"Take the automotive industry, for instance," he says. "A new car today is no longer simply an assembly of mechanical systems, but rather a rolling data center. You've got electronics and sensors and software throughout the vehicle—not just within the infotainment centers that everyone's familiar with, but also the transmission, the engine, the steering and braking systems—everything within the vehicle is software enabled, which means that you need to coordinate that complexity across different disciplines."

To do so requires a robust engineering platform, he adds, one with far greater flexibility than has been previously available. The UI must be streamlined and easy to use. It must support enterprise-level, context-sensitive search functions and graph visualization for simplified navigation across large data sets, giving users the ability to analyze information in "a more modern way than spreadsheets."

"Everything is changing at a faster pace than ever before," he says. "Sure, there's a new group of users coming along with new requirements, but you also have additive manufacturing, the Internet of Things, AI and machine learning. On top of that, or perhaps because of it, there's been a movement over the past decade where it's suddenly cool to be in manufacturing again. It's our job as software providers to support that movement as much as possible." DE

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

INFO

- **Aras:** Aras.com
- **Autodesk:** USA.Autodesk.com
- **Dassault Systèmes:** 3DS.com
- **Siemens PLM Software:** PLM.Automation.Siemens.com

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

The Path to Simulation

Industry veterans weigh in on how to make engineering simulation more accessible to a larger user base.

BY BRIAN ALBRIGHT

BOOSTED BY NEW, EASIER TO USE tools and more readily available compute resources, simulation technology is increasingly used more frequently and earlier in the design process, and by a wider array of professionals.

However, the path to truly democratized simulation requires both technological and cultural changes. *Digital Engineering* spoke with some leading industry organizations about progress toward this democratization, and some of the remaining challenges and opportunities.

We spoke to Matthew Ladzinski, vice president, Americas and special projects, NAFEMS; Joe Walsh, CEO of the ASSESS Initiative; Malcolm Panthaki, co-founder and executive committee member, Rev-Sim.org and VP of Analysis Solutions at Aras; and Chris Smith, senior analyst and cloud computing SME at Smart2Market.

Digital Engineering: We talk a lot in the industry about the "democratization of simulation." How do you see this process advancing in the industry? Is this a widespread trend, or more prevalent in certain markets?

Ladzinski: First off, I think it's important to understand what is meant by democratization of engineering simulation. This is not simply the deployment of simulation tools to non-experts. In order to bring simulation up front in the design process and avoid costly and time-sensitive bottlenecks, expert knowledge capture and reuse are critical in developing a safe and reliable environment for users to run a model without requiring a deep understanding of the underlying technology.

In most cases, there are a small percentage of models that lend themselves well to this concept because of repeated use and business impact. What we're seeing are numerous examples of companies, both small and large and representing all industries, which are leveraging this concept of "democratization" at a small scale but realizing significant savings—both in time and costs.

Walsh: The changing role of engineering simulation is really about business benefits. However, achieving those benefits and associated growth of the engineering simulation market is tempered due to the lack of expertise available. A simulation revolution needs to occur, which will bring a whole new set of opportunities and challenges. The changing role of engineering simulation is really about business drivers for improved competitiveness: increase innovation, increase performance, improve quality and risk management, reduce time and reduce cost.

Engineering simulation is a major key to all five business drivers in providing better understanding of product and process behavior, variability and risk. However, engineering simulation software is still typically used only by expert analysts and we need to expand the usage to a broader audience.

The goal is not to democratize simulation for the sake of broader use of simulation, but to enable more informed design

Matthew Ladzinski
NAFEMS

Joe Walsh
The ASSESS Initiative

Malcolm Panthaki
Rev-Sim.org and Aras

Chris Smith
Smart2Market

> **"In order to bring simulation up front in the design process and avoid costly and time-sensitive bottlenecks, expert knowledge capture and reuse are critical in developing a safe and reliable environment for users to run a model without requiring a deep understanding of the underlying technology."**
>
> – Matthew Ladzinski, NAFEMS

decisions throughout the entire design process by leveraging simulation early and often.

Panthaki: Progress at various companies has been slow. Some pick it up quite easily and run with it, and others are slow to adopt. I've even seen cases where companies begin to pick this up, but then the champions in the company who were moving things along internally leave, and the project dies on the vine. It has to do with culture. To do it well, there has to be a certain level of effort to prove it out, and keep things growing internally.

By definition, you must automate your simulations. That's the only way this can be done. If you expect non-experts are going to use your current set of tools, it simply won't happen. In today's environment, even those tools that allow you to create such automation require a lot of programming and scripting. That increases the cost of implementing democratization, and makes it challenging to maintain.

Automation doesn't mean that someone has to be able to run the simulation. It can be software that runs the automated simulation. There are strategic initiatives like simulating digital twins or additive manufacturing processes, and the hundreds of thousands of simulation required cannot be performed manually. That's a relatively new development that is pushing simulation automation. So we're at the point now that automation is essential for all sorts of reasons, not just democratization.

Smith: This is more about just putting the tools closer to the designer. You have to get the designers to use the tools. It's a corporate or cultural shift that has to occur to make these departments come together, and get the CAD designers trained in using the tools, and then figuring out how much analysis they will do before sending their designs up to engineering.

DE: How could this process be accelerated?

Ladzinski: Regardless of the task, most of us hesitate to take the road less traveled as we want to avoid pitfalls and the general unknown. While NAFEMS has identified democratization as a key theme at events like CAASE20, we realize the importance of working with other organizations in the community like Revolution in Simulation, which is a nonprofit-seeking initiative that offers numerous freely available reference materials on how other organizations have navigated the democratization waters to disseminate helpful information. Another organization addressing the topic of democratization is ASSESS, which has a working group dedicated to the Democratization of Simulation Engineering (DoES).

DE: What role could cloud-based simulation play in this process?

Smith: There are benefits the cloud can bring, and some limitations. It takes a lot of compute power to run these simulations, and the cloud can bring that compute power and make it more easily and cheaply available.

The problem is that the applications don't lend themselves to the way most cloud system are designed. If you look at CFD (computational fluid dynamics), those nodes have to be pretty close together. The vendors don't have a concept of the location of each system that is being assigned to run a problem.

To get any kind of performance, the machines have to be on the same high-performance network switch. Right now that's just not built in to the way these jobs are scheduled. They'll run them on 100 random machines around the data center.

DE: What do you see as the key challenges in making simulation more accessible in the design process?

> **"The goal is not to democratize simulation for the sake of broader use of simulation, but to enable more informed design decisions throughout the entire design process by leveraging simulation early and often."**
>
> – Joe Walsh, the ASSESS Initiative

On the CAASE

The Conference on Advancing Analysis and Simulation (CAASE), presented by NAFEMS and *Digital Engineering*, is a great way to learn more about simulation. CAASE happens live and in-person every other year, with CAASE2020 scheduled for June 16-18 in Indianapolis. It offers hundreds of learning opportunities, including a track on the democratization of simulation.

Can't wait till 2020? *DE* and NAFEMS Americas are teaming up to present CAASE19, a one-day Virtual Conference on Oct. 8, 2019. The CAASE19 Virtual Summit will be divided into four tracks: Simulation-Driven Design, Simulation Governance & Democratization, Manufacturing Processes & Additive Manufacturing, and Business Strategies & Challenges.

> **"Standards have not caught up with the need to classify data in a standardized way, so we're facing this 'Tower of Babel' problem, with every tool using its own language."**
> – Malcolm Panthaki, Rev-Sim.org and Aras

Ladzinski: While there are several identifiable challenges, the two that stand out to me the most are:

1. Safe, reliable and robust automation templates based on expert knowledge capture and reuse. These take time to build, which is why it's important to identify the right models and a well-defined process to democratize in order to realize a return on the investment.

2. Cultural and organizational challenges.

Panthaki: We still don't have enough success stories. That's where the Revolution in Simulation initiative comes in. It is essential to bring informant and the community together. With a lot of vendors in the fray and information spread out across various sources, it becomes very difficult to find what you need.

We also have to find better techniques for automating simulations. If we continue to rely on large amounts of programming and scripting, this will not be adopted.

Walsh: Those challenges are:

1. Significantly reducing the required level of expertise to do effective and appropriate simulation;

2. Understanding the concept of appropriateness of a simulation rather than numerical accuracy; and

3. Overcoming organizational silos and fiefdoms.

DE: What changes could simulation tool vendors make that would support this concept?

Walsh: Making existing tools easier to use will only make a small dent on this problem. The software vendors need to make the tools "smarter" to enable knowledge capture, and embedded artificial intelligence along with finding ways to remove the complexities to make the simulations invisible.

Panthaki: Companies use a large number of different tools, and each vendor has their own methodologies when it comes to automation. These techniques focus on their particular simulation tool that they offer to the market. There is a missing layer that is vendor- and tool-independent.

Standards have not caught up with the need to classify data in a standardized way, so we're facing this "Tower of Babel" problem, with every tool using its own language. The tool-independent layer would include a data management layer that is also tool-independent. That is a major hurdle from a vendor perspective.

DE: What about at the educational level—could engineering schools make changes in curriculum that would be helpful for future engineers and analysts?

Ladzinski: We are hearing from industry that they would like to see new hires better prepared upon entering into the workforce. However, universities are challenged with keeping their curriculum current without turning a four-year program into a five-year program.

There are efforts made by universities, like Ohio State University, which recently rolled out a certification program dedicated to finite element principles.

Another great example is Cornell University, which developed a free, web-based, hands-on introduction to engineering simulation. Over the last 10 years, NAFEMS has offered over 15 different FEA (finite element analysis) and CFD web-based courses and trained thousands of engineers from all across the globe. For the foreseeable future, it will be programs like these that will build off the existing curricula and ensure new hires are better prepared for the tasks that lie ahead.

Walsh: The introduction of concepts and simulation tools at the undergraduate level as part of appropriate engineering curriculums; theory to derive and develop should come as graduate work.

Smith: The mindset has to change, so at the university level the engineering students should be exposed to these tools and how to use them. There should be a dialog about how much engineering analysis does a CAD designer need to do? What is the end goal? People should discuss what end goal they are trying to achieve; for every company that will be different.

But how much better would it be to get those tools closer to designers, so that the analyses are not only running virtually in real time, but also suggesting changes based on designer inputs?

Panthaki: That is a very important point. The way simulation is taught drives people to either have nothing to do with it, or to jump in feet first and only receive exposure to expert tools. You need experts, but it shouldn't be viewed as the only way to run simulation.

> **"This is more about just putting the tools closer to the designer. You have to get the designers to use the tools."**
> – Chris Smith, Smart2Market

Within the system you also need a path where these tools are packaged in a form that others, who don't need to be experts, are exposed to their power. And those who are being trained as experts should be trained less as button-click tool experts, and more as template builders. As a template builder, you are creating recipes that are reusable, and you end up understanding what you are doing much better. You are writing a recipe for doing simulation, rather than using a simulation tool. DE

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

INFO ➜ ASSESS: ASSESSinitiative.com

➜ **CAASE:** NAFEMS.org/caase

➜ **NAFEMS:** NAFEMS.org

➜ **Revolution in Simulation:** Rev-Sim.org

➜ **Smart2Market:** Smart2Market.com

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

Simulation Applications for All

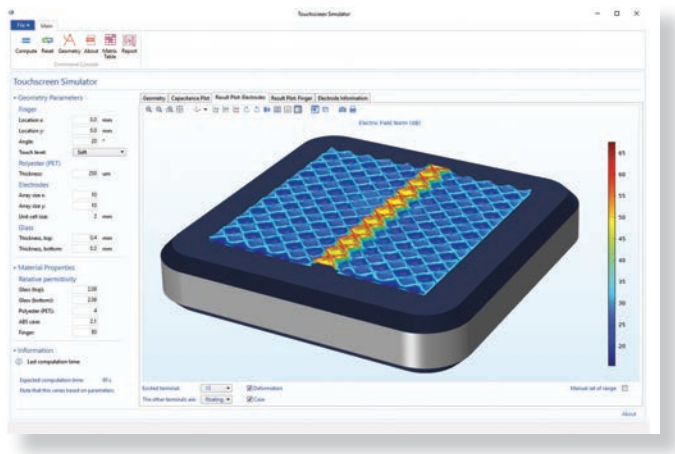
THE ERA OF SIMULATION applications is here. Tools are available for the rapid development and unlimited distribution of applications worldwide. Forward-thinking companies are taking the lead on democratizing simulation.

Q: Why do companies start using simulation applications?

A: Mathematical modeling and numerical simulation are ubiquitous tools for product development that have been around for more than half a century. However, the use of these tools has been restricted to simulation engineers. As the go-to persons for providing critical engineering analysis for an entire organization, they may become a bottleneck for maximizing the value of simulation. By creating easy-to-use simulation applications and distributing them throughout the organization, companies can now fully take advantage of the power of simulation, as employees without any experience with modeling can use applications. One example is Cornell Dubilier, a leader in manufacturing high-quality capacitors, which creates applications for the optimization of their electrical properties. Their research director, Sam Parler, comments that "[we] create applications for other departments to let them test different design configurations for their particular requirements and pick the best one."

Q: What is the role of simulation engineers in democratizing simulation?

A: Simulation engineers are the key to democratizing simulation. The creation of specialized applications is based on the computational models they develop. Applications enable anyone to test parameters and run repeated analyses without simulation expertise. The simulation engineer can instead focus on solving complex problems, developing innovative simulations, and building more applications. For instance, Samsung Audio Lab — a leading manufacturer of audio equipment — brings together multiple engineers to design high-quality loudspeakers using simulation and their applications. Get an inside look at their workflow in this blog post: comsol.com/blogs/samsung-amps-up-loudspeaker-designs-with-simulation.



A standalone application created with the COMSOL Compiler™.

Q: How do you bring simulation applications to everyone?

A: The tools for building and distributing applications are readily available. To go from model to application, a simulation engineer will start by creating a model in the COMSOL Multiphysics® software. Applications can be created in minutes using the Application Builder and its drag-and-drop functionality. The result is a specialized interface with controlled inputs and outputs so that the user can focus on the parameters pertinent to their work. There are two methods to give collaborators access to applications: compiling them into standalone executable files, using COMSOL Compiler™, or distributing them via the application management tool, COMSOL Server™. Compiled applications can be run by anyone without the requirement of a COMSOL® software license or the expertise to manage such. COMSOL Server™ helps those who want to upload and manage applications for an organization and enable collaborators to run simulations via a web browser or thin client — on any hardware, including phones and tablets.

Today's Competitive Edge: Simulation-driven Design

BY PATRICK FARRELL

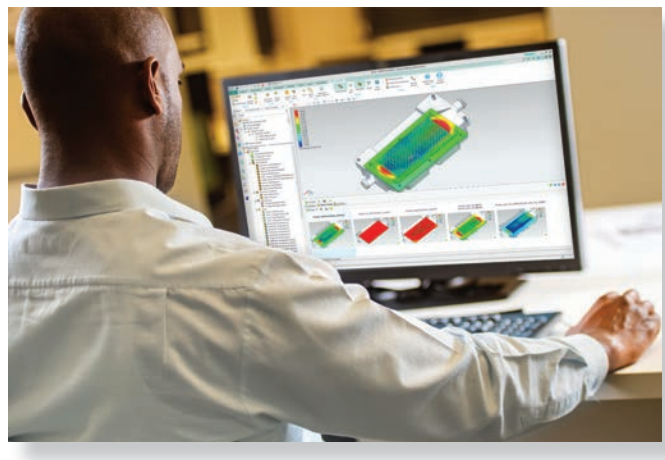
SIMULATION IS NO LONGER just a performance validation tool. It is now an organic part of the design process. It helps design engineers create better, more robust designs earlier when it's easier, faster and less expensive to address problems. We call it simulation-driven design. You'll call it your competitive edge.

Q: What is driving democratization of simulation?

A: Consumers want products with new functionality, better quality and reliability. Faced with shorter time-to-market pressures, companies have discovered a better way to innovate: simulation-driven design. Because design engineers outnumber simulation experts and have to rely on their knowledge to virtually test products, simulation has become a bottleneck. Best-in-class firms have responded by introducing simulation directly into the design environment. Aberdeen found that 73% of best-in-class organizations are using simulation as part of their detailed design processes which in turn has helped reduce their development time by 29% and deliver products that are more likely to work the first time.

Q: How is Siemens helping to democratize simulation?

A: Our aim to make simulation an organic part of the development process. Our NX CAD-embedded family of simulation tools powered by Simcenter technology offers intelligent technology and user experience to make simulation more accessible to designers, thus enabling them to better understand product behavior during the design phase and ensure the proof-of-concept works. In addition, scalability of the solution allows the development process to grow from simple analyses into more complex applications later in development. For example, a simulation model originally created by the design team can be re-used for more specialized analysis by a simulation expert. The increased collaboration between simulation and design engineers then serves as part of a looped feedback from design to manufacturing to the customer and back again, which further accelerates democratization.



The Simcenter family of simulation tools help engineers design products right, first time.

Q: How are companies benefitting from democratization today?

A: Companies worldwide are greatly benefiting from deploying simulation-driven design. For example, designers at Design Automation Associates have experienced situations where an analysis that previously required 40 hours is done by an automated process in 15 minutes. And Mitsubishi Materials Corporation designers were able to perform the basic CFD analysis easily within their CAD environment and ultimately achieve an 11% increase in flowrate through the cooling system being optimized. To learn more about simulation-driven design, please go to https://sie.ag/31yWoJD to watch the short presentation:.

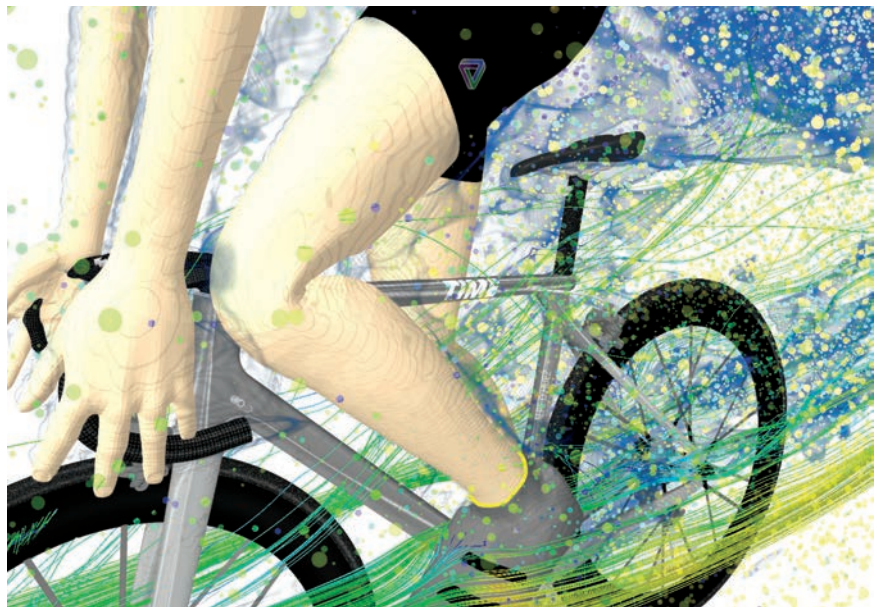
Consumer vs. Professional TUG OF WAR

Can consumer hardware be adapted for professional usage?

BY KENNETH WONG

CAN YOU RUN professional CAD software on a wallet-friendly off-shelf PC? Can you press an affordable consumer-grade gaming virtual or augmented reality (AR/VR) headset into professional service? Like recurring allergies, the tempting question returns whenever economic hardship and tight budgets force firms and people to seek ingenious ways to cut costs.

The simple answer—the one hardware makers like to give you—is, it's not a good idea. But looking for an explanation and speaking to industry insiders, we found out the answer is not that straightforward. In certain aspects of the design workflow and exploratory AR-VR applications, you may indeed be able to get away with consumer hardware. The key is to make an informed decision with full awareness of the trade-offs.



A sophisticated Tour de France cyclist's aerodynamics simulation such as this, completed in ANSYS software, can take days even on GPU-powered workstations and clusters, making it impractical to run on consumer-grade hardware. ***Image courtesy of ANSYS.***

The Blurred Line

Generally, consumer PCs and professional workstations are regarded as different classes of machines, built for different purposes. But the recent introduction of entry-level workstations began to blur the long-established line. All launched in the last two years, the HP Z Mini (beginning $850), Dell Precision small form factor (beginning $650) and Lenovo ThinkStation P Tiny (beginning $750) were tailor-made to curb budget-conscious enterprise buyers' temptation to make do with a high-end PC. With these sub-$1,000 workstations, the price difference is no longer a good argument in favor of a high-end PC.

The division is further eroded by the rise of cloud-hosted solutions. Though occurring at a much slower pace compared with the consumer sector, the design and simulation software's migration toward the browser is a steady and irreversible march. With cloud-hosted software like Onshape, and with designer-focused simulation programs like ANSYS Discovery Live, hardware requirements become more relaxed. But it is a mistake to think the hardware makes no difference.

"Onshape will run on any device with a web browser. That includes iOS and Android devices," says John McEleney, co-founder of Onshape. "But if you have a better machine, the software gives you better performance. That's because it's architected to take advantage of your local GPU [graphics processing unit]."

Formerly, as the development team behind SolidWorks in the mid-90s, McEleney and his colleagues rode the seemingly infinite rise of computing power, dubbed Moore's law. CPU pioneer Gordon Moore predicted that the number of transistors in the processors would increase two-fold about every two

years. The so-called Moore's law held true for decades, becoming a bankable rule for investors and developers. Ultimately, Moore's law comes up against the laws of physics: there's a limit to how small transistors can get; therefore, after a certain period, it becomes impossible to fit more transistors into an integrated circuit to double the horsepower.

"When I was at SolidWorks, we rode the wave of increasing CPU horsepower. But today, it makes more sense to ride the wave of increasing bandwidth," says McEleney. This was the genesis of the cloud-hosted CAD company Onshape, poised to run on unanimous high-speed connections inside standard browsers.

The GPU Makes a Difference

CAD vendors don't encourage installing and running their software on consumer PCs. The required or recommended system specs usually point to professional-class hardware. But that doesn't mean it can't be installed and run on consumer hardware. Certain operations still work, even in an underpowered system. The lack of reliable, consistent performance is unacceptable for serious engineers and power users, but perhaps tolerable for dabblers and infrequent users.

"The graphics have an undue effect on your perception of performance," notes McEleney. Most CAD operations involve model rotation, object selection and geometry manipulation. The GPU-driven visuals often affect the perception of responsiveness in these operations, even if the cause of the drag happens to be elsewhere. "The snappiness with which you see these operations executed is directly related to the GPU," McEleney points out.

Originally developed for workstations, established vendors such as SolidWorks from Dassault Systèmes and Solid Edge from Siemens PLM Software are also revising their code bases and product lines to address the cloud's appeal.

"One of the biggest differences between consumer hardware and professional hardware is the graphics card and the graphics driver," says Ian Baxter, VP of worldwide technical services, SolidWorks. "If the customer wants to optimize all of the sophisticated rendering capabilities available in some of our solutions, then they may need the type of graphics card usually found in pro hardware; if they're using a consumer PC, these functions may not work optimally, or at all in some cases."

"Our official recommendation is that the PC has a professional graphics card designed for CAD applications. Using these cards typically results in a hassle-free experience with optimal performance," explains Jeff Walker, director of Solid Edge at Siemens PLM Software. "However, we do not take a hardline approach in our tech support. It is particularly common with students and other users to see gaming and lower performing graphics cards in their machines."

Faster Simulation on Lighter Hardware

With systems requirements that are higher than CAD, simulation software is a good argument in favor of professional workstations. Yet, the launch of ANSYS Discovery Live, which targets non-ex-

In rotating large assemblies and selecting components, the GPU-rendered visuals impact real and perceived software performance. ***Image courtesy of Solid Edge, Siemens PLM.***

perts and promises speedy results, signals a new direction from one of the leading names in this sector.

"Discovery Live runs perfectly well on high-end consumer or gaming PCs. It will load [and] launch, and all features will operate," says Mark Hindsbo, VP and GM of the design business, ANSYS. "The requirement is a NVIDIA graphics card. Specifically, it runs on either NVIDIA's GeForce graphics cards (typically found in gaming laptops and desktops or high-end multimedia PCs) and Quadro (standard GPUs for professional workstations). All aspects work on both, but the extra you get on the professional Quadro GPU is more memory and compute power, which translate to solving larger problems faster and with more details."

It's not detrimental to run ANSYS software on consumer PCs; the nightmare scenario of your PC suddenly going up in smoke when you click on "solve simulation" is highly unlikely. But the key question is: How time sensitive is your simulation job?

"A small problem could take five minutes to solve on a normal PC, while a large and complex problem could take days on a super computing cluster," points out Hindsbo. "Many of the high-end problems could possibly be run on a standard PC but might take months to complete the computation." In other words, it's not the technical barrier, but the practical needs to complete the simulation in a reasonable time that makes the professional workstation a better alternative.

Testing the Waters in VR

Though rooted in gaming and entertainment, mixed reality (MR), virtual reality (VR) and augmented reality (AR) gears are attracting enterprise users. In addition to the affordable units built purely for entertainment and priced for impulse buy, enterprise-targeted AR-VR units have begun to appear. The price difference between the consumer and professional editions is not always significant.

In April, HP launched HP Reverb, a high-res Windows-based VR headset, priced at $649. "When you look at HP's consumer and commercial variants of the HP Reverb, they only vary in price by approximately US$50," points out John Ludwig, product manager of consumer and commercial VR, HP. "This is because the core VR experience remains identical. On the commercial end, we have add-ons like a wipeable facemask, a short cord for connecting to a VR backpack and a commercial warranty."

In May, at the Augmented World Expo (AWE, Santa Clara, CA), Lenovo announced its enterprise-focused ThinkReality A6 AR-VR glasses, set to ship in the third quarter of this year. ThinkReality A6's price hasn't been published yet. The company's consumer-targeted Mirage Solo VR headgear is priced at $399, and the VR-capturing Mirage Camera is $299.

The Next Wave

For early enterprise adopters still testing the waters with no clear usage or return on investment identified, the less expensive consumer units are a legitimate option.

"Around 2015, the decidedly consumer-oriented devices were attractive to certain enterprise buyers whose use cases didn't benefit from the higher quality afforded by headsets like HTC Vive and Oculus Rift," says J. C. Kuang, an analyst from Greenlight Insights. "These were usually confined to stationary experiences used in tourism and hospitality, education, healthcare and location-based entertainment. So it comes to pass that mobile VR devices, especially Samsung Gear VR, enjoyed high-unit shipments for a brief period."

"Today's VR customers are primarily made up of enthusiasts who are educated on the sector and products. Because of this, HP places a larger focus on value rather than cost," says Ludwig. "The HP Reverb headset has a higher price tag than others on the market, but we have experienced incredibly high demand from both the consumer and professional markets due to its overall improved value proposition."

But the debut of higher priced enterprise-focused VR gear, such as Varjo and VRgineers, may be ushering in a new

The Consumerization Effect

"Consumerization is the specific impact that consumer-originated technologies can have on enterprises," according to analyst firm Gartner. "It reflects how enterprises will be affected by, and can take advantage of, new technologies and models that originate and develop in the consumer space, rather than in the enterprise IT sector," Gartner states.

adoption wave. With exploratory use cases whetting the appetite, more serious implementation is expected to follow. This is where the higher end units offering higher quality visuals and more sophisticated interaction such as gesture recognition can outshine the generic consumer units.

"We've certainly seen larger enterprises commit to integrating VR into their workflows over the next few years, especially within the automotive and defense industries, where detail and fidelity are critical to avoiding costly mistakes in evaluative processes," says Kuang.

Design and Simulate in AR

A similar tug of war between consumer and enterprise units is also taking place in AR.

"AR for field service is among the most compelling areas of growth for the industry; as such, buyers are looking for features that help workers conduct tasks more quickly and safely," says Kuang. "This means they may not necessarily favor features like high resolutions or FOV (field of view) measurements, but things like voice interfaces, modularity and longevity features (like ruggedization and battery hot-swapping). This is what has allowed hardware providers like RealWear [with voice command] to excel where other fully-featured devices, like HoloLens 2, have struggled."

In anticipation of AR/VR use for design and engineering, CAD software developers like SolidWorks and simulation solution providers like ANSYS have begun to add AR/VR support to their offerings.

"Graphics and visualization intensive software from ANSYS like Ensight, SPEOS, OPTIS VR Suite and VRXPERIENCE already support Enterprise VR through cave-based VR and devices like Canon MREAL and VR services and product providers like TechViz. In addition, some high-end consumer devices like Oculus Rift and hardware and software solutions like zSpace are also supported," says Dipankar Choudhury, vice president of research at ANSYS.

"Through this support, we enable engineers to get into the virtual cockpit of a vehicle, for example. The engineer can then test the driving experience in various virtual environments. ANSYS is also working to bring support of devices like the HTC Vive and Microsoft HoloLens to the full range of ANSYS simulation products," adds Choudhury.

The HP Reverb Pro Edition comes with accessories to extend the battery life and durability of the hardware. ***Image courtesy of HP.***

"The use of consumer-oriented products is far less common in the AR industry than the VR industry, due to higher overall price points and relatively lower demand, and any convergence between the two is unlikely to materialize within the next decade or so," says Kuang. More of Kuang's insights and assessments are in "The Augmented Reality Industry Report" published by Greenlight Insights. It includes a five-year forecast on the AR market and its applications.

Changing Buying Patterns

Assuming software's move to the cloud and users' acceptance continue, the hardware buying patterns are bound to change. Though entry-level workstations have cut into the high-end PC domain, powerful GPUs remain an essential component.

"With increasing adoption of engineering simulation on the cloud, we expect enterprise customers to only invest in on-premise hardware sufficient for their steady-state usage. Intermittent workloads and periods of peak demand will be pushed to the cloud," says Todd McDevitt, director of product management at ANSYS. "For 3D interactive use cases, engineers are gravitating towards high memory instances with capable graphics cards. Interactive performance and addressable memory for their largest models also rank high with engineers' requirements for using cloud resources."

Enterprise buyers have distinct hardware refresh cycles—the delay between one enterprise hardware upgrade and the next. Here, too, cloud-hosted software is expected to have a notable impact.

"Hardware refresh cycle for [an] installed user base is typically three years. Quite frankly, after three years, the machine becomes too slow and buggy to run the newer software," says Onshape's McEleney. "With browser-based software like Onshape, the hardware refresh cycle gets longer, probably a five-year cycle."

The consumer market's continued pressure on professional solution providers doesn't mean lower-quality products repackaged and sold at a higher price. It means professional hardware vendors will need to offer much more value and features if they plan to charge a premium. "Companies attempting to serve both consumer and enterprise buyers with the same product may find this to be unsustainable over a longer period," Kuang warns. 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.*

INFO ➜ ANSYS: ANSYS.com

➜ **Dassault Systèmes SolidWorks:** SolidWorks.com

➜ **Greenlight Insights AR industry report:** GreenlightInsights.com/reports/2019-augmented-reality-industry-report

➜ **Microsoft HoloLens:** Microsoft.com

➜ **Onshape:** Onshape.com

➜ **Siemens PLM Software, Solid Edge:** SolidEdge.Siemens.com/en

➜ **Varjo:** Varjo.com

➜ **VRgineers:** VRgineers.com

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

Budget Workstations for Engineers

Tasks, not price, define today's entry-level engineering workstation offerings.

BY RANDALL S. NEWTON

EVER SINCE THE FIRST desktop computer hit the market in 1960—the DEC PDP-1 for $125,000—computer vendors have made it a priority to build single-user desktop computers for professional scientific and technical applications. The hardware and software have changed drastically over the decades, but the nature of the marketplace is the same. Buyers still look for the best ratio of price vs. performance while placing a high value on reliability and suitability for purpose.

The computer workstation industry seems to have settled on dividing the market into four segments based more on performance than price. Market research firm Jon Peddie Research (JPR) calls these four segments Mobile, Entry Level, Intermediate and High. Entry-level desktop computers comprise more than half the total workstation market.

The sweet spot for the entry-level market segment is the design user who does a mix of 2D and 3D work in products like Dassault Systèmes' SolidWorks or Autodesk AutoCAD or Revit.

"Depending on one's CAD workflow, less can be more," says Chris Ruffo, who manages Lenovo's architecture and engineering workstation team. "A SolidWorks user in wireframe mode doing small to mid-sized CAD assemblies will perform just as well on an entry-level workstation as on a more sophisticated workstation."

Workstation customers all have "specific optimized workflows," Ruffo says, it is just a matter of "channeling the right workstation to the right need. The most important thing in CAD is clock speed."

An entry-level workstation today might have the ability to drive 8K monitors, multiple 4K monitors or 10-bit color, features available only at the high end of the market a couple of years ago, says Bill Ma, senior product manager for professional graphics at AMD. "Workstations have definitely changed over the years, but only in that they evolve to meet customer needs," he adds.

There is great value in ensuring a workstation is suitable for every task its user may need, like rendering. Two years ago, a photorealistic rendering on a typical entry-level workstation might have run for three hours, says Chris Ramirez, strategic alliances manager for Dell Workstations. "Now with real-time rendering and denoising, it is nearly instantaneous."

Dell makes entry-level workstations in three form factors: Tower, Small Form Factor and Rack-mounted. ***Image courtesy of Dell.***

Budget is a Relative Term

The difference between entry-level and other segments is based on the CPU and graphics processing units (GPUs). An entry-level workstation comes with 1 CPU that is either an Intel Core-I or AMD Ryzen Threadripper. These workstations are optimized for high-frequency single-threaded applications, which include most CAD and engineering software. Workstations with dual CPU sockets are not targeted to the entry-level market, and often ship with Intel Xeon CPUs instead of Core-I.

"I can build a $10,000 workstation with dual Xeons or a $5,000 workstation with a single i9; the Core-I will run circles around the Xeon" when running SolidWorks or Autodesk Revit, says Randall Copeland, CEO of Velocity Micro. If you need to do a lot of visualization, Copeland says "an AMD Threadripper is the best workstation [CPU] you can buy."

An exploded view of the HP Z2 SFF G4 workstation. ***Image courtesy of HP.***

"There are a number of 'budget' configurations, driven by different applications," notes Robert Bragaglia, CTO of @Xi Computer Corp. "The intended application and the class of CPUs are the primary factors. Socket count is also a factor to a lesser degree."

"For our purposes, the Dell Precision 3630 is our entry level for 3D or complex 2D," says Ramirez. "A SolidWorks user just wants maximum frequency. They aren't looking for 'entry level;' they are looking for the best system for their workload." The Precision 3630 is available with a choice of Intel CPUs, with the most popular one at the moment being the i7-9700K. It runs at 3.6 Ghz as-is or up to 4.9 Ghz when overclocked.

More Sizes to Choose

There are more choices in the market today for case size, also called form factor. All workstation vendors offer the traditional desktop tower, while some offer slimmed down towers and a third variation known as small form factor (SFF). The larger units can be upgraded after purchase, while the SFF generally is bought without expectation of upgrade.

The HP Z2 SFF G4 workstation is typical of this new breed of very small workstations. It measures 13.31x15.0x3.94 in. (WxDxH) and weighs slightly less than 14 lbs. *Digital Engineering* Contributing Editor David Cohn reviewed the Z2 G4 when it first came out: "It packs a lot of power for its size" (see digitalengineering247.com/r/21787).

Lenovo notes that "power is shifting to smaller form factors," says Bill Martin-Otto, Lenovo's senior performance manager for workstations. "CPU frequencies at this [entry] level continue to go up, which helps a lot of CAD users." It is not uncommon for users to start with CAD, but then be asked to do more visualization work. They might stick with their initial GPU such as the NVIDIA Quadro P1000 or the AMD WX 3100, but most vendors are now offering more powerful GPUs at the entry level.

The most commonly mentioned GPUs in our interviews were the NVIDIA RTX line of GPUs and the AMD Radeon Pro WX line. The NVIDIA RTX line offers a real-time ray tracing engine and contains architecture suitable for deep learning tasks. The AMD WX line has models optimized for large scale complex modeling and rendering.

A few vendors, including Dell and HP, also provide workstations as rack-mounted units. "If a company does not want all the data sitting underneath the desk, with all that heat and noise," Ramirez says, Dell has 1U racks in its Precision workstation line. "Buy a 42-rack, slide in 42 units and you have 42 engineers running as if their computer is under the desk but with the extra security of being the data center," he adds.

Lenovo ships a Small Form Factor workstation, which it calls "the world's smallest workstation." ***Image courtesy of Lenovo.***

Certification Counts

Hardware specifications are a major distinction between workstations and computers for the home and office market. Another is certification. All workstation vendors work with the leading engineering software companies to gain their certification.

"We have to explain all the time to our smaller customers why they should buy instead of build," says Ramirez. "Was that extra $100 you saved worth it?" The conversations are around the value of certification and the critical importance of the work.

"Do-it-yourself boxes are not certified," says Cassidy Lammers, worldwide marketing manager for workstations at Lenovo. "ISV [independent software vendor] certification is crucial; the software is the crucial part of an engineer's workflow."

There is another aspect to a close tie between workstation and software vendors, says @Xi Computer's Bragaglia. When software is updated, it may not run at peak performance on an outdated workstation.

"The right time to upgrade is when old technology slows down the workflow due to its inability to handle the requirements of the updated applications," he says. "It is also best to upgrade when a new product cycle is readily available that provides a higher level of performance." 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.*

INFO ➜ Dell: Dell.com

➜ **HP:** HP.com

➜ **Jon Peddie Research:** JonPeddie.com

➜ **Lenovo:** Lenovo.com

➜ **Xi Computer:** XiComputer.com

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

AFFORDABLE POWER: A Tale of Two Dells

We evaluate Dell's Precision 3540 and 3541 mobile workstations.

BY DAVID COHN

EARLIER THIS YEAR, we reviewed the Dell Precision 3530 (see *DE* January 2019; digitalengineering247.com/r/22062), a system that delivered great performance and more than 9 hours of battery life at a very affordable price. Imagine our surprise when Dell followed up by sending us not one, but two new mobile workstations—the Precision 3540 and 3541—as successors to that very successful system.

Outwardly, the 3540 and 3541 appear identical. Both share the same chassis design, charcoal gray case and connectivity options, although there are minor differences. For example, the Dell Precision 3540 measures 14.14x9.30x0.80 in. (WxDxH), while the Precision 3541 measures 13.85x9.29x0.86 in.

Although the actual weight varies a bit depending on the installed components, the 3540 we received weighed 4.25 lbs. plus 0.79 lbs. for its 90-watt power supply, while our 3541 tipped the scales at 4.78 lbs. plus 0.98 lbs. for its 130-watt power supply. Despite the wattage difference, the power supplies were otherwise identical.

What's the Same

Lifting the lids of both systems reveals a 15.6-in. display with a webcam centered in the top edge of the bezel, flanked by a pair of microphones and a camera status light. The webcam is optional on the 3540 but standard on all 3541 systems.

Both the 3540 and 3541 include a 102-key keyboard with a separate numeric keypad and mostly full-size keys. Though the base configuration keyboards are not backlit, the systems we received included backlit keyboards, an option that adds $35.

A round power button with optional fingerprint reader is located to the upper-right of the keyboard. Although the base configurations include only one pointing device and no fingerprint reader, the Precision 3540 and 3541 systems we received included both a 3.87x2-in. gesture-enabled touchpad with two buttons and a pointing stick nestled between the G, H and B keys, along with its own three buttons.

The available ports are identical for the Dell Precision 3540 and 3541. The right side provides a micro SD memory card reader, a headphone/microphone jack, two USB 3.1 Gen 1 ports, an HDMI port, an RJ-45 network port and a security lock slot. The left side hosts a round power connector, a USB Type-C 3.1 Gen 2 port with DisplayPort/Thunderbolt support, an additional USB 3.1 Gen 1 port with PowerShare and space for an optional Smart card reader. The remainder of the left side is consumed by a ventilation grille. There are no other ports or

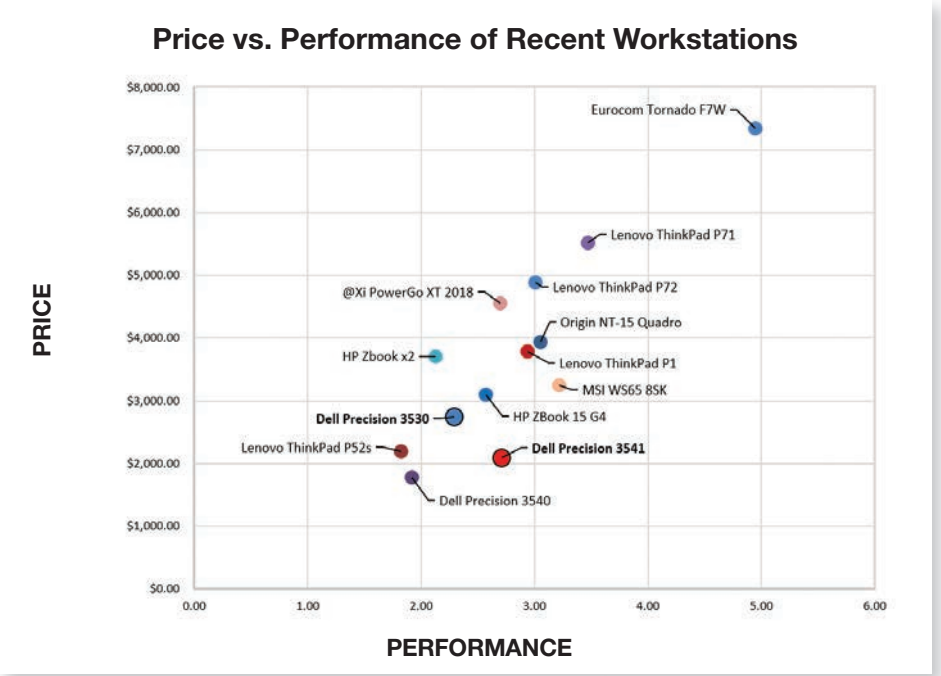
ABOVE: Dell's latest budget-friendly mobile workstations, the Precision 3541 (left) and Precision 3540 (right), look identical, but are based on very different internal components. ***Images courtesy of David Cohn.***

lights on the front or rear. The bottom includes only a fan vent and a pair of speakers for the built-in Realtek audio. Both systems included Intel dual band wireless AC 9560 adapters with Bluetooth 5.0.

What's Different

Since both Dell Precision workstations are billed as budget-friendly laptops for "graphics or power-intensive tasks" and share many of the same features, you are probably wondering about the differences. Beneath the nearly identical exteriors, these are two very different workstations.

According to the Dell representative we spoke with, the Precision 3540 is a new entry-level system equipped with a U-series processor and lower-performing graphics while the Precision 3541 is the true successor to last year's 3530, offering H-series processors and higher-performing graphics.



Price/performance chart of recent mobile workstations, based on the SPECwpc Product Development benchmark.

The Dell Precision 3540

The Dell Precision 3540 has a base price of $769 for a system equipped with a 1.6GHz quad-core Intel i5-8365U CPU, 4GB of RAM, a 500GB 2.5-in. 7200 rpm hard drive, and a 1366x768 display powered by the integrated Intel graphics. But that is just the starting point. Dell offers three other quad-core CPU options, including the Core i7-8565U in our evaluation unit (adding $77). That 1.8GHz Whiskey Lake processor has a maximum turbo speed of 4.6GHz and an 8MB cache while managing a frugal 15-watt thermal design power (TDP) rating.

Our 3540 also included an AMD Radeon Pro WX 2100 graphics board with 2GB of GDDR5 memory and 512 cores. At $84, this is the only discrete graphics option offered for the Precision 3540. Our evaluation unit also included a 1920x1080 WVA display with 100% sRGB gamut and an infrared (IR) camera, adding $129. Touchscreen options are also available.

The Precision 3540 can support up to 32GB of memory. Our evaluation unit came equipped with 16GB, installed as a pair of 8GB 2400MHz DDR-4 dual-inline memory modules (DIMMs; $210). Our system also included a 512GB M.2 PCIe NVMe Class 40 solid-state drive (SSD; $287). Unfortunately, the 3540 supports only a single hard drive, but you can choose from SATA or M.2 drives of up to 2TB capacity.

With the inclusion of the AMD graphics card, our evaluation unit also came with a four-cell 68Whr ExpressCharge-capable battery ($25) and a 90-watt power supply. Dell offers a choice of a standard power adapter with a 7.4-mm diameter barrel, or a power adapter that plugs into the USB Type-C port. Our system came with the latter, but if we had to choose, we'd opt for the standard power adapter so that the single Type-C USB port remained available.

Windows 10 Home 64-bit came preinstalled. Other OS options include Windows 10 Pro ($42) or Ubuntu Linux ($67). The Precision 3540 is backed by only a one-year warranty, not what we have come to expect from a major manufacturer. As tested, our Dell Precision 3540 priced out at $1,782 after applying current online discounts and adding $115 for a three-year warranty with onsite service after remote diagnostics.

The Dell Precision 3541

At $879, the base model Dell Precision 3541 includes a ninth-generation 2.5GHz Intel Core i5-9400H CPU quad-core CPU, 4GB of RAM, the same 500GB 2.5-in. 7200rpm hard drive as the base-model 3540, and the same 1366x768 display powered by the integrated Intel graphics. But Dell offers many more options for the 3541, such as a choice of five other CPUs, including a 2.8GHz Intel Xeon E-2276M. Our evaluation unit came with a six-core 2.6GHz Intel Core i7-9750H, adding $305. That Coffee Lake processor has a maximum turbo speed of 4.6GHz and a 12MB cache yet maintains a TDP rating of 35 watts.

Our Precision 3541 also included an NVIDIA Quadro P620 graphics processing unit (GPU) with 4GB of GDDR5 and 512 compute unified device architecture (CUDA) cores. At $90, this is the only discrete graphic option offered for the 3541. Our evaluation unit also included a 1920x1080 WVA display with 100% sRGB gamut and an IR camera, adding an extra $148. Touchscreen options are also available.

The Precision 3541 can support up to 32GB of memory, including error-correcting code memory for systems equipped with a Xeon processor. Our evaluation unit came with 16GB, installed as a pair of 8GB 2666MHz DDR4 non-ECC DIMMs ($207). Our system also included a 512GB M.2 PCIe NVMe Class 40 SSD ($283) and unlike the 3540, the Precision 3541 can support a 2.5-in. SATA drive in addition to an M.2 SSD.

Mobile Workstations Compared

	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	Origin PC NT-15 Quadro 15.6-inch 2.20GHz Intel Core i7-8750HJ 6-core CPU, NVIDIA Quadro P4200, 32GB RAM, 1TB NVMe PCIe SSD, 2TB 5400rpm SATA HD	MSI WS65 8SK 15.6-inch 2.90GHz Intel Core i9-8950HJ 6-core CPU, NVIDIA Quadro P3200, 32GB RAM, 512GB NVMe PCIe SSD	Eurocom Tornado F7W 17.3-inch 3.60GHz Intel Core i9-9900K 8-core CPU, NVIDIA Quadro P5200, 64GB RAM, 500GB NVMe PCIe SSD, 2TB HD
Price as tested	$2,0687	$1,782	$4,887	$3,938	$3,249	$7,346
Date tested	7/3/19	7/3/19	3/26/19	3/11/19	12/12/18	12/12/18
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	47.53	16.54	143.97	138.82	115.40	146.67
catia-05	53.63	31.56	247.85	178.96	194.32	284.42
creo-02	52.16	15.27	213.88	174.77	152.49	239.22
energy-02	8.25	0.42	36.33	30.46	9.16	19.15
maya-05	56.88	35.19	223.95	167.29	172.92	249.59
medical-02	12.63	8.52	51.37	44.55	32.06	61.63
showcase-02	21.87	11.20	69.64	75.87	61.69	73.96
snx-03	71.37	41.00	303.66	241.75	249.74	382.28
sw-04	60.95	49.00	150.18	124.58	128.91	184.40
SPECapc SolidWorks 2015 (higher is better)						
Graphics Composite	4.16	4.14	4.86	3.80	4.67	5.84
Shaded Graphics Sub-Composite	2.69	2.28	3.18	2.26	2.98	4.03
Shaded w/Edges Graphics Sub-Composite	3.51	3.09	4.01	3.08	3.88	4.99
Shaded using RealView Sub-Composite	3.05	2.87	3.62	2.70	3.37	4.49
Shaded w/Edges using RealView Sub-Composite	3.50	4.87	4.11	3.19	3.89	5.08
Shaded using RealView and Shadows Sub-Composite	3.48	3.02	4.15	3.13	3.87	5.11
Shaded with Edges using RealView and Shadows Graphics Sub-Composite	3.66	4.83	4.34	3.39	4.11	5.28
Shaded using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	10.13	7.75	12.14	10.11	12.97	13.83
Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	9.73	11.27	11.69	9.80	12.14	13.68
Wireframe Graphics Sub-Composite	3.69	3.50	3.95	3.50	3.69	4.45
CPU Composite	4.17	3.37	3.06	2.78	4.58	3.86
SPEC Workstation v3 (higher is better)						
Media and Entertainment	1.37	0.92	1.73	1.73	n/a	1.78
Product Development	1.57	1.21	1.57	1.93	n/a	1.59
Life Sciences	1.00	0.94	1.44	1.61	n/a	1.80
Financial Services	1.41	0.80	1.59	1.24	n/a	1.82
Energy	0.95	0.50	1.11	n/a	n/a	0.94
General Operations	1.67	1.52	1.45	1.78	n/a	1.28
GPU Compute	1.00	0.35	2.76	2.20	n/a	2.41
Time						
AutoCAD Render Test (in seconds, (lower is better)	59.70	77.50	42.80	63.80	35.50	34.10
Battery Life (in hours:minutes, higher is better)	15:28	15:17	5:38	4:05	9:01	4:40

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

The inclusion of the NVIDIA GPU also required the addition of a six-cell 97Whr ExpressCharge-capable battery ($50) and a 130-watt power supply. Again, Dell included a power adapter that plugs into the USB Type-C port. We think users would be better served by an older-style adapter, freeing up the Type-C port for other devices while saving $21.

Although Windows 10 Home is included in the base configuration, the system we received had Windows 10 Pro 64-bit preinstalled, adding $42. Windows 10 Pro for Workstation is required for systems equipped with a Xeon CPU. Like the Dell Precision 3540, a one-year warranty is standard, but our as-tested price of $2,087 includes a three-year warranty.

Evaluating Performance

Both Dell Precision workstations remained cool and nearly silent throughout testing, with fan noise barely audible even under heavy compute loads. Although the Precision 3540 ran for 15 hours and 17 minutes, the Dell Precision 3541 astounded us when it lasted a record-setting 15 hours and 28 minutes.

That was where the similarities ended, however. On the SPECviewperf test, which evaluates pure graphic performance, neither system turned in great results, but the scores for Precision 3540 placed it at the bottom of the pack, comparable to an ultrabook rather than a full-fledged workstation. But scores for the SPECapc SolidWorks benchmark were much better for both Precision workstations, illustrating that they are indeed very capable of running mainstream CAD software.

On the very demanding SPECwpc benchmark, the Dell Precision 3541 performed moderately well, with decent results for tests more reliant on CPU and storage performance, while its graphics results were quite low.

For the Dell Precision 3540, the SPECwpc results were disappointing, with almost all results near the bottom of the pack.

The only high points here were results dependent on storage. The Toshiba M.2 drive in the Precision 3540 turned in the best storage subsystem score we have recorded to date. Scores on our AutoCAD rendering test were respectable at best, with the Dell Precision 3541 averaging 59.7 seconds to complete the rendering, while the Precision 3540 averaged 77.5 seconds.

Conclusions

As configured, the Dell Precision 3540 priced out at $1,782, making it one of the most affordable mobile workstations available today. But at $2,087, the Dell Precision 3541 may be a better choice for most users, despite costing $305 more.

As you would expect, both the Precision 3540 and 3541 are independent software vendor (ISV) certified for major CAD, digital content creation and scientific applications. Both systems also came with a copy of the Dell Precision Optimizer, which automatically tunes the system to run ISV applications, but a new Dell Precision Optimizer Premium version costs $123 extra after a 30-day free trial period.

Although neither system blew us away in performance, the Dell Precision 3540 and 3541 are half the price of those mobile systems with the top-rated benchmark results. Both are well-designed, affordable, lightweight, and deliver incredible battery life. Although either Precision workstation would be a great choice for a mainstream CAD user on the go, we preferred the Dell Precision 3541 thanks to its more robust graphics and better storage options. 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.*

INFO ➜ Dell: Dell.com

Dell Precision 3540

- **Price:** $1,782 as tested ($769 base price)
- **Size:** 14.14x9.30x0.80 in. (WxDxH) notebook
- **Weight:** 4.25 lbs. plus 0.79-lb. power supply
- **CPU:** 1.8GHz Intel Core i7-8565U 4-core w/8MB Smart Cache
- **Memory:** 16GB (2x8GB DDR4-2400MHz non-ECC SDRAM)
- **Graphics:** AMD Radeon Pro WX 2100 w/2GB GDDR5 memory
- **LCD:** 15.6-in. FHD WVA 1920x1080 anti-glare non-touch
- **Storage:** 512GB M.2 PCIe NVMe Class 40 SSD
- **Audio:** Realtek audio with built-in speakers, built-in microphone array
- **Network:** Intel Dual-Band Wireless-AC 9560, 802.11ac, MU-MIMO Dual Band 2x2 plus Bluetooth 5.0
- **Other:** Three USB 3.1 Gen 1 (one with PowerShare), one USB Type-C/Thunderbolt 3, HDMI, headphone/microphone combo jack, microSD card reader, RJ-45 LAN port, integrated 1MP IR webcam, fingerprint reader
- **Keyboard:** Integrated 102-key full-size backlit keyboard with numeric keypad
- **Pointing device:** Gesture-enabled multi-touch touchpad with two buttons and pointing stick with three buttons

Dell Precision 3541

- **Price:** $2,087 as tested ($879 base price)
- **Size:** 13.85x9.29x0.86 in. (WxDxH) notebook
- **Weight:** 4.78 lbs. plus 0.98-lb. power supply
- **CPU:** 2.6GHz Intel Core i7-9750H six-core w/12MB Smart Cache
- **Memory:** 16GB (2x8GB DDR4-2667MHz non-ECC SDRAM
- **Graphics:** NVIDIA Quadro P620 w/2GB GDDR5 memory
- **LCD:** 15.6-in. FHD WVA 1920x1080 anti-glare non-touch
- **Storage:** 512GB M.2 PCIe NVMe Class 40 SSD
- **Audio:** Realtek audio with built-in speakers, built-in microphone array
- **Network:** Intel Dual-Band Wireless-AC 9560, 802.11ac, MU-MIMO Dual Band 2x2 plus Bluetooth 5.0
- **Other:** Three USB 3.1 Gen 1 (one with PowerShare), one USB Type-C/Thunderbolt 3, HDMI, headphone/microphone combo jack, microSD card reader, RJ-45 LAN port, integrated 1MP IR webcam, fingerprint reader
- **Keyboard:** Integrated 102-key full-size backlit keyboard with numeric keypad
- **Pointing device:** gesture-enabled multi-touch touchpad with two buttons and pointing stick with three buttons

Manufacturing-as-a-Service: Dawn of a New Horizon?

Engineers are using online manufacturing services to meet design deadlines.

BY JIM ROMEO

MANUFACTURING IS CHANGING. Never mind the remarkable utility of 3D scanning, the customization capability of additive manufacturing, or the facile methods of rapid prototyping—there's a whole new way of using cloud computing to disseminate design information instantly. Potentially, it provides a new chapter in the way we manufacture everything. Welcome to contract manufacturing—also known as manufacturing as a service (MaaS).

"For decades now, companies have shifted from vertically integrated design, engineering and manufacturing, to relying on external contract manufacturing partners," says Andrew Edman, industry manager for Product Design, Engineering and Manufacturing with Formlabs in Somerville, MA.

"Even manufacturers that continue to be highly vertically integrated depend on external vendors for components that go into their finished goods," he adds. "Outsourcing production, whether via traditional manufacturing methods, or more cutting-edge practices like on-demand 3D printing, frees up organizations to focus more on their core competencies and less on the complexities of dealing with the literal nuts and bolts of manufacturing."

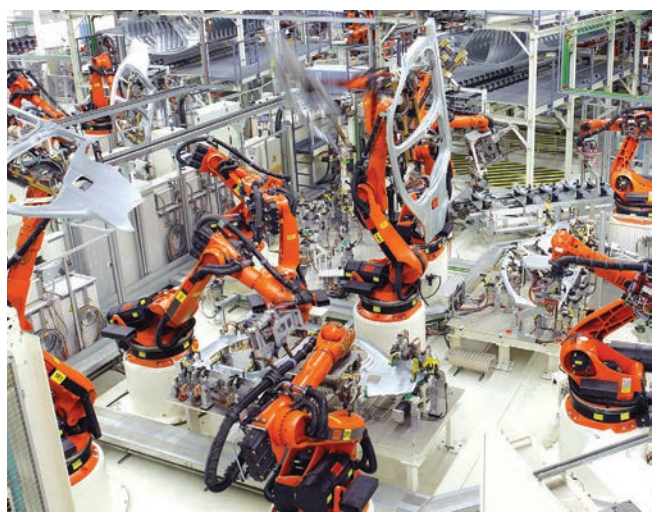
Borrowed Processes

This shift in focus has already made inroads in other industry verticals. Curt Heverly is the managing director of Open Doors Consulting in Glendale, CA. He likens the MaaS evolution to that of other industries, such as plastics injection molding, where the concept is successful.

"Injection molding output (IMO) is sold as a service, instead of purchasing an injection molding press, auxiliary equipment and robotics," he says. "All traditional equipment purchases require technical support and trained employees to optimize processes for each unique project. Current financial and timing hurdles must be overcome in the competitive race to get products quicker to market."

Heverly says IMO is the plastic industry's take on a share economy. OEM suppliers are selling moldable hours or pounds.

"A complete documented process that is plug and play for the newly laid out plastic plants of the next millennium. You are purchasing a block of plastic processing output tailored for the current projects in the facility," Heverly says. "Speed to market and shorter product life cycles require nimble and flexible equipment financing arrangements. Lack of labor, technical and non-technical, requires an automated solution. Building blocks of automation must be able to be assembled and repositioned as product and project mix accelerates in every quickening consumer demand velocity."



Automation will play a key role in on-demand manufacturing. ***Image courtesy of KUKA Robotics.***

Having available—and ready—assets is the goal of many robotics firms. The robotics industry is aware of the trend and is preparing to meet the demand of contract manufacturing. Joe Gemma, chief robotics officer at KUKA Robotics explains that the company is putting the right tools in place.

"We have engaged with other companies on a 'pay per use' basis to help manage capital expenditures, while providing

manufacturing flexibility," he says. "Other companies are providing this type of service like Vicarious on the West Coast, as an example, and many others are beginning to enter this space. We see this change in manufacturing philosophy taking hold, but it may not be widespread in all industries, particularly with low volume and high mix portfolio products."

Bright Horizon

Although KUKA isn't fully preparing for cloud-based manufacturing orders, most firms are orienting their business models to the cloud. The future of contract manufacturing is accelerated by other "as a service" functionalities emerging in the cloud.

"I would say the great initial benefit has been centered on networking and the low overhead of communicating to solicit bids and efficiently identify capable suppliers," says Dr. Stephen J. Rock, senior research scientist and additive manufacturing lab director at Rensselaer Polytechnic Institute's Center for Automation Technologies and Systems in Troy, NY.

Rock says that as more complex manufacturing operations are contemplated for outsourcing, distributed processing via the cloud is an opportunity. According to Rock, the cloud enables the rapid access of "simulations that might support automated quoting of higher complexity parts or assemblies, assists in cross-organization production scheduling, or perhaps enables value-added design optimization suggestions based on the particular manufacturing capacity available at any moment in time."

"The computational and networking capabilities of the cloud may also support sophisticated material modeling that relies on multi-organization expertise across the design and manufacturing spectrum," he says. "Longer term, manufacturers can also benefit by leveraging cloud computing concepts and applying them directly to manufacturing operations.

"Distributed manufacturing may allow a job to be easily divided between several facilities for faster turn-around or cost optimization," Rock adds. "Networking efficiency can enable load shifting between a wide array of solution providers. The resilience afforded by independence from any single point of failure should help suppliers and their customers sleep well at night."

Of course, even if the move to the cloud takes time, organizations are already seeing the effects of MaaS. "Manufacturing as a service is changing the way engineers work," says Alkaios Bournias Varotsis, Ph.D., technical marketing engineer with 3D Hubs in Amsterdam.

Varotsis says that online manufacturing will change the world on a similar scale as the introduction of the shipping container, which enabled a truly global manufacturing ecosystem.

"Online manufacturing will have the opposite effect," Varotsis explains. "By combining the connectivity of the cloud with the advantages of digital manufacturing technologies, like 3D printing and [computer numerical control] CNC machining, production will turn again local, eliminating altogether the need for transportation and storage and significantly reducing the waste and the environmental impact of manufacturing."

Manufacturing Limits?

As good as it sounds, MaaS may not be the panacea. It has limits.

"The limiting factor is all about the assembly of parts with different materials and processes—which is not yet possible with instant cloud quote services," explains Marco Perry, founder of Brooklyn-based product design firm Pensa. "Such projects need conversations, expertise and contracts. If that is available in the future, it will change the market."

Contract manufacturing could accelerate design cycles. ***Image courtesy of SalineLectronics.***

Another limiting factor may be the availability of skill sets to meet the potential upward demand that contracted and MaaS may impose. Although it widens the market of vendors to a worldwide scope, the skills still may not always be available where you need them, when you need them.

"The limiting factors to this shift include an unwillingness to change, reluctance to embracing new technology, inability to learn and adapt new technological processes of manufacturing and, finally, an unskilled workforce that can't use the technology," says David Armendariz an executive recruiter with the technical division of the Lucas Group.

MaaS: Manufacturing Lightning?

MaaS could become lightning in a bottle for a whole new world of product expectations, driven by a digital fabric, a super-agile supply chain and a crowd of end users who want parts as fast as possible.

Perry points out that since the industrial revolution, manufacturing companies have sold and mass-produced products that are the same design. That was then. This is now, though.

"The problem with that model is that people don't want exactly the same product," says Perry. "Today, more companies than ever are able to market to niche audiences—with a small production volume—because cloud fabrication is now possible. And for the future, it's the holy grail for companies to use cloud manufacturing to produce complete products." DE

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

INFO

- **3D Hubs:** 3DHubs.com
- **Formlabs:** Formlabs.com
- **KUKA Robotics:** KUKA.com/en-us
- **Lucas Group:** LucasGroup.com
- **Pensa:** Pensanyc.com
- **Rensselaer Polytechnic Institute Center for Automation Technologies and Systems:** cats-fs.rpi.edu

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

ParaMatters CogniCAD Walkthrough

Setting up topology optimization problems is clear-cut in CogniCAD.

BY TONY ABBEY

Editor's Note: *Tony Abbey provides live e-Learning courses, FEA consulting and mentoring. Contact tony@fetraining.com for details, or visit his website at fetraining.net.*

THIS ARTICLE REVIEWS the Paramatters CogniCAD Topology Optimization and Generative Design program from Paramatters. CogniCAD is a cloud-based application. The user uploads CAD geometry to define design space in STEP file format. The emphasis with CogniCAD optimization is that the resulting smooth geometry is directly suitable for export and use in additive manufacturing as an STL or STEP file. CogniCAD also includes stress constraints to help ensure the resultant structure has viable strength.

The Design Study

The design study carried out for this walkthrough develops a support structure for a container and its contents, connected to the ground at four attachment points. The container and its contents are subject to two inertia load cases: vertical and lateral.

Fig. 1 shows the design scenario, as displayed in CogniCAD. I have outlined the support bolts and the container to emphasize the design intent.

The blue geometry is the allowable design space, within which material can be added or removed by the Topology Optimizer. The container occupies the empty volume within the design space. Additional empty volume is defined for access to bolts during assembly. The four support bolts are defined as non-design space. The material in these regions is preserved. Further non-design space is defined around the container region; four attachment bolts and four support pads. This is shown highlighted in Fig. 2.

The single design space and multiple non-design spaces are defined by parts in an external CAD assembly and then imported into CogniCAD as a STEP file, with dimensions in mm. Fig. 3 shows the CogniCAD interface with the assembly imported. All parts are listed in the left-hand panel with design or non-design space status undefined by default.

Fig. 3 shows a sequence of steps from 1 to 6 in the right-hand panel. The first step, to add material properties, is shown pending. In this case a single material property, titanium TiAl6V4, is selected from the CogniCAD material library. The user can then proceed to step two—defining design and non-design space using the assembly parts. Of note is that non-design space is contained within design space, rather than abutting design space.

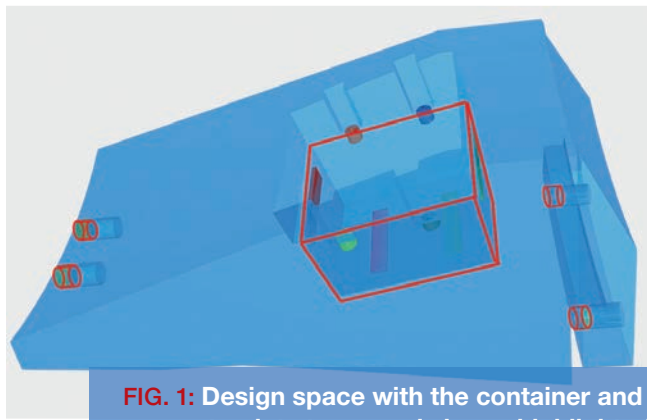


FIG. 1: Design space with the container and support points to ground shown highlighted.

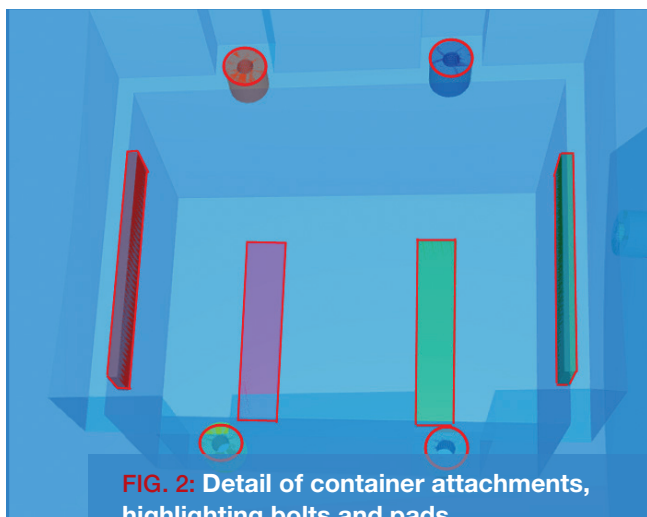


FIG. 2: Detail of container attachments, highlighting bolts and pads.

There is only one part defining design space, so the other 12 parts remain undefined in this step. Step three is to define these (the bolts and pads described earlier) as non-design space.

Step four defines the load cases, with their loading and constraint actions. The user has the option to define these manually, or to be guided by the CogniCAD AI tool. I am using the manual method here. For each load case the sequence is to define the load case name and analysis type, define the constrained parts and define the parts where loading is applied. Fig. 4 shows the loading defined as a group, applied to multiple parts. CogniCAD calculates the combined c.g. of the parts and then forces and moments can be applied through this point. Fig. 4 shows the user interface with constraints selected and a group load ready to be defined.

The c.g. can be used as the loading point, or any user-defined point. In this case accelerations are being used, so the acceleration tab is selected instead. This requires the definition of the non-structural mass of the group. This represents the payload of the container and its contents. In this case the value is 0.44 kg, distributed to the parts. This value can be edited for each part to give a more sophisticated breakdown. The value of acceleration (400 g) and direction (-y) is also defined.

The load case is saved, and another load case can optionally be created. The setup is repeated with the same mass and acceleration value, but this time in the (-z) direction. Conveniently, the constraints can be directly copied from the previous load case. The loaded parts can be highlighted for each load case as a check.

We can now move on to step five where the optimization controls are defined. There are two options here:

- ***Generative Design Exploration***

Described as maximization of design stiffness to specified fraction of material, this is the traditional topology optimization approach. It requires an estimate of the volume fraction and does not attempt to meet stress or displacement constraints. It is simpler technology and is less CPU intensive and hence cheaper and faster than the alternative option, which applies response constraints.

- ***Lightweighted Generative Design for Engineering Applications***

This is described as minimization of mass subjected to stress, deformation and vibration constraints. The version I have used is limited to stress constraints, but other constraints will be available in an upcoming release. In this case the volume fraction is automatically adjusted to get the most efficient design.

Paramatters emphasizes the power of its response constraint method to achieve practical designs quickly. The volume fraction method is useful as a complementary design space exploration tool. In this study I will use the volume

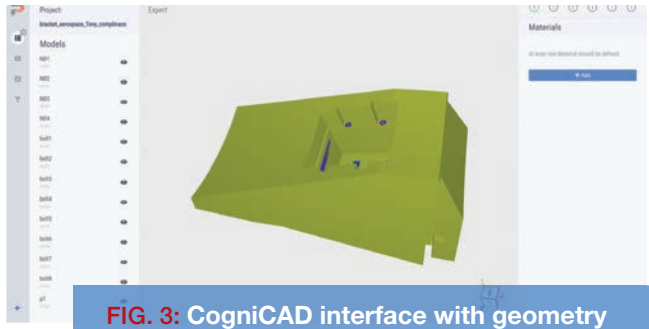


FIG. 3: CogniCAD interface with geometry imported and Step one pending.

FIG. 4: A group loading ready for definition.

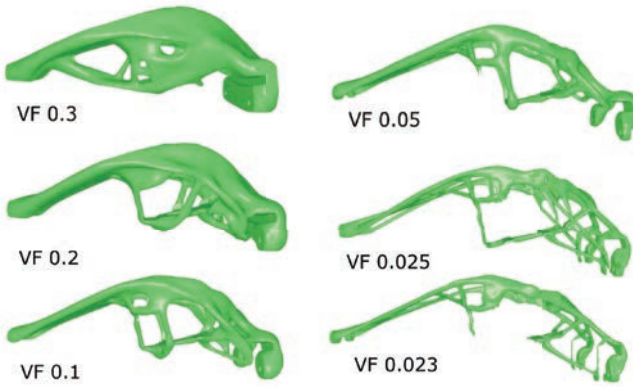


FIG. 5: Resultant configurations for minimizing compliance over a VF range.

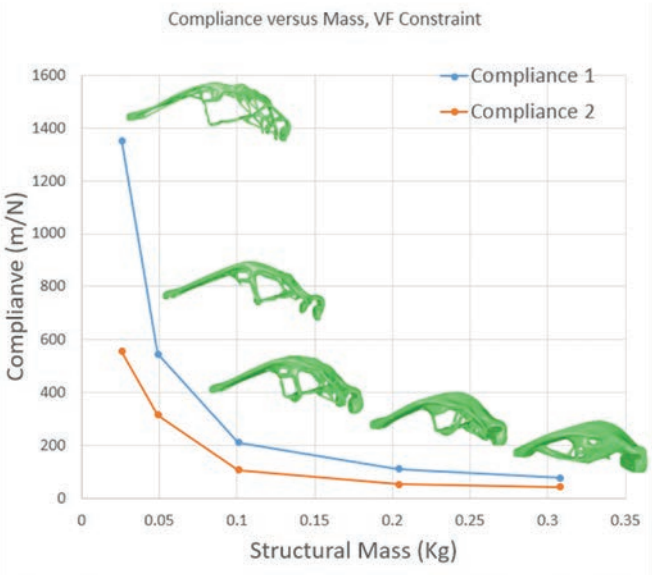


FIG. 6: Variation of compliance with structural mass for two load cases.

fraction constraint and then the stress constraint method.

Generative Design Exploration Runs

The objective is to minimize compliance (maximize stiffness) subject to the volume fraction constraint. Each load case can be individually weighted. For example, the vertical load case could be considered more important than the lateral load case. This is probably more useful in exploring design trends, rather than meeting formal loading envelopes. I have set the weighting to be equal and the volume fraction at 30%—meaning 70% of design space will be removed.

At this point CogniCAD estimates the solution cost in tokens. Two additional parameters that affect cost are solution speed (slow, medium, fast) and resolution (low, medium, high). Resolution will also directly affect the fidelity of the solution and hence minimum member size. My initial run used medium resolution as I was anticipating a slender configuration, rather than a chunky monolithic configuration. I also used fast solution time (medium speed is not available with medium fidelity).

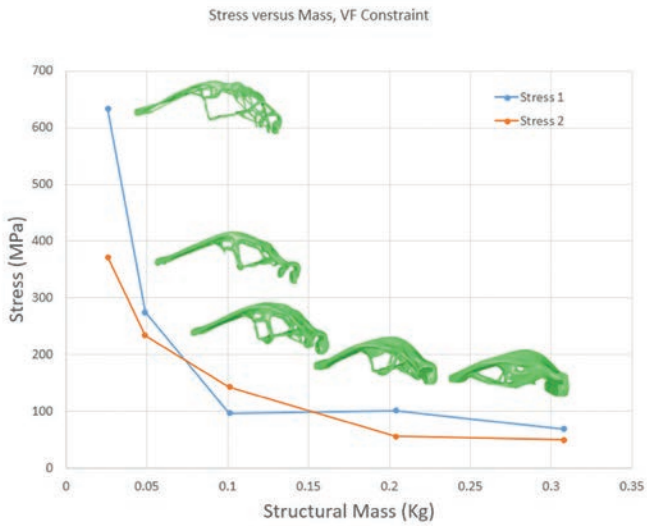


FIG. 7: Variation of Maximum stress versus Structural Mass for two load cases.

Two other design options are available: selecting between an additive manufacturing or investment casting manufacturing process, and in the case of additive manufacturing, controlling the overhang angle. I used additive manufacturing with a default overhang of 45 degrees. This attempts to promote arch-like supports for flat regions rather than abrupt vertical to horizontal transitions, which are too fragile to build.

Once this final step is complete the optimization can be run. The project is saved to your Paramatters cabinet in the cloud, queued and launched. The graphical cabinet display includes a real-time update of the optimization progress and a preview of the configuration as it becomes available.

The first analysis used a target Volume Fraction (VF) of 0.3. The level of VF to aim for is always a guess for a new structure. It turns out that a VF of 0.3 gives a structure with maximum stresses below the limit of 300 MPa assumed for the material and maximum deflections of 0.027 mm. Based on this evidence I explored progressively lower VF. Fig. 5 shows the six configurations achieved with VF 0.3, 0.2, 0.1, 0.05, 0.025 and 0.023.

Configurations with VF 0.3, 0.2, 0.1 and 0.05 show progressively more slender members being developed, which form a cage-like structure around the payload region. The bolted support regions morph from a monolithic arrangement toward individual supports.

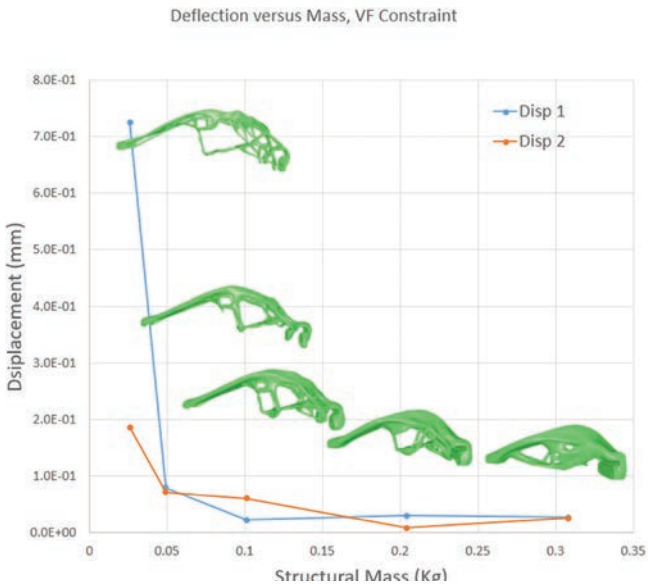


FIG. 8: Variation of Maximum displacement versus Structural Mass for two load cases.

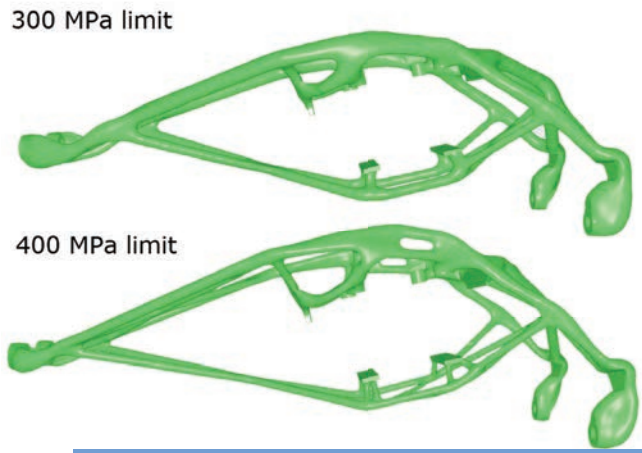


FIG. 9: Configuration minimizing compliance under varying stress constraints.

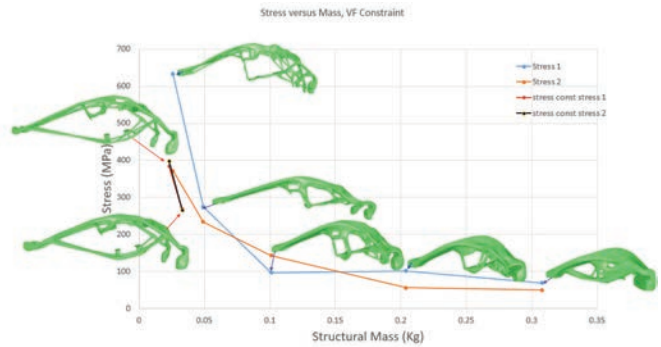


FIG. 10: Stress versus structural mass for VF constraint (right side images) and Stress constraint (left side images).

Configurations with VF 0.025 and 0.023 needed to be run at a very high mesh fidelity to be able to achieve continuous structure with a level of fineness. This is a very challenging problem for the optimizer. Coarser fidelity mesh, and a correspondingly chunkier structure will fail to find a continuous volume.

The structural mass is directly proportional to the VF. The payload mass of 0.44 kg remains constant. The two curves, blue (Compliance 1) and orange (Compliance 2), show the compliance of load case 1 (vertical 500 g) and load case 2 (lateral 500 g). Load case 1 dominates at all levels of VF. The relationship between mass and compliance is fairly linear up to around 0.1 F when the compliance rapidly increases with reduction in VF. The configuration changes from chunkier to finer at this point.

The influence of the inertia loading is interesting. The loads induced by the payload mass remain constant, but the loads due to structural mass are decreasing with a lower VF.

I also wanted to review the variation with peak stress for the various configurations. Fig. 7 shows the trend.

The stress quoted in the figure is the maximum throughout the structure for each load case. There is no constraint on stress for these configurations, so the value is a byproduct of the compliance-driven configuration. The smoothness of the stresses is surprising and is a testament to the smooth geometric surface fitted through the configuration. This point was confirmed when the resultant geometry was exported as a STEP file, imported into SolidWorks and analyzed using SolidWorks simulation.

The vertical load case is the dominant case for most of the configurations, apart from around VF of 0.1.

The maximum stress limit is assumed to be 300 MPa, later amended to 400 MPa. VF of 0.05 and above satisfy this requirement.

I also wanted to see the displacement trend, and this is shown in Fig. 8.

Fig. 8 shows a relatively small increase of maximum deflection with mass for both load cases up to a VF of 0.05. The deflection then rapidly increases, particularly for the vertical load case. The transition to the slender configuration gives high levels of deflection.

The lighter structures (VF 0.05 and below) seem to be much more deflection sensitive than stress sensitive. Not shown here was a further configuration of VF 0.23. This resulted in a 600% increase in deflection compared with VF 0.25, but only a 25% increase in stress. There is clearly a cliff-edge type effect on deflections around these slender configurations.

Lightweighted Generative Design Runs

Finally, I switch to the alternative optimization strategy of minimizing compliance, but with a stress constraint.

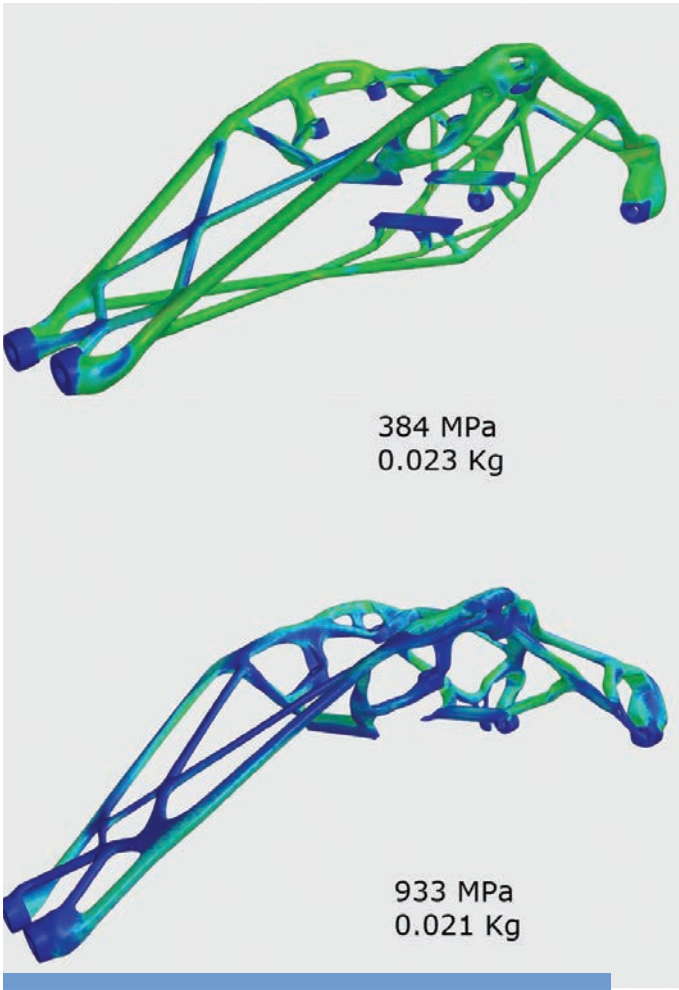


FIG. 11: Contrast between minimum mass without stress constraint (lower) and with stress constraint (upper).

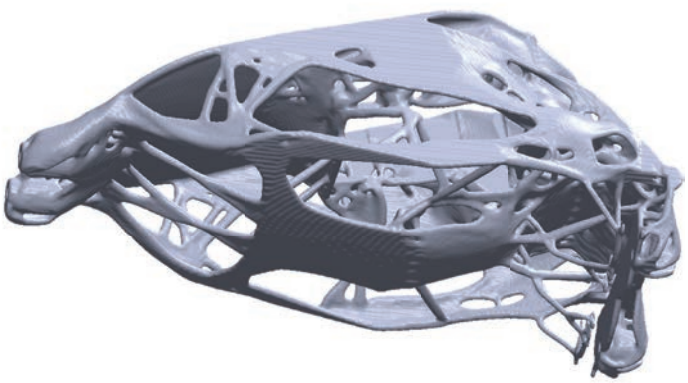


FIG. 12: Meso-design result at 10% Volume Fraction.

Based on the results so far it should be possible to target a stress constraint around 300 MPa and expect a mass of around 0.25 Kg (VF of 0.025). I ran this setting, and also a stress constraint of 400 MPa, which should be even lighter.

The two configurations are shown in Fig. 9.

The two configurations are different from the previous set, with no attempt to "cage in" the payload region. The comparison of mass and stress response is shown in Fig. 10.

Fig. 10 shows that the target stresses of 300 MPa and 400 MPa can be achieved with a 0.033 Kg and a 0.023 Kg structure, respectively. These analyses had to be run with a very high-fidelity mesh. Both structures by definition are viable from a stress perspective, as opposed to the structures with no stress constraint seen previously. Stress responses without a stress constraint at 0.021 Kg reached 933 MPa. Fig. 11 shows the contrast in the two configurations.

The deflections are still high for the stress constrained analyses at 0.451 mm and 0.602 mm (0.033 kg and 0.023 kg). However, they are an improvement on the unconstrained analyses. It will be interesting to see if this can be tightened up once CogniCAD has displacement constraints available. In the meantime, if the compliance and displacements are known from a previous run, then compliance can be used as a constraint to control displacement. A stress of 400 MPa and compliance of 550 N mm is used, based on the trend shown in Fig. 6. This resulted in mass of 0.33 kg and a maximum deflection of 0.511 mm, which is an improvement on 0.602 mm.

I also had a preview of the upcoming meso-design option, which allows for an organic cellular type design. The problem was run at a 0.1 VF level and the resulting design is shown in Fig. 12.

Conclusion

Setting up topology optimization problems is straightforward in CogniCAD. The ability to copy design studies within the cloud-based cabinet means that variations on VF, constraint type and so on were easily achieved. Once complete, each model can be reviewed independently within the cloud-based cabinet.

The optimizer was very successful in achieving smooth high-fidelity configurations at the very small, and hence challenging, Volume Fractions that this study drove toward. There was an expected big demand on computing resources.

I look forward to trying out future releases of CogniCAD with displacement and vibration constraints. I am also keen to explore the distributed meso-structure options due shortly. DE

Tony Abbey *creates e-learning classes which are presented in partnership with NAFEMS. Check out the latest course and contents at http://bit.ly/courses-Sept.*

AUTODESK® **FUSION 360**™

Integrated CAD, CAM, and CAE Software.

Engineering has changed. So should your tools.

Schedule a demonstration:
autodesk.com/f360contact

Talk to a Fusion 360 Representative:
1-833-843-3437

Autodesk Fusion 360: Getting **Better** All the Time

Autodesk consolidates Fusion 360 into a single, more powerful package.

BY DAVID COHN

FUSION 360 is a CAD-CAM-CAE program from Autodesk that combines 3D design and modeling, simulation, generative design, documentation, collaboration and manufacturing in a single, integrated environment.

Originally introduced in 2012 as a free technology preview, Autodesk Inventor Fusion offered solid and surface modeling tools and supported parametric and freeform modeling. Two years later, the company discontinued Inventor Fusion when it released Fusion 360. Since then, Autodesk has continued to improve Fusion 360 with frequent updates, to the point that today it rivals and often surpasses the capabilities of Inventor.

When we last looked at Fusion 360, Autodesk offered two different editions: Standard and Ultimate. Both provided a full suite of tools for design, documentation, data management, collaboration, simulation and manufacturing. But the Ultimate edition—which cost five times as much—included more advanced simulation such as buckling and nonlinear stress, support for manufacturing using four- and five-axis machining and generative design shape optimization.

In October 2018, Autodesk consolidated Fusion 360 into a single product that includes generative design, advanced simulation and multi-axis machining. Although the price for Fusion 360 increased from $40 per month to $60, it represents a significant reduction from the $190 per month Autodesk had been charging for Fusion 360 Ultimate, and existing users had the opportunity to lock in the old price.

Simple Interface

At first glance, the Fusion 360 user interface appears quite spartan compared to other CAD-CAM-CAE programs. An Application Bar in the upper-left provides tools to create, save, export and 3D print as well as undo and redo changes. To the right of this, tabs let you select among open projects. Below this, most tools appear in the toolbar.

To keep things simple, the program's capabilities are grouped into workspaces. When you select a workspace from the toolbar drop-down, you see tools and commands specific to that workspace. For example, the Model workspace provides tools for placing 3D solid primitives, and for sketching and converting sketches into features, like what you would find in a traditional 3D CAD environment.

After selecting a tool within the current workspace, you work on your design within the canvas, left-clicking to select objects and right-clicking to access a marking menu that contains frequently used commands. A ViewCube in the upper-right corner of the canvas lets you orbit your design or view it from standard positions.

A floatable Browser palette lists the objects in your design and lets you control their visibility. A navigation bar near the bottom of the canvas contains commands used to zoom, pan and orbit as well as providing display settings that control the appearance of the interface and how designs are displayed in the canvas. You can also use the mouse and gestures to navigate the view.

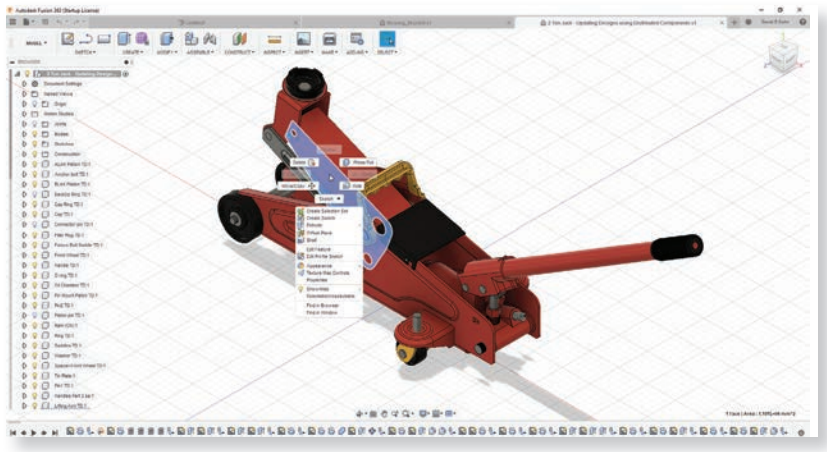
A timeline across the bottom of the window lists the operations performed on your design. You can right-click operations in the timeline to make changes, and drag operations to change the calculation order. You can also use a tool in the Application Bar to open a Data Panel, which provides quick access to your design files for data management and collaboration.

In addition to the Model workspace, Fusion 360 provides 13 other workspaces. Sculpt is a sub-environment of the Model workspace, with tools for pushing and pulling vertices and edges to achieve the desired shapes. The Patch workspace allows you to create and edit complex parametric surfaces. The Generative Design workspace lets you simultaneously generate multiple design solutions based on manufacturing and performance requirements. The Printed Circuit Board (PCB) workspace provides tools for designing printed circuit board layouts. And the

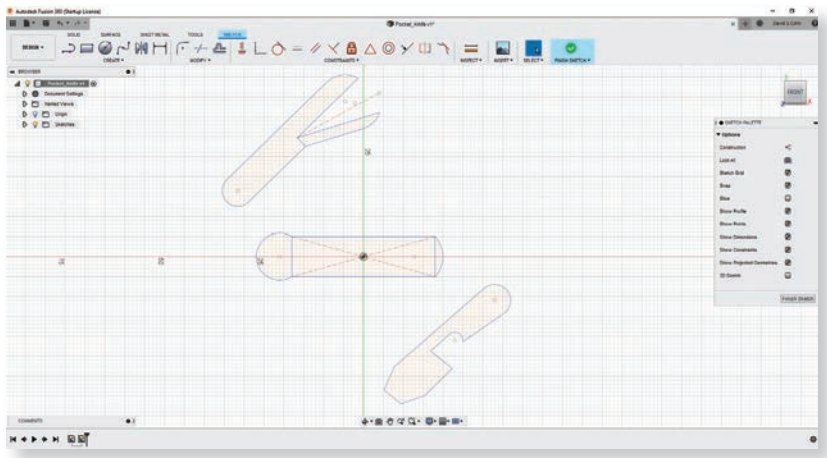
Mesh workspace lets you edit and repair imported scans or mesh models.

There is also a Render workspace for generating realistic images of your designs, an Animation workspace with tools for creating videos and a Simulation workspace with tools for testing your design using finite element analysis. The Simplify workspace is a subenvironment of the simulation workspace for making simulation-specific modifications to the model geometry, while the Compare workspace becomes available after a simulation study completes successfully so you can compare results side by side.

The Manufacture workspace then lets you create toolpaths to machine components, while the Drawing workspace provides tools to document your designs.



Tools in Autodesk Fusion 360 are organized into task-specific workspaces. Right-click to access a marking menu. *Images courtesy of David Cohn.*



The latest version of Fusion 360 offers a preview of a new UI featuring tabs for switching between sets of tools. When sketching, a new contextual tab provides more intuitive access to commonly used tools.

Leveraging the Cloud

In Fusion 360, you create projects to contain and organize your design data. You can then invite other people into a project to collaborate. You can start designing in a blank canvas or start sketching over imported images. Fusion 360 lets you switch between direct modeling and history-based modeling, or even simultaneously use both.

Although the software runs locally, all designs are saved to Autodesk's A360 cloud-based storage. If you do not have access to the internet or lose your connection, you can still use Fusion 360 in Offline mode, though you won't be able to perform some file operations. The last-saved version of files changed while in Offline mode will be synced to the cloud when your connection is restored.

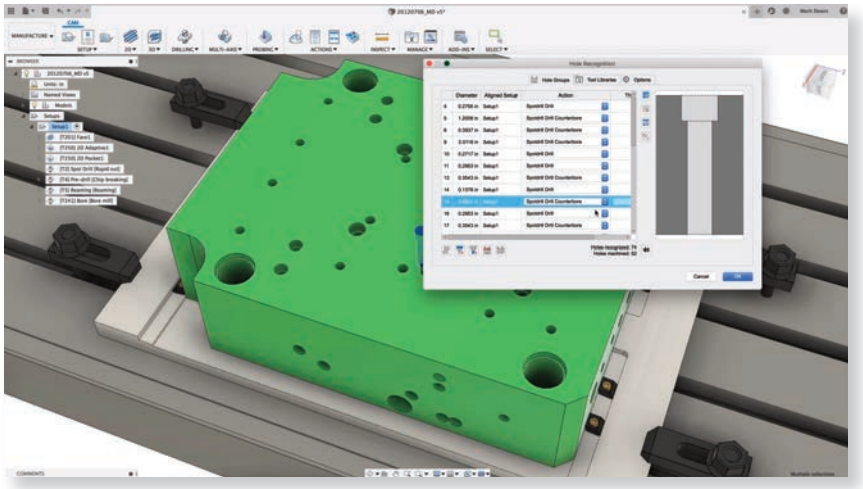
As an Autodesk 360 product, Fusion 360 updates automatically, so you always have the latest version, and Autodesk revises the software regularly. The latest version fixes a number of modeling, sketching and manufacturing issues while another recent release introduced an optional Fusion Team environment. One particularly powerful feature in the Team environment is the ability to differentiate a particular version of a model as a milestone, which makes it easier to identify and return to that version if necessary.

Several additional features also can be activated from the Preview tab of the program's Preferences dialog. Autodesk recently introduced a tab-based toolbar user interface (UI). Instead of starting from the Modeling workspace and then selecting one of eight other workspaces from a drop-down, the new toolbar starts from a Design workspace with seven other workspaces available in a drop-down. Then, within a given workspace, the toolbar includes tabs for switching between sets of tools. For example, in the Design workspace, you can switch between the Solid, Surface, Sheet Metal and Tools tabs. Similarly, when you switch to the Simulation workspace, the Setup tab contains tools for setting up a simulation study while the Results tab provides tools for result analysis.

There are also contextual tabs that become active when you select specific commands. For example, the Form tab contains the tools formerly found in the Sculpt workspace and becomes the only tab visible when you start the Create Form tool.

The old toolbar offered very little space for sketching tools, and getting out of sketch mode was not very intuitive. With the new UI, Create Sketch reveals a new Sketch contextual tab with a dedicated toolbar containing the most commonly used sketch tools. In addition, sketch constraints appear on the toolbar by default and a Finish Sketch button lets you know that you are currently in a temporary mode.

For now, you can switch between the old and new UI by selecting a checkbox in the Preferences dialog. You must



You can pay 125 cloud credits to activate the new manufacturing extension to perform state-of-the-art processes like complex surface finishing, automated drilling and additive manufacturing.

close and restart the program, however, whenever you switch between the toolbar UIs. Later this year, the new UI will become the default and the ability to switch between them will eventually be eliminated.

Other recent updates include highlighting of edges that cause a fillet or chamfer operation to fail and the ability to edit a sketch offset. Autodesk recently announced the introduction of extensions for Fusion 360. Extensions enable users to allow groups of high-end capabilities by paying with Cloud Credits.

Cloud Credits are a special Autodesk currency required to perform certain tasks. For example, users of various Autodesk products pay one cloud credit per megapixel when rendering in the cloud. New users receive a grant of Cloud Credits when they subscribe to a product and can purchase additional Cloud Credits at any time.

In Fusion 360, Cloud Credits are already required to perform generative design explorations and cloud-based simulation. With the introduction of the manufacturing extension for Fusion 360, users can pay 125 cloud credits per month when needed to activate a hybrid manufacturing environment that enables them to perform state-of-the-art processes like complex surface finishing, automated drilling and additive manufacturing.

Free for Many

Like nearly every other Autodesk product, you can download a free trial of Fusion 360 that gives unlimited access to its full suite of tools for 30 days. After the trial, however, students, hobbyists and startups making less than $100K per year can continue to use Fusion 360 for free, while others must pay a monthly or annual subscription fee.

With the elimination of the Ultimate edition, Fusion 360 now costs $60 per month if purchased on a month-to-month basis. But you can save quite a bit by committing to a one-year ($495) or three-year ($1,335) subscription.

Fusion 360 is quite impressive. It provides a full suite of tools in a single, integrated package that is available for both Macs and PCs. Fusion 360 is also interoperable with files from other programs, including Alias, AutoCAD, CATIA, NX, Creo, Rhino and SolidWorks. Although its price has increased, so has its toolset.

Autodesk Fusion 360 remains affordable and flexible, making its powerful tools available to anyone, whether working alone or as part of an extended design team. DE

David Cohn *has been using AutoCAD for more than 35 years and is the author of over a dozen books on AutoCAD. As senior content manager at 4D Technologies, he creates the CADLearning courses for AutoCAD and AutoCAD LT (cadlearning.com). He is a contributing editor to* Digital Engineering, *and also does consulting and technical writing from his home in Bellingham, WA. You can contact him at david@dscohn.com or visit dscohn.com.*

INFO ➜ Autodesk: Autodesk.com

Autodesk Fusion 360

PRICES

Autodesk Fusion 360 is only available by subscription. Students, startups and hobbyists (making less than $100K per year) receive the functionality available in the Ultimate tier for free.

- **Monthly:** $60
- **1 year:** $495
- **3 years:** $1,335

SYSTEM REQUIREMENTS

- **Operating System:** Apple macOS Mojave v10.14; Apple macOS High Sierra v10.13; Apple macOS Sierra v10.12, Microsoft Windows 7 SP1; Windows 8.1; or Windows 10 (64-bit only)
- **CPU:** 64-bit processor (32-bit not supported)
- **Memory:** 3GB RAM (4GB or more recommended)
- **Graphics Card:** 512GB RAM or more; except Intel GMA X3100 cards
- **Disk Space:** approximately 2.5GB
- **Pointing Device:** Microsoft-compliant mouse, Apple Mouse, Magic Mouse, MacBook Pro trackpad
- **Internet:** DSL internet connection or faster

progeCAD Professional 2020: **Low-Cost CAD**

This affordable CAD program looks a lot like AutoCAD, but brings functionality at an affordable price.

BY DAVID COHN

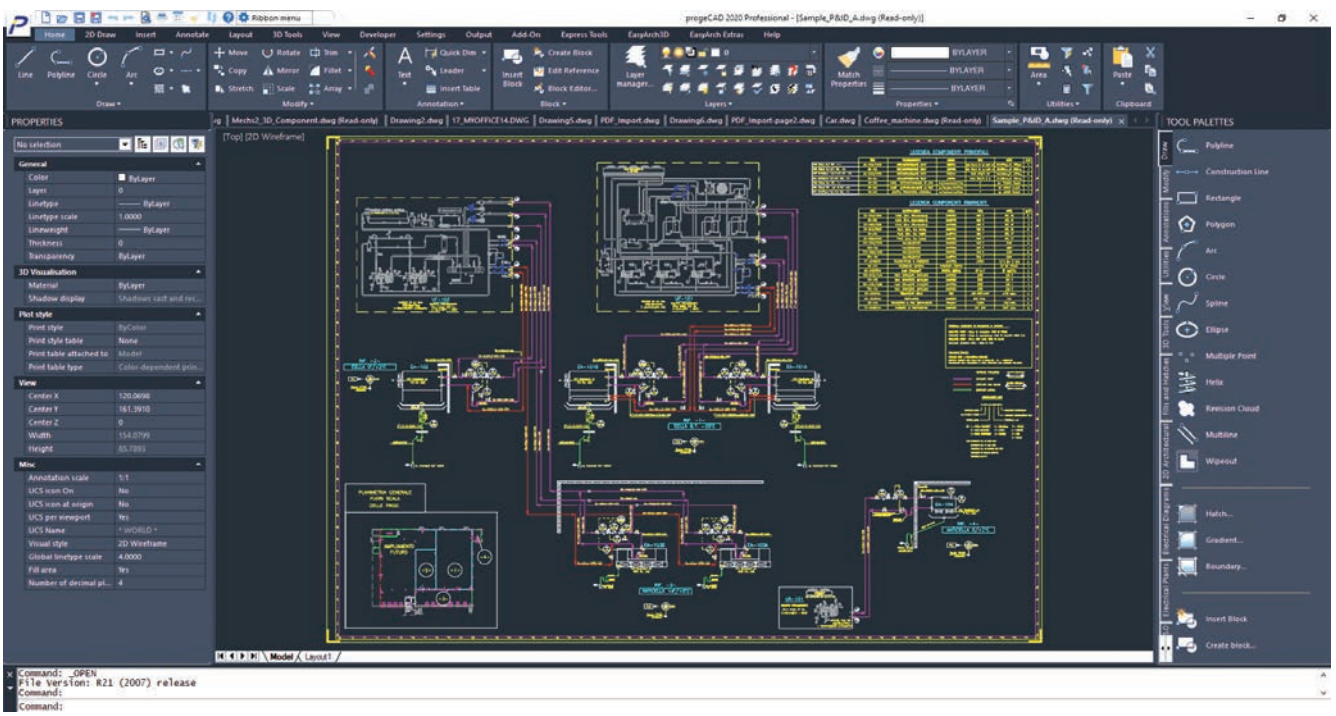
IN THE WORLD OF AutoCAD workalikes, progeCAD may not be as well known. Developed by the Swiss company progeSOFT, a founding member of the IntelliCAD Technology Consortium (ITC), progeCAD is based on the Theiga library from the Open Design Alliance (ODA). It uses DWG as its native file format.

The latest version, progeCAD Professional 2020, reads and writes files compatible with the most recent (2018) AutoCAD file format and can also work with DWG files going back to AutoCAD Release 2.5. With the new release, progeCAD can also import Autodesk Revit RFA and RVT files as well as IFC files. It even supports point clouds saved in Autodesk's Recap formats (RCP and RCS) as well as the PCG, ISD, XYZ, PLY and LAS formats.

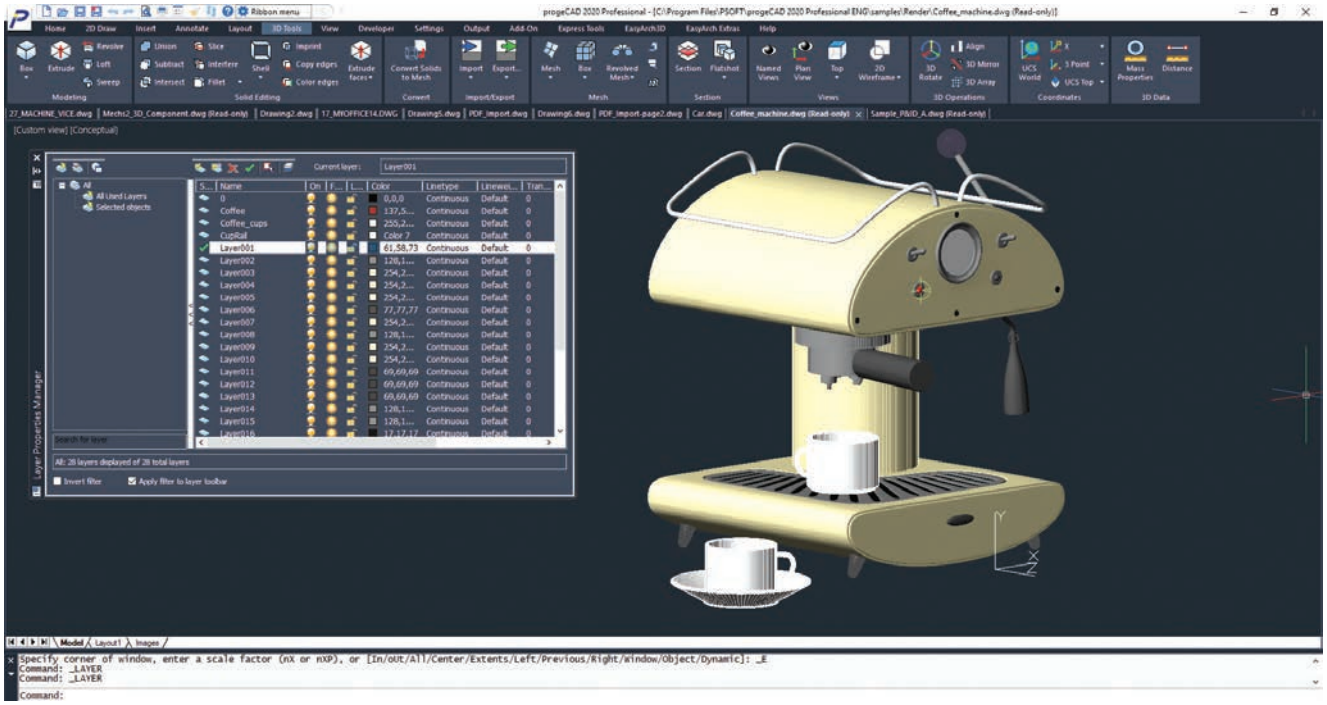
progeCAD also stands out for its ease of use. Unlike some other AutoCAD clones that intentionally look different than AutoCAD, progeCAD should appear familiar to anyone who has ever used AutoCAD. But its compatibility only goes so far.

Strikingly Similar

When you first start progeCAD, you can choose between a classic interface with



The progeCAD 2020 user interface looks strikingly similar to AutoCAD. *Images courtesy of David Cohn*.



progeCAD offers many of the 2D and 3D tools found in AutoCAD but lacks other capabilities that AutoCAD has had for many years.

The latest version of progeCAD includes a separate program that converts PDF files into DWG.

pull-down menus and multiple toolbars, or a ribbon interface that looks nearly identical to that of AutoCAD. You can then easily switch between them at any time by simply changing workspaces.

With the Ribbon Menu workspace active, the user interface (UI) is nearly indistinguishable from that of AutoCAD, with an Application Menu button in the upper-left, a Quick Access Toolbar across the top of the screen, and a ribbon with tools that look almost exactly like those in AutoCAD.

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

A default Properties palette is docked on the left side of the screen and a Tool palette on the right. These and other progeCAD palettes look and feel just like those in AutoCAD. There is also a command window that is initially docked across the bottom of the screen, and it too behaves identical to AutoCAD. Even the status bar, which extends across the bottom of the program window, looks strikingly similar to AutoCAD, right down to the appearance of the various icons. And like AutoCAD, you can change the items that display on the status bar.

Within the drawing window, progeCAD features in-canvas controls for restoring preset views and selecting visual styles, just like AutoCAD. The drawing window also includes a user coordinate system (UCS) icon similar to that in AutoCAD, and things like object snap, object snap tracking, polar tracking and direct-distance entry work just like AutoCAD.

Very Much Different

Of course, progeCAD is not AutoCAD, which means that once you start looking around, you will find lots of differences. For example, when a command is active in AutoCAD, options appear on the command line and you can select the desired option by typing, by clicking the option in the command window, by pressing the down-arrow and choosing from a menu, or by right-clicking and then selecting from a shortcut menu.

In progeCAD, you can also use any of these methods except for right-click. Although you can right-click at other times to display a shortcut menu—right-clicking when no command is active displays a menu of frequently used commands and shift+right-click displays an object snap menu just like AutoCAD—right-clicking in progeCAD while a command is already active does not bring up a list of command options. It often does nothing.

More glaring, however, is progeCAD's lack of support for dynamic blocks. The latest version of progeCAD finally intro-

duces a dedicated Block Editor authoring environment for creating and modifying block geometry. But there is currently no provision for creating dynamic blocks, something that AutoCAD added in the 2006 release, nearly 15 years ago.

If you open a DWG file containing dynamic blocks created in AutoCAD, you cannot edit those blocks in progeCAD's Block Editor and the only dynamic functionality accessible in progeCAD is the ability to change the visibility state—assuming that capability was included when the block was created in AutoCAD. The only saving grace is that progeCAD will not even allow you to open a dynamic block for modification.

And that's just the tip of the iceberg. Lots of other AutoCAD features and functions are missing from progeCAD. For example, the program lacks any rendering capabilities until you download and install the free Artisan for progeCAD renderer. Once installed, you can render images, but the process is very different from that of AutoCAD.

The list of AutoCAD functions missing from progeCAD is quite extensive. progeCAD lacks roll-over tooltips, intelligent dimensioning, DWG compare and geometric center object snap. You cannot modify the UCS by right-clicking the UCS icon. There is no ViewCube for orienting 3D models. And while progeCAD has no trouble displaying two-dimensional drawings of 3D models created in AutoCAD using the drawing views tools, there are no similar tools in progeCAD for creating a base view and projected views. Also you cannot modify drawing views that had previously been created using AutoCAD.

In addition, due to a lack of context-sensitive ribbons, functions like adding a hatch pattern, creating text and placing dimensions feel like you're using a much earlier version of AutoCAD. For example, progeCAD uses a dialog box when creating or editing hatches.

Interesting New Features

A number of new features have been added to progeCAD 2020, including tool palettes for blocks, hatches and frequently used commands; the ability to digitally sign a drawing; infinite construction lines; the functionality to include formulas in tables; a balloon notification when an external reference is modified; system variable monitoring; path-based arrays; and an Add Selected tool that lets you create a new object of the same type and with the same properties as a selected object. Although new to progeCAD, these functions have been available in AutoCAD for many years.

The program can also import and export STEP and IGES files and convert PDF files into editable DWG geometry. Unlike AutoCAD, however, progeCAD's PDF to DWG capability is accomplished using an add-on that converts a PDF file into a new DWG file, rather than importing the PDF into the current drawing. And like other AutoCAD clones we have recently reviewed, progeCAD does not recognize text in a PDF file originally created with SHX fonts.

What's more, when importing a multi-sheet PDF file, progeCAD only converts the first page. In addition, while progeCAD can attach a PDF as an underlay, it cannot convert an attached PDF into drawing geometry. PDF underlays exist only as an image within the drawing. You cannot turn PDF layers on and off nor can you snap to geometry in the PDF underlay. To its credit, however, progeCAD 2020 can export 3D PDF files.

The program also comes with a number of add-ons, including a Raster to Vector program that can convert images or scanned drawings into DXF files that can then be brought into progeCAD. There is also a block library with more than 20,000 2D and 3D ready-to-use blocks for architecture, mechanical design and electrical. There is also an interesting perspective image correction tool, but again, this is an add-on program that runs separate from progeCAD.

Very Attractive Pricing

With all of these differences and numerous gaps in functionality, progeCAD's main appeal is its price. Educational licenses are free and a single copy for commercial use costs just $499 for a perpetual license. Annual maintenance and support costs just $220 per year.

You can download a 30-day free trial from the progeSOFT website, complete with sample files and .chm-based help. There are also a number of video-based tutorials available on the progeSOFT website as well as a 696-page manual and a 233-page tutorial for new users and those who already know AutoCAD. Unfortunately, the manual is based on the 2011 release of progeCAD while the tutorial is based on progeCAD 2017.

There's a lot to like about progeCAD, which is then somewhat tempered by frustration over incompatibilities and missing features. If you are looking for an affordable alternative to AutoCAD or AutoCAD LT, progeCAD is worth considering. Just be aware of the differences. DE

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

INFO ➜ progeCAD USA: progeSOFT.com

PRICING

progeCAD Professional: $499 (single license, perpetual)

- **USB portable, perpetual:** $675
- **Per seat, network license, perpetual:** $675
- **Educational license:** FREE
- **iCARE maintenance/support:** $220 per year

MINIMUM SYSTEM REQUIREMENTS

- **OS:** Windows 10, Windows 8.1, Windows 8, Windows 7 (32-bit and 64-bit)
- **Processor:** 1GHz processor or faster (2.5GHz recommended)
- **RAM:** 4GB (8GB recommended)
- **HD:** 4GB or more free space
- **Display:** 1024x768 with TrueColor

Next-Gen Engineers

Student Design Competition Profile: WPI's SailBot

Robotics Engineering Takes to the Seas

BY JIM ROMEO

THE INTERNATIONAL Robotic Sailing Regatta (SailBot) is a robotic sailing competition held in North America in which teams of university, college and high school students compete. The first event, in 2006, was hosted by Queen's University in Kingston, Ontario, and took inspiration from a successful senior project at the University of British Columbia that built a robotic sailboat.

Since 2008 teams have annually competed throughout the U.S. and Canada, traveling from as far away as Europe and Brazil. The goal is to create an unmanned sailboat that navigates through a variety of challenges with limited, if any, human control.

Ken Stafford is a professor of Robotics Engineering and Mechanical Engineering, and serves as the director of the Robotics Resource Center at Worcester Polytechnic Institute in Worcester, MA.

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

Ken Stafford: The competition is oriented to boats competing in the SailBot Class (up to 2 meters in length) but smaller boats are popular due to their easier logistics. There is an Open Class (which are boats up to 4 meters in length) oriented toward non-school teams.

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

Stafford: Recently, the designs have focused on sloop-rigged monohulls (single-masted, single-hulled boats with main and jib sails) meeting the SailBot class rules (under 2 meters in overall length). There have been a variety of different configurations over the years, however, including trimarans, "open class" (up to 4 meters long), and a few 1.2-meter boats meeting the "maxiMOOP" class rules.

This competition stresses control and seaworthiness over speed so most of the classic radio-controlled sailboat hulls are a poor fit.

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

Stafford: It continues to be a real challenge in terms of software development, sensor integration, control algorithms, aerodynamics, hydrodynamics, structural analysis and system integration. Over the three years I've been involved I've seen innovations such as canting keels, above-water movable ballast, ultrasonic wind measurement and camera/GPS integration. So while the point is not so much to produce some radical new boat design as it is to exercise the engineering process to solving these challenges, there have been incremental innovations that could be implemented on ocean drones.

DE: Anything else you'd like to tell us about the event?

Stafford: Over the years, the event has expanded from basic general sailing challenges such as short- and long-course racing, and navigation accuracy demonstrated both along a course and by staying in a confined area with a judged technical presentation to incrementally more complex events.

Interestingly enough, the Station-keeping and Search and Discovery Challenges have direct applicability to several start-up companies. One company has designed a fleet of sailing robots that navigate to a certain ocean position then simply stay in that area collecting environmental data until told to return. Large commercial freight haulers are looking into deployable unmanned rescue craft that could find overboard sailors. As with most good academic projects, there actually is valuable and appropriate practical research going on. DE

Autonomous sailboats compete in the SailBot regatta. ***Image courtesy of WPI.***

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

MORE ➜ sailbot.org

Advertiser Index

America Makes MMX Event....C3
ANSYS....C2
Autodesk-Fusion 360....41
CAASE19 Virtual Conference....1
CAASE20 Conference....25
COMSOL....C4
COMSOL Sponsored Content....22
DE Upcoming Vendor Hot Seat Webcast....13
Dell/NVIDIA....7
ESTECO SpA....17
Okino Computer Graphics Inc....37
Onscale....3
Siemens Sponsored Content....23

NCDMM

ACCELERATING THE ADOPTION OF 3D PRINTING!

Connect and Collaborate!

America Makes

MMX

Members Meeting & Exchange

October 22 & 23, 2019 • Youngstown, Ohio

What is MMX?

The annual America Makes MMX event unites the additive manufacturing (AM) community to collaboratively achieve the goal of advancing AM technology, adoption, commercialization, and education.

Why attend?

Gain insight into project progress, roadmap development, Institute strategy, and who's who in the additive industry. An exciting agenda is planned, making the 2019 MMX an event you will not want to miss!

Who should attend?

Members and Non-members!

MMX brings together Individuals from industry, academia, government, and economic development agencies that are willing to collaborate for the acceleration of AM technology.

REGISTRATION DISCOUNT FOR DE READERS! USE PROMO CODE "DE50"

BECOME A SPONSOR!

Connect your brand with this high impact event!

REGISTER NOW!

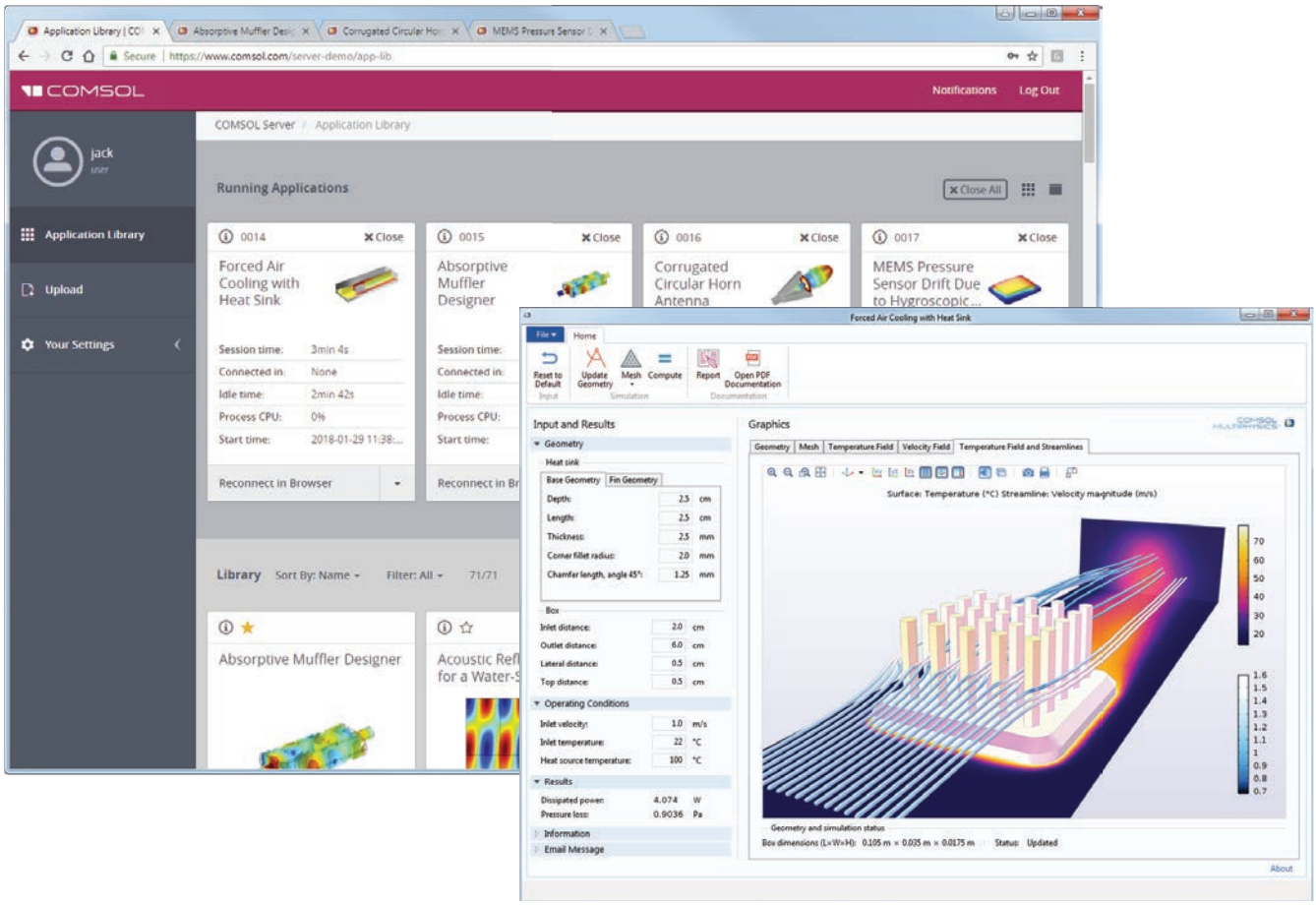
Connect with the additive community!

Registration and sponsorship details at
AmericaMakes.us/MMX

America Makes | Driven by NCDMM

@AmericaMakes /AmericaMakes **AmericaMakes.us**

Develop better products — faster.



An example of a simulation app in the COMSOL Server™ app library. App users can find an optimal heat sink design without having any knowledge of the underlying mathematical model.

Industry engineers and researchers are accelerating product development by building numerical simulation apps and deploying them throughout their organizations. COMSOL Multiphysics® enables you to build specialized apps and COMSOL Server™ helps you distribute them to the right contributors at the right time in your product development workflow.

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 to product development.

comsol.blog/product-development

COMSOL