

April 2021

DE247

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3D Printing by Design



Gains and Losses

IF THERE WAS A SINGLE news story that summed up the technological contradictions of the past year, it may be the announcement in February that Fry's Electronics, the eccentric chain of retail electronics stores, was shuttering. Those 30 stores, which served nine (mostly western) states, were a mecca for the tech-obsessed of all stripes, who could wander the seemingly endless aisles, handling all manner of parts and components, computers, gaming systems and cameras.

Fry's was a victim of online shopping, but the recent pandemic was the final nail in the coffin.

We did not have Fry's where I grew up in Ohio (we had Radio Shack, which was similar, but underwhelming). Based on the stories I have read and heard, though, Fry's was like Toys"R"Us for burgeoning engineers. Headquartered in San Jose, CA, it served as something of a go-to source of supplies and inspiration in Silicon Valley. So it is ironic that many of the developers and engineers who found inspiration at the stores went on to work for Amazon and other companies that would eventually put it out of business.

The company did manage to outlast similar outfits like Circuit City, in part because of the affection customers had for its jam-packed stores, all of which were decorated based on various different themes. In Palo Alto, CA, it was the Wild West. The Phoenix store was decked out like an Aztec temple.

But the company was already hemorrhaging customers and suppliers, by most accounts, and the pandemic-related shutdowns ripped away all the bandages. Fry's was not alone, of course. Just a few months into the shutdown, we all got a look at how many markets, businesses and people were just a few disruptive weeks away from disaster.

Over the past year we have seen technology successes and failures. Online delivery services thrived, even as many of their gig-economy contractors have struggled. Powerful computing resources were deployed to create vaccines in record time, while aging and disconnected federal and state systems hampered the delivery of those same vaccines. Social media brought us together and pulled us apart.

As I mentioned, I never went to Fry's, but I went to places like it. They were more than a place to buy things; they were spaces to explore, full of unex-

pected discoveries. I won't romanticize shopping, but that combination of commerce and accidental inspiration is rare and growing rarer by the year.

I cannot say I would trade virtual shopping away; it has infinitely broadened my ability to obtain things I need, as well as things I want. But it has been a long time since I accidentally stumbled across something that I didn't know I needed. Algorithms ensure that I mostly find what I was already looking for.

I have been writing about technology in some form or another for more than two decades, and the one thing that holds true across every sector I have covered is that with every advancement, there are consequences and not all of them are positive. I am not endorsing a proscription of progress, of course, but a more thoughtful attitude toward it.

In the engineering sector we hear a lot about systems-level simulation and holistic approaches to design. The effects of a design change do not just impact the component in question, but also have ramifications for the software developer, the electronics, the entire assembly, the finished product, the manufacturer, the global supply chain, the retailer and the human operator. As certain physicists like to remind us, everything is connected, and I think the past year has certainly highlighted the ways in which those connections can play out, for both good and ill.

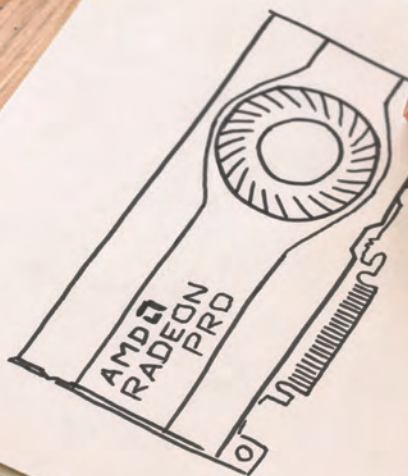
Technologically, we are better equipped than ever before to analyze those connections. How the experience of the past year will affect what we do with that information remains to be seen.

.....
Brian Albright, Editorial Director
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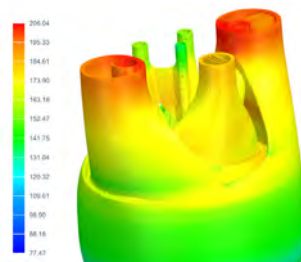
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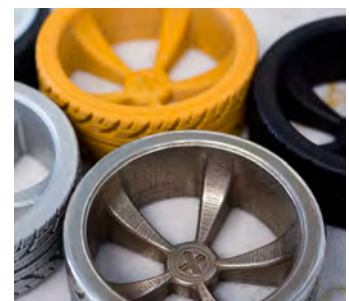
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Global 3D Printing Market Forecast 2019-2027

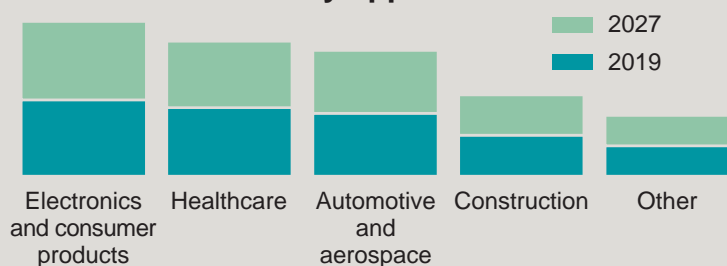
North America is the **DOMINATING** region in 2018

Asia Pacific is the **FASTEST GROWING** region

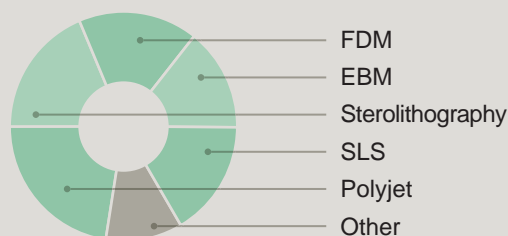
Top companies

3D Systems Corp.
EOS GMBH
Materialise NV
Proto Labs, Inc.

Market by applications



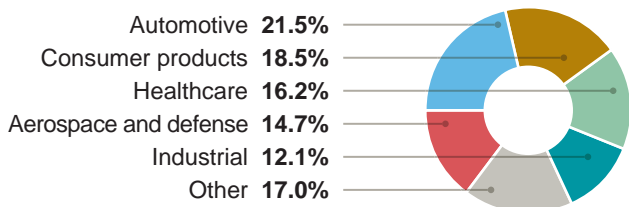
Market share by technology



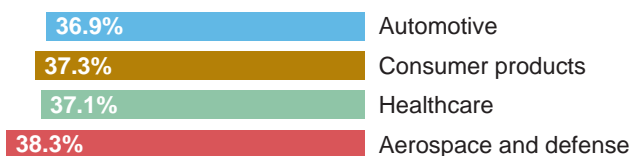
Source: Inkwood Research

Global 3D Printers Market by End-User

Market Share (2016)



CAGR (2016-2021)



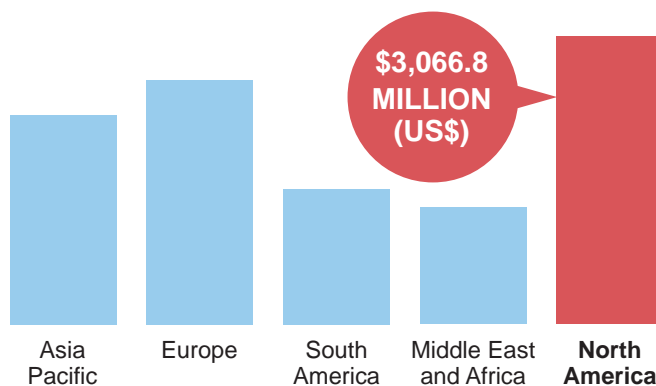
The global 3D printer market is projected to grow to **\$11.92 billion** by **2021**, at a CAGR of more than **35%** over the forecast period.

Source: Technavio

Global 3D Printing Market Revenue

(by region, U.S. \$M)

The global market for 3D printing is expected to cross **\$32.3 billion** by the end of **2025**, up from **\$7.3 billion** in **2016**. The market is projected to expand with a CAGR of **18%** during the forecast period.



Source: Transparency Market Research

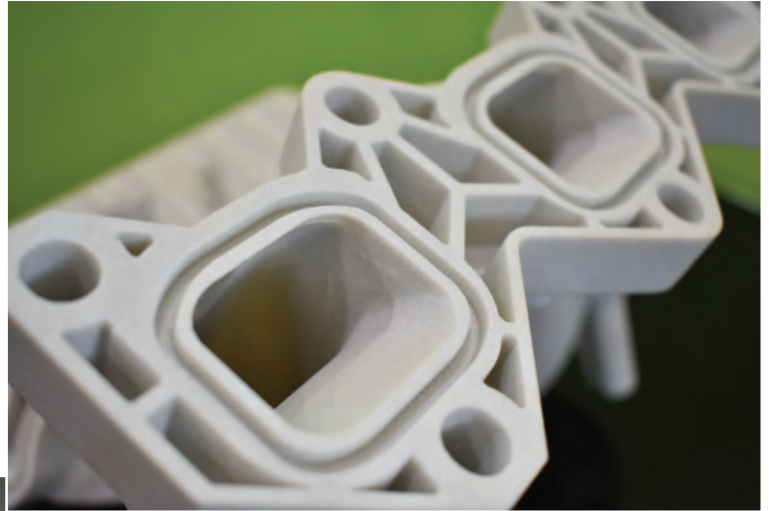
\$6.07 BILLION

The size of the global healthcare additive manufacturing market by **2028**, according to Verified Market Research. The market stood at **\$1.3 billion** in **2020**, and is expected to experience a CAGR of **21.23%**.

Source: Verified Market Research

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ROAD TRIP

3DEXPERIENCE World 2021

Dassault Systèmes Promotes Cloud-Centric 3DEXPERIENCE Works, Promises to Keep Desktop SOLIDWORKS

BY KENNETH WONG AND BRIAN ALBRIGHT

In February, Dassault Systèmes' 3DEXPERIENCE World 2021 (3DXW2021) came online. In 2020, the annual event (which had been rebranded from SOLIDWORKS World) was one of the last in-person engineering industry conferences to be held before the COVID-19 pandemic put an end to live events.

According to Gian Paolo Bassi, CEO, SOLIDWORKS, the global pandemic also affected the way customers are using the 3DEXPERIENCE World suite of solutions. "It has accelerated the transformation of many businesses toward cloud platforms," he said in the opening general session on Feb. 9. "Physical presence was not possible. Many started using our platform of integrated tools instead of disparate products."

Bassi provided an overview of the 2020 SOLIDWORKS Grand Challenge, which saw more than 500 employees from across the company and around the world collaborating online to design a digital space station. The station includes more than 11,000 parts. A scale model will be fabricated and displayed at the SOLIDWORKS corporate campus.

The company also announced two new SOLIDWORKS offerings,

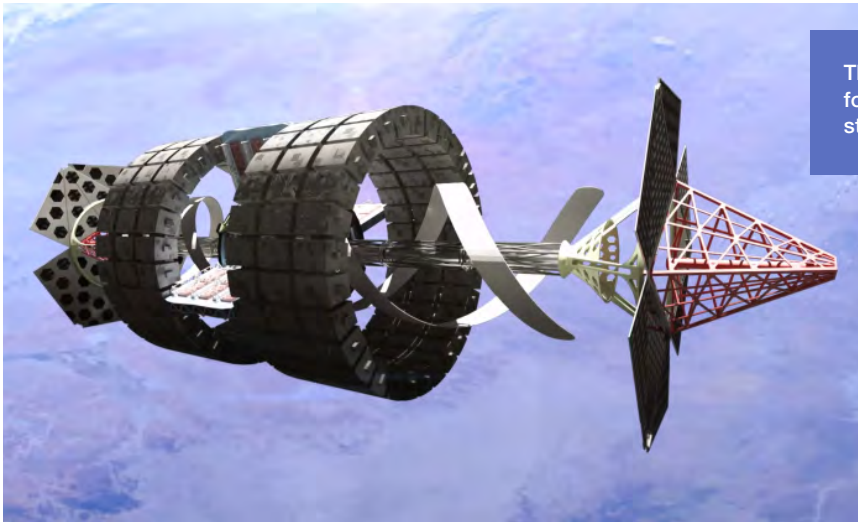
SOLIDWORKS for Makers and SOLIDWORKS for Students. The Maker version includes 3DEXPERIENCE SOLIDWORKS Professional, 3D Creator and 3D Sculptor applications, as well as access to a new global makers community called Madein3D that will be curated by Dassault Systèmes with the participation of makers, influencers and innovators.

In rebranding the conference to 3DEXPERIENCE World, Dassault Systèmes signaled a desire to transform SOLIDWORKS from a largely independent subsidiary revolving around a single product into an integrated part of the larger ecosystem. This began with the introduction of 3DEXPERIENCE Works, a suite of ancillary products to

augment the flagship CAD package SOLIDWORKS. This year, the transformation continues.

"Products are beyond their physical characteristics. They integrate experiences to establish true and loyal relationships between the customers and the brands," said Florence Hu-Aubigny, executive VP of Research & Development, Dassault Systèmes, in a general session. "You have to define not only the sketches and the designs, but also the necessary behaviors to deliver the expected experiences."





The 2020 SOLIDWORKS Grand Challenge focused on designing a digital space station. Image courtesy of Dassault.

Holding on to the Old; Heading Into the New

In the fireside chat with the executives during the conference, the top voted questions were about the future of the classic SOLIDWORKS software. Will it continue to be available for workstations? Will it evolve into cloud-hosted software? Will the R&D team continue to refine it?

“3DEXPERIENCE Works is the same SOLIDWORKS but connected and better,” said Manish Kumar, SOLIDWORKS Research & Development VP, Dassault Systèmes. “The investment in SOLIDWORKS is not changing.”

Bassi added, “Any intent to transition SOLIDWORKS to a completely cloud-based product? There is no such intent. But the cloud is our optimal method to give our customer amazing new possibilities, like high-end simulation. How else can we offer this capability? We will offer you the ability to work on desktop as long as you want. But just like today nobody can think of a household without internet, the entire world is going in that direction [of cloud-hosted products].”

Under the newer 3DEXPERIENCE SOLIDWORKS (3DEX SW) licensing plan, the company offers three tiers.

- 3DEX SW Standard: 3D Creator,

3DEX SW Standard and other ancillary features;

- 3DEX SW Professional: 3D Sculptor, 3D Creator, 3DEX SW Professional and other ancillary features; and

- 3DEX SW Premium: 3D Sculptor, 3D Creator, 3DEX SW Premium, 3DEX SW Simulation Designer and other ancillary features.

3D Sculptor, a subdivisional modeler for creating complex shapes, and 3D Creator, a quick concept design program, are cloud-hosted products. The SW CAD package included in the tiers remains a desktop product, with some cloud-hosted features.

The company also allows you to try out the full-featured SW software from the browser, indicating there’s no technical barrier to offering the product as a cloud-hosted product.

The 3DEX SW bundle is comparable to how Dassault Systèmes’ rival Autodesk offers its flagship CAD package Autodesk Inventor with other complementary titles under the Product Design and Manufacturing Collection.

Connecting with Customers

In the general session on February 10, featured customers included Skinny Guy Campers, which offers truck-mountable camping structures, and

Square Robot, which designs, builds and operates autonomous robots for inspecting oil storage.

“We’ve got team members from out of state, and those who need to work from home, so the ability to be on the cloud with easy access helped,” said Rob Miles, Engineering Design & Technical Documentation lead, Skinny Guy Campers. “Being a small startup, we don’t have internal IT resources, so the simplicity of downloading the apps we need helped us tremendously.”

“We really needed a mechanism to control and organize revisions and CAD data in the cloud. We looked to 3DEX to do that,” said Charles O’Connell, senior mechanical engineer, Square Robot. “It’s enabled us to synchronize our local CAD data sets over distances. We no longer had to archive and pack [the files] to go. Multiple users can easily exchange high-level vehicle models.”

Hybrid as the Future

The virtual event attracted 37,000 registrants, estimated Bassi during the live fireside chat with executives. The number includes 12,000 students, according to Suchit Jain, VP of Strategy & Business Development, Dassault Systèmes.

While the in-person events attracted largely a North American crowd, the virtual event attracted a worldwide audience, giving the executives new ideas.

“What we have learned is, the future might be some kind of hybrid events. Physical connection is important but we have now found a new way to connect with people worldwide,” said Jain. **DE**

SIMULATION

Siemens Partnership Fuels Autonomous Vehicle Development

Software giant provides MaRS innovation hub access to Xcelerator portfolio, accelerating development through widespread use of simulation and data management.

BY BETH STACKPOLE

Simulation and data management are essentials for the development of any complex engineered product, perhaps even more so for autonomous and connected vehicles. To jumpstart development in this emerging category, Siemens Digital Industries Software has partnered with MaRS Discovery District, a Toronto-based innovation hub, to provide its member companies with access to Siemens' Xcelerator portfolio of software.

As part of the relationship, eligible companies will gain a year of free access to Siemens' NX Mach 3 CAD software, Simcenter PreScan simulation tools, and Teamcenter PLM platform. Within its ecosystem, the MaRS Discovery District hosts

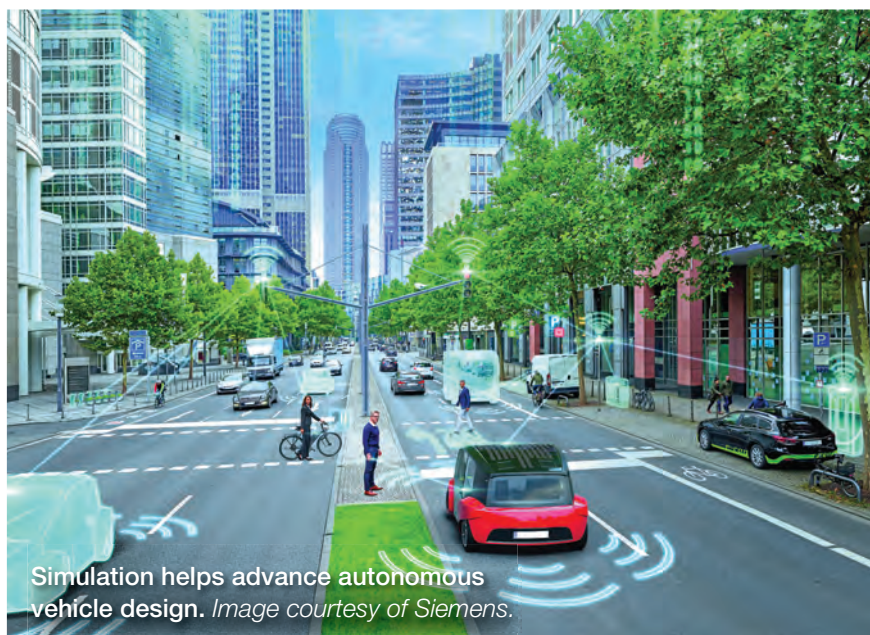
about 1,400 Canadian science and technology companies, many of which are working on advancing autonomous and connected vehicle design. "AV, connected vehicles, and intelligent transportation infrastructure are among the six areas where we are focusing our energy and resources to identify startup companies that want to innovate," says Oshoma Momoh, chief technical advisor at MaRS.

While most startups leverage CAD for design, the need to expand the tools portfolio in areas like software and data management is critical, especially for the design of highly complex products like AV, where iteration and validation is continuous and very difficult to do in a physical prototyping environment, Momoh explains. "With autonomous

vehicles, there is a huge amount of safety and validation work that needs to be done and that's where the Siemens tools come into play," he says. "It's about doing massive verification of products virtually and testing with simulation."

Specifically, Simcenter Prescan is tuned for advanced simulation of autonomous systems, helping to reduce field testing and expand coverage over infinite possible real-world scenarios—an important hurdle when developing autonomous vehicles. Teamcenter provides data management, collaboration, and traceability capabilities that can improve product delivery and promote reuse, accelerating development cycles and eliminating costly rework. Teamcenter's data management capabilities, in particular, are critical to accommodate the huge amounts of data collected from radar, Lidar, and artificial intelligence, Momoh says.

Siemens and MaRS work together to find potential startups that would be the best match for the software and specifically, for which elements of the Siemens platform. Once selected, the partners put together a curriculum that instructs engineering users in how to use the tools as well as how to optimize for particular use cases. Maya HTT, a long-time Siemens partner with experience in technical challenges from chip design to full vehicle system validation, supports the MaRS companies with software development and training services. Eligible participants can make use of the software for one year free of charge along with the training. **DE**



Simulation helps advance autonomous vehicle design. Image courtesy of Siemens.

GENERATIVE DESIGN

AM and GD Co-Pilot Hyundai's new Ultimate Mobility Vehicle Concept

Autodesk and Hyundai partner to push the boundaries of increasing strength while reducing weight for TIGER's modular platform architecture.

BY BETH STACKPOLE

When creating something as unique as the first un-crewed Ultimate Mobility Vehicle (UMV), it makes sense that an R&D team would take a novel approach to design.

Hyundai Motor Group's New Horizons Studio, established in late 2020 to draw on research from Silicon Valley and other innovation hubs to create a new class of intelligent mobility vehicles, is doing just that with its latest concept models. The studio is leveraging an ongoing partnership with Autodesk to wield advanced technologies like generative design (GD) software and additive manufacturing (AM) to deliver TIGER (Transforming Intelligent Ground Excursion Robot), a concept vehicle announced earlier this month.

As a follow-on to Elevate, its first UMV concept with moveable legs, the TIGER X-1 concept vehicle is based on a modular platform architecture that includes a sophisticated leg and wheel locomotion system, 360-degree directional controls and a range of sensors for remote observation. The UMV can transform from four-wheel drive to four-leg walking and operate without a crew to perform different missions such as delivery in urban settings, transport of critical supplies in remote environments or carrying sensors and instruments as part of a mobile scientific exploration platform.

TIGER X-1's modular platform and leg-wheel articulation are what sets it apart from other mobility solutions as it enables the vehicle to handle a range of extreme situations while keeping payloads more level than a

typical ground vehicle. "We believe the combination of leg robotics and wheels results in vehicles of unprecedented mobility," says Dr. John Suh, head of New Horizons Studio.

When its legs are retracted, TIGER performs at its most efficient, driving like an all-wheel drive vehicle. When the vehicle gets stuck or needs to traverse uneven or impassable terrain, it can switch to walking mode. "We use the walking capabilities to keep moving when other vehicles can't," Suh says. The unit also can connect to unmanned aerial vehicles (UAVs), for communications during complicated explorations or for charging TIGER's batteries when in inaccessible locations.

Key to the development effort was Hyundai's open innovation approach. The New Horizons Studio team worked with Autodesk on lightweighting parts and components, leveraging Autodesk's 360 Fusion and generative design capabilities to design specifically

for additive manufacturing (DfAM). TIGER X-1's legs, wheels, chassis and tires were all conceptualized with generative design capabilities and then produced using carbon fiber composite AM techniques.

The combination of generative design and AM was critical to helping the New Horizons team achieve its strength and durability design objectives using the least amount of material, Suh says. The design approach was also key to eliminating a number of assembly applications, which together with the material choices, helped in the lightweighting strategy.

"AM lets you minimize or eliminate the need for assembly, which gives you a chance to reduce weight," he explains. "Every ounce of this vehicle counts—there is no room for an extra gram of weight."

While the team is using AM to produce components for the concept vehicle, it will reevaluate AM and its consolidated design strategy as the Elevate and TIGER get closer to mass production, depending on such factors as design for repairability, for example. "Even if we could single print a chassis, the better strategy might be to break it into components for repair," Suh explains. "It is still an evolving discipline and needs to be explored." **DE**

The TIGER vehicle includes parts lightweighted with generative design tools. Image courtesy of Hyundai.



Subtractive and Additive Under the Same Roof

DfAM triggers an evolution of parametric CAD with algorithms, generative design and 3D printing microservices.

BY KENNETH WONG

As the phrase design for additive manufacturing (DfAM) has gained prominence in the engineering lexicon, traditional 3D CAD programs have been forced to reckon with an uncomfortable truth. With standard commands such as Extrude, Revolve and Trim, parametric CAD programs' fundamental architecture is rooted in subtractive manufacturing, a production method that relies on removing materials. AM, by contrast, produces parts by depositing layers of materials—the reverse of subtractive manufacturing.

When affordable 3D printers hit the market, design engineers realized the new breed of hardware could build shapes previously deemed impossible or impractical for consideration. Thus, the mad scramble to develop geometry modeling tools to match the capability of 3D printing began. Some now wonder: does DfAM demand a new breed of CAD? To answer, we spoke to the software and hardware developers on the front lines.



Cut views of a redesigned version of the heat-exchanger using nTopology software to create complex gyroids that direct fluid flow to dissipate heat more effectively. With the auto-assignment of recipes found on VELO3D's AM system, engineers can 3D print these complex designs. *Images courtesy of nTopology.*

Classic With A New Twist

Though admitting most parametric CAD modelers come up short in tools for sculpting AM-optimized geometry, developers also gave forceful arguments against completely writing off classic CAD programs. Perhaps the most compelling reason to continue working with parametric CAD is the need to support subtractive and additive designs for the foreseeable future.

"A lot of our customers are adding additive parts to their existing designs. They're not starting from scratch. So, you need the interplay between the two approaches," says Brian Thompson, vice president and general manager of CAD, PTC.

"Aside from things like medical implants that are fully 3D printed, there will be very few discrete manufacturing products like tractors and engines where the entire bill of materials is filled with AM components," he adds.

The incorporation of AM parts is rapidly growing, driven by the desire to reduce complex assemblies into a handful of 3D-printed parts. Such assembly simplifications usually lead to tremendous cost savings in production as well as assembly.

According to GE Additive on its website ([inventor/3e1DPqQ](https://www.geadditive.com/inventor/3e1DPqQ)), "In a new advanced turboprop engine, a dozen 3D-printed parts replace 855 components produced by multiple contractors ... The impact of parts consolidation will grow as maximum part sizes and build rates increase in additive manufacturing."

"I don't think the AM software should be an independent software. Having independent software means having to train on a new platform, which increases the barrier of entry. The



Close-up of a long board with AM-specific wheel-holding bridges. *Image courtesy of Autodesk.*

industry can make a platform that allows you to smoothly navigate between the two environments [additive and subtractive],” says Kevin Acker, senior research engineer, Manufacturing Industry Futures, Autodesk.

Parametric CAD programs are beginning to enable AM-optimized objects such as unit cells with variable thickness, meso structures and meta materials. Acker believes CAD vendors need to continue augmenting their existing offerings with these functions.

Ongoing Integration

Two years ago, PTC acquired Frustum, the startup behind the AM-targeted modeling software Frustum Generate. PTC’s Creo Parametric CAD software can be augmented with an Additive Manufacturing Extension, which allows you to model AM-optimized lattice structures and manage print tray setup, among other tasks.

Autodesk Fusion 360, an integrated CAD/CAM/CAE program, includes parametric and direct modeling design tools for AM. It also offers integrated generative design tools, an algorithm-driven design method for generating complex structures for the desired manufacturing methods. Some print preparation and AM simulation tools from Autodesk Netfabb have been added to Fusion 360. PTC and Autodesk’s strategy exemplifies the integration of AM tools into their existing flagship modeling programs.

Algorithms vs. Manual

Though traditional parametric CAD programs serve as geometry sculpting tools that allow the user to produce the desired topology, offerings from AM-focused startups like Frustum and nTopology have shown that artificial intelligence-like algorithms will play a greater role in DfAM software. This

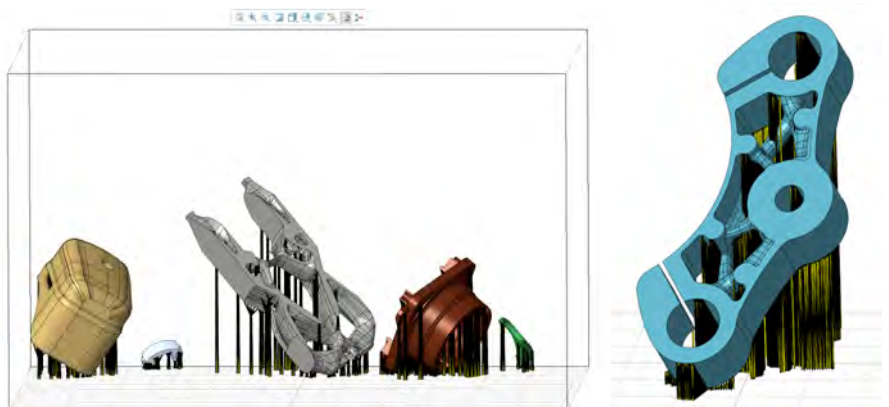
has been the case as well with Autodesk’s incorporation of generative design tools in its Fusion 360 features.

“Because of the degrees of freedom possible with AM, it’s impractical to design the geometry manually. Most likely, it’s the computer algorithm designing it for you,” says Mike Grau, technical manager, Autodesk Research.

“Fewer parameters will drive more design decisions. Algorithms will play a greater role in AM design,” says David Busacker, senior engineering consultant, Stratasys.

CAD-integrated AM tools serve designers who are building products that, for the most part, will be produced using traditional manufacturing methods (machine, injection molding, sheet metal, etc.), but also incorporate 3D-printed components; however, for those looking to design products to be made entirely in AM, Busacker says “the software will likely be a different product than parametric CAD.”

In partnership with nTopology, Stratasys offers an FDM (fused deposition modeling) Fixture Generator, allowing users to easily generate the required fixtures and support structures for AM-specific parts. Such fixtures are a good example of parts impossible to model manually; they are generated based on AM- and hardware-specific rules.



The integrated AM tools in PTC Creo let you optimize the support structures and print tray orientation. *Images courtesy of PTC.*



At Autodesk Tech Center, an engineer designs AM-optimized topology in Autodesk Fusion 360 software. Image courtesy of Autodesk.

“The design of these fixtures is not a common skill, so we just turn that into a program using hidden parameters,” says Busacker. In his view, this is just one type of AM-related microservices we can expect to see as DfAM adoption gains momentum.

Busacker also points to GrabCAD Print as another type of microservice—a simple app that allows a software user

to interrogate the design for possible AM failures and get it printed. GrabCAD, a 3D modeling community and collaboration hub, was acquired by Stratasys in 2014.

New File Formats, New Methods

The standard 3D printing file format has been STL, a mesh-based 3D file format. But the quest for better file formats has led to the development of 3MF, a format spearheaded by the 3MF Consortium. Autodesk, GE, nTopology, PTC and Stratasys are all active members of this consortium.

“When it comes to lattices, you need a different infrastructure to mathematically define these. You might be able to create them in parametric CAD, but when you save the file, it might be a 30GB file that nobody can open,” warns Zach Murphree, vice president of sales, VELO3D.

VELO3D offers a print preparation software called Flow.

“Our software is specifically designed for our printers. It’s designed with the knowledge of our processes,” says Murphree. “It’s important to know the limitations of your manufacturing process as you’re designing, so when considering AM it would be helpful to have AM-specific tools in your parametric CAD program.”

As DfAM gradually replaces parts and assemblies previously made with subtractive methods, CAD vendors are expected to add more features and tools to address the void. This makes startups with robust AM-focused software offerings attractive acquisition targets for the CAD software titans. But for a large portion of the projects, subtractive methods remain the ideal solution, due to volume and cost considerations. Therefore, even if subtractive and additive are rival technologies, modeling software needs to evolve to accommodate both types of designs. **DE**

A Lattice Building Engine

On March 2, 3D printer maker Carbon announced in a press release that “all of its subscribers now have access to the Carbon Design Engine software to automate the process of creating performance-oriented lattices, saving design engineers significant time and effort.”

“Traditional CAD tools have not kept pace with the innovation of 3D printers and materials. This lack of progression limits the ‘idea to design’ stage of the product development life cycle. With the release of Design Engine to all Carbon subscribers, we are helping designers iterate through their design thinking, faster,” says Phil DeSimone, chief product and business development officer.

Carbon uses what it calls the Digital Light Synthesis process. Its technology has been used for brand name athletic footwear and helmets, such as Adidas and Riddell. (For more, read “A Diamond-Studded Football Helmet” in July/August 2020, DE; digitalengineering247.com/r/24936.)

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- Stratasys: [Stratasys.com](https://stratasys.com)
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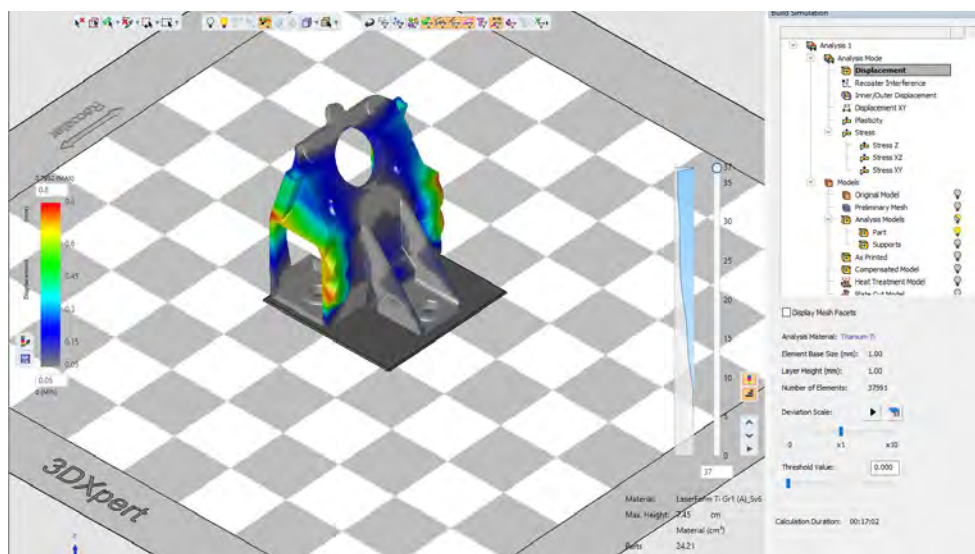


Simulation: New Driving Force Behind Additive Manufacturing

Simulation replaces trial-and-error processes and a reliance on tribal knowledge to pave the way for widespread AM adoption for production use cases.

BY BETH STACKPOLE

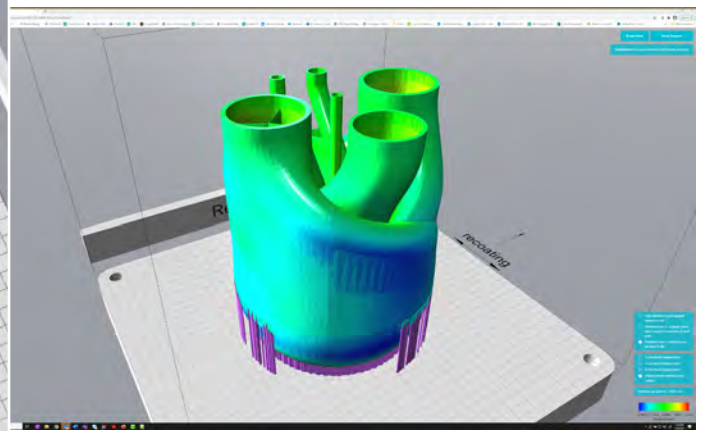
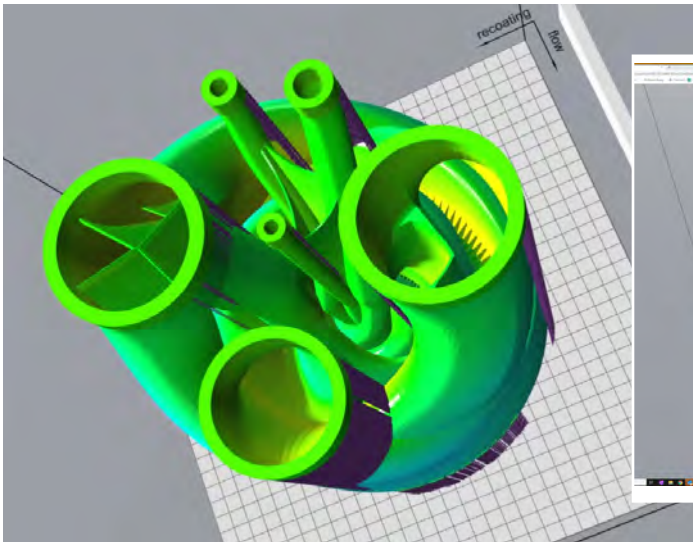
Trial and error—it's been the go-to practice for additive manufacturing (AM) experts, who typically take months and churn through reams of expensive materials trying to iterate and troubleshoot in the quest to output a perfect part. Simulation, long a fixture in design workflows that help cut back on physical prototyping, is now rearing its head on the AM scene. An emerging category of AM-specific simulation tools are providing a way for design, manufacturing and process engineers, along with others in the production workflow, to work out the kinks and optimize parts for AM output without having to rely on time-consuming, experimental work performed by a small group of specialized experts.



By simulating the build process with 3DXpert, engineers can predict issues that might result in build failure or damage to the printer before sending the part to print. Image courtesy of 3D Systems.

“This trial-and-error process has to change if the industry was really going to take off and AM is to go to have the impact that it could have,” says Brent Stucker, distinguished engineer in AM at Ansys. “You can’t have every new user learn on the job—you need something that will help teams take advantage of best practices immediately, and simulation is key. It’s the great equalizer in allowing anyone from any background to do what they want to do in AM.”

Traditional simulation tools like finite element analysis (FEA) and compu-



Designers need simulation to orient parts optimally in 3D printer build trays and to create the best support structures for a given geometry. Since they often aren't simulation specialists, they need a quick, easy solution to get as close as possible to a successful additive build. Siemens recently purchased Atlas 3D to provide such a solution. AM Build Optimizer is a cloud-based simulation tool that provides designers an “easy button,” automatically choosing the best orientation and generating necessary support structures for a successful build. *Images courtesy of Siemens.*

tational fluid dynamics (CFD) can help engineers design more AM-friendly parts while newer variations like generative design software turn out optimized and organic shapes based on key parameters that could only be output with AM technologies.

However, these simulation offerings are limited in their ability to tackle AM-specific challenges such as determining potential part deformation during a build or as-built component performance, which is governed by material properties and the layer-by-layer AM process. These scenarios require a new level of computational modeling and horsepower.

As costs for sophisticated AM technologies—metal 3D printing, for example—drop, new categories of simulation tools and methodologies are being introduced to tackle these problems and position AM as a viable alternative to conventional manufacturing practices.

With companies moving beyond prototyping into production-scale 3D printing use cases, there is growing emphasis on the need to print the part right the first time without wholesale reliance on tribal knowledge and free from the costly trial-and-error exercise.

The requirement has sparked interest in a new class of AM-specific simulation software ranging from tools that optimize build plate layout and support placement to more sophisticated capabilities such as design identification and recalibration in the virtual world to address part deformation before the print runs.

“Build failures are extremely common—there could be upwards of 10 failures on production-scale parts, which run into costs of tens of thousands of dollars,” says Erik Denlinger, principal researcher on AM simulation at Autodesk. “The ability to provide insight into if and how a part might fail is extremely valuable.”

Where Simulation Can Help

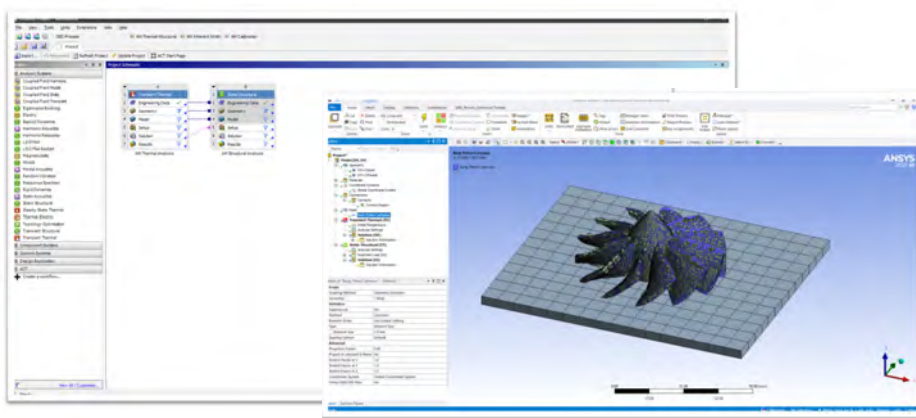
AM simulation software can help predict and prevent a range of 3D printing failure modes, but some more prevalent issues include extensive distortion, support structure issues and interference with the re-coater blade—a common issue with metal AM technologies.

AM simulation software is also helping teams optimize the build environment, whether to maximize the number of parts per print, orient support structures effectively, direct part placement to ensure the desired performance characteristics or eliminate cracking and other defects.

From a broader standpoint, simulation can have further impact on the AM process. Simulation tools can aid in parts certification to reduce the amount of destructive physical tests, help companies determine the best part candidates for AM processes and automatically tune the machines based on individual part characteristics. Over time, new simulation packages are emerging that function as in situ print monitoring tools, and are able to automatically recalibrate and adjust machines in process to avoid print failures.

“How 3D printer manufacturers optimize the process is the secret sauce that lets them accurately produce parts from machines, but it’s a peanut butter spread of parameters that give the best balance for the widest range of parts,” says James Berlin, senior software product manager, manufacturing and alliances, at Stratasys. “Simulation gives us the tools to look at parts at an individual level and make decisions.”

Stratasys has a long-standing partnership with MSC Software, part of the Hexagon Group, to collaborate on AM material and process modeling. The company is working with MSC’s e-Xstream Engineering group to create tighter integration between its platforms and Digimat, a multi-scale material and structure modeling platform that can predict



Workbench Additive gives users an opportunity to use ANSYS Mechanical for metal additive manufacturing process simulations. *Image courtesy of Ansys.*

behavior for a large mix of composite materials. Simufact Additive, also from Hexagon, focuses on predicting distortion and automated distortion compensation for metal binder jetting sintering technology.

Rival 3D Systems has been developing AM-specific simulation capabilities as part of its 3DXpert AM software. In addition to the ability to position and modify part orientation, optimize structures with lattice, and infill features and analyze design supports, 3DXpert has simulation capabilities for predicting issues that might result in build failure or printer damage. The software also can create a compensated geometrical model to offset deviations created during printing.

“Having CAD, simulation and slicing capabilities allows us to further close the loop on design to print,” says Jeph Ruppert, director, application innovation group at 3D Systems. “It gives users full control down to a single laser spot in the way the build process goes.”

Many new AM-specific tools take a completely different approach to simulation because it’s been too computationally

expensive to simulate AM—specifically the micro-structure behavior on materials and the AM process.

Autodesk’s answer is multi-scale modeling methodologies as part of its Netfabb AM suite and simulation extensions for the Fusion 360 software. The technique breaks the process into two pieces—the small-scale simulation (1x1 mm, for instance) at high resolution for the part and material; the learnings from that model are then applied to the rest of the build volume as a way to circumvent the computational expense, Denlinger says. Autodesk’s solutions also leverage adaptive meshing, whereby the solver interrogates the geometry at every level to determine whether the part calls for solving at high resolution or a lower resolution, coarser mesh.

Autodesk Build delivers features for full production control, including positioning on the build plate and supports. Autodesk Simulation Extension, the process simulation module, focuses on predicting distortion, suggesting geometry resolution fixes and addressing re-coater blade interference.

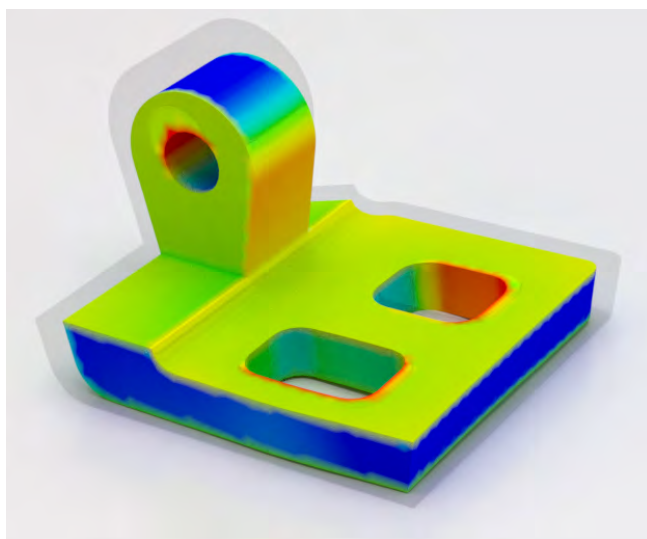
Teton Simulation is blazing new ground with simulation capabilities aimed at print parameter optimization and validation based on end-use requirements for Fused Deposition Modeling (FDM) AM systems. SmartSlice is a plug-in that integrates into Ultimaker Cura, evaluating geometries and automatically adjusting print parameters such as infill patterns, density, layer height and wall thickness to optimize part production and ensure the final output meets performance demands.

“To create a model by hand without the use of simulation built for AM can be daunting if not an impossible task,” says Rick Dalgarno, Teton Simulation’s director of operations and alliances.

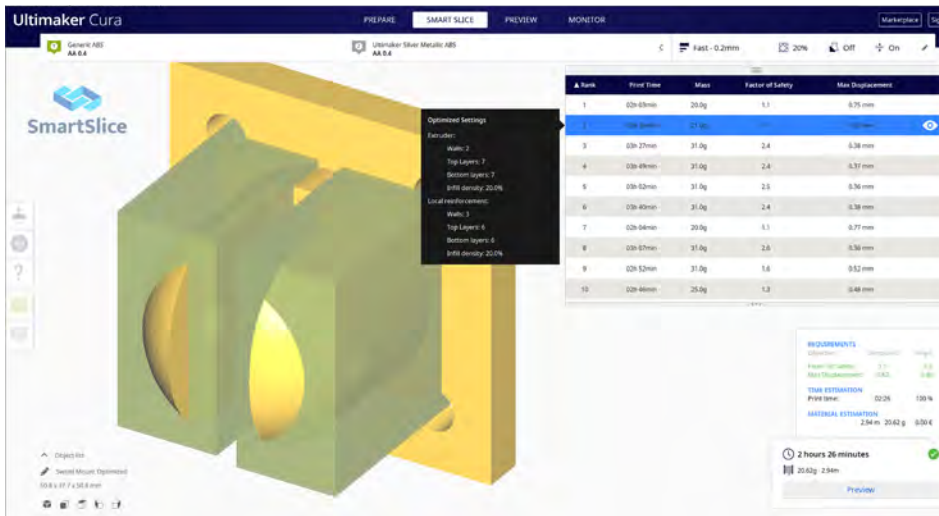
Companies like Siemens Digital Industries Software, Ansys and Hexagon’s Manufacturing Intelligence division are pursuing an end-to-end strategy as it relates to integrating simulation into AM workflows.

For Siemens, simulation tools will play an upfront role in determining how to orient a part in a printer for the least amount of distortion and predict the microstructure and macrostructure behavior of parts to direct material deposit or identify gaps and overheating areas on the build plate.

Simulation also can be tapped predict material properties from the manufacturing process applied or to map out and plan AM factories, according to Aaron Frankel, vice president of additive manufacturing program at Siemens.



Simufact Additive is used to determine shrinkage of parts printed in Metal Binder Jetting technology. *Image courtesy of Hexagon’s Manufacturing Intelligence division.*



SmartSlice is a Cura plug-in that performs validation and optimization of print parameters based on end-use requirements, freeing reliance on tribal knowledge or trial and error. *Image courtesy of Teton Simulation.*

companies need to do their part to make the software accessible to a wider range of users.

“People work in silos—design people don’t talk to manufacturing people,” says Mathieu Pérennou, strategy director, additive manufacturing, for Hexagon’s

Manufacturing Intelligence division. “We’ve developed products that can be used by process people on one side as well as made it simple enough for someone without deep knowledge of AM to set up manufacturing processes and check whether their design makes sense.”

In addition, because AM creates a part from the inside out, it flips the manufacturing process on its head, which requires a realignment between design and manufacturing functions.

“Design simulation experts lock down performance in CAD, but with AM, it’s not locked down until you define the steps of manufacturing,” says Stratasys’ Berlin. “There’s work to be done reconciling redistributed responsibilities between someone designing parts and someone manufacturing parts. Simulation needs to bridge that gap and take into account the intent of both areas.” **DE**

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→ MORE INFO

- Ansys: [Ansys.com](https://www.ansys.com)
- Autodesk: [Autodesk.com](https://www.autodesk.com)
- Hexagon, Manufacturing Intelligence Division: [HexagonMI.com](https://www.hexagonmi.com)
- MSC Software: [MSCSoftware.com](https://www.mscsoftware.com)
- Siemens Digital Industries Software: [SW.Siemens.com](https://www.sw.siemens.com)
- Stratasys: [Stratasys.com](https://www.stratasys.com)
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As part of its portfolio of products, Siemens offers NX Build Optimizer for orienting parts and NX Path Optimizer, technology for powder bed fusion parts that combines physics-based simulation and machine learning to minimize overheating challenges that cause inconsistencies in part quality. The Simcenter3D simulation portfolio serves up various capabilities, including process capabilities for predicting and addressing distortion of metal parts and multi-scale modeling capabilities for predicting failure in advanced materials. Siemens is also partnering with a range of AM printer providers, including EOS and Evolve, to optimize its simulation tools for specific platforms and AM technologies.

Ansys’ vision for end-to-end AM simulation covers design for AM (DfAM), build setup, process simulation, materials analysis, data acquisition and management, and part qualification.

On the materials side, the Additive Science platform performs material analysis to predict meltpool dimensions based on machine parameters and material, porosity grain size and orientation, and thermal sensor simulation to evaluate thermal properties during printing. Though this portfolio of tools is aimed at simulation and materials experts, Ansys also offers Additive Print, a set of core push-button AM simulation capabilities aimed at non-experts.

“We aim to give everyone across the spectrum value from simulation with an interface that meets them where they are,” Stucker says.

The Road Ahead

Though AM simulation tools have potential for streamlining and perfecting the 3D printing process, the trick is to successfully integrate the software into engineering workflows, which is no easy feat.

For one, companies need to build up trust in the accuracy of simulation methods and educate users on their potential benefits. The complexities of simulation and AM processes can make for a very complicated platform, so

Taking Care of Business

Chart the next frontier in materials and engineering design with confidence.

BY JIM ROMEO

Continuous digital tool introduction has catapulted engineering design forward. Such a trend is compounded with modern technologies such as 3D printing and new fabrication methods.

Compound this with other progress made in the development of materials and material science, and remarkable things can happen.

The characteristics of materials change daily. However, the new frontier of mechanical design and rapid prototyping is at a pivotal moment. Products may be designed with great precision, and with very precise properties. These advance-

ments help produce high-performing products that are easier to design, easier to fabricate and that can positively impact those who used them.

Material Importance

Numerous perspectives on new materials are now available for engineering design and used in manufacturing. Such materials include new plastics and composite materials that are emerging that offer many benefits to designers and end users. Many may be used within the scope of 3D printing and additive manufacturing (AM), for industries such as automotive, aerospace, medical, defense, oil and gas, robotics and other industries.

Brandon Ribic is the technology director at America Makes, a proponent of the U.S. additive manufacturing, technology and additive manufacturing education ecosystem.

“What I am hearing is less about new materials than the new application of existing material solutions, which effectively address a need in various industries—automotive, aerospace, defense,” says Ribic. “The benefits may include enabling lower low-cost customization, lower cost tooling or brackets, shorter lead time or even performance improvement.

“Most of our efforts at America Makes have successfully demonstrated significant lead time reduction due to the production of low criticality polymer and composite components for aerospace applications. In addition, [there is] the ability to tailor patient specific orthoses through AM processes using polymer and composite materials,” he adds.

Polymer and composite materials are being used more widely as their properties and functionality are becoming suitable to many applications and uses. Peter Foley is the executive vice president and chief technology officer at Skydex, a company focused on advanced impact mitigation and energy absorption solutions. He touts the benefits of foam, for example, as an engineered material with many uses.

“Foam is how many industries have historically dealt with impact, cushioning or vibration challenges,” says



Products may be designed with great precision, and with precise properties that help them become high-performing products that are easier to design and fabricate. Image courtesy of Rapid Applications.



Companies will be more sustainable and decrease their global footprint, which has led businesses to new opportunities and a chance to adjust their priorities. *Image courtesy of Skydex.*

Foley. “And if you pull a piece of foam off the shelf and it does not meet your needs, unfortunately, you either have to use a thicker piece of it or a denser piece of it. As it relates to emerging trends, for example, at Skydex we use a more modern approach with geometries that we engineer to very precisely solve impact and cushioning problems—especially for the military and defense community.”

Materials science and engineering has advanced much recently. But its advancement has been catalyzed with the advent of 3D printing and additive manufacturing, along with digital technologies that ferret out the precise properties and characteristics needed to achieve the desired specifications.

This means manufacturers are demanding composites and materials with different requirements to be lightweight, durable, sustainable, less costly and complementary to other materials.

“We have seen an international industry effort to move in the direction of sustainable products,” says Foley of Skydex. “Whether it’s B2B [business to business] or B2C [business to consumer], there is an expectation that companies will be more sustainable and decrease their global footprint, which has led businesses to new opportunities and a chance to adjust their priorities.”

Foley adds that there is also an increasing demand for more customized solutions. He says that this requires a tre-

mendous effort behind the scenes to make plastics that could be reused, recycled and reclaimed.

“For example, at Skydex, instead of adding a second material we add a geometry to add a property,” Foley adds. “That material can then be reclaimed, reground and put back into the polymer stream easier than a composite material.”

Reverse Engineering Parts for Convenience

Though mechanical design is often pictured as fulfilling a proverbial mission of moving forward with new products, engineers are often called on to move backwards, and recreate old products.

Engineers must often find solutions for parts and designs no longer supported or available. Along with all the numerous challenges that have always faced those in need of spare parts, obsolescence remains a problem. The compatibility and characteristics of materials bring solutions to parts obsolescence.

A part may have been manufactured long ago, but the manufacturer is no longer in business, does not produce the part and maintain spares of a sought after part or was acquired by another firm and their business model changed. This leaves the burden of producing a new one to those who need it. The required part must be reverse-engineered to achieve the same functionality as the original part. Digital



The mechanical properties and characteristics can be controlled when combined with the proper material selection and specific technology. *Image courtesy of Rapid Applications.*

technology is helping this effort.

Teton Simulation uses simulation software to reverse engineer parts and extract their strength and load characteristics to recreate them using 3D printing. This is useful for rapid prototyping in that an existing part needs to be recreated.

Their simulation application, Smart Slice, is a technology solution that may be embedded within commercial slicing programs. It employs the fused filament fabrication (FFF) additive manufacturing process. This combines with an algorithm that is physics-based and can validate the structural performance of prototyped parts, and extract from those being replicated. Using optimization algorithms, it provides the precise printer settings for a given feedstock, so that printed parts meet the stiffness and strength requirements of the part. In addition, it optimizes printing time and material used.

“Fiber-reinforced polymers seem to be prevalent for AM along with ABS [acrylonitrile butadiene styrene], TPU [thermoplastic polyurethane], Nylon, PETG [polyethylene terephthalate glycol-modified], PLA [polylactic acid],

The characteristics of materials are changing daily. However, the new frontier of mechanical design and prototyping is at a pivotal moment. *Image courtesy of Rapid Applications.*

PEKK [polyetherketoneketone], PEEK [polyetheretherketone] and PEI [polyethylenimine] polymers,” says America Makes’ Ribic.

“There are many AM processing conditions which impact material properties and product performance,” Ribic adds. “Designers should be aware of the finished product requirements and design intent. During [the] product manufacturing process and material selection, these requirements will be critical to ensure the final product will meet the end customer’s needs.”

Manufacturing Self-Sufficiency

In addition to part supply, digital technologies such as Teton Simulation’s Smart Slice serve as a boon to manufacturing self-sufficiency. Should a part’s strength, stiffness and material characteristics be known and scanned, and other digital data archived, the part can be printed as needed.

This offers obvious benefits to a supply chain, where one incidental part—no matter how big or small—may serve as the critical path to moving forward in any capacity. With smarter technology tools that accelerate reverse engineering, this risk is reduced, if not eliminated.

“The supply chain process stands to benefit from better engineered materials and properties that offer an extended life cycle and our unique technologies last longer than the traditional materials they replace,” says Skydex’ Foley. “De-



Designing original parts to last an order of magnitude longer eliminates the need for spares or replacement parts, which leads to another avenue for maintaining sustainable business practices. *Image courtesy of Skydex.*

signing adaptable materials that can accommodate a variety of tasks will ultimately impact the supply chain in a positive manner. We believe that designing original parts to last an order of magnitude longer eliminates the need for spares or replacement parts, which leads to another avenue for maintaining sustainable business practices.”

Terry Hill is the CEO of Rapid Application Group, an engineering and AM company centered on AM technology. He notes the unprecedented contribution of AM to self-sufficiency.

“Additive manufacturing yields rapid prototyping, high levels of customization, complex designs and the ability to take advantage of lights-out manufacturing,” Hill says. “The mechanical properties and characteristics can be controlled when combined with the proper material selection and specific technology.”

Hill says engineers now can design a part in free space; they are no longer constrained to subtractive or legacy methods of manufacturing composite parts.

“We also use additive manufacturing that enables rapid tooling for composite layup tools,” Hill says. “The mechanical properties of current developed additive manufacturing material allow for autoclaving and low coefficient of thermal expansion.”

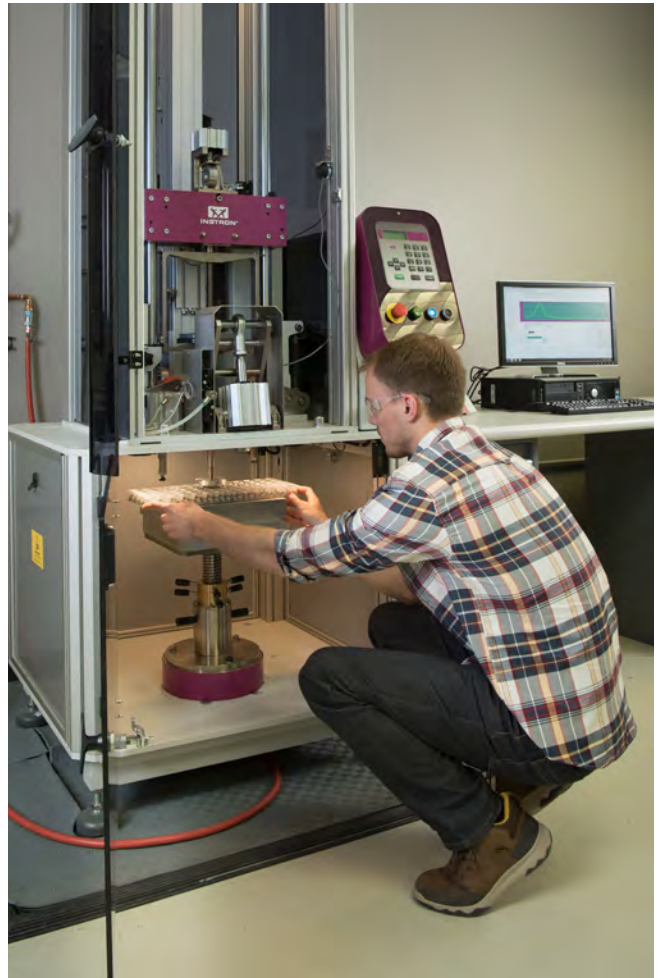
Future of Materials and Digital Thread

Digitization and materials science may collaborate more than ever. Advancements in software and digital engineering applications increasingly are playing a critical role in the outcome of mechanical design, and the materials used to produce them.

“The ability to manufacture a spare part from a digital thread is where we are seeing the future of manufacturing,” Hill says. “The material properties of 3D printed parts become increasingly important as a project matures from concept to production. It is the combination of material selection combined with AM technology that will dictate the final characteristics.”

Management consultancy firm McKinsey & Company points out that a technology strategy, amid an ocean of new digital technologies, must collaborate with an overall business strategy. This should synchronize with material selections and considerations, as businesses plan with engineering finesse approach their own ecosystem smartly.

“The first step is a clear articulation of the company’s desired future state, which is linked to business strategy and



goals rather than the technology with the greatest buzz. Selection of use cases for pilots is based on a favorable business case, to be refined as the pilots are implemented,” McKinsey states in a report titled, “Industry 4.0: Reimagining manufacturing operations after COVID-19” (mck.co/305fCHO).

“Outlining a clear business case becomes more complicated when expanding beyond the four walls of the factory but is even more important,” the report states. **DE**

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→ MORE INFO

- **America Makes:** AmericaMakes.us
- **Skydex:** Skydex.com
- **Teton Simulation:** TetonSim.com

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Safeguarding Engineering in the Work-from-home Era

Securing design data requires a holistic approach that includes both technology and good policies.

BY RANDALL S. NEWTON

It has now been more than a year since most engineering firms moved to dispersed, work-from-home (WFH) operations. A shift to digital design collaboration had already started, but the COVID-19 pandemic accelerated those efforts. Now, engineering departments realize security measures put into place before WFH continues to evolve.

DE discussed the current state of security in product

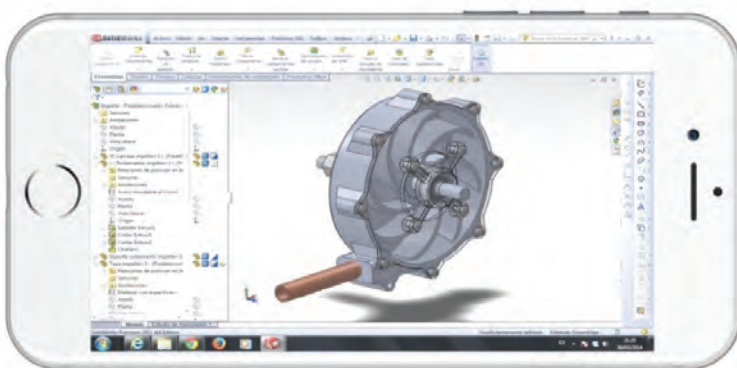
development with software vendors, computer workstation manufacturers and specialized engineering services vendors. Our conversations centered on how each of them help engineering teams protect their designs, data and intellectual property.

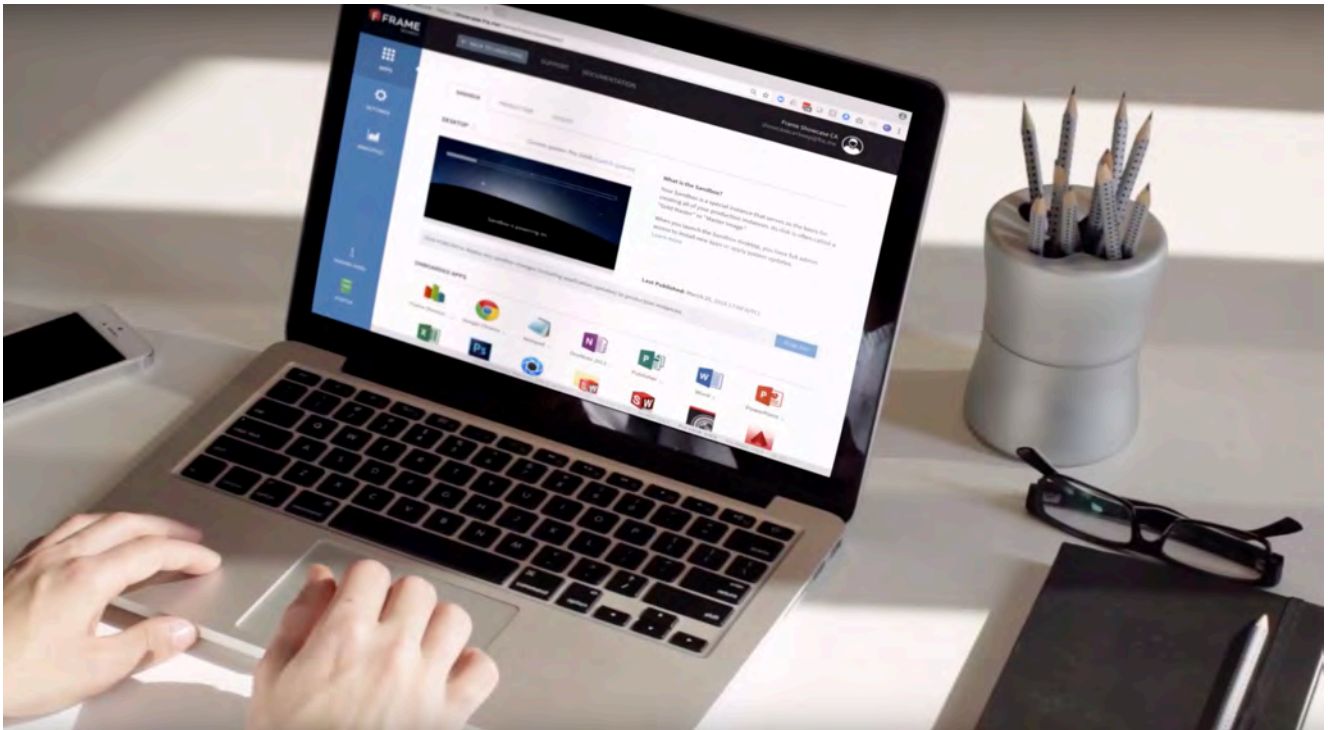
While each had their own angle on what constitutes good security practices for WFH setups, there were some common threads. First, security must be comprehensive. More than one expert referred to it as the onion approach, using many layers of overlapping security. Second, a weakness in any aspect of the system affects the whole system. Third, practices are as important as the technology.

Where is the Workstation?

“At the beginning of the pandemic we thought people would just take their workstations home,”

Nutanix Frame creates a virtualization experience that can be used on any compute device, including smartphones. Image courtesy of Nutanix.





Nutanix Frame offers a complete virtualization experience, and has its roots in serving engineering users. *Image courtesy of Nutanix.*

says Rod Mach, CEO and founder of TotalCAE, a provider of cloud-based simulation and analysis services. “They took them home and realized it didn’t work.”

Most engineers were still connecting to either a workstation or a server at the home office.

Mach says many of his clients are now using remote visualization, a technology that performs the engineering on a cloud server or a high-performance computing (HPC) cluster, then transmits only the images to the end user. The user can run the CAD or CAE program as if it were running on their local computer, but only pixels are being transmitted back and forth between the remote user and the centralized server or cluster.

“The technology already existed,” Mach notes. “Now there is much more interest.”

Having engineering models on a device outside the office—and its firewall—is a scary notion for IT departments, Mach says.

“Having an encrypted laptop at home does not prevent someone from accessing your home network,” Mach adds.

One TotalCAE customer is a large automobile manufacturer that started using remote visualization before the pandemic.

“Now they like it because remote users don’t download data,” Mach notes. “You can’t ‘thumb drive’ a model from the visualization. Securing data from theft is easier.”

Mach says TotalCAE customers seem to be gravitating toward three remote visualization services: FastX from StarNet Communications; ZCentral Remote Boost from HP; and NICE DCV from NI SP GmbH, which is offered by Amazon Web Services (AWS).

“While these solutions are not new, because of the pan-

demic we have seen a large uptick in their usage,” Mach says. “They all have provided additional security benefits to clients. These solutions will likely persist even after things return to normal, as clients realize the benefit of having a solution for secure remote access to engineering data.”

CAD as a Service

“Security is not just about technology, it is also about practices,” says Jon Hirschtick, general manager of Onshape and Atlas at PTC. “Most hacking is social engineering,” and security has to be built in. “Work from home is ‘work from what device?’ Sometimes you can’t guarantee how a remote user is connecting to the company server,” he adds.

In the “old days” of standalone CAD workstations using servers to share files, Hirschtick says it was “CAD first, then data management, then security.” Engineering needs to reverse that order, making security first, then data management and finally the CAD program.

Hirschtick speaks from his experience in bringing Onshape to market. Onshape remains the only purely cloud-based product development CAD product. When PTC acquired Onshape in 2019, Hirschtick became a PTC senior vice president and oversaw the company’s Software-as-a-Service division. Using Onshape, the data is stored in one place, on the cloud server. Files are never copied, even if several people share design access.

“We don’t put a copy of data on anybody’s computer. It doesn’t exist there; it can’t be stolen,” Hirschtick says.

Access rights can be set so a user can edit data but not download a copy, and there is a complete audit trail of data use. There is no software to install; Onshape works from any up-to-date web browser.

Hirschtick says that while he promotes the Onshape paradigm as the new order of things, he still realizes that not everyone can stop using their existing software and jump into CAD as a service. He recommends “complete virtualization,” where the application is hosted at the home office and remote users access it using a virtual private network (VPN).

“Complete virtualization is reasonably secure,” Hirschtick says. “It’s the best you can do with the copy/paste paradigm.”

Virtualization is also known as virtual desktop infrastructure (VDI). One powerful workstation or server can host multiple instances of remote access, with each user getting the equivalent of a desktop experience. Some companies use VDI to keep intellectual property on-premises. Others use it to provide top-of-the-line hardware resources to more users. A workstation equipped with two or more high-end graphics processing units (GPUs) can provide a pool of users access to the same hardware for much less than equipping each user with an equivalent physical workstation.

Virtualization software is available from several vendors. Commonly used engineering offerings include Rescale; Nutanix Frame (formerly Frame from Mainframe2); Teradici Cloud Access Software; VMware; VirtualBox (open source, supported by Oracle); QEMU KVM (open source, Linux only); Citrix Hypervisor (open source, supported by Citrix); Xen Project (open source, supported by The Linux Foundation); Dell Custom Virtual Desktop Interface, based on Teradici technology; and Mechdyne TGX.

Securing Email for Data Exchange

“Email is a big gaping hole for security,” says Brian Schouten, director of technical presales at PROSTEP. “The easiest way to communicate is what many will use.”

PROSTEP offers OpenDMX GlobalX, software for managed file transfer (MFT). Engineering clients use it to transfer various data and document types between customers, suppliers and partners.

PROSTEP was started as a German consortium of automotive manufacturers. Its first initiative was the STEP file format, an ISO standard still in common use today. OpenDMX GlobalX works with email protocols to create a secure file transfer system on the desktop. The software integrates well with digital twin/digital thread workflows, Schouten says.

“The master copy is stored the right way, not through an active process but through a backend process of systems integration,” Schouten says.

OpenDMX Global X can be on-premise or cloud-based.



Mechdyne TGX is remote access software designed for demanding graphics applications, including product development, geosciences and broadcast. *Image courtesy of Mechdyne.*

Schouten recommends Microsoft Azure Government and AWS as good cloud services for hosting an OpenDMX GlobalX installation.

“They have good practices for security,” Schouten explains. “But remember the onion approach. They have their own onion, and you have yours.”

“Security and collaboration are sometimes at odds with each other,” Schouten says. “The more secure the environment, the less you can share data. Practices for making this easy and transparent is an IT issue.”

Schouten says one PROSTEP customer is a defense specialist that is “always pushing up against” security considerations. Sometimes the problems are as low level as what computers they can use on the secure networks. More common is establishing separate networks to isolate usage by data type or user requirements.

“To get to the network, to get to the web, should be like layers of an onion,” he says.

Security by Design

Autodesk has generally taken a hybrid approach to cloud technology usage. Most of its software products are desktop applications extended into an ecosystem using cloud services.

Autodesk does not differentiate between working from home or working from the office, says Reeny Sondhi, chief security officer.

“We aim to make customers’ files equally secure when they’re in our care, regardless of whether a file is worked on from inside the firewall at the office, on a workstation at home or on a laptop in a café.”

Sondhi notes that a crucial factor that affects data security is that data must be encrypted both when it’s stored “at rest” and when it’s “in transit” to the engineer doing the work.

“Autodesk takes a holistic approach to security and believes it should be built into the system at every level and

throughout the process,” Sondhi says. “This is what we refer to as security by design.”

“We find bolt-on security doesn’t scale nor protect data effectively,” Sondhi says. “Security needs to be integrated into the applications, the platform and the infrastructure on which these applications run.”

Regarding the use of cloud software in engineering, Sondhi explains that “the greatest difference in data security when using cloud software is that the cloud helps ensure best-in-class security is both affordable and hassle-free for the customer.”

“Of course, just like any security measure,” Sondhi says, “if you use even the best lock in the world but you leave the key under the mat, your house won’t be very secure. It’s more important than ever today that customers work in partnership with cloud software providers, consistently follow security best practices such as choosing complex and unique passwords, protecting identities and log-in credentials, and utilize valuable security features such as two-factor authentication.”

Optimize for Speed

Key to WFH infrastructure is faster network technology, says Nick Pandher, product manager at BOXX Technologies.

“What made the transition to heavy remote GPU use is the ability to make the user feel like they are working on a physical workstation. As long as you have the right latency experience, remote users will see a performance uplift,” he says.

BOXX is introducing BOXX Cloud, technology for private, high-performance cloud-hosted workstation access. BOXX Cloud is based on BOXX Flex systems, a rack-mounted blade server system using workstation components.

“Too many [engineering companies] run workstation apps on servers not optimized for engineering work,” Pandher says. “Specific CPU and GPU settings are required.”

BOXX believes a core tenet of remote work for engineering should be “if implemented correctly the remote workstation can be more secure than one in your own building,” says Tim Lawrence, BOXX founder and CTO.

Part of the additional security is the use of “air gaps,” which means there is a server not connected to the internet. Another server for outside access is the only device to directly connect to the data server.

Remote delivery is not the major bottleneck for remote delivery of engineering services, says Pandher; the sharing of CPU and GPU time is the bigger problem. The BOXX method connects one remote user to a dedicated workstation blade, which he says makes the system faster than virtualization for engineering.

“Virtualization does have its place in the stack for economic reasons,” says Lawrence. “But virtualization is contrary

to optimal performance for engineering. Where performance drives productivity, VDI is not the best tool.”

Being Sneaky With Intellectual Property

IronCAD is a product development application known for its ability to work with various data sources. In the work-from-home era, IronCAD President Tao Yang Han says multiple authorization levels are important.

The most common level is authorization via password. The next level up is authorization by role, allowing access to specific directories or features. A third level is additional authorization.

“All of these are on the application side,” says Han. A fourth level of protection will be forthcoming soon in IronCAD—encryption. “Even if hacked, the intruder won’t understand the data.”

WFH adoption increases the risk of a data breach, Han notes. He says IronCAD works with customers to help them select a remote collaboration and access system that matches their situation. For some customers, an added sneaky step is to substitute a standard part inside an assembly when sharing with certain suppliers.

“Visualize a substitute but don’t use the secret proprietary piece,” Han says. DE

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➔ MORE INFO

- Amazon Web Services: [AWS.amazon.com](https://aws.amazon.com)
- Autodesk: [Autodesk.com](https://autodesk.com)
- BOXX Technologies: [BOXX.com](https://boxx.com)
- HP (ZCentral): www8.hp.com
- IronCAD: [IronCAD.com](https://ironcad.com)
- Onshape: [Onshape.com](https://onshape.com)
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GPU Acceleration Pays Dividends in SOLIDWORKS 2021

3DEXPERIENCE World sessions focused on big performance boosts.

When SOLIDWORKS 2021 was announced last year, its developers emphasized new graphics improvements enabled by GPU acceleration. At the 3DEXPERIENCE World conference this year, presenters went into even greater detail about some of those improvements, as well as hardware recommendations for getting the most out of the solution.

GPU acceleration is now the default setting in SOLIDWORKS 2021. Renderings in SOLIDWORKS Visualize directly leverage the GPU, which has made investing in a robust graphics card essential for optimized performance.

The benefits of GPU acceleration, and how they increase depending on licensing, were apparent in a session that focused on new mesher improvements.

Aaron Aoyama, senior technical customer support engineer at Dassault, explained how the blended curvature-based mesher (BCB Mesher). This mesher traditionally benefited users by successfully meshing models that failed with other meshers. However, as Aoyama explained, “the tradeoff has always been that you needed a longer time to perform the mesh compared to the standard curvature-based mesher.”

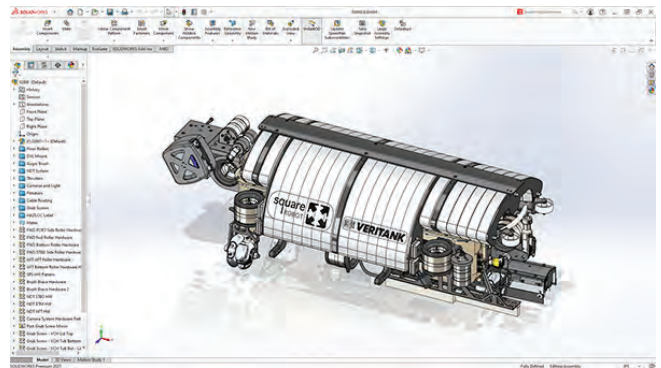
In SOLIDWORKS 2021, there has been a significant speed improvement thanks to optimization of the code architecture in the mesher for SOLIDWORKS simulation, as well as support for parallel multicore processing and multithreading for the SOLIDWORKS Simulation Professional and Simulation Premium licenses.

“All users should see an improvement in mesh performance compared to earlier releases,” Aoyama says. “Support for parallel processing will give an additional boost for Professional and Premium users, particularly on large models that take advantage of this enhancement.”

According to Aoyama, there is an average speed improvement of 4X between the 2020 and 2021 release, and a 20X speed improvement for the BCB Mesher in an example provided during the presentation.

“For large mixed mesh models, there are significant performance improvements in 2021, as well as when using the Premium license,” Aoyama says. “When using the BCB Mesher, performance will vary, but users should see faster mesh times in 2021 across the board compared to earlier releases.”

Parallel multicore processing has also provided solver improvements for users with Professional and Premium licenses. In general, the Intel direct sparse solver and FFEPlus iterative solver have shown improved performance across the board.



GPU acceleration is now the default setting in SOLIDWORKS 2021. Image courtesy of Dassault Systemes.

According to Aoyama, the time reductions are most noticeable with the FFEPlus solver, particularly with studies that have many surface-to-surface contact interactions.

For Premium and Professional users, parallel/multicore processing has helped improve studies for surface-to-surface contact stiffness.

“While both enhancements show the most improvement with FFEPlus, users can also see improvements with the large problem direct sparse solver,” Aoyama says.

For linear static studies with large amounts of surface-to-surface contact, users could see from 25% to 67% improvements.

The Intel direct sparse solver can now run larger studies with 4 million-plus equations, including many studies that could be run in previous releases. Aoyama said that RAM requirements for studies with high equation counts is large, and the software will use disk space when the memory capacity is exceeded. That can slow down performance of the solver compared to in-core equations.

“While you can solve larger studies, the FFEPlus solver is still typically faster for large degree of freedom problems,” Aoyama says.



MaaS Rewrites Rules for Manufacturing

The business model and the platforms that serve manufacturing-as-a-service are relatively new to the digital landscape, so it's critical to adapt technologies to meet market demands.

BY TOM KEVAN

Ever since Henry Ford installed the first moving assembly line for mass production, the manufacturing business model has operated as a work in progress. The latest stage of this evolutionary process, called manufacturing-as-a-service (MaaS), promises to deliver greater flexibility and efficiency by totally upending traditional supply chain and manufacturing practices, sweeping aside concepts like economies of scale, mass production and specification standardization.

Today, emerging MaaS platforms serve as the primary vehicle for implementing a new manufacturing model. These platforms provide a digital interface that facilitates interaction between service buyers and manufacturers, providing an efficient mechanism for specifying and ordering custom parts and products.

MaaS platforms typically include manufacturing configura-

tion, parts pricing, design for manufacture (DFM) evaluation and order tracking functions.

It's important, however, to keep in mind that the business model and the platforms that serve MaaS are relatively new to the digital landscape. To understand the emergence of the model and its supporting software platforms, organizations must examine how the traditional manufacturing model meets or fails to meet new market demands, and consider what the technologies must do to satisfy a new generation of consumers.

Change Brings New Demands

Originally, manufacturers produced and sold products in one-time transactions. Using the traditional manufacturing model, plant managers assumed one product would satisfy many customers.

As a result, factories made tens of millions of identical products, using standardized designs and assembly line techniques. Although this approach meets the requirements of economies of scale, it is far from Agile. Traditional manufacturing is slow, and plants must often wait weeks or months for custom components to be delivered.

Unfortunately, market dynamics have



Fig. 1: Manufacturing-as-a-service platforms promise product developers greater flexibility than the traditional manufacturing business model, accommodating increasing demand for customization and providing access to a broad range of production technologies, materials and finishes. Image courtesy of Xometry.

Digital Manufacturing Process

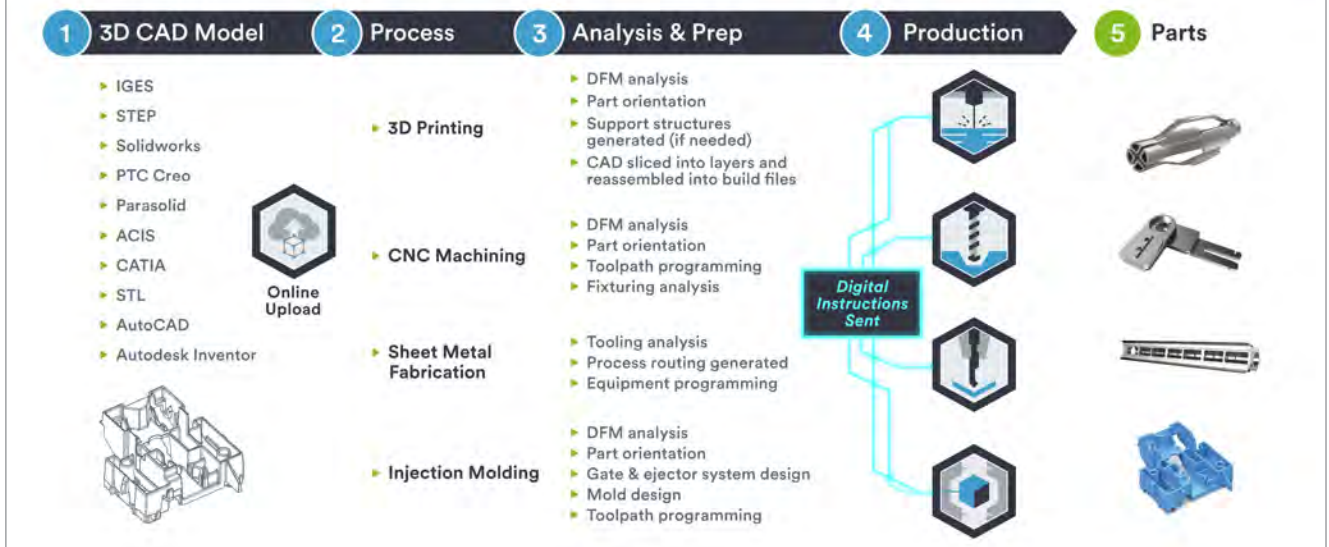


Fig. 2: Manufacturing-as-a-service platforms begin the production process with 3D CAD models, supporting various file formats. Once the CAD model is submitted, automation software found in many of the platforms takes over. The quoting software uses AI algorithms to analyze the part's geometry, evaluate its manufacturability and provide job quotes from a number of possible manufacturers. Image courtesy of Protolabs.

changed. Connected devices and machine commoditization plus the growing profile of software have set off a chain reaction that has caused consumers to expect more personalized experiences, as well as products that leverage the almost daily introduction of new technologies. These changes translate into demand for greater customization, with upgrades and new models delivered in months, not years (Fig. 1).

Faced with these challenges, product developers have realized that the traditional manufacturing approach simply cannot meet emerging market demands. A new, more flexible business model is required.

Digitization Brings a New Model

The MaaS model aims to meet the new demands, calling on manufacturers to offer production processes as a service, using scalable and adjustable assembly and manufacturing techniques to complete customized packages based on real-time or current data from clients (Fig. 2).

This approach promises to deliver greater efficiencies by allowing product developers and manufacturers to focus on their core competencies. Using this approach, manufacturers direct all resources to optimize raw material processing and machinery usage, while their customers concentrate on developing and marketing products.

Product-developing companies no longer have to maintain expensive machinery and the skilled labor necessary to operate it. This, in turn, reduces capital expenditures and allows them to choose manufacturing techniques not limited by their own production capabilities.

Market forces, however, are not the only factor driving the introduction of MaaS. Recent technology advances, such as faster internet speeds, cheaper cloud resources and increased protocol-based connectivity provide the infrastructure that makes MaaS possible.

Manufacturing Matchmaking

Combined, all these technologies lay the foundation that enable MaaS platforms to provide a venue where product developers can find a manufacturer with the right set of resources to cost-effectively produce the part or product that they require. This venue takes the form of a technology-driven access point through which customers can search a large database of manufacturers.

"A MaaS platform creates a seamless handshake for buyers and sellers without the need for direct connections or introductions," says Greg Paulsen, director of application engineering at Xometry. "It usually makes the experience of manufacturing as simple as ordering from sites like Amazon."

MaaS platforms add value by quickly providing reliable pricing and feedback for purchasing decisions. On the manufacturing side, the supplier benefits from a consistent interface to get work without additional sales or marketing investments.

A MaaS service is, in many ways, a storefront for manufacturing partners, allowing engineers, designers and procurement departments to source parts quickly and enabling manufacturers to have an efficient way to get work that fits them best.

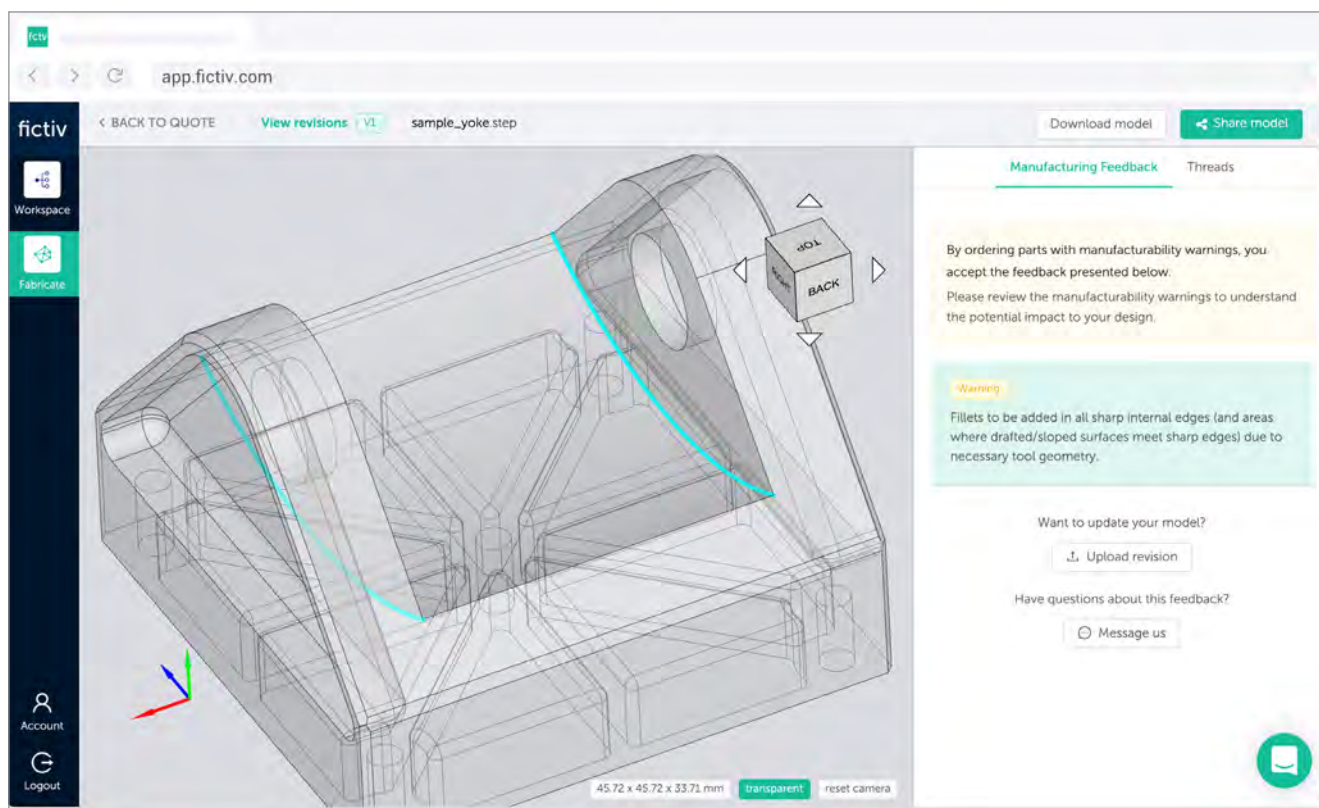


Fig. 3: Design-for-manufacture analytics help product developers determine how to minimize the challenges of manufacturing and avoid getting locked into designs that result in costly, time-consuming production processes. Image courtesy of Fictiv.

MaaS Building Blocks

It's important to note, however, that no two MaaS platforms are the same.

"Some systems are out-of-the-box solutions, ready for implementation," says Maricarmen Senosiain Villalon, direct manufacturing product manager at Stratasys. "Other more robust systems or platforms require customization to meet the needs of the business."

A typical platform, however, does include some basic sub-systems. These include a quoting engine that helps the user to quickly and accurately determine pricing and lead times; a design-for-manufacture feedback engine that allows customers to optimize designs for various processes; and an order-tracking system.

An essential element of these platforms is that they provide a seamless way for customers to securely load their files for a quote request. Ideally, the platform provides mechanisms that automatically parse, configure and provide instant quoting or feedback on the work.

"A true digital MaaS supplier must automate the labor-intensive portions of production," says Dan Barsness, vice president of product management and e-commerce at Proto-

labs. "Our software platforms start with quote generation, go on to machine instructions and then through quality systems, [which are] all encapsulated in an e-commerce buying experience. We auto-generate manufacturing quotes based on 3D CAD models and perform a design analysis, calling out any areas of manufacturing to prevent quality issues once production is complete."

With this type of up-front automation, engineers can produce multiple designs simultaneously and order multiple molds to test and iterate, thereby reducing manufacturing risk and quickly moving to final validation and manufacturing.

Holistic View of the Manufacturing Process

In addition to automated processes, companies that seek the services of a MaaS platform should evaluate other key production aspects. In many cases, this functionality involves providing transparency of the various aspects of the manufacturing process.

For example, it's important to understand how parts are sourced. Parts may be made through in-house production methods or outsourced to a network of manufacturing partners.

"If manufacturing is outsourced, then you should under-

Fig. 4: When placing an order, buyers can quickly configure parts with multiple finishes, uploading 2D drawings that call out tolerance and hardware installation requirements. Image courtesy of Fictiv.

stand if the network is a large marketplace, where parts are distributed through a job board or if they are matched in a smaller, quality-controlled ecosystem more similar to a digital version of a contract manufacturer,” says Dave Evans, CEO and co-founder of Fictiv.

MaaS platforms should also offer tools that provide insight into the manufacturability of designs (Fig. 3).

“When a company is selecting a MaaS platform to work with, they should look closely at the depth and timing of the DFM feedback,” says Evans. “Some platforms only provide minimal feedback or only provide feedback after the order has been placed, which can result in production delays or nonconformant parts. Ideally, DFM feedback should be comprehensive, [and] provided with pricing information pre-order so that there is upfront clarity around manufacturing expectations.”

Visibility, however, should not stop with the actual production process. MaaS platforms should also provide post-order visibility. One key feature to look for is the availability of on-demand production updates and real-time access to inspection data and photos.

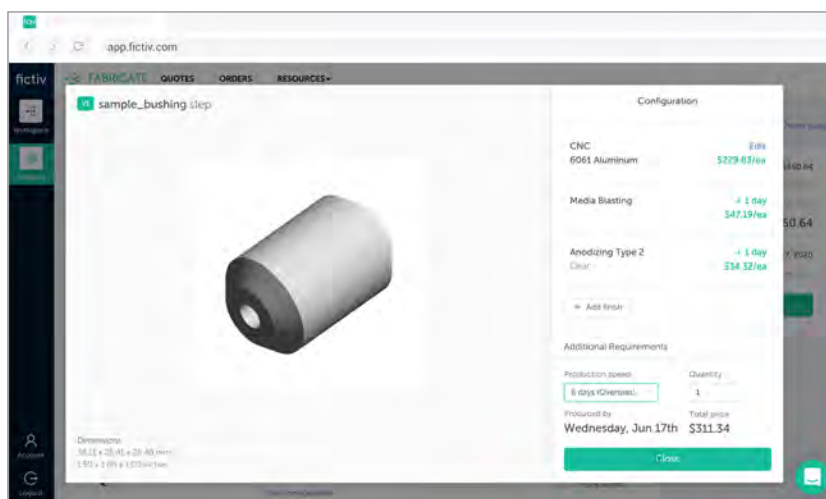
From Order to Delivery

Placing a manufacturing order begins by logging into the MaaS website. Here, the software’s dashboard allows users to perform functions ranging from viewing previous work and quotes to placing and tracking orders.

After the initial process, the buyer uploads the design files, which include 3D CAD files. If the buyer must call out specific requirements, such as tight tolerances, 2D drawings also may be included. Users should be aware that not all platforms accept 2D drawings, so be sure to confirm what file support their products require.

After the design files have been evaluated by the platform’s onboard analytics and the DFM recommendations have been presented, the buyer selects the desired manufacturing process. This can range from 3D printing to computer numerically controlled (CNC) machining and injection molding. During this process, the user also specifies the material and finishing requirements.

For example, this could be anodizing or powder coating. The buyer can also configure each order to add features, quality re-



quirements, even specific certifications needed for the project.

Once the buyer specifies the requirements, a list of manufacturers appears. The buyer selects potential providers who check the order and specifications and then present their quote (Fig. 4). On some MaaS platforms, buyers and manufacturers can also start chats or video calls to clarify aspects of the job.

At this point, the buyer can see how manufacturing location and lead time impact price, review any feedback on the design’s manufacturability and consider recommendations on ways to optimize designs to reduce cost and lead time.

After the buyers make their selections, they finalize the order. The buyer can then track the order’s progress online.

MaaS platforms also simplify the process for reordering parts. Buyers can typically visit an order’s page to review previous DFM feedback and configuration details at any time to easily place another order.

Insights and Flexibility

The value of MaaS platforms lies in the integration of powerful, complementary technologies. For example, much of the insight, accuracy and speed that MaaS platforms bring to pricing and manufacturability feedback can be attributed to the software’s secret ingredient: artificial intelligence (AI) algorithms.

“AI and machine-learning algorithms can derive important costing information through prior work,” says Paulsen. “In theory, the more diverse the work completed, the more accurate the pricing will be. Why not just manually quote? Because of scale. MaaS platforms like Xometry have an enormous supply of parallel manufacturing capacity, with over 5,000 shops globally.”

When the buyer uploads the 3D and 2D design files, the best platforms will analyze the designs to understand the full geometry of the part and determine how much material is required, the number of setups involved, the tools and tool paths called for and the machine runtime needed—every-

thing a manufacturer must know to make the part.

“Digital platforms can identify, for example, if a part is better suited to be milled versus turned, based on geometry,” says Protolabs’ Barsness. “In turn, cost savings can be had, surface finish improved and other manufacturing benefits obtained. Furthermore, digital manufacturing suppliers with multiple processes make it much easier to move from one process to the next.

“If an engineer is looking to take their 3D-printed design into lower-volume production with molding, that engineer can requote the same 3D CAD model for injection molding, get immediate feedback to design for moldability and quickly jump to a different manufacturing process—and more importantly, keep their development on schedule,” Barsness says.

There is, however, more to MaaS platforms than AI-empowered analytics. The software also harnesses visualization to help MaaS customers make the right decisions. Use of AI and visualization technologies becomes particularly important when considering the sheer number of factors that buyers must consider.

“Customers have more choices when using MaaS platforms, which aggregate multiple technologies in one location,” says Paulsen. “A combination of technical resources and integrated site features helps customers when reviewing parts to make better production decisions. Integrated 3D viewers and visual DFM also help show where features may have challenges in a given process.”

Glitches and Blind Spots

Despite the power of MaaS platforms, the systems aren’t without their problems. The reality is that this is a new way to work faster, easier and cheaper, but like any new technology, there are three main things to be aware of:

First, manufacturing jobs calling for special or uncommon features can pose problems, requiring special attention and precise communications.

“If your part needs very specific options, it is better to contact the platform and discuss the issues directly,” says Benoit Schildknecht, marketplace director at Dassault Systèmes. “Also, if you ask for a quote, communicate this clearly to the manufacturers. In some cases, with a specific part, instant quote, manufacturing checks or geometry evaluations can fail to provide the right analysis.”

Second, some platforms have manufacturing limitations.

“Some don’t accept 2D drawings and have limitations around tight tolerance machining, and so they may not be able to deliver on the precision you would expect from a local machine shop,” says Evans. “It’s important to evaluate these capabilities up front in the context of your design complexity requirements.”

Third, quality control issues can also extend beyond the MaaS platform. If parts are outsourced to a network of manufacturing partners, be aware that different platforms have

varying quality control systems.

For example, marketplace models optimize for scale, but not necessarily quality control, with every single partner. So, buyers should inquire about the ways in which the MaaS platform sources parts and manages quality systems.

Finding Its Niche

If you were going to describe the evolution of MaaS platforms, “start small, think big” would be a perfect fit. Additive manufacturing, or 3D printing, provided the catalyst for the emergence of MaaS. Early developers of these systems initially focused on 3D printing because some manufacturing companies were reluctant to invest in 3D printing machines, while those that did buy into the technology did not use the equipment full time.

MaaS platforms provide a cost-effective way for companies to use the technology without investing in the infrastructure and equipment. In addition, the approach lets 3D printing houses keep their operations up and running at or near capacity.

“Although many may have limited experience with 3D printing technology, companies in the services industry have been utilizing this tech for decades,” says Senosiain. “At the end of the day, MaaS platforms are driven by customer needs and requirements. The combination of those requirements with the expertise of a manufacturing service provider is vital when pursuing advanced application of 3D printing technology.”

The focus on 3D printing, however, was just the beginning. MaaS advocates realized that 3D printing accounts for only a small share of overall manufacturing. So, the developers of MaaS platforms have extended their model to traditional manufacturing processes, such as CNC machining and injection molding. The inclusion of these processes now accounts for the better share of their revenues. **DE**

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→ MORE INFO

- Dassault Systèmes: [3DS.com](https://3ds.com)
- Fictiv: Fictiv.com
- Protolabs: Protolabs.com
- Stratasys: Stratasys.com
- Xometry: Xometry.com

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Printing and Pest Management

Florida Department of Agriculture uses 3D printing to build a better bug trap.

BY KIP HANSON

A forester with the Tennessee Department of Agriculture says gypsy moths represent a significant threat to the state's forests (bit.ly/3uvuQUv). A Pennsylvania State University study estimates that the spotted lanternfly could cost the state's agricultural industry \$324 million a year and thousands of jobs (bit.ly/3dFx2D7). The Dallas Environment and Sustainability Committee met recently to discuss the emerald ash borer, which has destroyed millions of ash trees throughout the United States and now has set its sights on Texas (bit.ly/2NVabIQ).

Invasive species like these are everywhere. Some are from Asia, others from Europe, but all have at least two traits in common. First, they don't belong here in the United States, and second, they're killing trees, crops, insects—and in the case of the Asian tiger mosquito—humans (bit.ly/3kiXsMj).

James Snyder and his colleagues at the Florida Depart-

ment of Agriculture and Consumer Services know all about such pests. In fact, they spend their days developing better ways to trap and hopefully control insects like the corn earworm and the Asian citrus psyllid, two invasive species that wreak havoc on the state's agricultural industry.

Over the past few years, however, they've latched onto a manufacturing methodology that's making their job easier, faster and more cost-effective: 3D printing. When used in conjunction with modern design software and virtual reality tools, it is poised to turn this vital sector of the entomological sciences on its head.

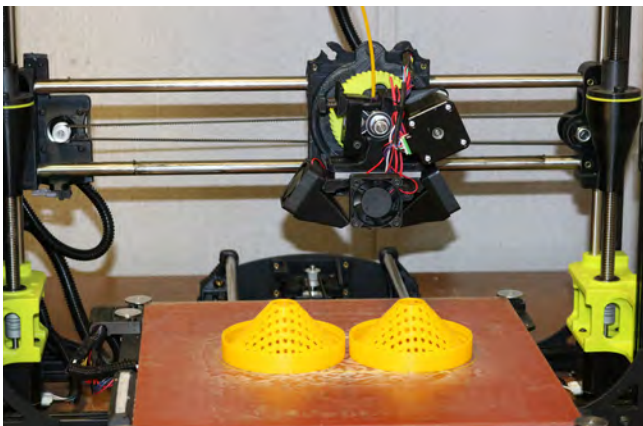
Building a Department

Snyder is a technician at the Division of Plant Industry's 3D printing lab, part of the state's Bureau of Methods Development and Biological Control in Gainesville, FL. He began working in the lab in 2017. It wasn't his idea to print bug traps—that was the brainchild of lead hemipterist (one who studies cicadas, aphids and other organisms of the genus *Hemiptera*) Susan Halbert two years earlier.

Given the endless parade of additive manufacturing success stories over the past few years, some might think, "The guy's 3D printing high-tech bug motels. So what?" And while that viewpoint is understandable, what's most interesting is the significant progress that Snyder and the others in the department



A completed insect trap hangs from a tree, ready to capture new invasive species.



Lab technician James Snyder has found that low-cost 3D printers are more than adequate for his manufacturing needs—in this case, parts for a corn earworm trap. All photos courtesy of Florida Department of Agriculture and Consumer Services.

have made, given the state's relatively small investment in 3D printers.

There are no hugely expensive laser-based industrial selective laser sintering machines here, nor equally costly design software. Using products within the financial reach of even a moderately serious hobbyist, Snyder can quickly prototype whatever bug trap design he's currently dreaming up, then print tens or even hundreds of them for field testing.

"We study an insect's behavior, its biology, environment and interactions with other insects, then figure out how to most effectively trap them," he says. "This might involve using different color materials, for example, or creating part geometries that encourage the insect to travel down a funnel. Many of these shapes would be extremely expensive or outright impossible to make using traditional manufacturing technologies like plastic injection molding."

Frugal but Effective

Snyder has a handful of low-cost 3D printers at his disposal. All use fused filament fabrication (FFF) technology, and all are easy enough to use that Snyder has been able to "pretty much pick it up on my own."

These include a LulzBot TAZ 5 and TAZ 6, a Tiertime UP BOX+ and UP mini 2, and his largest machines, a pair of Replicator Z18s from Makerbot and a Version 1 German RepRap X400. Most of his projects are made out of polylactic acid, although depending on the printer, he can also print acrylonitrile butadiene styrene, Nylon, polyethylene terephthalate glycol and other polymers.

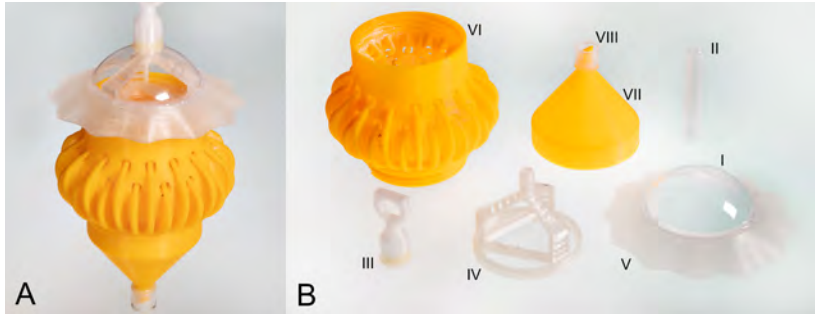
He also uses Rhino design and modeling software, which he says is more than adequate to his needs, even for the meshes and other complex shapes common with 3D-printed parts. Once he deems a design ready for printing, he exports the .STL file to whatever printer he's using for that project, then uses the software that came with the machine to ready the file for printing.

"I can design and manufacture most any geometry imaginable," says Snyder. "At some point, we'll have some of these products injection molded, but for now, we're focused on finding the best design possible without spending a bunch of money on tooling and outside services."

Bug's Eye View

Unless born with wings and antennae, how does anyone know what might be attractive to an insect? Here again, Snyder has taken an unorthodox approach to pest control by donning a virtual reality (VR) headset and "flying" into and around 3D models of his trap designs. This allows him

Tiny critters like these are responsible for millions upon millions of dollars in crop damage each year.



An assembled insect trap prototype (A) with its components (B) to trap some Asian citrus psyllids.



Though intended for prototyping work, Snyder also uses his small fleet of 3D printers to manufacture parts by the tens or hundreds.

to analyze light levels, material colors and small details that might otherwise go unnoticed by all but his intended targets: invasive species.

"The most important thing is to learn the insect's behavior," he says. "Most of it is basic stuff like what time of the day or night are they most active? Do they have good eyesight? Do they prefer certain colors and specific shapes? Do they hang out in the trees, or around the ground? There are all sorts of questions about how these invasive species interact with their environment, and 3D printing helps us answer them. It's a lot of fun." **DE**

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→ MORE INFO

• **Rhinoceros:** Rhino3D.com

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Solid Power With Dell Precision 3240 Compact

Dell introduces an ultra-small form factor compact workstation.

BY DAVID COHN

Ultra-small form factor workstations make sense in places where desk space is at a premium. These tiny systems—similar in size to a thin client—can even be mounted to the back of an LCD monitor. We have reviewed several of these miniature systems before (including the HP Z2 [bit.ly/2MO8j4A] and the Lenovo ThinkStation P320 Tiny [bit.ly/3e1ZXBu]).

Dell recently introduced its own ultra-small form factor workstation, the Dell Precision 3240 Compact, and sent us one to evaluate.

Housed in a charcoal gray aluminum case that measures 7.40x7.76x2.76-in. (HxDxW), the Dell Precision 3240 Compact looks like a miniature version of a Dell Precision tower workstation. The system we received weighed 4.22

lbs., plus an additional 2 lbs. for the 7.81x3.87x1.06-in. 240-watt power supply.

Despite its diminutive size, however, the Precision 3240 Compact proved to be a real workstation, powered by the latest generation Intel processor, a discrete NVIDIA graphics processing unit (GPU), up to 64GB of memory and lots of internal storage.

The case's front consists of a stylish, perforated screen with a small panel hosting a round power button, hard drive indicator light, a pair of audio jacks, a USB 3.2 Gen 2 Type-C port and a USB 3.2 Gen 2 Type-A port with PowerShare.

Fig. 2: Removing the top and side panels reveals a compact, well-organized interior with minimal expansion capabilities.



Fig. 1: The new Dell Precision 3240 Compact workstation packs plenty of power into an ultra-small form factor case. Images courtesy of David Cohn.



Compact Workstations Compared

	Dell Precision 3240 Compact workstation (one 3.7GHz Intel Xeon W-1290 10-core CPU, NVIDIA Quadro RTX 3000, 32GB RAM, 1TB SSD)	HP Z2 Small Form Factor G4 workstation (one 3.8GHz Intel Xeon E-2174G quad-core CPU, NVIDIA Quadro P1000, 32GB RAM, 256GB Z Turbo SSD, 1TB SATA HD)	Lenovo ThinkStation P320 Tiny workstation (one 2.90GHz Intel Core i7-7700T quad-core CPU, NVIDIA Quadro P600, 16GB RAM, 512GB SSD)	HP Z2 Mini G3 workstation (one 3.2GHz Intel Core i7-6700 quad-core CPU, NVIDIA Quadro M620, 32GB RAM, 250GB SSD and 1TB SATA HD)
Price as tested	\$2,893.00	\$1,949.00	\$1,479.00	\$1,698.00
Date tested	12/19/20	8/26/18	9/8/17	1/20/17
Operating System	Windows 10 Pro	Windows 10 Pro 64	Windows 10 Pro	Windows 10 Pro
SPECviewperf 13.0 (higher is better)				
3dsmax-06	116.11	61.02	n/a	n/a
catia-05	170.30	89.74	n/a	n/a
creo-02	171.61	75.51	n/a	n/a
energy-02	22.82	4.56	n/a	n/a
maya-05	175.54	78.69	n/a	n/a
medical-02	64.72	15.05	n/a	n/a
showcase-02	63.78	23.62	n/a	n/a
snx-03	192.66	107.91	n/a	n/a
sw-04	115.63	94.57	n/a	n/a
SPECapc SolidWorks 2015 (higher is better)				
Graphics Composite	4.28	4.17	2.59	2.51
Shaded Graphics Sub-Composite	2.86	3.13	1.99	2.04
Shaded w/Edges Graphics Sub-Composite	3.48	4.05	2.46	2.58
Shaded using RealView Sub-Composite	3.21	3.46	2.17	1.94
Shaded w/Edges using RealView Sub-Composite	3.68	3.92	2.60	3.33
Shaded using RealView and Shadows Sub-Composite	3.64	3.87	2.25	1.73
Shaded with Edges using RealView and Shadows Graphics Sub-Composite	3.83	4.08	2.55	2.84
Shaded using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	11.51	6.03	3.97	2.21
Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	10.89	6.75	4.49	3.37
Wireframe Graphics Sub-Composite	2.90	3.89	2.05	3.46
CPU Composite	2.53	2.53	1.67	2.78
SPEC Workstation v3 (higher is better)				
Media and Entertainment	1.18	n/a	n/a	n/a
Product Development	1.33	n/a	n/a	n/a
Life Sciences	1.11	n/a	n/a	n/a
Financial Services	0.85	n/a	n/a	n/a
Energy	0.76	n/a	n/a	n/a
General Operations	1.18	n/a	n/a	n/a
GPU Compute	2.57	n/a	n/a	n/a
Time				
AutoCAD Render Test (in seconds, lower is better)	70.40	45.10	109.90	62.40

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



Fig. 3: The rear panel provides plenty of connectivity.

All other connections are on the rear panel and include a RJ-45 jack for the built-in network, four additional USB 3.2 Type-A ports (including one with SmartPower-On) and two DisplayPorts for the integrated Intel graphics, as well as a Kensington wedge lock slot and a port for the external power supply.

Compact Interior

Gaining interior access is not immediately obvious. But after removing the top panel and loosening a single captive screw, the side cover slides off to reveal a compact, well-organized interior. A plastic cover housing a 2.5-in. cooling fan covers the CPU. Removing this reveals the CPU beneath a heat

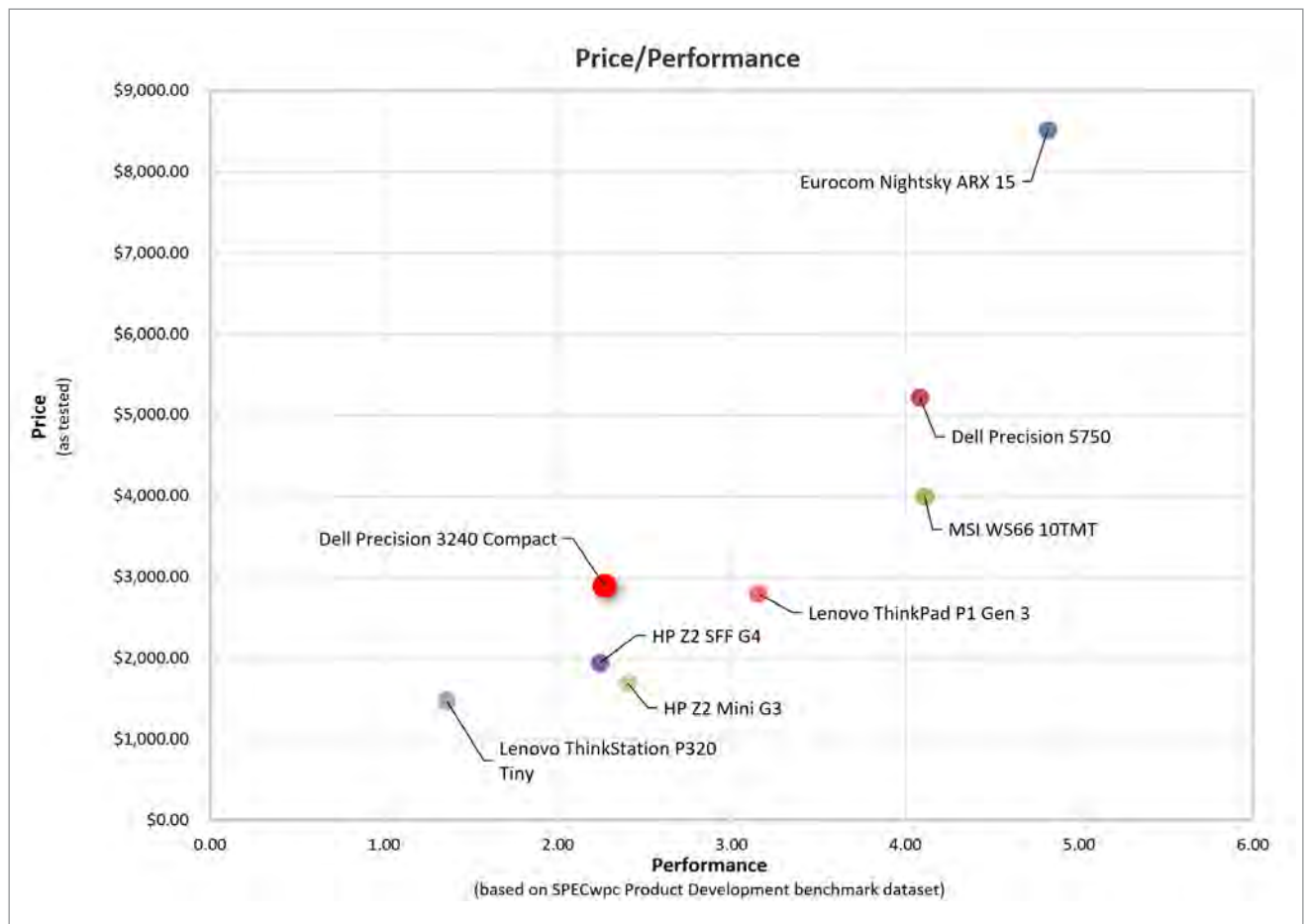


Fig. 4: Price/Performance chart based on SPECwpc Product Development benchmark dataset for ultra-small form factor and recently reviewed mobile workstations.

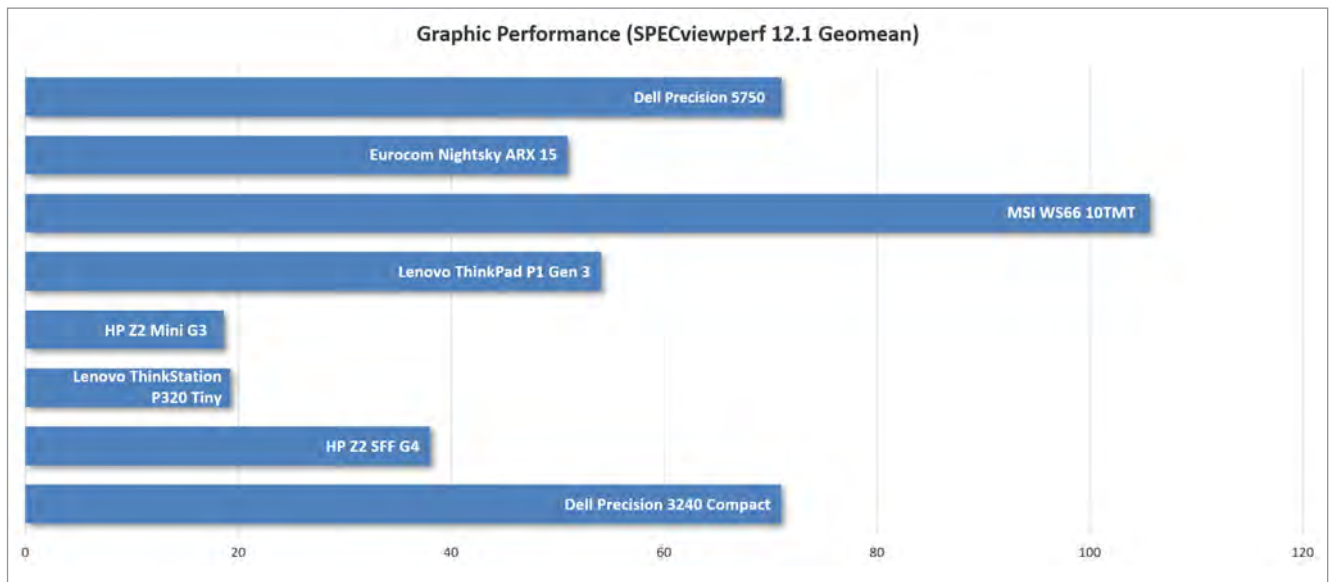


Fig. 5: Graphic performance of ultra-small form factor workstations and recently reviewed mobile workstations, based on the SPECviewperf 12.1 geomean results.

sink, as well as a pair of small outline dual in-line memory module sockets.

A riser card provides support for a discrete graphics card via a half-height Gen 3 PCIe x8 slot. Beneath this are a pair of M.2 sockets for solid-state drives (SSDs). Depending on the options selected, Precision 3240 Compact systems also can be equipped with an optional I/O card, a standard 2.5-in. drive (HD) and a wireless local area network card.

Prices for the Dell Precision 3240 Compact start at \$839 for a system based on a 3.7GHz Intel Core i3-10100 quad-core CPU, integrated Intel graphics, 8GB of single-channel DDR4 RAM, a 256GB PCIe NVMe Class 40 M.2 SSD, integrated network, a USB mouse and USB keyboard, a 180-watt external power supply and a copy of Windows 10 Pro, all covered by a three-year warranty. But that is just the starting point.

Dell offers a choice of eight different 10th-generation Intel processors, including five Core processors up to the 10-core i9-10900, as well as three Intel Xeon CPUs. Our evaluation unit came with a 10-core Intel Xeon W-1290 processor, which added \$409 to the base price.

This 3.2GHz Comet Lake CPU has a 5.2GHz maximum turbo speed and includes 20MB SmartCache and Intel ultra-high definition (UHD) Graphics P30, with a thermal design power (TDP) rating of 80 watts. Any of the CPUs with more than four cores requires an operating system upgrade to Windows 10 Pro for Workstations, however, adding \$148.

Although our Xeon-equipped system could support error-correcting code (ECC) memory, our evaluation unit included

32GB of non-ECC memory, installed using a pair of 16GB 2933MHz memory modules. These added \$148. The same amount of ECC memory would have added \$246.

In addition to the integrated Intel graphics present in all eight available CPUs, Dell also offers a choice of NVIDIA discrete graphics cards, including the Quadro P400, P620 and P1000. Our Dell Precision 3240 Compact included an NVIDIA Quadro RTX 3000, with 6GB of dedicated GDDR6 memory.

This virtual reality-ready GPU has 1920 compute unified device architecture cores, 30 ray tracing cores and 240 Tensor cores. Its 192-bit interface results in a maximum bandwidth of 336 GB/second while drawing 80 watts.

The system we received also came with a 1TB PCIe non-volatile memory express Class 40 M.2 SSD, which added another \$148. Dell offers SSDs ranging from 256 GB to 2 TB, as well as SATA hard drives from 500GB to 2TB. Precision 3240 Compact systems can accommodate up to two M.2 drives as well as a 2.5-in. hard drive, but systems equipped with a discrete GPU cannot also include a 2.5-in. drive; you must choose one or the other.

A wired Ethernet port comes standard, and our evaluation unit also included an Intel Wi-Fi adapter with an external whip antenna, a \$22 option, enabling us to access our local area network wirelessly. Other options include an additional USB Type-C port, a VGA port, an HDMI port or a serial port, which can be added to systems equipped with an NVIDIA GPU. There is also an optional PCIe I/O card that includes Thunderbolt 3 (\$81), but this can only be included on systems lacking discrete graphics.

Very Good Performance

Although the Dell Precision 3240 Compact workstation performed well on most of our benchmarks, as we have seen with other ultra-small form factor workstations, its results were more comparable to modern mobile workstations than desktop systems.

On the SPECviewperf tests, the Dell system easily outperformed the HP Z2 Mini and Lenovo ThinkStation P320 Tiny systems, thanks to its NVIDIA RTX graphics. On the SPEC SolidWorks benchmark, the Dell system lagged behind the HP Z2 on eight of the 11 datasets while surpassing it on three.

On our AutoCAD rendering test, which shows the advantage of fast CPUs with multiple cores, the Dell Precision 3240 Compact curiously lagged well behind every system but the Lenovo ThinkStation P320 Tiny. It completed the rendering in an average of 70.4 seconds, one of the slowest results we have recently recorded.

We also ran the very demanding SPECwpc workstation performance benchmark, and the Dell Precision 3240 Compact delivered excellent results on this test. Unfortunately, the newer version of this test was not released yet when we tested the HP and Lenovo ultra-compacts, so we have no results to compare against the Dell test.

The 3240 Compact did very well compared to those older systems on the previous version of this benchmark. The Dell Precision 3240 Compact remained cool and quiet throughout our tests.

Dell rounds out the Precision 3240 Compact with a USB keyboard and mouse, but our system included a very nice Dell wireless keyboard and mouse, which added \$26. The more powerful options in our evaluation unit also required an upgrade to a 240-watt power supply and heavier power cord, adding \$36 more. The system we received also came with a rear cable cover, which added another \$20. All in all, our Dell Precision 3240 Compact priced out at \$2,893.

Dell preloaded Windows 10. Ubuntu Linux and Red Hat Enterprise Linux are also available. The workstation is independent software vendor certified (ISV) for use with software from companies including Autodesk, Dassault Systèmes, PTC and Siemens and is backed by a three-year basic on-site warranty.

Other warranty options of up to five years as well as ProSupport with next-business-day on-site service are also available.

The new Dell Precision 3240 Compact is an excellent ISV-certified ultra-small form factor workstation. It delivers very good performance at a price that, although a bit

more than other tiny workstations we have recently tested, is in line with what is packed inside its tiny case. If space is at a premium, the Dell Precision 3240 Compact is an excellent choice. **DE**

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

→ MORE INFO

- Dell: Dell.com

Dell Precision 3240 Compact

Price: \$2,893 as tested (\$839 base price)

Size: 7.40x7.76x2.76-in. (HxDxW)

Weight: 4.22 lbs. plus 2-lb. 240-watt power supply

CPU: 3.20GHz Intel Xeon W-1290 10-core w/20MB Smart Cache

Memory: 32GB DDR4-2933MHz non-ECC (64GB max)

Graphics: NVIDIA Quadro RTX 3000 w/6GB GDDR6

Storage: 1TB Micron M.2 PCIe NVMe Class 40 SSD

Audio: Integrated built-in speaker, one line-out/line-in audio port and one 3.5-mm headphone jack

Network: RJ-45, Intel Wi-Fi 6 AX201 2x2, 802.11ax w/Bluetooth 5.1

Ports: Front: one USB 3.2 Type A Gen 2 (10Gbps) with PowerShare, one USB 3.2 Type-C Gen 2 (10 Gbps); Rear: one USB 3.2 Type A Gen 1 (5 Gbps), one USB 3.2 Type-A Gen 1 (5 Gbps) with SmartPower, two USB 3.2 Type-A Gen 2 (10 Gbps), two DisplayPort 1.4 (for integrated graphics)

Other: One Kensington security-cable slot, one padlock hoop

Keyboard: 104-key wireless keyboard

Pointing device: Wireless mouse

OS: Windows 10 Professional for Workstations 64-bit

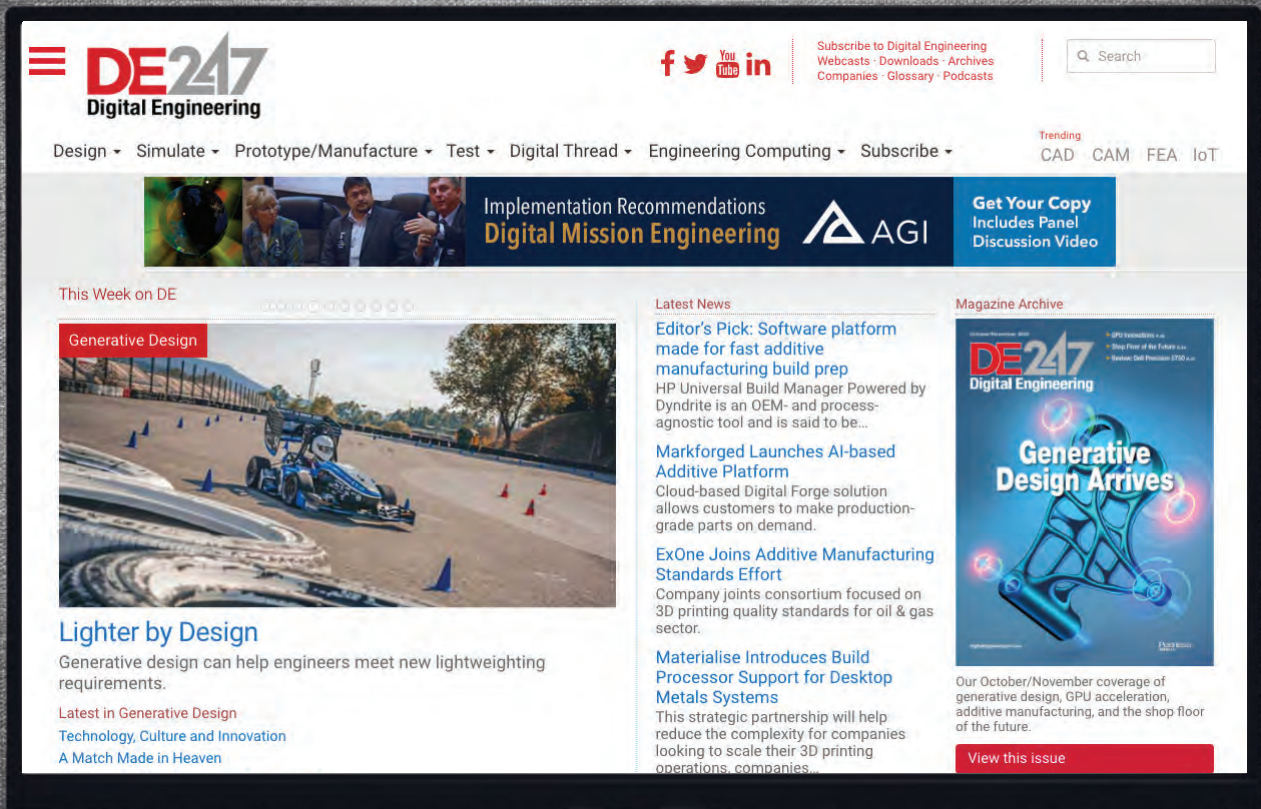
Warranty: One-year basic on-site (three-year warranty included in as-tested price)

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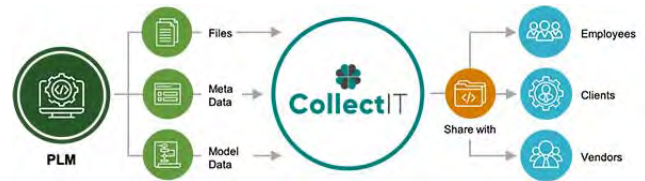
Each week, DE's editors comb through dozens of new products to bring you the ones we think will help you do your job better, smarter and faster. Here are our most recent musings about the products that have really grabbed our attention.

Explore PLM File Management Software

Razorleaf opens ability to securely extract, package, distribute PLM file, data types.

Razorleaf says CollectIT streamlines the process of creating a model-based engineering (MBE) workflow. CollectIT is based on CLOVER, the company's communications hub for exchange of product data management (PLM) data and processes. CLOVER is used to streamline PLM data exchange between systems, vendors and domains. Razorleaf says CollectIT is vendor neutral, allowing it to connect to major PLM platforms.

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Production-ready 3D Printing With Recycling

The Formlabs Fuse 1 SLS 3D printer system can fit on a desktop.

Formlabs introduces the Fuse 1 Selective Laser Sintering (SLS) 3D printer, a production-ready printer that can fit on a workbench. The company says the Fuse 1 is the centerpiece of a new production system offering production-ready Nylon printing, uses recycled powder and can be set for continuous printing.

The company also debuts Fuse Sift, an all-in-one post-processing system that recovers powder and facilitates part extraction, powder storing and powder mixing.

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Simulate Production Costs of Polymer-based Parts

Digmat update has CT scan data to validate, enhance composite microstructure.

e-Xstream Engineering says this version of Digimat allows engineers to take a holistic view of part production, including finishing processes, to determine the best method of production. The software can be used to optimize batch printing, to see if producing parts in parallel using additive manufacturing is viable. The update also is designed to aid with production planning, by comparing total cost of ownership of machines, amortizing costs over the production run.

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Assessing the Cost of Binder Jet 3D Metal Printing

Metal Cost Calculator offers per-part estimate for binder jet 3D printing.



ExOne launched an online tool for estimating cost of using high-speed binder jet 3D printing as an alternative to traditional methods. The company says certain assumptions are made based on a user's choice of material, machine, dimensions and volume. The calculator then compares use of an ExOne Pro Series printer with the cost of building the part with traditional fabrication methods. ExOne says its family of Pro series printers are qualified to 3D print more than 20 materials.

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Next-Gen Engineers

Student Competition Profile: Syracuse University Invent@SU program

Calling Attention to Invention

BY JIM ROMEO

The Invent@SU program is the progeny of the Invention Factory program that began at The Cooper Union in 2013. The founders, Alan Wolf and Eric Lima, oversaw cohorts of 20 engineering students through a six-week process of ideating, prototyping, pitching, provisional patent application filing and competing. Students accepted into the program receive a stipend to participate in the intensive program that runs full-time.

Louise R. Manfredi, assistant professor of industrial and interaction design and lead for Syracuse University's Invent@SU student invention accelerator program, spoke to us about the program.

Digital Engineering: Can you provide an overview of the Invent@SU competition, how it came to be and the intent of the program? Who will be participating or who has participated?

Dr. Manfredi: The program was introduced to Syracuse University in 2017 and has evolved to develop a stronger focus on interdisciplinary collaboration amongst students from any discipline, led by faculty with equally diverse expertise. The intent of the program is to give students the opportunity to focus on developing an innovative idea without the stress of studying at the same time. With financial support, they can devote six full weeks to experimenting and learning with and from their peers of different disciplines.

Some teams come in with an idea to pursue, and others join us to find a



Porta-Splint, which placed first in the 2019 competition, is a portable, collapsible emergency splint system to enable users to be medically prepared for any outdoor environment.

Image courtesy of Syracuse University.

niche. Either way, it is wonderful to see them work through the ups and downs of the design process and ultimately present a patentable invention on judging day. Since 2017, the program has run from two locations—campus and New York City.

Students self-formed into two-person teams and brainstorm to find a problem area. At the end of the first week, students pitched a need-based design.

During weeks two through five, students receive a \$1,000 budget per team to prototype. As they iterate, they pitch weekly to an audience of alumni and faculty to receive suggestions for design and narrative improvements. The pitches are filmed and critiqued by the faculty and acting coach the following day. Students also work on their provisional patent applications during this

period, which helps them to iron out all their product features and functions.

In week six, students file provisional patent applications with the U.S. Patent and Trade Office and pitch their invention to a judging panel comprising trustees and successful entrepreneurial alumni. The judging panel then awards the \$5,000 first-place prize and \$3,000 second-place prize.

We were looking forward to working with our 2020 cohort over the summer, but, unfortunately, we were unable to run the program during a global pandemic. We are, however, planning a big comeback for 2021 with a revamped program structure that promotes interdisciplinary teamwork and a more user-centered design approach, plus an expanded prize structure.

Next-Gen Engineers

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

Manfredi: We have supported some excellent design innovations in the past four years, and our students have enjoyed success beyond the program.

In 2019 Nikita Chatterjee (economics, '20) and Briana Howard (public health, '20) developed a low-tech sari water filter for women in the slums of India and have since been developing their product and providing support for people in India during the COVID-19 pandemic.

SugEx, a glucose monitoring watch developed by Russell Fearon (engineering and computer science, '20) and Ricardo Sanchez (industrial and interaction design, '21), has had extraordinary success by winning \$55,000 from the American Heart Association's National EmPOWERED to Serve [program for] the business plan competition. They are developing their product further.

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

Manfredi: Inventions aside, this program has provided students with a unique experience that they would not have received in their regular curriculum. The feedback has been incredibly encouraging, and we use this to continually improve the program.

From a broader perspective, the goal of the program is to catalyze an interdisciplinary mindset in our students that is needed to solve global engineering, which has led to the development of scholarly research in interdisciplinary professional identity.

The United Nations Sustainable Development Goals for 2030 are a stark reminder of the fragility of humanity. With 30 distinct complex



Treminate placed second in the 2019 competition. It is a device to manage hand tremors while drinking from a cup or bottle. Image courtesy of Syracuse University.

challenges that require immediate attention, of which 14 the National Academy of Engineering identifies as engineering centric, the profession has mounting expectations leveled upon it to make an impact. Insight from multiple disciplines is needed to understand the complexity of these problems; therefore, graduating engineers need to be prepared for interdisciplinary collaboration.

For engineers to have meaningful impact on solving these challenges, new ways of thinking and learning need to be developed. It is no longer enough to have technical competencies—an interdisciplinary mindset and skills base are required.

A program of research is being developed to understand identity development during and after participating in Invent@SU. The goal is to develop

a better understanding of how engineering identity needs to evolve to encompass new competencies in design thinking, interdisciplinary collaboration and appreciation for other disciplines in complex problem-solving. **DE**

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➔ MORE INFO

- Sari water filter project: bit.ly/2NOnFGw
- SugEx glucose monitoring project: bit.ly/37ZxjUa

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