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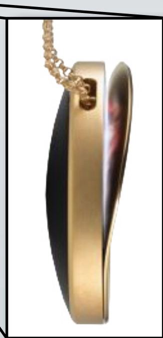
September 2015 / deskeng.com



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by Jamie J. Gooch

Mobility Means Complexity

For our family vacation this year, we drove through parts of New England so our daughters could appreciate the different scenery — the Green Mountains, the coastline, the forests of Maine ... What they mostly saw were the screens of their electronics. This turned me into a shouting tour guide: "Look at that view!" or occasionally, just to make sure they would look up: "Bigfoot!"

Fortunately for me and much to my daughters' dismay, they lost cellphone coverage in parts of Vermont, New Hampshire and Maine. I didn't blame them for complaining. I didn't go old man on them and tell them (again) that we didn't even have FM radio in our car growing up. "It was a simpler time," as people of every generation invariably say when they reach a certain age. This generation is growing up in an age of constant connectivity — Instagram, Spotify, YouTube and more — it's what they expect.

In the age of immersive technology, everyone will want access to design data.

That expectation of constant connectivity and mobility is a driving force in just about every industry. Not content with connected computers in our pockets, we're putting them in every device where they make sense — and in some that don't. Wearable electronics are the next frontier, according to industry watchers. "In 2014, global mobile data traffic of wearable devices amounted to 15 petabytes per month and is projected to grow to 175 petabytes per month in 2018," according to Statista. That presents some interesting challenges and opportunities for design engineers.

Engineering increasingly smaller products with constant connectivity opens a can of worms that includes battery requirements, software integration, antennae placement, thermal dynamics, electromagnetic interference and user interfaces, just to name a few. As we show on page 16, the upcoming fifth generation (5G) of wireless systems is expected to help solve some of those issues, but there are other, less technical and more personal requirements to consider when designing wearable devices.

Personalization vs. Platforms

In an in-depth interview in *The New Yorker* ("The Shape of Things to Come," Feb. 23, 2015) just before the Apple Watch was launched, Sir Jonathan Ive, Apple's chief design officer, addressed one of the big differences of designing and engineering wearable technology: personalization.

"Ive's position was that people were 'OK, or OK to a degree,' with carrying a phone that is identical to hundreds of millions of others, but they would not accept this in something that's worn," according to the article. "The question, then, was 'How do we create a huge range of products and still have a clear and singular opinion?'"

Creating a "huge range of products" to satisfy different consumers' tastes has equally huge ramifications up and down the supply chain. Beyond the design engineering challenges, it equates to more more manufacturing considerations, more stock-keeping units, more retail display space, and the potential for customer service and maintenance issues are multiplied.

Apple, which is almost as famous for its efficient supply chain as it is for design, took a platform approach with the Apple Watch that was similar to what some automakers have done. They chose to produce just two sizes of the device, then addressed personalization with different finishes and watch band options. This approach reduced complexity where it counts most, but still allowed for the personalization that is critical in wearables.

Collaborate to Control Complexity

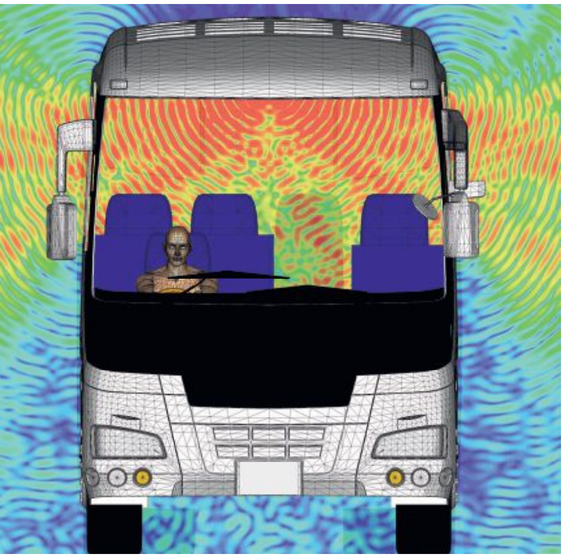
Common platforms are just one approach to dealing with increasing complexity, and the current wearable market is just the first step toward what Intel CEO Brian Krzanich referred to as "immersive technology" and "computing as an extension of you" at the Intel Developer Forum (IDF) keynote in San Francisco in August. "What is changing is that computing and the computing experience is becoming personalized," he said.

As personalization increases in importance, it will drive even greater collaboration among industrial designers, mechanical, electrical and software engineers. Design and engineering need to work hand-in-hand to make the increasingly complex product development process as efficient as possible.

Design engineering software that enables that collaboration is another part of the solution. But to fully realize the potential of collaboration, that software needs to be part of an infrastructure that supports enterprise-wide data management and sharing initiatives. In the age of immersive technology, everyone will want access to design data.

In the not too distant future, maybe my daughters won't have to yell at their kids to put down their phones and enjoy the scenery. Their kids might look out the window and still socialize and be entertained via a heads-up display in the glass. And my daughters will remember when they didn't even have 100% cellular coverage and think "It was a simpler time." DE

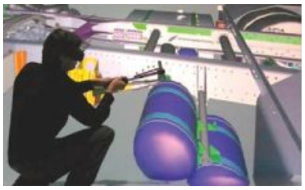
Jamie Gooch *is the editorial director of* Desktop Engineering. *Contact him at de-editors@deskeng.com.*



DE September 2015 VOLUME 21/ISSUE 1

ON THE COVER: Wearables raise the bar for design aesthetics and custom engineering. Images courtesy of iStockphoto, Artefact, IDE Inc., Recon Instruments, Solidscape and MEMI.

DEPARTMENTS



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by Kenneth Wong, Beth Stackpole & Jessica Lulka

Intel Bets on Integrated Iris Pro Graphics

In June at Computex in Taipei, Taiwan, Intel gave attendees a peek at its upcoming processors, including the new Xeon E3-1200 V4 family for the professional market. As he presented the new lineup in a keynote, Kirk Skaugen, senior vice president and general manager of the Client Computing Division, hailed Intel Xeon products as "processors that power more than 90% of the world's data centers."

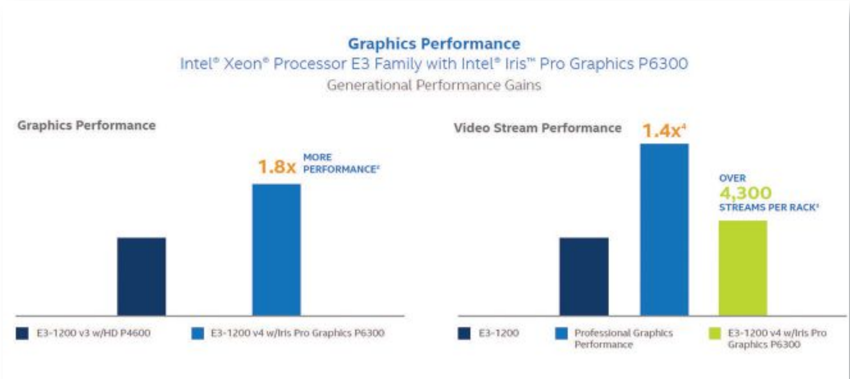
Featuring Intel's Iris Pro integrated graphics, the Xeon E3-1200 V4 processors are a countermeasure to the encroachment of discrete graphics. "Intel is beyond CPU performance. We've been working on graphics and imaging over the last few years," says Skaugen.

Integrated vs. Discrete Graphics

For graphics-intensive applications, gamers, engineers, visual artists and content creators often augment their hardware's processing power with GPUs (graphics processing units), a market dominated by NVIDIA and AMD. By incorporating graphics-boosting features right into the processor architecture, Intel hopes to entice those users to rely less on discrete graphics cards.

"Integrated graphics have a lower bill of materials (BOM), smaller footprint and lower power envelope," says Skaugen. In its product sheet for Xeon E3-1200 V4, Intel writes: "The tight integration of compute and graphics in the same processor increases performance and density, while reducing power consumption and data movement."

In an Intel Chip Chat podcast that aired shortly after Computex titled "Advancing Cloud Graphics with the



Graphics performance benchmarks of Intel Xeon E3-1200 V4, according to Intel.

New Intel Xeon Processor E3-1200 v4," Jim Blakley, Intel's general manager for Visual Cloud Computing, pointed out that the Xeon E3-1200 V4 offers "substantial performance over previous generations." He added, "We get up to almost 2x in graphics improvement overall, almost 2x in media processing and video transcoding." The improvement is expected to produce "very good user experience for remote workstation kinds of applications," Blakley says. He singled out "3D rendering, 3D composition, virtual reality, collecting videos and turning it into 3D representations" as operations that can benefit from integrated graphics.

According to Intel's own published benchmarks, E3-1200 V4 with Iris Pro Graphics P6300 offers 1.8x graphics performance compared to E3-1200 V3 with HD P4600 graphics.

If Intel's integrated Iris Pro offers visualization comparable to what users currently get from the combination of CPU and professional GPU, the new CPUs could disrupt the workstation and server markets. But the professional application developers' ability to harvest the full power of Iris Pro is a critical factor. Reaping computational benefits from the NVIDIA GPUs is made possible by software makers' willingness to embrace NVIDIA's CUDA (compute unified device architecture) parallel programming language.

Virtualization Ahead

Those who plan to deploy remote workstations can expect to benefit from Intel Graphics Virtualization Technology (GVT), which allows administrators to dedicate and distribute resources from the processors to remote workers as they see fit. GPU maker NVIDIA is also aggressively pursuing the virtual workstation market with its own NVIDIA Grid products. (For more, read "Don't Install — Stream!," deskeng.com/virtual_desktop/?p=7794).

Xeon E3-1200 V4 is based on Intel's fifth generation Broadwell microarchitecture. The sixth generation microarchitecture code-named Skylake is expected to debut at Gamescon in September.

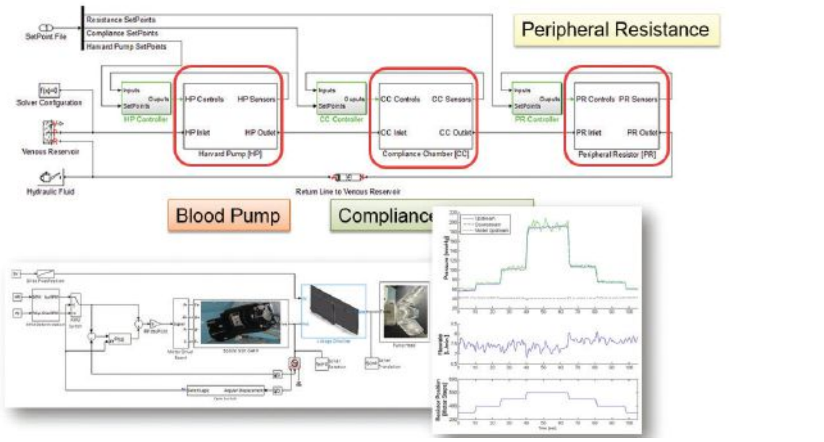
— K. Wong

by Kenneth Wong, Beth Stackpole & Jessica Lulka

Model-Based Design for Medical Devices

Medical technology and modern medicine is constantly seeing new advances. From heart monitors to insulin pumps, new capabilities are being added to these devices, resulting in increased complexity. To address the challenge of product complexity, MathWorks is helping medical device companies see Model-Based Design (MBD) as an option to help optimize, automate and document the design workflow.

MBD implements a hierarchical system model in the center of product development. This means that the executable model serves as a reference throughout design, implementation and testing. With this design method, the workflow is structured to include continuous testing and verification, self-documentation and provides more time for design, says Arvind Ananthan, medical devices industry manager at MathWorks. It also provides the ability to connect the workflow among research, design and implementation — instead of having them siloed.



Simulink model of an experimental setup, and plots comparing pressure in the numerical model and the physical system. *Image courtesy of MathWorks.*

Complexity Drives Medical MBD

While MBD is something that companies in the aerospace and automotive industries have been using for decades, it's now making its way into the medical device design market. This is in part due to the increasingly complex software, greater code requirements and compliance needs. By using multi-domain system modeling, engineers can find ways to catch errors and possible bugs earlier in the design process and fix them while they are cheap to correct.

Carlos Osorio, product applications engineer at MathWorks, recently showcased the capabilities of MBD during a presentation at MathWorks using the combined text and visual environment of MATLAB and Simulink. His talk, titled "Designing a Robot Arm using Model-Based Design," was focused on illustrating how the tools and MBD could help solve a complex engineering problem. The challenge? Creating a programmable robot arm with several motors and several mechanical properties.

What these tools provide, Osorio noted, is a more automated workflow. Instead of taking several hours (or days) to calculate a single property of his robot arm by hand, Osorio managed to simulate several design iterations within minutes. "Once you start thinking of a system, going into a graphical environment allows me to look at the system as interconnected pieces the way they are in the actual physical [product]," he says. Such additional features as CAD-part import and user-specific libraries also help Osorio bring together a series of text files into a fully working simulation.

Osorio's robot arm illustrated how designs can become quickly complicated — even when they are broken down into separate calculations. But by using MATLAB and Simulink, he was able to expedite the design process and predict how his robot would react to certain parameter choices and input stimuli.

The level of automation and reporting MATLAB and Simulink provide is something that more medical device companies are starting to leverage in their own processes to reduce the amount of time they spend documenting their work. "What we have been seeing lately is that some of the top engineers who have moved to medical device companies after working in the aerospace and automotive sector for many years, notice the lack of simulation and modeling methodologies, and call us to equip their new employers with our design tools" says Ananthan.

He observes that part of the medical industry's growing adoption of MBD can be attributed to startups and a host of industry partners.

"MBD is showing its value in the medical device design space. With MBD, engineers can automatically generate code for embedded deployment and create test benches for system verification, saving time and avoiding the introduction of manually coded errors that have a higher likelihood of occurring with the traditional approach," says Ananthan.

Ananthan notes that while MBD is being used for medical device design, it'll be a few years before it becomes a widespread practice. But there are companies such as Philips who uses MBD to develop a digital radio frequency power subsystem for use in MRI systems.

— *J. Lulka*

Aras Innovator Touches Down in Airbus' PLM Backbone

Aras, once a little known, quirky take on open source PLM (product lifecycle management), appears to be carving out a spot in the big leagues, landing yet another large enterprise deal — this time with aerospace giant Airbus.

Airbus recently signed a deal to deploy the Aras Innovator platform across the global enterprise, to support a variety of engineering business processes for up to 30,000-plus users. Airbus, a veteran PLM user, employs multiple PLM and design tool platforms, including Dassault Systèmes' CATIA for digital mockups and ENOVIA as the MCAD vault in addition to PTC's Windchill, which is used to manage and control product data. PTC Windchill is also the cornerstone for the PHENIX (PLM Harmonized Enhanced Innovation Excellence) initiative, an effort to standardize the PLM landscape across the various Airbus divisions.

PLM flexibility is key to supporting Airbus' highly customized global engineering processes for its fleet of aircraft. *Image courtesy of Airbus.*

Complementary Technology

Rather than serve as a replacement for any of the legs of its PLM backbone, Aras is a complementary technology that will augment existing PLM solutions and support niche applications that apply to specific business processes, according to Henrik Weimer, senior manager in Airbus' IT department for engineering organization. While many industry watchers are raising eyebrows over the deal, reading into it that Aras might eventually replace the stalwart PLM systems, Weimer maintains that it's simply not the case.

"Aras is another layer on top of the PLM backbone, but there are other parts as well," he says.

While Aras has had a home in pockets of the organization, Airbus got serious about the company's PLM platform for a number of reasons: For starters, its open architecture and its agility for building solutions due to its interactive GUI (graphical user interface). The key criterion was better visibility into total cost of ownership compared to traditional PLM. Airbus has over 2,000 applications in its PLM portfolio and a variety of different platforms to support, which makes for a very complex environment, heavy on customizations.

As part of its unique subscription model, Aras covers all of the work and cost involved in migrating customizations to a new release — a feature that has a huge impact on the total cost of ownership for PLM, Weimer says. "Upgrading all our customizations can be a very significant cost for us, but because Aras includes it in the subscription, all customizations are carried forward to the next release … and Aras carries the risk and cost of the upgrade," he says.

What makes that promise possible is the underlying technology in the Aras Innovator platform, says Marc Lind, Aras senior vice president of marketing. "With our platform, you are modeling as opposed to writing compiled custom code," he says. "What that means is that the platform underneath can be upgraded while maintaining the integrity of the models — not just out of the box features, but customizations as well."

Aras Innovator's first use case was for a Test Information Management system used across the structural test pyramid in a multi-site operation. For this application, which involves 500 users, Aras helps manage the structure tests, including requirements and test specifications. There are currently three other Aras applications in the pipeline and there will be others going forward, Weimer says.

— B. Stackpole

Licensing, Software & Hardware Configurations

How to optimize COMSOL Multiphysics for common simulation environments.

OPTIMAL computer performance that provides quick simulations is an important factor when choosing appropriate engineering software and hardware. However, a greater need is often how quickly your organization can innovate, design and optimize its products or processes, and how quickly you can get them to market. Finding the right hardware and software configuration for optimal simulation performance that remains flexible for your organization's needs depends on what it is you are trying to simulate.

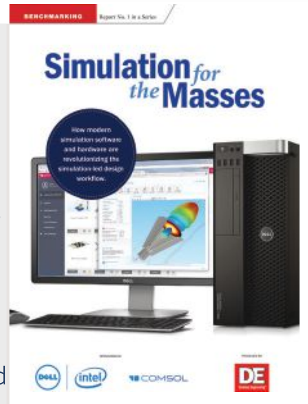
In many cases, the fundamentals of your products' or processes' behavior need to be investigated and operating ranges established. This usually entails small simulations that use the flexibility of COMSOL Multiphysics to quickly set up models, add and couple physics, and investigate many different scenarios. Such simulations can make use of a simple CPU-locked (CPU) or user-locked (NSL) license that will run on any laptop, PC or workstation.

As you optimize your design, you need to investigate more parameters and, ultimately, introduce complexity to your simulations. COMSOL Multiphysics utilizes both shared-memory and distributed modeling through its hybrid modeling feature when using a Floating Network License (FNL). This allows you to model large simulations on standard workstations that support parallel processing or on as many cores and nodes as you want on a cluster.

Once most of the operating conditions or design parameters have been decided, you are often required to find optimal values for operation or manufacture. This can involve sweeping through hundreds or thousands of parameters on clusters in your network or in the cloud. Once again, the standard FNL will support you with this modeling, irrespective of the number of processors you run in parallel.

Finally, you may want to use the experience and knowledge of your organization through engineers who may know a lot about the product or process, but do not have a background in creating simulations. The COMSOL Application Builder can be used to create simplified apps where you control the number and range of inputs and outputs for these engineers to manipulate. A COMSOL Server License (CSL) allows your organization to run these apps from anywhere in the world for a much lower cost than a full version of COMSOL Multiphysics.

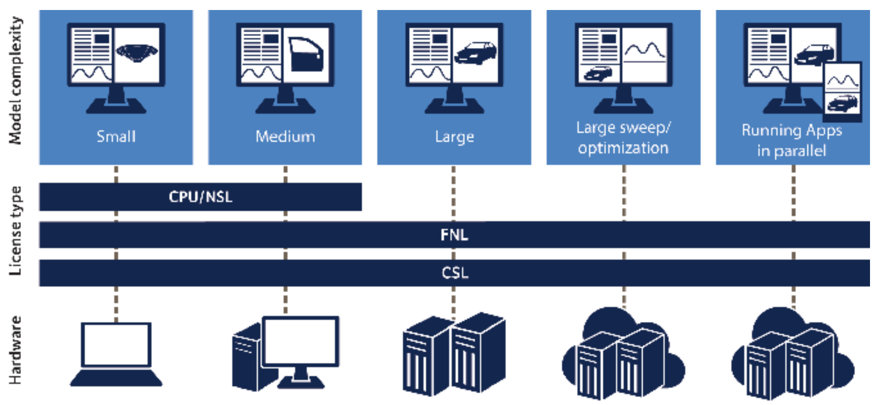
6X Faster Simulations



To learn more about how modern hardware and software can optimize your enigneering team's design process, download "Simulation for the Masses," the first in a series of benchmarking studies produced by ***Desktop Engineering*** with Intel, Dell and independent software vendor sponsors.

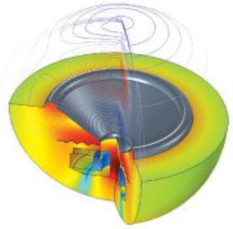
Each benchmarking study pits three-year-old workstations and simulation software against their modern-day equivalents to see how much time can be saved by updating both your hardware and software. In COMSOL's case, the new hardware and latest software completed some multiphysics simulations 6X faster.

Download "Simulation for the Masses" here: deskeng.com/de/benchmark1.

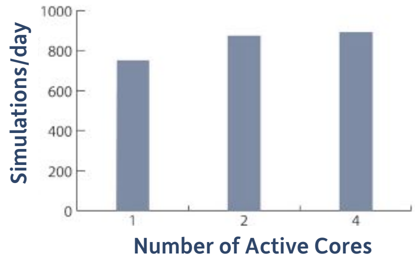


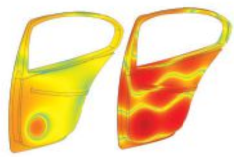
COMSOL offers a number of licensing options. CPU: machine-locked, multiple users. NSL: user-locked, up to four machines. FNL: concurrent-usage controlled, multiple users, unlimited number of nodes. CSL: concurrent-usage controlled, multiple users, worldwide license, unlimited number of nodes. Image courtesy of COMSOL.

Example of Computer Configurations for Different Simulations of Loudspeaker Acoustics in a Car's Interior

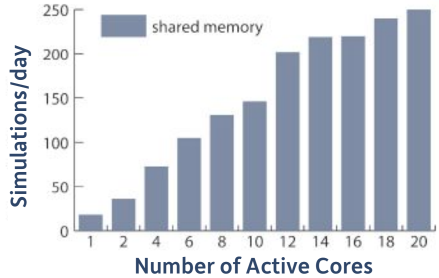


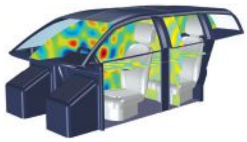
Small
Hardware: Entry-level workstation
Processor: Intel® Core i7-3720QM @2.60 GHz
CPU usage: Shared Memory
Solver: Direct Solver
Memory usage: 2GB RAM (57kDOFs)
Network communication: NA



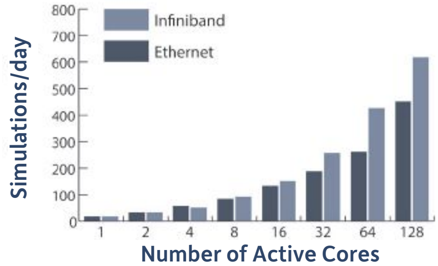


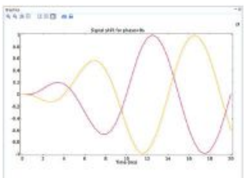
Medium
Hardware: Workstation
Processor: Intel®0 Xeon E5-2643 @3.3GHz
CPU usage: Shared Memory
Solver: Direct Solver
Memory usage: 33GB RAM (1.3MDOFs)
Network communication: NA



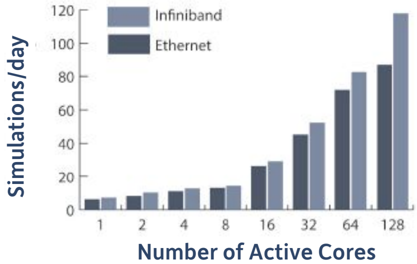


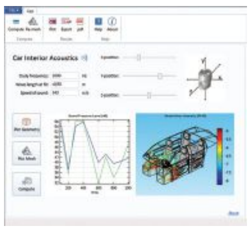
Large
Hardware: Cluster
Processor: Intel® E5-2690v3 @2.6 GHz
CPU usage: Distributed, Hybrid Modeling
Solver: Segregated Solver
Memory usage: 76GB RAM (8MDOFs)
Network communication: Ethernet
v InfiniBand



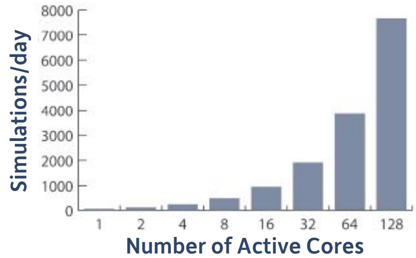


Large sweep/optimization
Hardware: Cluster
Processor: Intel® E5-2690v3 @2.6 GHz
CPU usage: Distributed, Hybrid Modeling
Solver: Direct Solver
Memory usage per parameter: 12GB RAM
(712kDOFs)
Network communication: Ethernet
v InfiniBand





Running Apps in parallel
Hardware: Cluster
Processor: Intel® E5-2690v3 @2.6 GHz
CPU usage: Distributed, Shared Memory
Solver: Direct Solver
Memory usage per App: 2GB RAM
(57kDOFs)
Network communication: Ethernet



Survey is Heavy on Metal

At a recent media summit in Austin, TX, executives of Stratasys Direct Manufacturing (DM) presented strong evidence that current and near-term prospective additive manufacturing (AM) users are expanding into production parts and materials. The company, formed in 2014, combines the strengths and capabilities of Stratasys Red Eye, Solid Concepts and Harvest Technologies manufacturing services, which include a wide range of complementary AM options.

More than three-quarters of the 700 individuals who completed a 36-question survey listed more complex design capabilities and reduced lead times as key benefits of AM. In addition, 73% of the respondents value having access to advanced systems (at minimal risk) through service-bureau options.

Much of the users' viewpoints in this field still revolve around benefits and challenges related to the operation of specific AM approaches. Challenges include cost of equipment, and materials, and slow speeds.

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GF Machining Solutions Integrates 3D Printing

A tool and die company has entered the 3D printing space. Additive manufacturing specialist EOS has entered into a strategic cooperation with GF Machining Solutions, a subsidiary of Switzerland-based industrial company GF (Georg Fischer), to combine EOS' direct metal laser sintering (DMLS) technology and with GF's machine tooling solutions.

The companies will focus on the mold and die sector.

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US Navy Tests Printing Drones at Sea

The U.S. Navy has been actively pursuing 3D printing as a solution to logistical problems for some time. The first solution to be unveiled is the Navy's intention to produce 3D-printed drones on ship. The ability to print drones while at sea can offer commanders a tactical advantage by allowing them to tailor a drone's capabilities for the current mission.

The first test was on board the USS Essex. Digital plans were transmitted by satellite link, and fed into the 3D printer by sailors. The crew then took the printed parts and assembled them, including electronic parts (motors, radio, controller and a GPS unit), which were already on board.

The result was a drone equipped with a camera that offers Navy vessels improved intelligence capabilities when dealing with piracy, drug smuggling or rescues at sea. The drone can provide an overhead look at a ship, or zip around to a side that isn't visible and monitor activities.

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3D Print Custom Bike Parts

Australian start-up Bastion was formed by three Toyota Australia engineers. The company plans to produce custom performance bike frames that include titanium 3D-printed lugs and spun carbon tubes. Bastion will use the Lab 22 facility run by the Commonwealth Scientific and Industrial Research Organization (CSIRO) for production.

The company will create ribbed titanium lugs that allow them to tune the compliance and stiffness of the bike based on customer preferences. The lug design has allowed the company to produce the frame tubes from carbon fiber via filament winding — a process not typically used for frames because of limits on separating compliance and stiffness qualities.

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Harvard Prints Jumping Robot

The Harvard Microrobotics Laboratory has created a jumping, explosive robot. It can jump and land upright thanks to a combination of soft and rigid parts created using a multi-material 3D printer.

The robot's jumps are powered by a butane-oxygen explosion. It can aim itself using a pneumatic leg, then fill its body with oxygen and butane, fire an igniter that expands its flexible bottom and launch itself to a height of 0.75 meters.

The parts of the robot's body were designed with different levels of stiffness to enable the jumps and provide enough protection so the robot would not shatter upon landing. The researchers were able to print the structure as one piece to reduce points of failure in the robot.

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See the Next Generation of Additive Manufacturing

Conference attendees will learn how to integrate additive manufacturing with traditional manufacturing processes.

Over the past few decades, additive manufacturing has been leveraged for applications such as prototyping and short-run production. But as the technology has evolved to provide faster print times, more material options and larger parts, companies are seeing it as an alternative to traditional manufacturing methods in industries like aerospace and automotive. But how do companies integrate it into an established workflow?

From November 17 to 20, formnext powered by TCT answers that question by gathering the world's leading companies in additive manufacturing technologies and specialized tool-making. The conference is organized in partnership with TCT, a company at the forefront of 3D printing, additive manufacturing and product development communities for more than 20 years.

Attendees can discover how the comprehensive combination of additive manufacturing and tool-making can bring faster production times, more customizable parts and lower costs. The event makes Frankfurt, Germany, an epicenter for additive manufacturing by centralizing technology, materials, software and services all under one roof.

An Integrated Workflow

"Many events try to represent additive manufacturing in isolation from the manufacturing process of a product or even highlight only individual aspects. formnext powered by TCT, on the other hand, showcases the full range of opportunities and technologies," says Sascha Wenzler, vice president of formnext at Mesago Messe Frankfurt GmbH. "Above all else, however, formnext powered by TCT demonstrates the interplay between additive manufacturing and conventional procedures such as tool- and form-making. We are convinced that precisely this interplay between new technology and proven procedures harbors enormous potential for the manufacturing industry. formnext will essentially highlight the next generation of product development and manufacturing."

Not only does this event give attendees insight into the latest technology, it also provides the opportunity to see applications of additive manufacturing in a host of industries. These include automotive, health care, aviation, energy, research and development, and electronics. Additionally, formnext examines just how additive manufacturing and tool-making fit into a wider workflow, with discussions on the manufacturing industry, original equipment manufacturers and the process chain.

Learn from Industry Stalwarts and Start-Ups

The conference boasts over 113 exhibitors – including big names such as Stratasys, Materialise and Renishaw. U.S. visitors will be exposed to a host of companies and products exclusive to Europe, bringing new insight into their own practices and technology.

Wenzler says the program highlights both the status quo of additive technologies as well as their short- and long-term prospects. This year's featured speakers are:

- Dr. Hans Langer, CEO of EOS GmbH
- David Reis, CEO of Stratasys
- Michael Breme, head of Toolmaking at Audi AG

The presentations highlight past acheivements of these industry giants and give attendees an exclusive look at their future plans for additive manufacturing applications and materials.

Additionally, visitors can tune in to specific sessions titled "Introduction to Additive Technologies" and "Further Reading," to grow their own knowledge of cutting-edge software, materials and machinery in the industry. Organizations such as the German Society of Materials Science and Fraunhofer Society will be providing insight into these discussions.

Beyond presentations, formnext includes a start-up competition, allowing young European companies the chance to showcase their innovations in additive manufacturing.

"We believe that formnext will provide a valuable impetus to visitors from the U.S. in particular with their resurgent manufacturing industry to reduce time to market as well as improve international competitiveness," says Wenzler.

Register now at formnext.com

Put **Your Design** on Your Sleeve

Artefact Token.
Image courtesy of Artefact.

Wearables present challenges on engineering and design fronts.

BY JESSICA LULKA

Wearables, once only seen on the wrist of Dick Tracy or the worlds of "Star Trek," are now part of peoples' everyday reality, and sometimes their augmented reality. Consumers can track their daily fitness, get the weather or even text messages; all from a device that isn't a smartphone. It's often a watch, bracelet or even glasses. But while the technology is used every day, most consumers don't consider the engineering aspects of a wearable once they put it on.

Consider the Facts

Designing a wearable device requires extensive research and development as well as data collection. The product must function well from both engineering and aesthetic viewpoints. This brings up additional concerns such as comfort, weight, usability and fashion. Ultimately, designers and engineers are tasked with making a product that will give consumers metrics and feedback, and also be something they'll want to wear.

"Unlike technology products that we have in our homes, on our desks or in our pockets, wearables are much closer to us — both literally, on our bodies, as well as often emotionally, as they become an expression of our self. These fundamental differences — comfort, emotional connection and aesthetics — become key design considerations that we have to take into account and solve for when we design wearables," says Markuz Wierzoch, design director at Artefact. "One of our main challenges is to find the right balance between designing a product that is authentic to its technologic core while at the same time has the personality and aesthetics of the everyday items we are used to wearing."

Additionally, engineers need to account for how many possible ways a consumer could interact with their wearable in a way that is easy to learn and intuitive. "Interfacing with the device is always a challenge. You want it to be as hands-free as possible, so buttons and things are not always [an optimal solution]. And voice control works well if you're by yourself. There is noise-cancelling technology if you're in public, but people are hearing what you're saying. The psychology of that is [something to consider]," says David Moriconi, president of IDE Inc., a product design and development firm based in California.

With all these possibilities, it can help to hone in on a niche market, and consider what users in that specific marketplace would want. For instance, at Recon Instruments, a developer of smart eyewear, engineers decided they wanted to provide a product for cyclists and runners, says Ben McConnell, director of Product Management. This helped the team figure out what type of data to provide – such as pace, distance and workout duration – and focus on what hardware was necessary to gather that info.

Taking the "What If" Out of Design

So if you're designing a wearable, how do you ensure a product is going to function, is comfortable for the wearer and has the aesthetic appeal crucial to a success? Iterative prototyping and real-world testing can account for ergonomics and aesthetics.

IDE has in-house CNC (computer numerically controlled) machines, high-precision 3D printers and more to create iterative prototypes quickly and visualize concepts such as look, fit and the human factor, Moriconi says. He also notes it's helpful to realize that you can't create a "one-size-fits-all" product, and to make sure that a product has some adjustability to fit multiple wearers.

"Normally on one end you have engineers who are designing transmission systems, and on the other hand you have an artist who is designing something that is appealing," says Fabio Esposito, president at Solidscape. "What we have been able to do [at Solidscape] is link these two sides."

For example, Solidscape helped MEMI, a smartbracelet developer, finalize its own design through the company's wax 3D printers. To be fashionable, the bracelet incorporated thin walls and curved edges but still needed to house the necessary antennas. To optimize this design, the company used Solidscape's printers to run through several iterations, lower costs and decrease time to market, says Esposito.

Playing Technology Catch-up

In addition to aesthetic and fit considerations, wearables are also seeing some challenges on the technology front. The rise of the Internet of Things (IoT) has brought a push for smaller form factor sensors and power sources. However, wearables such as smartwatches and smartglasses are still somewhat of a niche market, which can make accessibility to components limited.

At Recon Instruments, engineers used chipsets that were optimized for mobile phones when it started developing its Jet smart eyewear product about two years ago. While this helped them create a device that can provide data to athletes, engineers had to figure out how to integrate all the pieces.

But the availability of more wearable-specific components is growing, McConnell says. Companies such as Intel are conducting efforts to create smaller form factor chips that are more suited for wearables. At this year's International Consumer Electronics Show, it released the Curie module, the first purpose built wearable system on chip (SoC). The module is equipped with 80KB of SRAM, a low-power integrated DSP sensor hub, pattern-matching technology and runs on a coin-sized battery. Intel is also investing more in the wearable market, and acquired Recon Instruments in June.

Synopsys, a provider of electronic design automation products and services, is helping wearable companies that are tasked with some of that reinvention.

"One of the keys is to reduce the voltage of those systems," says Ron Lowman, strategic marketing manager for IoT at Synopsys. "By lowering the voltage, you lower the power significantly, that's one of the biggest contributors. We offer low-voltage IP starting with memory and logic libraries that can be characterized down to near threshold or subthreshold voltages. The other piece is having efficient processors with custom instructions."

Additionally, Lowman says it helps to look at the design to evaluate and reduce the number of power cycles to accomplish certain tasks. By doing so, engineers can address challenges such as heat dissipation and power.

A New Generation of Design

Wearable products are ushering in a more expansive workflow. That means having a collaborative team that can bring together the engineering and cosmetic considerations, or requiring product designers to have knowledge of both.

"[I think] there's going to be a blending between fashion designers and product designers who traditionally design hardware gadgets. I don't think it's going to be one over the other, I think it'll be a hybrid designer," says Moriconi.

Recon Instruments consulted with eyewear experts and used mobile phone technology to create smart eyewear for athletes, such as runners and cyclists. *Image courtesy of Recon Instruments*

The Kopin Golden-i Gen 3.8 designed in partnership with IDE, is a hands-free computer with a 14MP video camera, Bluetooth and Wi-Fi for information access. *Image courtesy of IDE Inc.*

By having a team or engineer who is versed in both disciplines, companies can provide not only functioning devices, but a wider variety of design customization. "The lack of variety of design [is noticeable with smart devices]. If you look at the choices you have if you want to go out and buy a wristwatch, you have almost unlimited choices from products that are very inexpensive up to fine art Swiss watches," Moriconi says. "I just don't think that the digital wearables are established enough to have that [variety]."

But even with the smart device market being in a developmental stage, companies still need customization options to help reach a larger consumer base. In the case of Apple's smartwatch, the company offers a host of different wristbands to accommodate varying wrist size and lets users personalize the device.

Even with the emergence of a more hybrid designer or workflow, it's possible that the consumer market for wearables will help establish best practices to the different design challenges. "I liken the head-worn wearable market to where wrist wearables were four or five years ago. And at that time, there were no best practices and it really was a trial and error thing. Now, there's an expectation from the customer on what level of characteristics that need to be included in any smartwatch and they've got best practices there," McConnell says.

Though some wearable Sci-Fi technology is still only available in comic books and movies, it's clear that the industry is innovating to satisfy the need for smaller, faster and more portable technology. **DE**

Jessica Lulka *is associate editor of* Desktop Engineering. *Send e-mail about this article to DE-Editors@deskeng.com.*

INFO ➜ Artefact: ArtefactGroup.com

➜ **IDE:** IDEInc.com

➜ **Recon Instruments:** ReconInstruments.com

➜ **Solidscape:** Solidscape.com

➜ **Synopsys:** Synopsys.com

IoT Connectivity & Communications

5G wireless is on the horizon. What will it mean for design engineers and the Internet of Things?

BY BRIAN ALBRIGHT

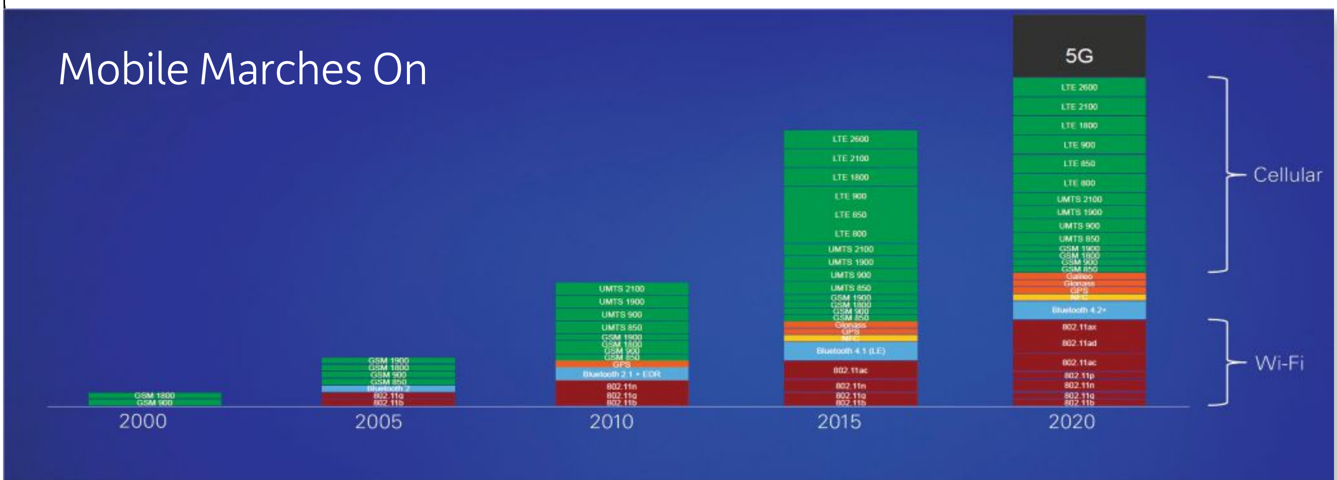
It wasn't too long ago that the switch from 3G wireless networks to 4G LTE technology was looming. 4G adoption in the U.S. now stands at 20%, according to Juniper Research, but a lot of regions still rely primarily on 3G connections, and many machine-to-machine (M2M) solutions use 2G cellular technology.

But even though 4G usage isn't expected to hit 30% until around 2020, the next iteration is already in development. Various industry and standards bodies are working to define fifth-generation (5G) networks, and unlike the move from 3G to 4G (which primarily increased speed and bandwidth), the next shift could require major changes to the network infrastructure. It will also open up new possibilities for designers of connected devices that will be part of the Internet of Things (IoT).

5G is expected to arrive in 2020, and be able to handle roughly 1,000 times the amount of mobile data as today's networks (about 10Gb/s). With 5G, users will see an increased data rate, reduced end-to-end latency, improved energy efficiency and better coverage.

"One thing that 5G is trying to do is address some of the deficiencies in current networks; it's not just focused on increasing data rates," says James Kimery, director of marketing for the 5G, RF and software defined radio group at National Instruments (NI). "It's not just about having a great Netflix experience on a smartphone. This will really open our eyes to what wireless can do for a number of different applications."

Another benefit of 5G is its potential for stronger, vaster coverage. "One problem with cellular network performance is that it degrades at the edge of the network. 5G can solve that problem," says Ken Karnofsky, senior strategist at MathWorks. "Another issue is machine-to-machine communications, which take a number of forms. As you get sensing devices and machines communicating with each other, there are different network consider-



5G is still being defined, but it is expected to arrive in 2020 and eventually be able to handle roughly 1,000 times the amount of mobile data as today's networks. *Image courtesy of National Instruments.*

ations that need to be taken into account."

Those improvements will be critical for applications like connected cars and for IoT devices that are expected to send large amounts of data on a consistent basis to enable real-time visibility. These devices may also communicate with each other over the cellular network, in addition to via Wi-Fi or Bluetooth links.

The move to 5G will also require an adjustment for designers, who will need different types of design skills to develop products with software-defined radios, including RF (radio frequency) design, system architecture, digital signal processing, software development and digital hardware specialists all working in close concert with one another.

"There are new considerations," Karnofsky says. "To optimize the system, the digital algorithm and RF and analog folks usually had different backgrounds and worked with different tools. Engineering teams can't do that anymore."

To accommodate the potentially billions of new devices joining the network via the IoT, researchers are investigating non-orthogonal multiple access scenarios so that many more end devices can share the same bandwidth. Latency also has to improve, because many of the potential IoT applications require direct remote control of devices over the network with real-time response rates.

"If you are trying to control a machine, or you have sensor data and you want to add control to that application, the networks have to be responsive," Kimery says. "For the true IoT experience, latency is one big thing that has to be addressed."

However, 5G is still in the very earliest stages of development — there are still disagreements in the wireless industry about exactly what 5G should be and do.

"It's a very future-looking concept, and there are no industry standards implemented yet," says Brian Daly, director, Core Network and Government/Regulatory Standards at AT&T. "Initial standards are expected to be unveiled through 2018, and relevant standards involving rich set of features will come in 2020 and beyond."

Still, the industry is moving out of the research phase and into building prototypes of potential 5G solutions. "We've seen a dramatic uptick in activity in the past year," Karnofsky says. "The race is on to not only define what the standard will look like, but also to get the IP (intellectual property) defined that will be part of that standard."

A New Type of Network

Whatever form it takes, 5G is expected to enable more flexible mobile solutions. "A concept being discussed is mobility on demand, where you tailor the mobility needs of the devices based on the context of the services the device is supporting," Daly says. "5G will also enhance efficiency by better supporting short burst communications, like you find with the IoT."

Context information will also be known to the network, which allows the network to determine how many resources need to be allocated to an end device within the context of the operator's policies. That's a much different approach than is used currently, and will change the way that end devices and network infrastructure interact.

Getting there will involve the development and adoption of new technology. There's no single technology that will enable 5G; a combination of innovations will make this faster, more responsive network possible, and they are at varying stages of development right now. The key technologies include:

New waveforms: Research is underway to increase the efficiency of existing networks by getting more bits per hertz. New 5G waveforms are probably one of the furthest along of all these technologies, and could be rolled out in the near future, according to Kimery.

Densification: In this case, increased network coverage would be using macro cells, small cells and pico cells. Adding more access points to a service area can create geographic division of the spectrum, thus improving efficiency. Densification is a technique that is already being tested in a limited sense around the world.

"Densification doesn't solve latency or power challenges, but it does address the issue of increased capacity and provides some data rate improvement," Kimery says. "It can be rolled out sooner than later, and then combined with these other technologies."

Massive MIMO (multiple input, multiple output): Massive MIMO can provide more bandwidth and energy efficiency. Massive MIMO base stations use hundreds of antenna elements to focus signal energy on a user. NI is working with several universities on this concept.

"If you have more antenna elements in the same base station, you can guide the energy more efficiently than just blasting waves all over the spectrum," Kimery says. "You transmit with less power, but you get faster data rates."

Millimeter Wave (mmWave) Communications: Spectrum below 6GHz is in short supply, and a dramatic reallocation in the near future is not likely, so researchers have turned their attention elsewhere to the more challenging environment of millimeter wave frequencies. Use of shorter, millimeter wavelengths can provide more spectrum bandwidth (28GHz, 38GHz, 71-76GHz). Nokia has prototyped a mmWave communication link that can produce data rates of 100 times 4G.

"At those frequencies, you don't have to move, or beg or borrow to free up continuous spectrum," Kimery says.

The shift to mmWave technology would require significant changes for both the base stations and handsets or connected devices to use a different part of the spectrum. Until recently, mmWave was considered a non-starter when it came to cellular communications, and significant work remains to commercialize it.

There are other advancements in the works as well. "It's premature to draw real conclusions, but there is a lot of talk about the virtualization of the network, having more software-defined architectures, and using open source solutions in a virtualized environment," AT&T's Daly says. "That represents a fundamental change in the architecture."

Impact on Wireless Design

Designers wondering how this will affect connected products will likely have to wait a while to see how the standards development process shakes out, and how the enabling technologies are rolled out.

There will be a number of advantages, though. In the case of millimeter wave spectrum, the higher the frequency, the smaller the antenna becomes. Product designers can have more flexibility about how the antenna is incorporated into the device.

With more responsive networks, designers will no longer have to accommodate for latency in the design of a connected product. "Most IoT device designers have to solve that problem locally," Kimery says. "Because latency is unpredictable, you have to accommodate that locally. For that to be pervasive, it has to be built into the network."

Power savings will also be an important improvement. IoT devices will need long-lasting batteries. 5G improvements can make the network and the devices connected to it more energy efficient. New 5G waveforms could improve battery life significantly.

For embedded designers, antenna placement and power use will be critical areas in 5G. "Where do you place the antenna, and can you come up with clever algorithms to compensate for the fact that the antenna won't always be in the perfect place?" Karnofsky says. "Low power is another consideration, so which technology is used will depend on how quickly that evolves for lower power types of operation."

IoT devices may provide small amounts of data in short bursts, or provide a continuous feed. A key element of 5G will be how the network serves those types of mixed-use requirements. "We need to provide higher data rates and reduced latency to accommodate certain functions, and there are devices that will require battery life that lasts years or tens of years," Daly says.

"Providing mobility is a really important part of what the specification and use cases are really geared toward," he says. "We want to make sure we build in the security levels to defend against security threats; we have to cope efficiently with high mobility scenarios, inside connectivity, and even high-speed train applications."

For the core physical layer components of the network, designers will have to deal with different ways of modulating the signal, and the interaction between the RF and digital parts of the design will be more and more important. "Companies will need to appreciate and understand the adjacent areas of expertise, and they will need teams staffed with those different areas of expertise, or tools that can help them compensate for that," Karnofsky says.

Another element of interest to designers will be how network signaling is affected by context awareness in the network, and how the device and network will communicate with each other in the future depending upon the application.

MathWorks has already worked with a number of companies that are testing and simulating new waveforms and modulation methods like massive MIMO using its MATLAB tool. "In the past, RF simulation was done in circuit-level simulation, separate from digital simulation," Karnofsky says. "You can use the MATLAB base programming for the digital piece, and high-level graphical simulation for the RF piece in a single simulation."

For designers looking ahead to product development in the post-2020 timeframe, it will be important to research these new enabling technologies, and follow their development. "5G will have an impact on the full ecosystem: the air interface, transport, device, core ... It will touch everything within that ecosystem," Daly says. "In order to understand the direction of 5G, it is important to understand each of those touchpoints." DE

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INFO → **AT&T:** ATT.com/edo

→ **National Instruments:** NI.com

→ **MathWorks:** MathWorks.com

→ **Next Generation Mobile Networks (NGMN):** ngnm.org

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Similar, But Faster

The BOXX GoBOXX 15 SLM mobile workstation outperforms its doppelganger, the MSI WS60.

DAVID COHN

The thin GoBOXX 15 SLM mobile workstation from BOXX Technologies delivers excellent performance in a familiar, lightweight package.
Image courtesy of BOXX Technologies.

This is definitely turning into the year of the thin mobile workstation. No sooner did we finish testing the MSI WS60 (deskeng.com/de/?p=22903) in March when we received the new GoBOXX 15 SLM from BOXX Technologies. Like the MSI mobile workstation, BOXX's compact, high-performance mobile workstation features an Intel Core i7 CPU and NVIDIA Quadro graphics, yet weighs 4.5 lbs. and is just three-quarters of an inch thick. It also appeared nearly identical to the MSI WS60. A quick call to BOXX verified that both are built by the same OEM (original equipment manufacturer).

Once we began our review, however, we noted some subtle differences. Both systems come housed in a black brushed aluminum case measuring 15.35 x 10.47 x0 .78 in. (W x D x H) and include the same 1.5-lb. 180-watt 6.5 x 3.25 x 1-in. external power supply, but BOXX goes with a logo centered on the lid rather than the glowing logo on the MSI system. And while the MSI system was only available with a 2.5GHz Intel Core i7-4710HQ CPU, BOXX offers two choices: A $2,484 system with a 2.6GHz Intel Core i7-4720HQ CPU and the 2.8GHz Core i7-4980HQ CPU in the evaluation unit we received.

Raising the lid on the GoBOXX 15 SLM also revealed another difference. Although the BOXX version of this mobile workstation uses the same 102-key SteelSeries backlit keyboard as MSI, BOXX chose a much less stylized font for its keys. So in spite of its somewhat awkward layout, the large keys on the main keyboard and separate numeric keypad felt more user friendly. Still, there is just one Windows key and we had to hunt a bit to find the function key combinations used to toggle between various power savings modes, control the webcam, toggle Wi-Fi, control the keyboard backlight, adjust the speaker volume and so on. And like the MSI system, the 4 x 2.75 in. touchpad is located about 2 in. to the left of center, resulting in less space to rest your left palm when typing. Although the touchpad includes multi-touch capabilities, the touchpad shut off when we plugged in a USB mouse.

Nicely Configured

Our system came with a 15.6-in. backlit LCD IPS (in-plane switching) panel with a native resolution of 2880 x 1620. A webcam is centered above the display with a single microphone to one side. An LED adjacent to the webcam glows white when the camera is active.

Two stereo speakers are located above the keyboard, beneath a perforated grill. A round power button centered above the grill glows white when the system is using the integrated graphics and amber when the discrete NVIDIA GPU (graphics processing unit) is active.

Bright LEDs along the front right edge of the case indicate the sleep state, hard drive activity, number lock, caps lock, integrated Intel Dual Band Wireless-AC 7260, Bluetooth and battery status. As a result of its slim design, all ports are located on the sides. The right side of the case houses a USB 3.0 port that can continue to charge external devices even when the computer is in power off mode, as well as an SD card reader for XC and HC cards, an HDMI port, an RJ45 connector for the Intel Gigabit LAN, and a Thunderbolt Gen2 port that can be used to connect fast external storage or external displays.

The left side includes headphone and microphone jacks for the built-in Sound Blaster Cinema 2 sound system, two additional USB 3.0 ports, a Kensington lock slot and the connector for the external power supply.

Ventilation ports are located near the rear on both sides, with additional ventilation ports on the bottom of the system. The bottom of the case also provides two additional stereo speakers. Like all of the other thin systems we have reviewed to date, the BOXX GoBOXX 15 SLM is a closed system. Although the bottom cover can be removed to access the fan, hard drive and battery, they are not meant to be user-serviceable.

Since BOXX offers few options, the $3,365 starting price is likely to be what you actually pay. Our GoBOXX 15 SLM Performance Edition came with a quad-core Intel Core i7-4890HQ processor with integrated Intel Iris Pro Graphics 5200. This mobile processor has a maximum turbo boost speed of 4GHz, a 6MB cache and a thermal design power (TDP) rating of just 47 watts. Although the CPU can support up to 32GB of RAM, BOXX only offers the system with 16GB of memory, installed as a pair of 8GB DDR3 1600MHz SO-DIMMs (small outline dual in-line memory modules) in the two memory slots.

Also standard is a pair of 256GB SSDs (solid-state drives). Although the standard configuration we received combines these two drives in a RAID 0 arrangement resulting in a 512GB primary drive, they can also be configured as a redundant RAID 1 array or as two separate drive letters. A 1TB 2.5-in. 7200rpm storage drive is also standard. Because the system lacks an internal optical drive bay, about the only significant option you might consider is a $45 external DVD/RW USB drive.

Also standard is an NVIDIA Quadro K2100M mobile GPU with 2GB of GDDR5 memory and 576 CUDA (compute unified device architecture) cores, the same GPU as in the MSI WS60. Like the MSI system, this mid-range discrete graphics card enabled the GoBOXX to turn in some very good graphics performance.

Excellent Performance

Because the GoBOXX 15 SLM was nearly identical to the MSI WS60, we expected its test results to be similar as well. Thanks to its faster CPU, however, the GoBOXX outperformed the MSI mobile workstation on all but one of our tests — battery life. The integrated 6-cell battery managed to keep the GoBOXX running for 2 hours and 15 minutes, nearly an hour less than the MSI WS60. And like the MSI system, the GoBOXX 15 SLM exhibited the same fan noise we encountered when testing the MSI system. Because the fans are active all the time, the system emits a constant 40dB whine, which climbs to as much as 56dB during compute-intensive tasks — clearly audible against the 29dB background noise in our test lab.

The GoBOXX beat the MSI system on all but one of the SPECviewperf datasets (see page 24). On the SPECapc SolidWorks 2013 benchmark, which is more of a real-world test, the GoBOXX 15 SLM was even more impressive, turning in the second fastest results we have ever recorded for a mobile workstation. We also ran the new SPECwpc benchmark. Here too, this BOXX mobile workstation turned in excellent results.

And on the AutoCAD rendering test, a multi-threaded test where systems equipped with fast, multi-core CPUs have a distinct advantage, the GoBOXX 15 SLM turned in the best results we have ever recorded for a mobile workstation, completing our test rendering in just over 55 seconds.

BOXX preloads Windows 7 Professional 64-bit. Windows 8.1 Pro 64-bit is also available or you can opt to upgrade to Windows 8.1 with DVD playback software for an additional $103. BOXX backs the system with a one-year warranty; a second year extended warranty is $295 extra.

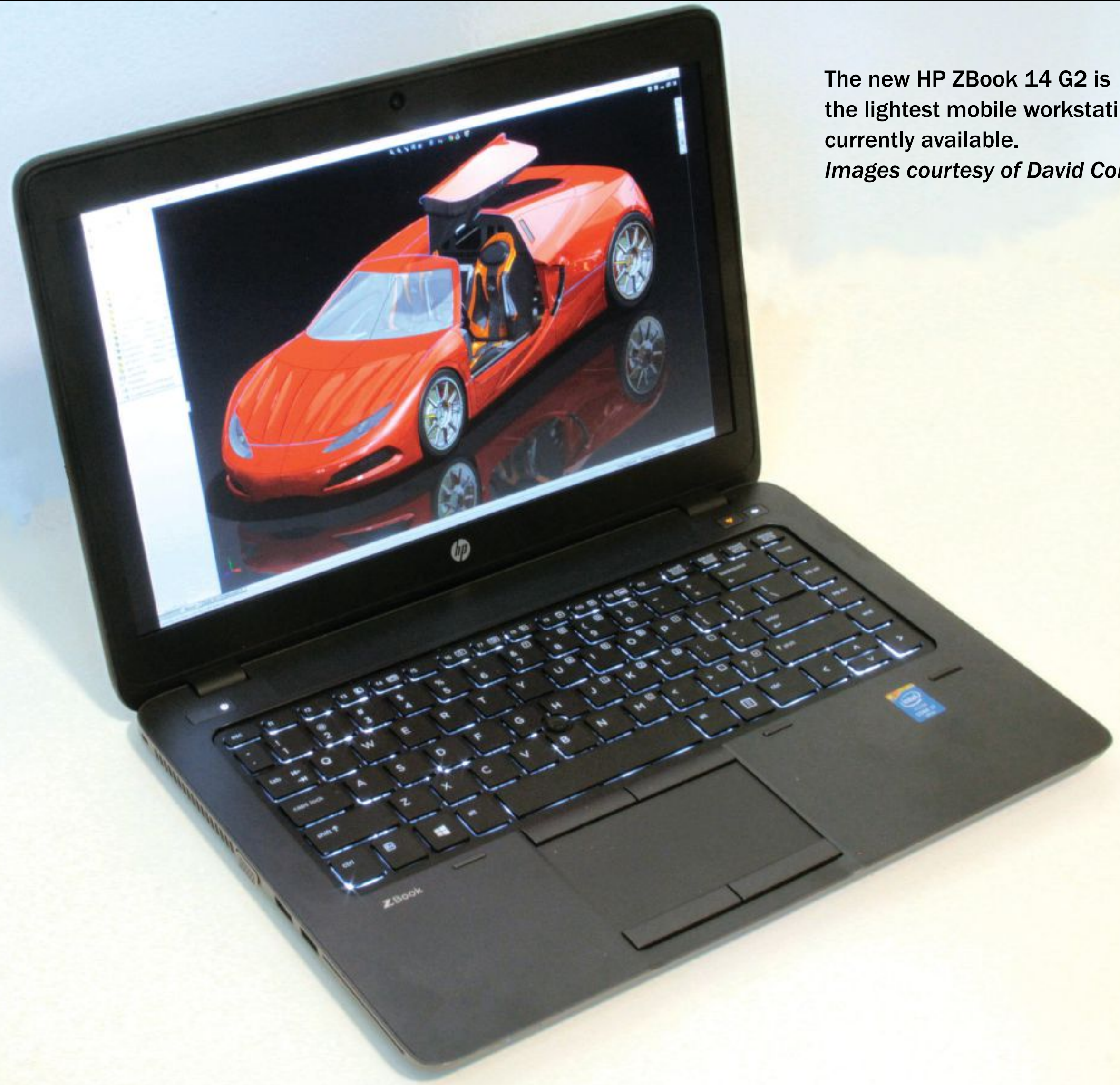
As configured, our GoBOXX 15 SLM costs $3,365. While that is $765 more than the similar system from MSI, the GoBOXX includes a faster CPU and four-times the amount of SSD space, which we think is money well spent. Once again, BOXX has improved on an OEM solution to deliver an excellent mobile solution. **DE**

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

INFO ➜ BOXX Technologies: BOXXTech.com

BOXX GoBOXX 15 SLM

- **Price:** $3,365 as tested ($3,365 base price)
- **Size:** 15.35 x 10.47 x0.78 in. (W x D x H) notebook
- **Weight:** 4.5 lbs. as tested, plus 1.5 lb. power supply
- **CPU:** 2.8GHz Intel Core i7-4980HQ quad-core w/ 6MB cache
- **Memory:** 16GB 1600MHz DDR3
- **Graphics:** NVIDIA Quadro K2100M w/ 2GB memory
- **LCD:** 15.6-in. diagonal (2880 x 1620)
- **Hard Drives:** 512GB SSD (256GB SSD x2 RAID 0) and 1TB 7200rpm SATA
- **Optical:** None
- **Audio:** Sound Blaster Cinema 2 with stereo speakers and built-in microphone, headphone-out and microphone-in
- **Network:** Intel Gigabit LAN (10/100/1000), Intel Dual Band Wireless-AC 7260, Bluetooth
- **Modem:** None
- **Other:** Three USB 3.0, Thunderbolt/mini DisplayPort, HDMI 1.4, 1080p webcam, SD (XC/HC) card reader
- **Keyboard:** Integrated 102-key backlit keyboard with numeric keypad
- **Pointing device:** Integrated touchpad with multi-touch



The new HP ZBook 14 G2 is the lightest mobile workstation currently available.
Images courtesy of David Cohn.

A Workstation in an Ultrabook Disguise

The second generation HP ZBook 14 mobile workstation is a winner.

DAVID COHN

While we have reviewed many HP Z-series workstations, it has been nearly three years since we last looked at a mobile workstation from HP. So we were quite happy when HP sent us its latest entry-level mobile workstation, the ZBook 14 G2, an update to the original ZBook 14 introduced several years ago.

HP refers to this thin, lightweight, solid-state mobile workstation as the "industry's first mobile ultrabook," and positions the system as a value-priced entry-level mobile workstation. Regardless of what you call it, the ZBook 14 G2 is likely the only 14-in. computer that qualifies to be called a workstation.

Weighing just 3.9 lbs. (plus 13 oz.

for its tiny 65 watt A/C power supply and cord), the HP ZBook 14 G2 is truly portable. It features a brushed aluminum exterior skin bonded to a magnesium-alloy chassis that measures 13.35 x 9.33 in. and is just 0.83 in. thick. The HP logo is centered in the top panel, which is surrounded on three sides by curved edges with a rubberized coating, making it easy to grip the system for carrying.

Raising the lid reveals an 86-key backlit keyboard with a mostly conventional layout and a good feel when typing. Our evaluation unit included a pointing stick nestled between the G, H and B keys, with dedicated left and right buttons below the spacebar. There is also a 3.8 x 1.12 in. touchpad centered in the palm rest, with its own dedicated left and right buttons below. A fingerprint reader is positioned below the right corner of the keyboard and a pair of speakers situated above.

The power button is located in the upper-left, above the keyboard, and glows white when the computer is on. To the upper-right of the keyboard are dedicated buttons to toggle the built-in wireless capabilities and mute the speakers. The caps lock and number lock indicators are within the keys themselves. LEDs along the left front edge of the case indicate wireless, power, charging status and hard drive activity. These glow but are not at all distracting.

Our evaluation unit came with a beautiful 14-LED FHD UWVA anti-glare 1920 x 1080 display, which added $75 over the base 1600 x 900 panel. Touchscreen capability would add another $125 to the price. An optional 720p HD webcam ($24) was centered above the display, flanked on the right by a white LED that lights when the webcam is active.

The HP ZBook 14 G2 provides a few more ports than many other thin, lightweight systems. For example, along the right side is a combination microphone-in/headphone-out jack, a DisplayPort, two USB 3.0 ports, an RJ45 network port, a docking connector, and the port for the external A/C power. On the left side are two more USB 3.0 ports (including one that can charge external devices), a VGA port, a smart card reader, and a security cable slot.

Modest Choices

HP equipped our ZBook 14 G2 with an Intel Core i7-5600U Broadwell CPU, a dual-core 2.6GHz processor (3.2GHz max turbo) with a 4MB cache and an extremely frugal 15 watt thermal design power (TDP) rating. Other CPU choices include the 2.2GHz Core i5-5200U, the 2.3GHz Core i5-5300U, and the 2.4GHz Core i7-5500U. All of those dual-core CPUs incorporate Intel HD Graphics 5000 and all ZBook 14 G2 models also

Mobile Workstations Compared

		HP ZBook 14 G2 2.6GHz Intel Core i7-5600U dual-core CPU, AMD FirePro M4150 and Intel HD Graphics 5500, 16GB RAM	BOXX GoBOXX 15 SLM 2.8GHz Intel Core i7-4980HQ quad-core CPU, NVIDIA Quadro K1100M, 16GB RAM	Eurocom P5 Pro 4.0GHz Intel Core i7-4790K quad-core CPU, NVIDIA Quadro K5100M, 32GB RAM	MSI WS60 2.5GHz Intel Core i7-4710HQ quad-core CPU, NVIDIA Quadro K2100M, 16GB RAM	Dell Precision M3800 2.2GHz Intel Core i7-4702HQ quad-core CPU, NVIDIA Quadro K1100M, 16GB RAM	MSI GT70 20LWS 2.4GHz Intel Core i7-4700MQ quad-core CPU, NVIDIA Quadro K4100M, 16GB RAM
Price as tested		$2,115	$3,365	$4,489	$2,600	$2,887	$3,200
Date tested		2/20/15	2/4/15	2/4/15	1/17/15	3/13/14	11/25/13
Operating System		Windows 8.1	Windows 8.1	Windows 8.1	Windows 7	Windows 7	Windows 7
SPECviewperf 12	higher						
catia-04		15.09	21.26	64.64	21.26	14.74	n/a
creo-01		16.57	20.28	48.70	19.98	13.37	n/a
energy-01		0.06	0.32	2.61	0.32	0.28	n/a
maya-04		9.09	18.20	48.84	17.90	12.79	n/a
medical-01		2.70	5.71	23.93	5.71	3.72	n/a
showcase-01		7.58	10.35	27.86	10.63	8.50	n/a
snx-02		20.06	22.10	58.41	22.05	14.74	n/a
sw-03		29.21	34.53	97.38	32.32	19.43	n/a
SPECviewperf 11	higher						
catia-03		35.23	47.85	80.24	45.66	33.56	72.47
ensight-04		17.51	24.55	86.39	24.09	17.50	50.62
lightwave-01		65.87	77.62	94.51	64.37	58.84	64.39
maya-03		61.30	81.14	178.55	77.78	61.83	112.33
proe-05		9.70	21.57	22.67	18.26	15.37	18.38
sw-02		43.45	52.31	81.17	47.80	39.48	55.00
tcvis-02		13.38	37.24	70.60	36.95	28.69	60.63
snx-01		23.55	31.76	89.35	31.85	23.76	59.76
SPECapc SolidWorks 2013	higher						
Graphics Composite		2.98	5.59	9.00	3.08	2.41	5.27
RealView Graphics Composite		3.26	5.86	10.61	3.23	2.71	6.27
Shadows Composite		3.20	5.92	10.65	3.23	2.34	6.26
Ambient Occlusion Composite		4.63	7.21	21.36	3.51	2.20	13.00
Shaded Mode Composite		2.90	5.36	8.88	2.96	2.31	5.78
Shaded with Edges Mode Composite		3.07	5.82	9.12	3.21	2.51	4.80
RealView Disabled Composite		2.08	4.61	4.66	2.55	2.40	2.62
CPU Composite		2.65	3.88	4.25	3.06	2.41	3.74
Autodesk Render Test	lower						
Time	sec.	124.28	55.39	56.88	63.30	71.42	60.33
Battery Test	higher						
		7:28	2:15	2:10	3:13	6:12	4:34

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

include a discrete AMD FirePro M4150 GPU (graphics processing unit) with 1GB of dedicated GDDR5 memory.

The base ZBook 14 G2 configuration comes with just 4GB of RAM. Our evaluation unit came with 16GB, installed as a pair of 8GB DDR3 1600MHz DIMMs (dual in-line memory modules), the maximum that the system can accommodate. This added $310 to the base price.

Unlike other ultra-thin laptops, the bottom of the ZBook 14 G2 is removable for easy access to the replaceable 3 cell 50 WattHour battery as well as the hard drive bay, memory slots and sockets for accessories like the optional broadband module. The ZBook 14 G2 can accommodate both an internal hard drive and an HP Z Turbo Drive, essentially a SSD (solid-state drive) on a PCIe mini card. Our evaluation unit came with a 256GB SSD installed in the drive bay. HP also offers SSDs up to 512GB and standard SATA drives with 512GB or 1TB capacities that can be installed in addition to the HP Z Turbo Drive. The 256GB SanDisk SSD in our system was a $358 option. At $398, the 256GB Turbo Z Drive might be a better choice — particularly if you also added a large data drive.

HP also sells a number of accessories for the ZBook 14 G2, including an external DVD+/- RW drive ($69) and an UltraSlim docking station ($149), but this is a side-docking solution due to the system's thin design. Near field communication and mobile broadband are also available.

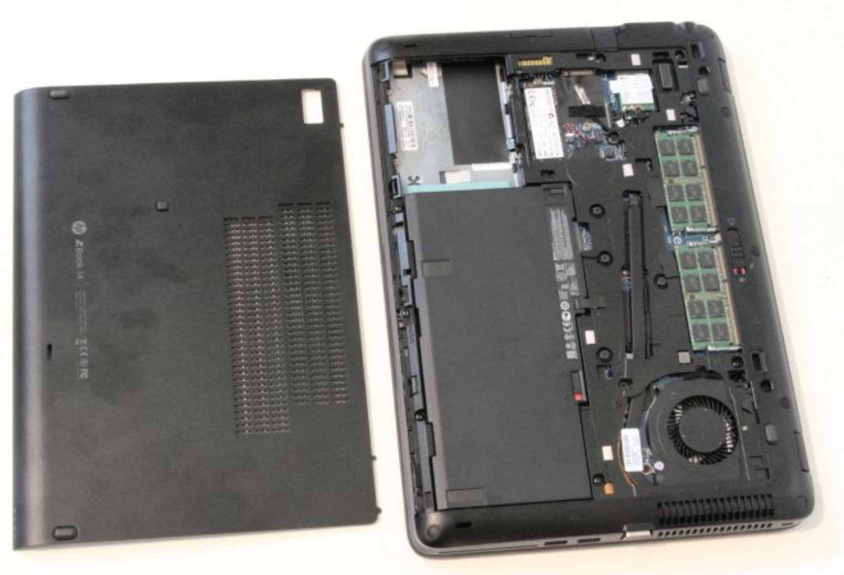
The Compromise

With its frugal power consumption, we expected the battery life to be quite good, but the results of our battery rundown test surprised us. The system ran for nearly 7.5 hours on a charge, the best result we have ever recorded for a mobile workstation.

Unfortunately, the tradeoff for being thin, light and thrifty is performance that definitely placed the ZBook 14 G2 at the lower end of the mobile workstation spectrum. On the SPECviewperf test, which looks solely at graphics performance, the HP ZBook 14 G2 lagged behind most of the other systems that we've tested over the past several years.

On the SPECapc SolidWorks benchmark, which is more of a real-world test, the ZBook 14 G2 did a bit better. Although it fell well behind many of the other mobile workstations we've tested recently, it did edge out the original Dell M3800 we reviewed last year.

But on the AutoCAD rendering test, a multi-threaded test where systems equipped with fast, multi-core CPUs have a distinct advantage, the HP ZBook 14 G2 lagged far behind the rest of the field, averaging more than 2 minutes to complete our test rendering. Those results were not unexpected. The ZBook 14 G2 is built around a dual-core CPU



A removable bottom panel makes the ZBook 14 G2 perhaps the only ultrabook with serviceable components.

while all the other mobile workstations we've reviewed recently incorporated quad-core processors. According to HP, the company opted for dual-core CPUs in the ZBook 14 G2 because the thin and light form factor doesn't allow enough space for the thermal requirements to include quad-core CPUs. That explanation seemed a bit curious, however, because the HP ZBook is a fraction thicker than the Dell M3800.

The ZBook 14 is also the only system we've tested recently that offers an AMD graphics card as the only discrete GPU option. Again, an HP FAQ provided an explanation: "The ULT processors on the HP ZBook 14 G2 work with the discrete AMD FirePro graphics to provide up to mid-level workstation-class performance. However, for heavily threaded applications or users requiring the greatest CPU performance, the HP ZBook 15 G2 and 17 G2 should be considered."

Interestingly, the AMD Catalyst driver automatically determines whether to run an application on the Intel HD graphics or the discrete AMD graphics. For most CAD and DCC software, the decision was straightforward and the software got it right. But for some of our benchmarks, particularly the SPECviewperf test, it guessed wrong and initially ran the test on the Intel graphics, resulting in terrible performance and some view sets that the system was unable to complete. You can, however, manually configure the AMD drive if necessary, which we did in order to obtain the best results.

Throughout our tests, the HP ZBook 14 G2 was practically silent. HP preloaded Windows 7 Professional 64-bit. Windows 8.1 is also available as well as FreeDOS and Ubuntu Linux. Like all of its other workstations, the ZBook 14 G2 is ISV (independent software vendor) certified and backed with a three-year warranty. Longer warranties as well as options such as next-day on-site service and accidental damage protection are also available.

The HP ZBook 14 G2 stands out as the lightest mobile workstation currently available. It looks great, has user-serviceable components, and delivers decent performance coupled with amazing battery life. Although our system priced out at $3,022 as configured, HP is currently offering a 30% discount, bringing the cost down to $2,115. At that price, the HP ZBook 14 G2 is hard to beat. DE

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INFO → HP: HP.com

HP Workstation Z1 G2

- **Price:** $2,115 as tested ($3,022 before discount)
- **Size:** 13.35"x9.33"x0.83" (W x H x D) notebook
- **Weight:** 3.88 lbs
- **CPU:** Intel Core i7-5600U 2.6GHz dual-core w/ 4MB cache
- **Memory:** 16GB DDR3 1600MHz
- **Graphics:** AMD FirePro M4150 w/1GB GDDR5 and Intel HD Graphics 5500
- **Hard Disk:** 256GB SSD (can accommodate both a PCIe mini card SSD and internal drive)
- **Floppy:** None
- **Optical:** None
- **Audio:** DTS Studio Sound with integrated stereo speakers and microphone
- **Video:** 720p HD webcam
- **Network:** Integrated Intel i218-LM gigabit network; optional dual-band wireless 802.11a/b/g/n, Bluetooth, mobile broadband and near field communications
- **Modem:** None
- **Other:** Three USB 3.0, one USB 3.0 charging, one DisplayPort, one microphone-in/headphone-out combo, A/C power, RJ-45, docking connector, VGA, smart card reader
- **Keyboard:** Integrated 86-key backlit keyboard with integrated pointing stick
- **Pointing device:** Integrated touchpad with multi-touch

Maximize SOLIDWORKS Performance

Performance can be dramatically improved with cost effective hardware upgrades and simple configuration changes.

DASSAULT Systèmes SOLIDWORKS has helped millions of designers bring products to market, but not every user is obtaining the full benefits of the design engineering software. The problem: sub-optimal computing environments that slow down the performance of SOLIDWORKS and other design solutions, causing a drag on the productivity of valuable employees.

Running SOLIDWORKS on an optimized and correctly configured workstation allows for faster design iterations, improved productivity, greater creativity and more innovation for SOLIDWORKS users and their employers. What's more, these optimized workstations don't have to be a drain on your departmental budget. In fact, critical improvements in performance can be achieved with a relatively low investment.

The Latest Research

So how do you know what the optimal workstation configuration is for your own team of SOLIDWORKS users? SOLIDWORKS reseller Computer Aided Technology (CATI) has, through years of testing and research, come up with an answer — or answers, as it turns out, because "optimal" performance will vary by end user. For more than 20 years, CATI has provided training, installation, configuration services and support to SOLIDWORKS users. And for the past seven years, the company has embarked on a lengthy and intensive research project to determine the best hardware environment for SOLIDWORKS software in order to ensure maximum productivity.

For its most recent research, CATI designed a series of rigorous tests using typical workstation configurations and ran them using customer-supplied test models of increasing complexity and size. They then ran a standard series of SOLIDWORKS operations on those models representing commonly performed work tasks.

The Optimal Computing Environment

CATI has outlined an optimal computing environment for SOLIDWORKS that can significantly improve performance. By investing in an Intel® Core™ i7-based CAD workstation environment with sufficient RAM, a solid state drive, fast processors and robust graphics, users can increase SOLIDWORKS productivity enough to provide a return on investment in months or even weeks through accelerated design operations.

There is no single best answer for improving SOLIDWORKS performance, but CATI has developed a methodology that can point to the most practical and affordable configurations based on model size and complexity, as well as graphics operations. Using their research as a guide, users can quickly identify hardware improvements that can immediately boost design productivity.

Defining the Research Methodology

For its most recent round of CAD workstation configuration testing, CATI took a slightly different approach than in previous tests. In those earlier tests, CATI loaded a large assembly and created a macro to run repeatable SOLIDWORKS functions against the assembly. The macro was performed on the baseline hardware configuration, and then repeated as different elements (such as the amount of RAM or the number of cores) were changed. The models were identical every time the test was run.

"Our data in the past was skewed toward people who really pushed the machines hard," says Adrian Fanjoy, CATI's technical services director. To provide a broader range of recommendations for users with different levels of assembly complexity, CATI developed a testing program that allowed them to test seven different model assembly sizes and five different levels of image quality. Assembly sizes ranged from 94 components to more than 20,000 components. The different sized assemblies are dropped into an existing base assembly, so that the same operations can be run each time.

The application programming interface (API)/instruction set was also altered to test computational work (such as modeling, rebuilds, etc.) separately from graphics functions.

The instruction set was meant to mimic operations routinely performed by CAD users, and included:

- Opens
- Rotations
- Modeling
- Rebuilds
- Switching Sheets
- Saves
- Closes

"The benchmark runs much faster this time around," Fanjoy says. "We're doing part modeling, adding components into the model, patterning features and parts, editing of features, and some deletion and creation of features at the part and assembly level."

CATI also focused on specific workstation variables this time, primarily the amount of RAM and the processor speeds, which also simplified the benchmark testing. Each assembly size was tested against these different workstation configurations to measure the amount of time it took for the API/instruction set to run.

The testing also required a flexible and scalable hardware platform that could be reconfigured easily to maintain the level of consistency needed for the study. As in the past, CATI partnered with workstation manufacturer BOXX Technologies.

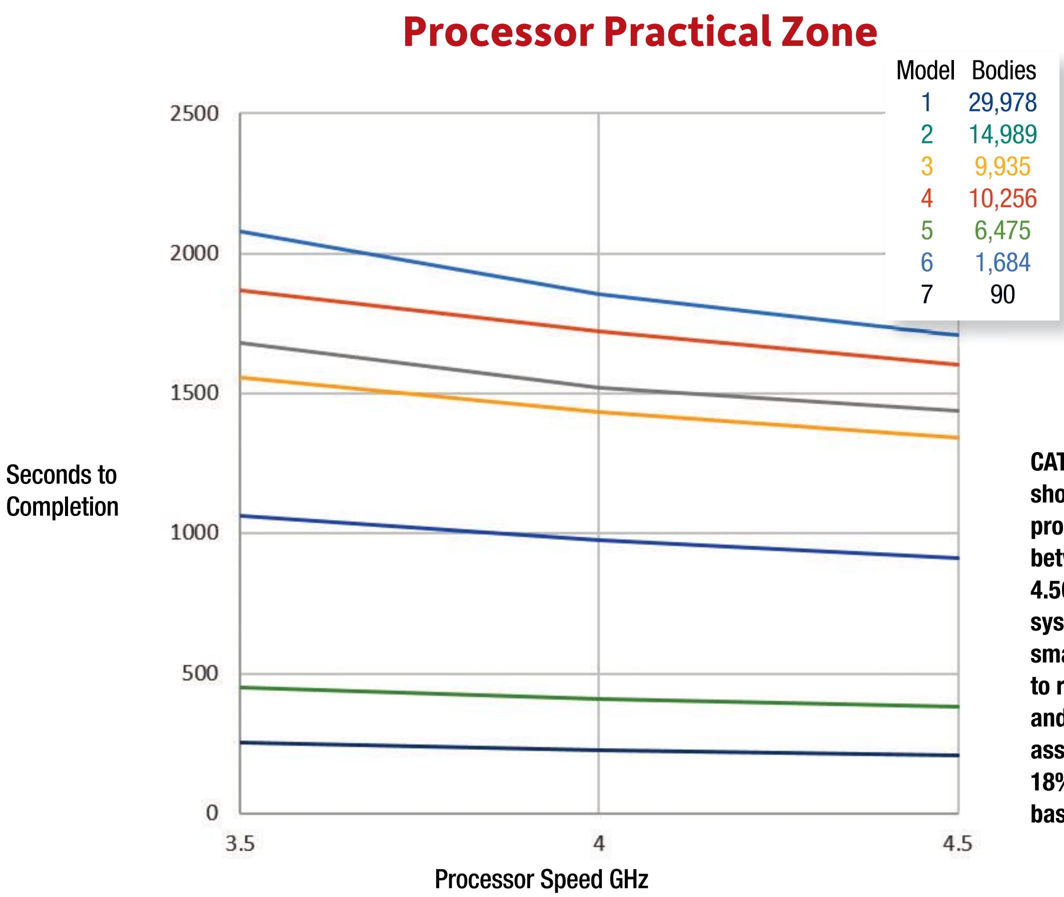
BOXX Technologies provided an APEXX 2 workstation with an Intel solid state drive (SSD) and one four-core Intel Core i7-4790K series processor running at 4.06GHz (4.5GHz when overclocked). CATI tested memory up to 32GB of RAM and several graphics card configurations. Overall the workstation is faster than previous models used for testing, but with fewer cores.

In addition to simplifying the instruction set, CATI also reduced the number of hardware variables it tested against. "We have a more general knowledge now of what will affect performance," Fanjoy says. "Everybody knows that SSD is the way to go, and we know that we don't need more than a reasonable number of cores, and we took out the very high range of graphics cards. We focused on what actually makes a difference in the environments we currently work in."

Find Balance

To learn how to balance your workstation's processor, memory, hard drive and graphics, read the white paper "Maximize SOLIDWORKS Performance," which was produced by *Desktop Engineering* based on CATI's research and sponsored by Intel. By following the guidelines found in this paper, you can configure a productive, affordable CAD workstation suited for your specific environment. The 12-page paper is available for free and requires no registration.

Download it here: deskeng.com/de/maximize



CATI's research showed that processor speeds between 3.5 and 4.5GHz allowed the system to run the smallest assembly to run 19% faster and the largest assembly to run 18% faster than the baseline.

Community Content Elevates Part Catalogs

Digital catalog aggregators confront rich-data requests and consider adopting some characteristics of user communities.

BY KENNETH WONG

Sam Wurzel, cofounder and CEO of Octopart would love to see the name of his company become a household word synonymous with searching for electronic components online. He said: "People now say 'Google it' to look up something. All design engineers might one day say 'Octopart it' — some already do." If it were up to Bob Noftle, president and chief evangelist of TraceParts Inc. U.S.A., engineers would say "TraceParts it."

Xerox and Google are among the few companies whose names became transitive verbs due to their pervasive influence. The use of data and content from catalog aggregators like Octopart and TraceParts Inc. is certainly pervasive in design engineering, but they're often integrated deep inside CAD and PLM (product lifecycle management) programs, so their brand recognition may not rise to the same level as a Xerox or Google.

Octopart serves as a gateway to more than 30 million electrical components from different suppliers. Its API (application programming interface) is integrated into CircuitHub, Omnify, Arena Solutions, Altium Designer and Autodesk PLM 360, among others. The TraceParts Inc. database contains more than 100 million 3D models of catalog parts. It's accessible from CAD products like Solid Edge, KOMPAS-3D, SolidWorks, Autodesk Inventor and SpaceClaim.

When design engineers migrated from the drafting table to CAD, paper-printed part catalogs became dead weight and doorstops. Today, the standard approach to specify a part or component in a project is to search for it online and insert it into a 3D assembly. For a time, CAD models, part numbers and costs were all the data required from part catalogs. But the engineers' increasing reliance on digital prototypes for simulation and compliance demands more data from part suppliers. The Yelp and Amazon generation's desire to rate products, post reviews and read comments also demand a new interface for delivering standard parts. To satisfy these changing needs, part catalog vendors may have to adopt certain characteristics of the online 3D user communities.

Downloadable Models Are in Demand

The two basic characteristics of digital part catalogs that make them a much better alternative to paper catalogs are interactive 3D previews and downloadable 3D models. "First, engineers can get a pretty good idea that the part is what they're looking for by seeing a viewable 3D model. Second, they can give it a quick once-over and make sure the model doesn't have any gross errors. It's a comfort to the designer that we're willing to show the model before they spend time downloading the data," says Jeremy Purcell, applications engineer at Digi-Key.

The growing need for these digital catalogs is in part due to the expansion of more compact, complex devices. "In the past, engineers could work with just the specs of the electrical components. But as the product form factors begin to shrink to become wearable devices, the 3D models of the components become increasingly important. With these devices, clearances are tight, heat dissipation is a major concern, and merging electronics and mechanics is necessary. So the 3D models are important," says Octopart's Wurzel.

But the CAD models may not always be available, not for a lack of effort among the catalog aggregators. "Some component manufacturers who are early tech adopters put in efforts and resources to create 3D CAD models of components. But many are not there yet. So some users — design engineers — are beating them to the punch," Wurzel says.

The long-lasting format war also complicates the delivery of downloadable parts. "I wish there was some mandate for a standard format, but the truth is, CAD vendors compete to steal seats from one another, so they want to protect their formats," says TraceParts Inc.'s Noftle.

But there are interoperable options available. "STP, IGS and PDF are the hot formats now. We do know there are many formats out there, but these three seem to be shaping up as the preferred options. In the future, there may be a more universal format created but we have not seen any clear option yet," says Purcell.

Simulation and Compliance

At the website explaining the requirements for REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals), the European Chemicals

Agency curtly warns: "No data, no market." The responsibility, it declares, is "on industry to manage the risks from chemicals and to provide safety information on the substances."

For design engineers assembling new products out of a mix of custom-designed parts and catalog parts, green facts and environmental data are now more important than ever. They can be the deciding factor in a product being rejected or approved for sales in the target region.

"One challenge is getting environmental compliance content directly from electronic component manufacturers. We see component manufacturers' data as authoritative," says Wurzel.

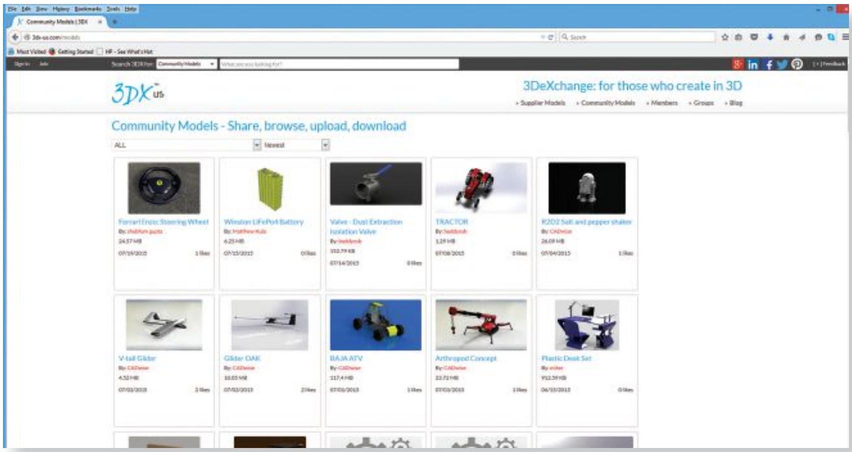
Aggregating content from more than 650 suppliers, Digi-Key delivers 3D models of components from Mentor Graphics, Xsens, Advantech, Samsung Electronics and other suppliers as 3D models "We are in many EDA (Electronics Design Automation) and CAD software since we have worked very hard to normalize and compile as much data on our parts as we can get. It takes a lot of effort to present the data from each manufacturer in the same context with an organized method," says Purcell.

GrabCAD originated as a space for 3D software users to share files, tips and network.

Some of the data collected may be critical to those who want to conduct simulation at the assembly level. "Data for electrical test and simulation is getting better. Some manufacturers offer 3D models and a few offer SPICE models (for Simulation Program with Integrated Circuit Emphasis). But most parts from manufacturers are basic symbol and footprint data, which does not aid in simulation or testing," Purcell says.

Tiptoeing into User-Created Content

Before he launched TraceParts Inc.,



The 3DXCommunity from TraceParts Inc. not only provides a wide selection of parts from suppliers, it also regularly holds design contests for its users.

Noftle helped launch SolidWorks 3D Content Central. In doing so, he noticed that most activities associated with user-contributed content were fueled by those creating and uploading component models they couldn't find. "When the users go to a supplier's site to download the model, they get a certified, supplier-sanctioned model. But if the model is not available, they might create the model themselves based on the supplier's reference materials and share it with others," he says.

This experience convinced him to make his new venture TraceParts Inc. a hybrid portal, housing both supplier models and user-created models. Noftle and his colleagues also offer digitization services to suppliers who do not have the resources to create their own 3D models.

User-created content on TraceParts Inc.'s 3DX portal is not strictly for pragmatic needs. It also has a lot to do with fun, friendly competition and bragging rights. Frequently, users try to outdo one another by showing off their modeling skills with complex spacecraft and alien creatures sculpted out of their favorite 3D packages in their own free time. TraceParts Inc. encourages this by holding regular design contests.

At GrabCAD, owned by global 3D printing and additive manufacturing solutions provider Stratasys, a thriving user community coexists alongside an online collaboration product called GrabCAD Workbench. "Users may find inspiration from a community project and decide to incorporate elements into their own design. We ask that people downloading from the community request the uploader's permission for any commercial applications," says Lindsey Christensen, director of Marketing at GrabCAD.

Regular design challenges are a well-known feature of GrabCAD. They give members a chance to flex their modeling muscles and win prizes, sometimes leading to paid assignments and contracts. "We've launched many exciting new design challenges in just the last few months: the Veteran's Association sponsored a challenge to design accessories for prosthetic limbs; the Stratasys Aerospace Challenge is bringing additive manufacturing to satellite design; and we've worked with repeat sponsors like GE, NASA and many others," says Christensen.

Digi-Key's Purcell said: "If an engineer can find a source with quality parts that meet their needs, I think there would be no hesitation to use both [manufacturer-supplied models and user-created models]. Several companies and websites have gained popularity, even so much that manufacturers have now been utilizing them to create content. Accelerated Designs and SnapEDA are examples."

Working with user-created models downloaded from a public source is a double-edged sword. On the one hand, it saves time because someone has gone through the trouble to create the 3D model. But GrabCAD's Christensen cautioned: "As with anything, an engineer should do their due diligence and inspect any part they plan to incorporate for production."

These user-created models may also not be as verified as others. "Usually supplier models have been checked for form, fit and function. User-created models should be the last resort, because the accuracy of the model is only as good as the author wants it to be," Noftle says.

Social Engineering

The ever-changing counter at GrabCAD's home page shows that, as of early August, the site is home to 2,280,000 engineers and 890,000 models. The site originated as a place for 3D software users to network, exchange tips and share content. It launched in August 2010 and reached a milestone in Christmas 2011 when it logged its 1 millionth download. The vast pool of active, engaged 3D users on GrabCAD is a tantalizing market for component suppliers and vendors.

GrabCAD's Christensen revealed that the company has been approached by many part suppliers who want to offer their content to the community. "The community currently consists entirely of user-created content. Including standard parts isn't something we've ruled out for the future. But we are not currently partnered with anyone," she says.

Member activities on GrabCAD are also fueled by Yelp- and Amazon-style peer reviews and comments. The social media-inspired features from the online community are carefully observed by component syndicators like Octopart, Digi-Key and TraceParts Inc. But, adopting a standardized rating system or allowing comments may prove challenging.

"What would work for one engineer may not meet another's expectations. Company engineers don't want to take the time to explain why and how parts don't meet their needs and the companies don't want their proprietary info pushed out to communities. In the end, everybody has different needs and many of the parts are very complex, and won't work with a one-size-fits-all rating system," says Purcell.

Wurzel agrees a rating system presents a challenge. "We have 30 million components in our database. Some components are very similar to others. They may only differ in their package sizes or temperature ranges. Some parts are used in such a niche market that the volume of reviews could never reach critical mass," he says.

Nevertheless, he believes a peer-review system or user-rating system is worth considering. "As a society, we are being conditioned to rely on crowd-sourced judgment and wisdom. The same expectations are spilling into the professional transactions. For younger engineers, it's second nature to use these reviews. Maybe it makes more sense to let people leave comments on certain component classes, not for specific components," Wurzel says.

Value in Data

Some suppliers prefer to hide the material data and internal structure of the component because they offer competitive advantages, containing clues on how the part is put together. But for engineers who wish to perform advanced structural analysis and study thermal behaviors of their products, the data is essential to make accurate predictions about part performance, wear and tear over time, breakage and failure. The tug-of-war sometimes puts the content aggregators in the middle.

"One form of data commonly requested is replacement parts information. If a part has been retired, engineers want to know a good replacement for it. Manufacturers will typically provide replacement part information when they sell the replacement part themselves. If another company makes the replacement part, we'll likely have to go to that other manufacturer to get that data," says Wurzel.

In order to get more data available, transparency from suppliers is needed. "[Rich data for simulation] will be the next evolution in manufacturers' offerings. Engineers keep pushing for more information on all aspects of the parts; manufacturers have it because they had to run tests on the parts to put the info in the datasheets. The challenge is to convince the suppliers to provide the data," Purcell says. **DE**

Kenneth Wong *is* Desktop Engineering's *resident blogger and senior editor. E-mail him at kennethwong@deskeng.com or share your thoughts on this article at deskeng.com/facebook.*

INFO → **Digi-Key:** DigiKey.com

→ **GrabCAD:** GrabCAD.com

→ **Octopart:** Octopart.com

→ **TraceParts Inc.:** TraceParts.com

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Multiply 3D Printing's **Material** Benefits

Multi-material 3D printing delivers new levels of realism.

BY BETH STACKPOLE

There's not much that inspires the same levels of fear and awe as a shark. Its menacing dominance of the sea might only be eclipsed by its swimming prowess — performance that researchers are striving to replicate for aerodynamic applications in industries such as aerospace and the marine sector.

The research team at the Wyss Institute for Biologically Inspired Engineering at Harvard University knew that the shark's flexible skin was the key to unlocking the secrets of its advanced propulsion, yet it was challenged to reproduce the unique makeup with existing manufacturing and prototyping practices, according to James Weaver, Ph.D., a senior research scientist with the team. Specifically, it was difficult to fabricate a material that closely mimics a shark's skin, which has a set of rigid, tooth-like structures that alter the flow of water as the animal moves forward.

Multi-material 3D printing is a game changer for Trek, allowing it to push designs further. ***Image courtesy of Trek Bicycle.***

It was next to impossible that is, until the advent of multi-material 3D printing capabilities — in the institute's case, use of an Objet500 Connex system available from Stratasys. "People have been throwing around the idea of replicating a shark's skin for a while, but until multi-material printing came along, there wasn't a way to design and manufacture the shark skin in any reliable manner," Weaver says. "With multi-materials, we are able to print the scales out of rigid thermoplastic-like materials and the skin with flexible material in the same build."

Without a multi-material 3D printer, Weaver says the research team would have to individually print every single scale — and there were thousands of them — and then align them all to be cast in a flexible base or explore alternative methods. "Either way, it would be very time consuming," he says. "The multi-material 3D printing capabilities allow us to streamline production of prototypes and explore design spaces we never would have considered."

Shark skin, which is the crux of aerodynamics research for reducing drag for aerospace and aquatic applications, is just one of the many efforts the team is exploring thanks to multi-material 3D printing. The Wyss research team also recently announced a successful proof-of-concept prototype of a soft-bodied autonomous jumping robot that was produced with multi-material 3D printing to mimic the biodesign principle of how organisms self assemble their bodies to produce a gradual transitioning from hard to soft parts. In one uninterrupted 3D print session, the team was able to create a single body built with nine sequential layers of material that increased in stiffness from rigid to soft toward the outer body, according to a press release. Traditional molding manufacturing techniques would have been impractical, the release states, because they would have required a mold change for each design modification.

Beyond the research world, mainstream manufacturers in a variety of industries are starting to benefit from advances in multi-material 3D printing. Companies in the automotive, sports equipment and medical fields, along with many others, are taking advantage of new materials and multi-material 3D printer hardware to create more realistic prototypes and to test novel design concepts they might have otherwise missed out on without ready access to the technology.

"Ultimately if you are using additive manufacturing as a prototyping tool, the prototype is only as good as it can be if it truly simulates what the production part is going to be," says Tim Caffrey, senior consultant at Wohlers Associates, a consulting and research firm focused on additive manufacturing. "Multi-materials get you closer to that."

In one example of multi-material 3D printing, Trek creates a paint mask part, including a soft durometer inside to fit closely with the carbon fiber link being painted. *Image courtesy of Trek Bicycle.*

More Materials, More Applications

Demand for multi-material 3D printers is definitely on the upswing, according to officials from both Stratasys and 3D Systems, the two primary providers of the technology. Companies are gravitating to the technology because of the time and cost efficiencies in producing complex prototypes in a single print vs. having to go through multiple steps, says Buddy Byrum, vice president of Product Management at 3D Systems. Moreover, the ability to digitally mix multiple materials to create new properties hasn't been available with traditional 3D printers and is another big incentive since it allows companies to expand the range of applications for both prototyping and production applications, he says.

"Multi-material 3D printing allows instant selection of specific material properties/characteristics that are exactly matched to the application need," Byrum says. "This allows only a single print instead of assembling multiple prints made out of different materials. Multi-material 3D printing also reduces time-consuming production of different components and having to manually assemble the finished product."

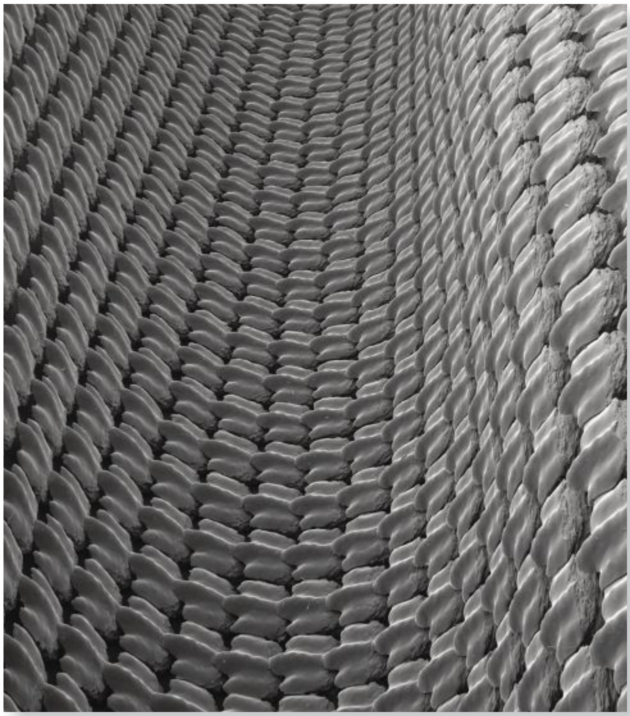
For The Connecticut Center for Advanced Technology, Inc. (CCAT), a non-profit development organization charged with promoting innovation in advanced manufacturing technology, among other initiatives, the advent of multi-material 3D printing has enabled far more realistic prototypes than in the past, according to Eric Wold, machining applications specialist III at CCAT. The ability to blend materials allows for results not possible in the past, culminating in a prototype that can be tried for fit, form and function, he says.

"Before multi-material printing, a prototype would have to be made from a block of material, usually out of metal or some other material, and that could take days to do," Wold says. Now, using 3D Systems' ProJet 5500x multi-material printer, CCAT can easily create and produce prototypes with greater flexibility in design, more detail and complexity, and within a much shorter timeframe.

"Having a prototype allows designers and engineers to physically handle and examine a part instead of having to evaluate a 3D model on a screen," he says. "The technology allows designers and engineers to think differently, no longer constrained by the mechanical limits of traditional manufacturing equipment."

For a long time, 3D Systems, with its ProJet 5500X based on the MultiJet Printing (MJP) technology, and Stratasys with its Objet Connex family, have been the only game in town for multi-material 3D printing. 3D Systems touts the MJP technology for printing part details that are precise, sharp and match the original design intent in CAD, including replicating features like sharp edges and corners. The system also features advanced file and print management tools to make the process accessible for non-3D printing experts along with simple post process-

The Objet500 Connex lets engineers 3D print components using two or more materials in one fast process. *Image courtesy of Stratasys.*



The team at Wyss Institute was able to replicate the unique structure of shark skin by incorporating multiple materials into a single 3D printed model. *Image courtesy of Wyss Institute.*

ing steps, including use of a unique wax support material that melts away from a part in a hands-free batch process without requiring special chemicals, Byrum says.

Stratasys' Connex line, available in three sizes, offers 16-micron layer accuracy in a range of 140 materials, including the ability to print three materials simultaneously, says Bruce Bradshaw, vice president of Marketing at Stratasys. The ability to combine two base resins in specific concentrations and structures enables engineers to incorporate a range of hardnesses, opacities, shades and thermal properties into a single model allowing for the creation of more realistic prototypes, Bradshaw says.

While 3D printing with a single material is perfect for drop testing or creating jigs and fixtures on the factory floor, Bradshaw says multi-material capabilities are a natural fit for prototyping applications, especially when reproducing the exact look and feel of a design is essential for feedback and for adequately communicating the design intent. "When you need to resemble the real product, there's no better way to do it," he says. "If you want to show there's a rigid part here, a soft part there, and a clear lens on something and print it all at the same time, there's no other technology than us."

Soon, there will be some significant and widely heralded competition, however. Hewlett-Packard (HP) last year announced the Multi Jet Fusion 3D printing technology, based on intellectual property associated with its Thermal Inkjet printing. The proprietary three-axis printing process, which operates at a voxel or volumetric pixel level, allows for speed, precision and resolutions previously unheard of within the 3D printing space, according to HP claims. The printer, currently in beta test, will be commercially available in 2016 and is expected to let users selectively print a different color (and material type) at a voxel level, which drives the higher grades of accuracy for both multi-materials and selective use of color.

"HP's emphasis is on extreme detail and quality," says Scott Schiller, worldwide business director for 3D printing at HP. "To achieve new levels of part quality, HP Thermal Inkjet arrays — capable of utilizing multiple liquid agents — provide new levels of accuracy with uniform part strength in all three axis directions. Additionally, this technology has the potential to enable systems that are 10 times faster with breakthrough economics and top-level part strength."

Beyond the current use of thermoplastics, Schiller says HP aims to lead the market by developing new materials using biocompatible, ceramic, metal and other materials.

Over time, HP plans to deliver color capabilities for the same set of full-color solutions it currently offers in the traditional printing space. The HP Multi Jet Fusion solution will also be an Open Platform, allowing partners to develop versatile and innovative materials, he says.

While HP is raising the bar, Stratasys and 3D Systems, along with the major CAD vendors, have their own advances in the works to address existing challenges with multi-material 3D printing. For example, most CAD programs don't allow materials or other properties to be specified at the voxel level, and if they did, the average design engineer doesn't have the expertise and familiarity with the technology to take advantage of those capabilities, says Wohlers' Caffrey.

"Unless they are well informed, the CAD designer might pick a material or combination [of material] that the model shop has not loaded into the printer or have in inventory," says Stratasys' Bradshaw. "Because they're not familiar with the technology and not specifying properly, the CAD designer might end up getting a part back that isn't the best result because they didn't take advantage of what's available on the printer."

To address that gap, Stratasys has partnered with PTC to create a seamless design-to-3D print workflow between Creo and Stratasys 3D printers, and the company has plans to forge similar relationships with other design tool vendors, Bradshaw says.

Even without such advances, multi-material 3D printing capabilities are still a game changer for organizations in terms of driving more efficient design workflows and paving the way for more realistic prototyping. At Trek Bicycles, for example, the ability to employ multiple materials in one build has radically changed its design process, eliminating many time consuming and costly steps and creating a longer window to explore more design iterations, says Mike Zeigle, manager of Trek's prototype development group.

Prior to use of its Objet Connex printer, Trek engineers might create a prototype of a handlebar design using traditional 3D printing processes to create the hard resin part and then use a silicon mold to produce the rubberlike grip, then join the two together using manual labor. "Now there is no additional labor to join the two — they come off the machine all assembled," says Reggie Lund, R&D engineer at Trek, citing other benefits like not having to schedule two machines at once or bringing someone in to do post-processing work.

Having access to multi-material 3D printing capabilities also helps the team make their prototypes as close as possible to the production version while encouraging more design iterations. The combination of different materials choices and use of color helps the team give product managers a better idea of how a finished version would look and because it's relatively easy and less expensive to transform a design concept into a realistic, working prototype, the team is encouraged to explore ideas they might otherwise not have considered, Lund says.

"If we can bring product managers something they can actually ride and see that it works, we can win them over to something they previously might have thought was a crazy idea," he explains. "This lets us step further out on a ledge than we would have done in the past," Lund says. **DE**

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INFO ➜ 3D Systems: 3DSystems.com

➜ **Connecticut Center for Advanced Technology:** CCAT.us

➜ **HP:** HP.com

➜ **PTC:** PTC.com

➜ **Stratasys:** Stratasys.com

➜ **Trek Bicycle:** TrekBikes.com

➜ **Wyss Institute:** Wyss.Harvard.edu

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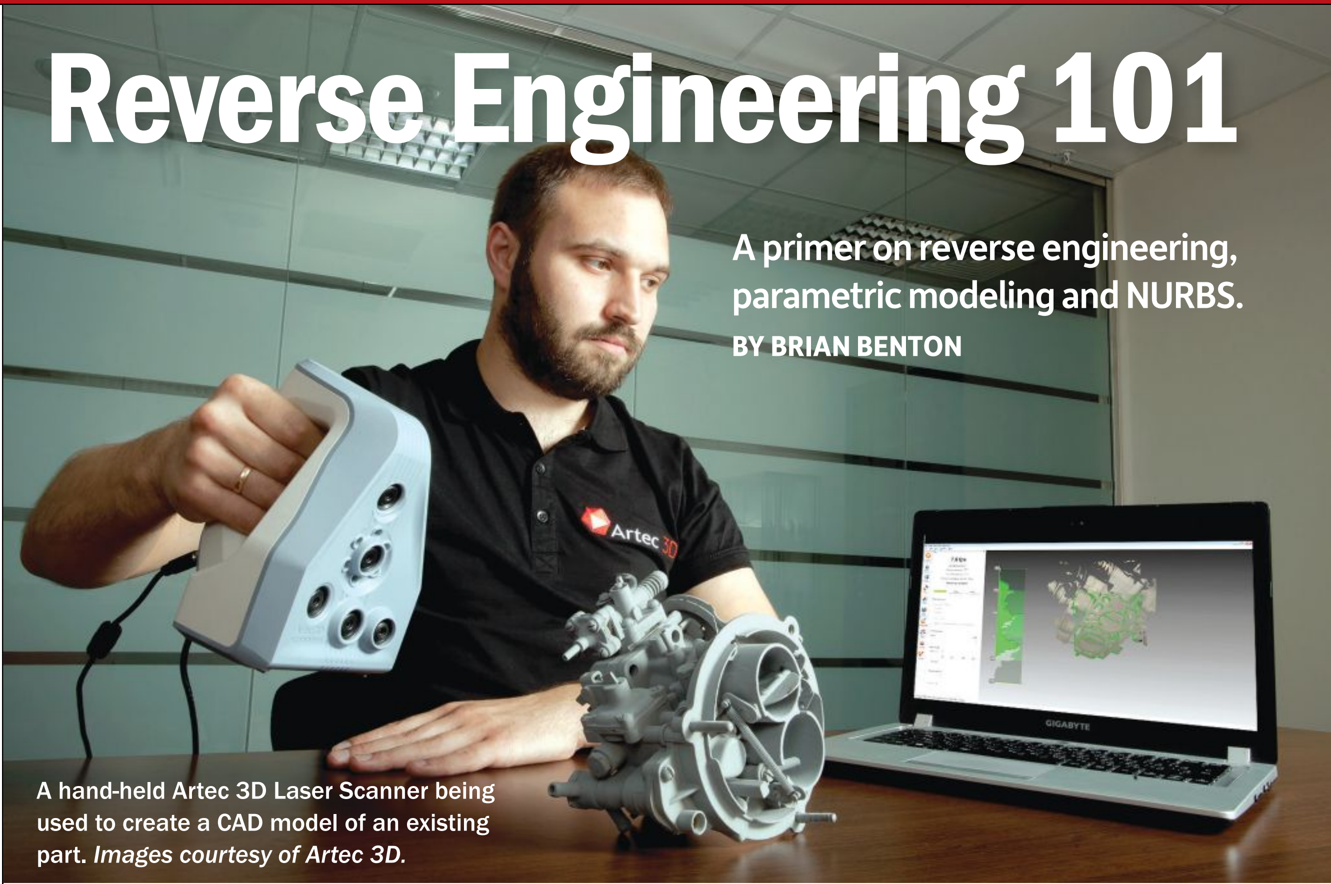
Reverse Engineering 101

A primer on reverse engineering, parametric modeling and NURBS.

BY BRIAN BENTON



A hand-held Artec 3D Laser Scanner being used to create a CAD model of an existing part. *Images courtesy of Artec 3D.*

Reverse engineering is the process of studying a physical product in order to extract its design information with the intent to reproduce the product, or to create another object that can interact with it. In the past, designers had to physically measure the product to redraw the geometry. Today, designers can use 3D scanners to capture measurements. The scanned data can then be imported into CAD where the design can be processed, manipulated and refined. Designers, engineers, manufacturers and makers today are using 3D scanning and 3D modeling to retrofit designs, create third party add-ons, or to restore older products and designs. They are also using these techniques to create new products that interact with existing designs.

When is Reverse Engineering Useful?

Andrei Vakulenko, Artec 3D's vice president of Business Development, presented several cases where one might need to reverse engineer something. He said that perhaps you have a situation where, "you have some kind of technical object, but, for various reasons, you don't have the documentation for it or the mathematical model. For example, the object was made years ago when CAD was not used in the manufacturing and design industry. Or perhaps the manufacturer just did not provide the documentation. Or the documentation was lost."

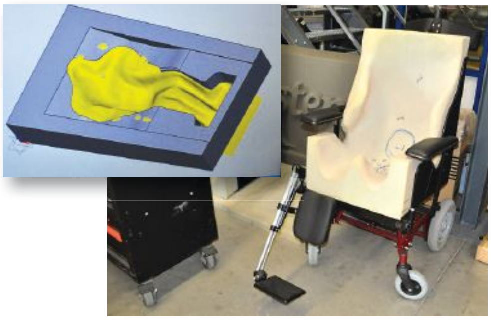
There are many reasons for the need to recreate an object. Vakulenko says that you may need to "recreate the object, either because you need the object itself or because you need to make something around the object for which you need its exact measurements." He added that reverse engineering often involves modifying or recreating a pre-existing object.

The Reverse Engineering Process

Martin Chader, country general manager at Creaform, presented a paper at the SME RAPID 2008 conference on the value of third-generation parametric modeling from 3D scan data. His paper discusses using non-contact dimensional measurement tools such as 3D scanners for shape capture to assist with conceptual design models, to perform competitive analysis, document legacy parts and tooling, and to define the spatial constraints into which a new part must fit.

"Each of these uses results in the capture of physical shape into a CAD model, often for further engineering," he writes. Once the object has been scanned, the data collected can be manipulated in CAD software. The CAD designer uses the data as a template to create a NURB (non-uniform rational basis spline) or parametric model.

"Parametrics modeling is used for designing mechanical, simple geometric objects (objects that can be made up of cylinders, spheres, cuboids, etc.)," says Vakulenko. "NURBS is for making models of more complex, freeform objects — e.g. people — and uses curves and points to recreate the shapes."



A CAD model of a scanned pad that forms around a wheelchair user (inset) leads to a finished mattress that fits the user's body.

Nika Holding, a company that makes custom automobile accessories, preparing to scan the floor of a car to make custom floor mats.

Nika Holding's CAD model of the scanned car floor.

When Should Parametric Modeling Be Used?

Parametric or history-based modeling environments "require advanced planning of features, constraints, relations and dependencies within a model," says Michael Kasten of Kasten Marine Design Inc. This method of 3D modeling in reverse engineering creates a "history of the logical genesis of the model." This history is "maintained so that changing a pre-defined parameter changes the model," he says. Once the parameters, or the parametrics, of a design have been set, the CAD model will interact with the scanned data appropriately.

In his paper, Chader stated one of the main reasons for using parametric modeling in reverse engineering projects: "If we anticipate any changes to the engineered part from its current form, or if we want to record and edit the part's form in CAD, then parametric models are preferred," he writes.

Kasten describes the process of scanning an automobile brake drum in order to reverse engineer it to improve it. He proposes that if analysis is done on the scanned object and a design change is required, then the engineer would not want to manipulate the scanned data nor would they want to alter a NURBS network. "The engineer will modify a single parameter in the CAD model," writes Chader.

Parametric models are used when exact surfaces and parts are needed. They will often consist of multiple parts.

Implementing NURBS Surfacing

Shashank Alai, a former student at the Sandip Institute of Technology, wrote a paper for the *International Journal of Emerging Technology and Advanced Engineering* reviewing the use of 3D design parameterization in reverse engineering in which he described cases where using NURBS for CAD modeling was preferred. "Converting data points into NURBS surface models has been automated," he writes. However, we cannot fully automate the conversion of 3D scanned data into parametric solids because "the original design intent embedded in the data points must be recovered and realized in the parametric solid model.

"Designers must be relieved from dealing with tedious point data manipulations and primitive geometric entity constructions," Alai continues.

NURBS surfacing techniques would be employed when the design needs to be more organic and not dependent on exact design circumstances. NURBS designs are often made of one piece.

Why Not Choose Both?

There are some instances where a designer would want to use parametric and NURBS surface modeling for the same design. Ome example is a cellphone case. These types of coverings need to be exact on the inside to connect to the mobile device correctly. However, the outside of the design needs to fit the palm of a hand and may be modeled more easily using NURBS surfacing. The phone that is to be covered can be scanned and converted into a 3D CAD model where a parametric model is used. The outer surface of the case can be a NURBS surface.

Kasten said that he prefers to use direct or free-form modeling environments when he designs. "They allow a more intuitive and flexible hands-on manipulation of the model regardless of how or in what sequence the model was created," he says. "In many cases relationships can be defined, such as for trimming or to bond surfaces along an edge or to enforce tangency between surfaces, but they are not needed in order to create the model, and they do not affect one's ability to grab parts of the model and push, pull, move, etc."

The most important steps in reverse engineering a product are "First, capturing the form of the object – i.e., 3D scanning it," says Vakulenko. "Second, making the CAD model." When deciding which type of CAD surface modeling technique to use one must consider the design intent. What are you trying to accomplish? Is it a free form, organic model or an exact and engineered device that may need to change? DE

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INFO ➔ **Artec 3D:** Artec3D.com

➔ **Creaform:** Creaform3D.com

➔ **Kasten Marine Design Inc:** KastenMarine.com

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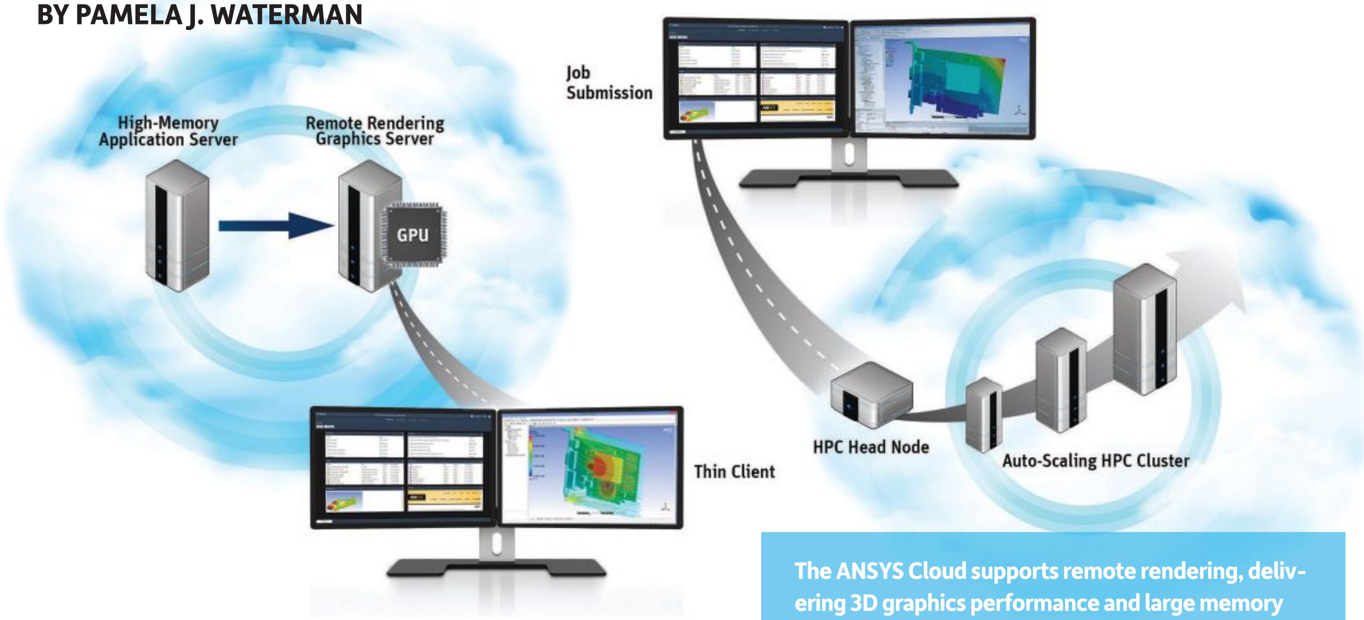
The Sky is the Limit for Cloud Computing

Who knew there were so many options for cloud-enabled simulation?

BY PAMELA J. WATERMAN



The ANSYS Cloud supports remote rendering, delivering 3D graphics performance and large memory resources. Cloud HPC power is auto-scaled on-demand, assigning machine configurations optimized for specific workloads. *Image courtesy of ANSYS.*

If you've ever submitted a batch job to a remote computer across a building or across the country, you've worked with a variation of cloud computing. Shared hardware has made sense for more than 50 years and it still does; we have moved well past the why and onto exploring the how, but sometimes the "how" can seem dull. Is the decision now more like choosing between cable or dish TV? Are cloud resources just repackaging or is there really value added? What are the different business models for accessing high-performance computing (HPC) resources, specifically for intensive engineering simulation projects?

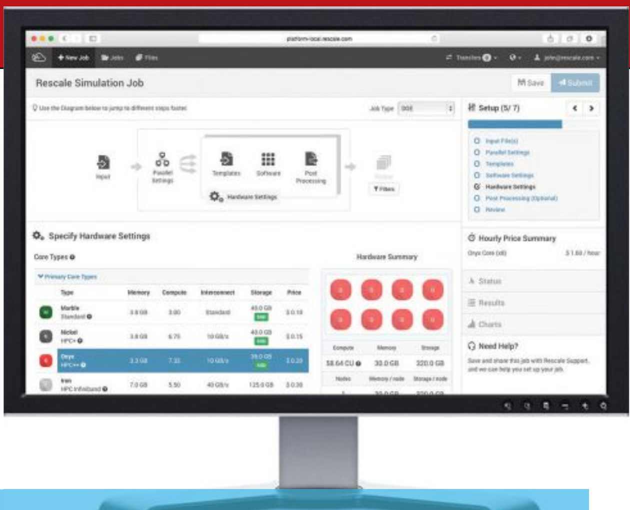
DE has been following the evolution (or full-circle trip) of remote computing almost since the founding of the magazine; coverage ranges from "FEA (finite element analysis) Over the Web" *DE* March 2001 to "Cloud-Based Analysis: Silver Lining or White Fluff?" *DE* June 2011 (deskeng.com/de/?p=3734). Here we explore some possibly surprising approaches to mechanical and fluid simulations on-cloud.

By the Hour, By the Core, and More

Large models and detailed analyses can tie up multiple in-house cores for hours or days. Companies are running more simulations than ever, design teams are spread across the globe, and manufacturing groups need timely access to the latest data. All these factors are driving software vendors, cloud managers and third-party groups to offer cloud-based resources with different perspectives on licensing and accessibility.

CD-adapco, developer of STAR-CCM+ and other CFD (computational fluid dynamics) and mechanical simulation software, has been working for years on a strategy to revolutionize the way users access its resources. The company's flexible Power on Demand (PoD) plan, introduced in 2010, was originally targeted to small- and medium-sized businesses (SMBs) that couldn't otherwise afford a traditional license. "In fact," [the first use] was by big companies who had a certain configuration for their daily activities but sometimes needed burst capacity," says Bill Clark, executive vice president, CD-adapco.

Gradually the method migrated down to other users such as consultants who found the capability helpful for planning client billing and controlling costs. Customers may still set up their



Workflow set-up window for performing simulation on Rescale cloud-based HPC resources. The company offers more than 120 natively integrated simulation applications, with options for individual users, SMBs and enterprises. ***Image courtesy of Rescale.***

models locally, but in the first year, they logged 24,000 hours of PoD time; in 2014 this figure increased to 2.1 million hours.

Clark says cloud resources also offer the benefit of running simulations on the newest cores, specifically optimized for STAR-CCM+ calculations. The company's ultimate objective is for industrial customers to run STAR-CCM+ on petaflop clusters such as the Blue Waters supercomputer.

Dassault Systèmes took its first steps into the cloud with the 2011 launch of its Version 6 open platform. It integrated the company's software products into the real-time 3DEXPERIENCE with options for on-premise and on-cloud delivery. 3DEXPERIENCE is the company's hub for its four product groups, divided into functions of 3D modeling, simulation, information intelligence and social/collaborative interactions. Through separate cloud licensing, 3DEXPERIENCE 2015x now offers access to SIMULIA Abaqus multiphysics software.

Many current customers are looking to the cloud as a means to burst beyond their existing compute capacity, while new customers will find a range of benefits such as project collaboration, says Eric Weybrant, research and development product manager, SIMULIA. "3DEXPERIENCE is a Software-as-a-Service (SaaS) offering that combines cloud-based data and license management with a suite of role-based business applications," he says. Simulation "tokens" offer flexible software deployment access, and a product called 3DPlay Simulation Extension that permits viewing full simulation content for seamless teamwork on premise and on cloud.

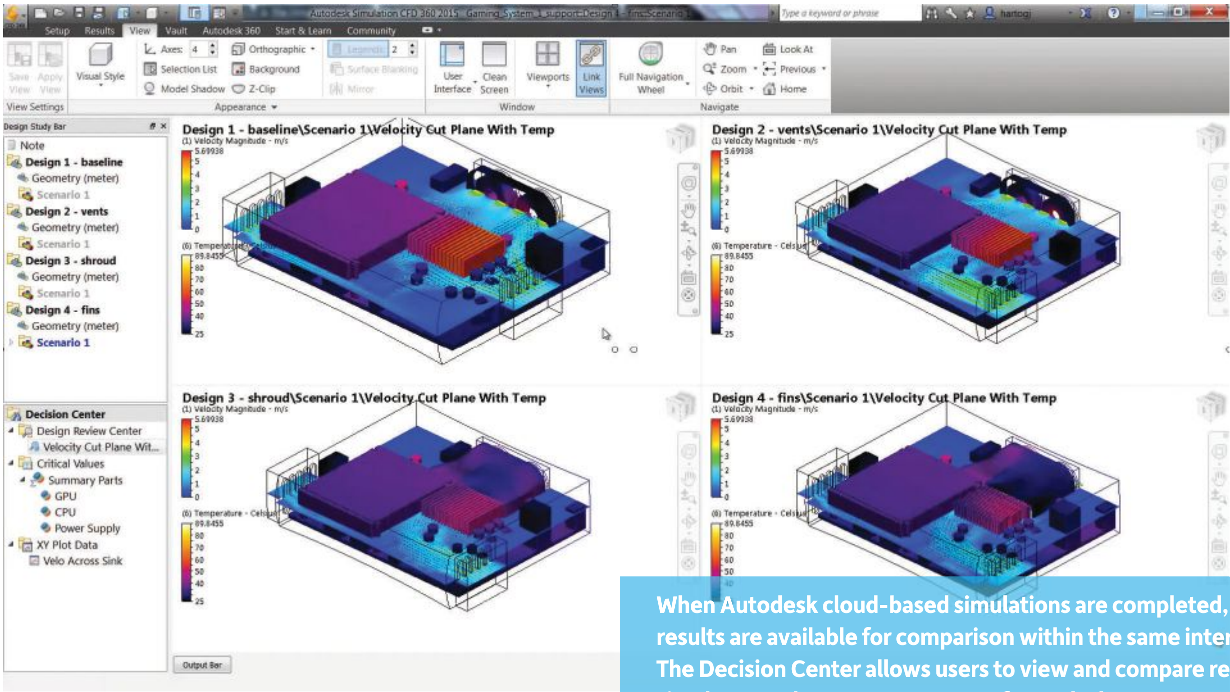
Autodesk offered linked, collaborative CAD services as far back as the late '90s then expanded its global-access philosophy in 2011 with the launch of Autodesk 360. Scott Reese, vice president of Autodesk cloud platforms sees two trends converging to drive more tasks to the cloud: their customers use talent all over the world, and you can no longer separate design from simulation.

"There's a continuum to this process," says Reese, "and everybody needs access to design information. We're now putting it out to a broader set of customers." Autodesk offers two cloud-based project services in its Product Design Suite: Free A360 collaboration software that supports view, search and share functions and paid Advanced Cloud Services that include Autodesk PLM (product lifecycle management) 360 and Fusion 360.

Reese sees a big shift in the way people are accessing software, saying the cloud has really opened this up. "They want to pay for what they use, as they use it," he says. "We are moving to subscription models where they can pay month-to-month or annually, and, more relevant to simulations, a consumption-based model where you have access to the simulation tools and simply pay for it as you use it with Autodesk 'cloud credits.'"

The appeal of cloud-enabled resources has clearly been behind several announcements this year from major simulation vendors. ANSYS already has close to 10 years experience with various cloud partners who host and manage ANSYS software on an HPC clusters — one of many cloud solutions is aimed at SMBs. More recently, it created an enterprise-level solution that provides agility to scale depending on business requirements.

Barbara Hutchings, ANSYS director of Strategic Partnerships, is the company's expert on the Enterprise Cloud. "This is a response to the old way of deployment which is that every guy who needs simulation gets a machine and a license," she says.



When Autodesk cloud-based simulations are completed, the results are available for comparison within the same interface. The Decision Center allows users to view and compare results simultaneously. *Image courtesy of Autodesk.*

"Now, [we're] moving it off of the desktop and into the data center where everybody can get access to it.

"What makes it complete," Hutchings says, "is the ability for the user to do the entire process on the cloud: model preparation, pre-processing, meshing, solving with interactive controls, post-processing and data management." Customers can also move other software into their cloud.

For more than a decade, Altair Engineering customers have been able to access Altair HyperWorks software through pay-per-usage licensing. Now, Altair has extended its cloud product suite to include full cloud simulation resources (HyperWorks Unlimited Virtual Appliance) along with its existing private cloud architecture product (HyperWorks Unlimited Physical Appliance), Simulation Cloud Suite (a complete CAE lifecycle management system operating in the cloud), and just-announced turnkey solutions through Microsoft Azure HPC resources.

Cloud-based simulation is bringing design work to a whole new level according to Ravi Kunju, vice president of strategy and business development at Altair Engineering. In the past, he says, fixed computational resources forced engineers to optimize a model size or limit analyses to just three or four design variations. "Now, it means that engineers can not only solve more problems," says Kunju, "but can also reformulate the kinds of questions they're asking, doing design of experiments and varying a whole suite of analyses." Cloud resources are therefore the perfect vehicle for employing HyperWorks, the company's multidisciplinary design exploration and optimization product.

Hosted on Amazon Web Services (AWS), a HyperWorks Virtual Appliance compute-cluster of any size can be created in about 10 minutes. Customers can request that resources be optimized for computational work, high memory or graphics. Altair does the setup, supplying a URL, setting up monthly billing, and compiling a list of users. And, third-party software can be added.

Doing end-to-end simulation on HPC resources while staying in the same environment is just what Exa Corporation had in mind when it introduced its IBM-hosted ExaCLOUD. Web-based and scalable, ExaCLOUD lets users access all Exa software products for fluid flow and heat transfer analysis on a pay-per-use or pre-paid basis, without companies having to own local licenses.

"Engineers are beginning to use this as their central environment, more than just to upload batch jobs, run a calculation and download results," says Kevin Horrigan, ExaCLOUD product manager. "It's more that they are uploading initial design data, then running through an entire project, submitting dozens or hundreds of runs, until the project is complete." Settings can be saved from one run to another, and automated.

Horrigan adds that one of the driving factors behind Exa's end-to-end approach was eliminating moving files back and forth for each run and worrying about storage space, saying their own engineers had been facing that problem.

Because discussion about the evolution of simulation software usually brings up mention of Nastran variations, it's interesting to note that MSC Software was offering remote simulation compute-resources as far back as 2001, through its Engineering-e.com site. Users with local licenses paid a monthly fee to upload an MSC Nastran analysis run. This service was discontinued but a related Web-based offering began in 2006 with the advent of MSC Software SimManager. This portal, among other functions, lets users automate running thousands of intensive simulations, so it greatly enhances performing design optimization.

More recently, MSC Software has developed its MSC Apex product with cloud use in mind, so stay tuned for the company to expand in this direction.

Third-Party Solutions

Looking to do more than just simulation on the cloud? Check out the following independent SaaS resources that have made a splash online, some with a cloud-based track record longer than many traditional vendors.

Rescale, a Platform-as-a-Service company, has been coming on strong since its founding in 2011. It offers 120+ pre-tested, natively integrated simulation applications and operates through a multi-cloud network comprising public/private clouds and HPC data centers. This is important for enterprise customers who typically procure simulation packages from different software providers, according to Shing Pan, vice president, Marketing and Corporate Development, Rescale.

"For CIOs and IT administrators, Rescale's ScaleX Enterprise platform provides flexibility to select across a broad variety of hardware specifications, all with no queues," says Shin. For individuals and SMBs, Rescale's ScaleX Pro lets them perform simulations either through supported licenses or on demand.

An example of how Rescale partners with software vendors comes from Rob Kaczmarek, director of Marketing for Convergent Science. Since October 2013, "We've allowed our customers to 'point' their CONVERGE CFD software licenses anywhere they want, including to Rescale," he says. This option helps users who either own older hardware or don't have the money in their current budget to buy a regular license.

Ciespace, acquired by ESI Group this past April, is a player whose "On-Demand" offerings include both SaaS products and a cloud-based platform for high performance and 3D graphics intensive applications. The company first developed a browser-based end-to-end CAE workflow for CFD in early 2013, then added a platform-approach integrating multiphysics applications. The initial solution included pay-per-use OpenFOAM technology (open-source software originally developed by OpenCFD Ltd — now owned by ESI Group – with ongoing development by CFD Direct) and customer-uploaded solvers plus tools for geometry preparation, meshing, visualization and collaboration. Now, with ESI's support, Ciespace has ambitious ideas for the future, including hosting its parent company's products.

Sanjay Choudhry, ESI Group vice president, cloud business unit, says they will be expanding far beyond just on-demand services. "The first two areas will consist of on-demand compute services with results processing and collaboration for existing customers with on-premise products, and end-to-end SaaS products for various physics types for SMBs," says Choudhry. The latter is designed to reduce training time, increase collaboration, and increase productivity through complete workflows that can be cloned and rapidly re-used in the cloud.

A third direction for Ciespace is building vertical solutions in certain markets where codification of best practices into workflow templates will serve as a starting point for fast design re-use by even non-experts.

Taking an open-source approach to cloud simulation is SimScale, a Web-based platform dedicated to making simulation technology more accessible in terms of cost, know-how and infrastructure. Currently available simulation applications include OpenFOAM technology for CFD, CalculiX for mechanical simulation, snappyHexMesh for meshing and ParaViewWeb for visualization. The cloud service, begun in 2013, already has customers in more than 35 countries.

Lastly, UberCloud is a an HPC-on-the-cloud resource that can serve as your simulation-learning and social hangout space, your direct connection to trial-software options or your portal to pay-per-use simulation power. Launched in 2012, this company began as an exploration of roadblocks to cloud computing with crowd-sourced solutions. More than 2,500 companies are now part of the initiative.

Fast, Flexible and Fully Connected

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Contributing Editor **Pamela Waterman**, DE's *simulation expert, is an electrical engineer and freelance technical writer based in Arizona. You can send her e-mail to DE-Editors@deskeng.com.*

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FEA Case Studies – Errors and Checking

Get insight on how to validate model correctness with these examples.

BY TONY ABBEY

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This month's article is a follow-up to the two part *Desktop Engineering* series on Accuracy and Checking in FEA (finite element analysis) models (January 2014 and February 2014). Several case studies are shown where errors have crept into the modeling. We look at how to identify the errors, as part of our normal checking routine, and subsequently how to debug and correct the issues.

Many modeling errors are simple data entry mistakes, others are more complex and involve constraint boundary conditions, meshing problems or misunderstanding of the physics involved in the simulation. The range of potential errors is vast — ask any FEA support engineer! We are investigating a small subset here.

Case Study 1: Loaded Crank

The crank model and loading setup shown in Fig. 1 was used in the February 2015 article on Free-Floating models (deskeng.com/de/?p=22402).

The FEA model uses the 3-2-1 method to put the structure into minimum constraint to support a balanced set of loads. In the new case study, the analysis is run and the stresses and deflections checked as shown in Fig. 2.

The stresses look all right, and agree with the distribution and peak magnitude

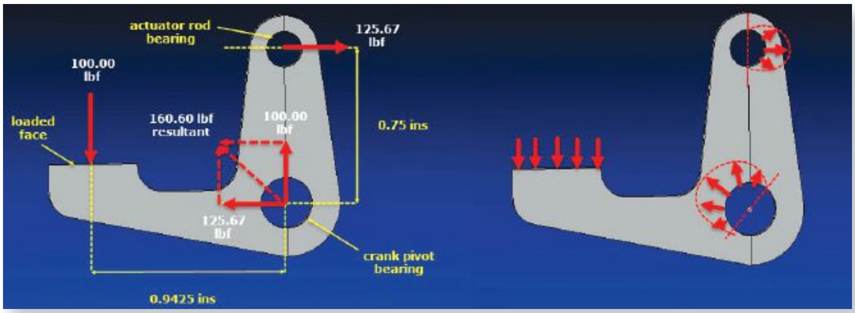


FIG. 1: Configuration and loading for case study 1

(69,437 psi, 478.8 MPa) from the previous article. It is tempting to leave it there and carry on with writing the analysis report. However, two items must always be checked first with any FEA result: stresses and deflections. The distribution of deflection is shown in the deformed plot, and can be animated for more clarity. In our case the deflection is relative to the fixed horizontal clamp face. The loading action of the actuator rod causes the vertical arm to translate and rotate. Because the constraint system is not relative to the crank pivot, the crank pivot appears to move relative to the clamp face. This is acceptable in the model and is expected behavior, but it is worth thinking about carefully. You may have to explain to a client or manager why the crank is not showing "realistic" motion.

Many post processors have the ability to plot all displacements relative to a target nodal displacement. This is very useful in understanding the deformed shape, particularly in cases such as ours. We do however need a node at the center of the pivot, which is coupled into the analysis, but does not change the stiffness or load path of the model. It just acts as a datum. We can use a "flexible spider" type element for this purpose (sometimes called a load application element). This is shown in Fig. 3. We can create a center node and connect it to the inner faces of the pivot with the spider. The spider adds no stiffness. The node will displace as a type of least squares average of the motion of the pivot face nodes. It acts as a tracking node and is just what we want as a relative position. The displaced shape plot in Fig. 3 is now set as relative to the new pivot center node. The post processor calculates all deformations relative to this point and the plot is much more understandable. Flexible spiders are excellent tools for this and similar type of situations where a datum or reporting point is needed.

So far we have focused on the sense of the deformation. However the scale of the deformation is equally as important. In Fig. 2, the peak deflection magnitude is reported in the legend on the screen shot. The value may be shown in a summary file, or require a result probe

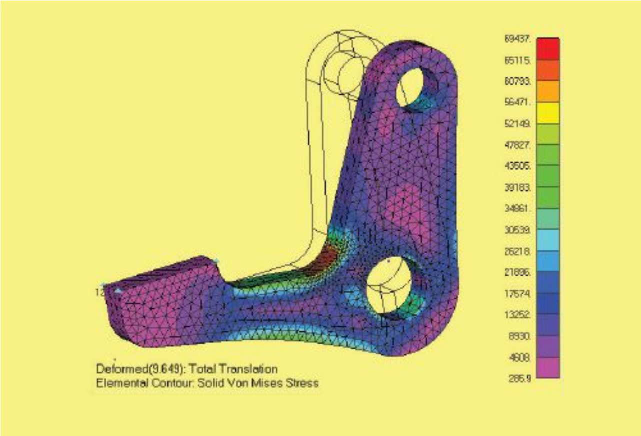


FIG. 2: Stress and Displacement results for case study 1

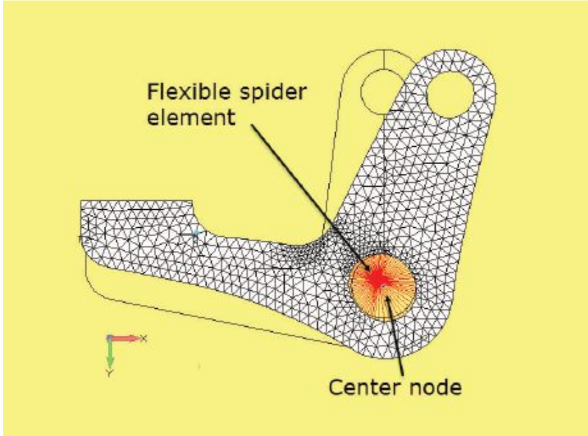


FIG. 3: Spider element added with center node to give a meaningful displaced shape

of some kind. The displacement in our case is in inches — and is therefore a very suspicious value of 9.649 in. (245 mm). This is obviously an error as it is so large, but in general we should have in mind what would be a typical ballpark value for our structure. A stiff structure like this is going to have deflections in the order of thousands of an inch (0.003 mm).

We have identified the problem, what might have caused it? A quick checklist includes:

- Wrong material properties
- Wrong loading
- Constraint error
- Boundary condition stiffness error

We start first with the simplest to check: material properties and loading. The loading seems OK initially as the stresses are acceptable. A quick look at the material properties shows an error with Young's Modulus set as 2.9E4 psi, not 2.9E7 psi for AISI 4340 Steel. For a simple rod the relationship between deflection *d* and applied force *P* is given by P=(AE/L)d, where *A* is the cross sectional area, *E* is Young's modulus and *L* is length. So a factor of 1E3 down in *E* results in a factor 1E3 up in *d*. The correct peak deflection value is .0096 in. (.245 mm).

The stress relationship to applied force is just stress = P/A. So stress is insensitive to errors in material property in our simple case. In fact in more complex structures with parallel load paths having different materials (multiple *E* values), the relative stiffness will change with an error in one *E* value. The stresses may then be in error as too much load is attracted to the higher *E* value material.

If we wanted to check further we could pull out the reaction forces and make sure the value balances the load we think we have applied. However, for the 3-2-1 method that is not meaningful as the applied loads balance to zero by definition. We could overcome this by setting up two dummy models. The first constrains the pivot point face nodes only and applies clamp and actuator loads. The second constrains the clamp and actuator connection regions and applies load through the pivot. This splits the loads and allows separate checking of each. The loading and load paths for the 3-2-1 model are therefore effectively checked. Other complex load paths can be checked in a similar manner.

Case study 2: Yoke with Seeker Head

Fig. 4 shows a Yoke with Seeker Head FEA model. This has been explored in the two *DE* articles on Dynamic Response (May and June 2015). The Yoke is fixed to ground at its base and the Seeker Head is modeled as a lumped mass connected to the inside bearing faces of the pivot points.

In our case study, a static inertia load is applied to the structure. The resulting stresses and deformations are shown in Fig. 5.

From Fig. 5, the deformation looks very high at 0.625 in. (15.9 mm). A stiff cantilever structure like this would be expected to have less deformation. The stresses also look high. This seems like a sweeping statement, but we can relate the stress level back to the yield stress of the material. Yield stress is 215,000 psi (1482 MPa), we have three to four times that value. In this situation several questions arise:

- Has the material yielded in practice, if so we need a nonlinear material analysis to understand the level and extent of plasticity?
- Is the structural design anticipated to be significantly under strength?
- Are the loads applied correctly?

The significance of the first point is that a stress much more than 1.5 to two times yield is physically impossible and can only occur with significant plasticity. In that case a nonlinear analysis is the only valid solution. A linear analysis will be completely wrong.

The second point indicates an engineering judgment. Can the design be that bad? How have previous designs worked? Can a ballpark hand calculation show an acceptable design?

If the answer to the second point is that the structure is anticipated to have reasonable strength, then suspicion falls on the third point. The loads are very

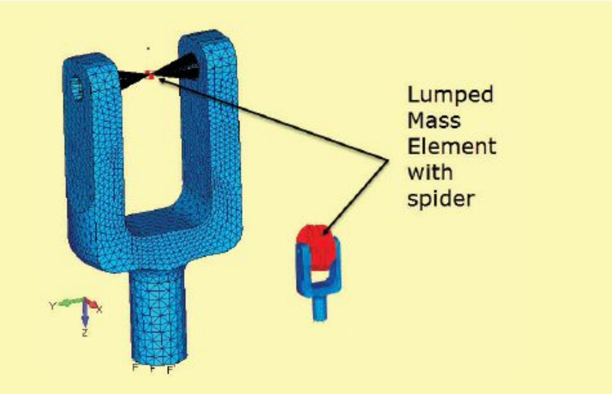


FIG. 4: Yoke and Seeker Head model showing lumped mass idealization

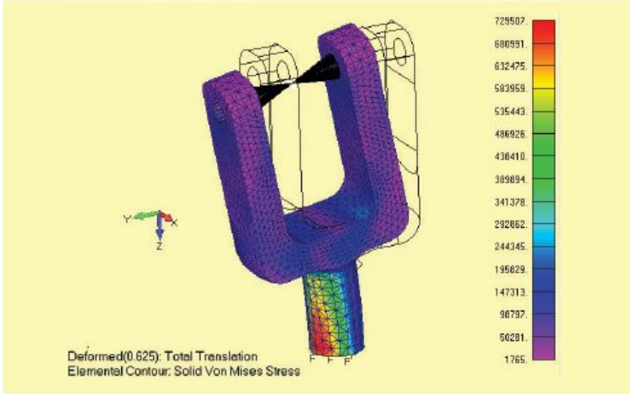


FIG. 5: Yoke and Seeker Head stress and deformation result

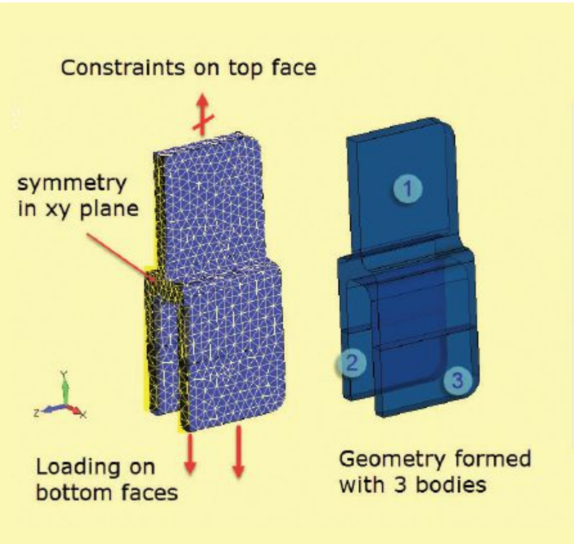


FIG. 6: Geometry and mesh of Tang model

likely to be overly severe by mistake. The fact that the displacements are way too high tends to confirm this.

In this case there is a slight twist in that inertia loading is used. The relevant loading factors are 15g in x, 30g in y and 10g in z. Inertia load is developed throughout the body by multiplying each element mass by the body acceleration. So the mass or the acceleration may be in error. Using the principle of checking the simplest item first, we inspect the following data:

- Material density
- Reported volume and mass of the Yoke mesh
- Lumped mass of the Seeker Head

The material density is easily checked and is correct at 7.33145E-4 lb. mass/in^3. The volume of the Yoke mesh is 16.6 in^3 and gives a correct system mass of 0.0124 lb. mass. The lumped mass Seeker Head representation is 60 lb. weight, 0.15528 lb. mass. One point here is that the mass moment of inertia of the Seeker Head has been ignored. This may be a consideration when the debugging is completed and should be corrected. It is a secondary effect at the moment.

So it all points to the loading input! There are two approaches now; checking the raw input data as well as the reaction forces. Checking the raw input is easiest so is carried out first. A check reveals that the load levels have been factored by 10 in error and are 150:300:100 not 15:30:10. This kind of error when manipulating and preparing load data is quite common – I have done it many times!

A straight linear scaling by 0.1 gets us down to 0.0625 in. (1.59 mm). The loading is severe and therefore this order of deflection seems reasonable for a cantilevered beam. We can check by running a 1g in x direction case and comparing with a simple hand calculation. The deflected shape plot in Fig. 5 also shows evidence of twisting as well as bending under the combined loading, which is a useful sanity check.

The stresses now scale down to peak Von Mises of 72,951 psi. It is a high stress, but the loading is severe. A hand calculation could easily check the values here at the base of the Yoke. Knowledge of similar successful designs would reinforce that the design was feasible and hence the FEA result is sensible.

Case Study 3: Tang Half Symmetry Model

The Tang model shown in Fig. 6 is a variation of the model used as a 3D verification in July's *DE* article on plane stress and plane strain. It features a half symmetric model that is loaded on its top face and constrained on the two lower faces, so that a load path through the fork section is created. In this case the geometry is created from three separate bodies. The geometry is meshed and a linear static analysis is created. Automatic linear glued contact is created between all mating surfaces (body 1 to body 2 and body 1 to body 3).

The resulting analysis ends with a failure message reporting an excessive pivot ratio. An excessive pivot ratio discovered during the matrix solution process indicates that the highest and smallest Degree of Freedom (DOF) stiffness terms are too widely separated. The system default is exceeded and the analysis is stopped automatically. If the analysis were to continue it could reach a point where the solution "blows up" with a

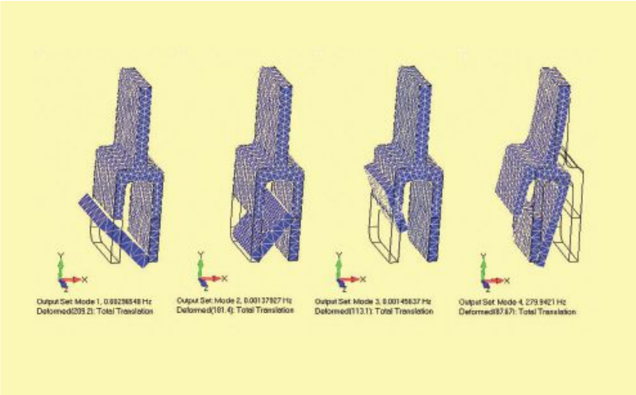


FIG. 7: Tang Rigid Body mode 1-3 and elastic mode 4

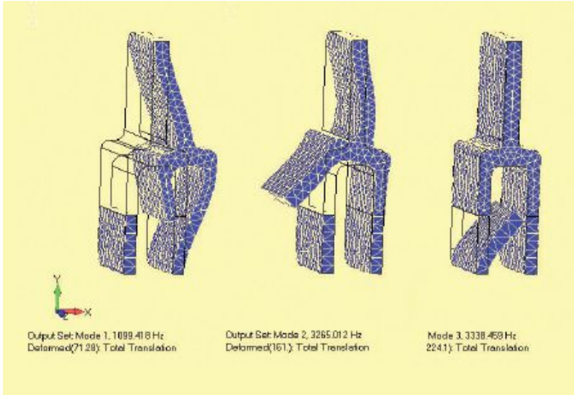


FIG. 8: Fully constrained Tang with crack showing elastic modes 1-3

near divide by zero operation. The results from such an analysis would be unusable.

Our task is to find the cause of the excessive pivot ratio. The likely reasons include:

- The model is not fully constrained in all DOF — resulting in rigid body motion.
- Cracks are occurring in the mesh — resulting in rigid body motion.
- Material properties are incorrect — giving high and low stiffness terms.
- Elements are highly distorted giving spurious high and low element stiffness terms.
- DOF are cross-coupled in error by multipoint constraints, springs, spider elements, etc.
- Elements are badly connected at one or two DOF resulting in high flexibility.

A review of the model shows:

- The constraint systems have been checked and the presence of the XY symmetry plane (DOF z is constrained) and constraint in DOF x and y on the top surface should have eliminated any rigid body motion.
- The three bodies are mated via contacts, so there should be no effective cracks in the mesh.
- Material properties are straightforward (a zero value for E, or wrong orthotropic or hyper-elastic data can cause problems).
- There are no distorted elements.
- There are no MPCs, Springs or Spiders in the model.
- There is no sign of badly connected elements.

At this stage a diagnostic analysis is carried out using a Normal Modes Analysis. This analysis will permit rigid body motion in the solution and will reveal such via low frequency values and rigid body mode shapes.

Fig. 7 shows the resultant natural frequencies and mode shapes. Body 2 is decoupled from the structure and has three rigid body modes with effectively 0Hz frequency. Mode 4 is an elastic mode at 279Hz and shows the remaining bodies cantilevering about the fixed top constraint. The analysis shows Body 2 is constrained by the symmetry boundary condition (translation z and couples about x and y), but is free in the other three DOF.

So what went wrong with the static analysis model? Clearly the contact is suspect and investigation shows the contact between body 2 and body 1 was not automatically set. So, in fact, this is a form of crack created in the mesh. Normally cracks are subtler and result from meshing errors. Here, they are predicted as being the joint between bodies and a free surface check shows them. However, the assumption is the contact will take care of this.

The use of automatic contact in all forms of analysis is very convenient and is now very widespread. However there is a clear danger of errors creeping in — the use of a normal modes analysis to demonstrate effectiveness of contacts is highly recommended. A variant of the Tang model was run which has top and bottom surfaces constrained and lateral loading applied. Fig. 8 shows there are now no rigid body modes, and the analysis will run statically. However, the normal modes check run shows the error in the contact surface makes this load path invalid.

Finally, the correction for the original model is to create the missing contact surface connection. It is always useful to work out what went wrong. Often this is due to tolerance definitions being too tight and hence the automatic contact creation misses out any surface pairs with a larger gap. Conversely, unwanted surface pairs can be connected in error. The normal modes check run will show these clearly.

Case Study Conclusion

Modeling errors are many and varied in practice, from the very obvious to the subtle. We all make these errors as part of every analysis project. Spotting the errors with good checking procedures and having a rational debugging approach is essential for everyone carrying out FEA. Hopefully these case studies give some ideas what to look for. In a future article we will look at other batch of case studies, all drawn from my own experiences! DE

Tony Abbey *is a consultant analyst with his own company, FETraining. He also works as training manager for NAFEMS, responsible for developing and implementing training classes, including a wide range of e-learning classes. If your Company is interested in a customized training class on any topics discussed contact tony.abbey@nafems.org.*

Pixels Drop and Metal Crashes

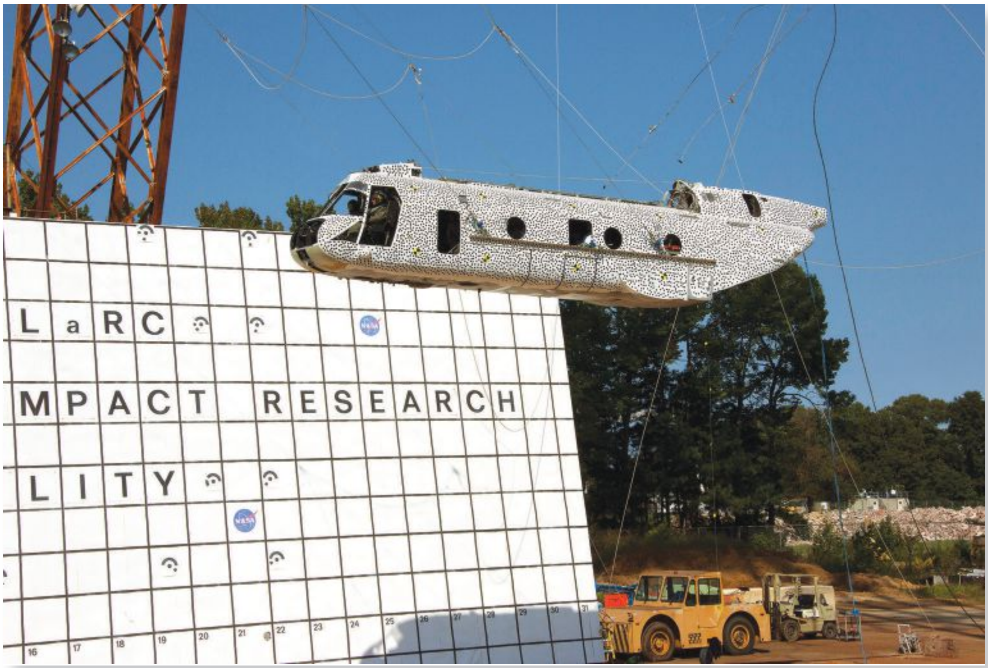
Virtual simulations and real-world tests reinforce each other.

BY KENNETH WONG

April 27, 2012, was a clear, balmy day in Mexicali, Mexico — a picture-perfect day for a Boeing 727 to crash-land in the middle of a desert. The crash was intentional. It took four years to arrange the event, captured for a special two-hour episode of Discovery Channel's "Curiosity TV." The ill-fated passengers were crash-test dummies worth more than half a million dollars (ABC News, "Good Morning America," Neal Karlinsky, October 2012).

Last October in Langley, VA by order of NASA, a CH-46E Sea Knight helicopter smashed into the ground at 30 mph from a 30 ft. height. The doomed vehicle carried 13 manikins, whose experiences were captured by the 40 HD cameras onboard snapping away 500 images per second.

These two tests represent the most extreme type of product testing. The cost of the sacrificial plane or helicopter is only a fraction of the expense involved; they take much time and effort to prepare and they have very little room for error. You get one shot at capturing the critical data you need from the event. That gives Diversified Technical Systems (DTS), a sensor and data acquisition system supplier, a lot of bragging rights. The manikins on the 727 and Sea Knight were wired up with hundreds of sensors and DTS data recorders. Their final moments were preserved as loads, stresses, acceleration and displacement values for posterity, even if some of them didn't survive the impact in one piece.



In October 2014, NASA conducted a drop test with a Sea Knight helicopter in Langley, VA. The agency used data recorders from Diversified Technical Systems (DTS) to capture the critical values from the test. ***Image courtesy of DTS.***

Protecting the Data Recorder

Large-scale destructive tests like the 727 crash in Mexicali and the helicopter drop in Langley are usually the final verification to determine if the vehicle's structure would hold up during impact, and whether the human passengers onboard could walk away from such a catastrophic event with superficial wounds or suffer fatal injuries. Damage to the test vehicle is expected, but the extent of the damage becomes clear after the experiment.

While the survivability of the test object is undetermined, the survivability of the data recorders must be ensured. Oth-


The manikin representing a real passenger in the drop test is wired with DTS data recorders that can withstand up to 500g shock. *Image courtesy of DTS.*

erwise, all the critical data the test is designed to capture will be lost in a pile of shattered instruments. "In a test like [the helicopter drop], the data-acquisition systems are going to take quite a beating. Most won't survive the shock of the impact. Our recorders are tested to survive 500 g shock. If the shock anticipated is even greater, we can refine our equipment to make sure it survives," says Hans Hellsund, director of Sales and Marketing at DTS.

DTS uses a shock machine and a drop tower at its facility to test the survivability of its own data recording systems. "We test our products to survive 500 g in every axis before it goes out the door," says Hellsund. Some DTS products have been used to record the impact behaviors of missiles. NASA has been using DTS data acquisition systems for the past 15 years, according to the company.

In the Sea Knight helicopter drop test, NASA uses DTS' TDAS G5 module, which is smaller than a deck of cards. The SLICE NANO version is as small as a box of mints, just a quarter of the size of the other module. "We use durable components, shock-isolation mounts to make sure things don't rattle around during impact, and anodized aluminum for enclosure," Hellsund says.

For a plane crash or helicopter drop, the added weight from the data acquisition systems and sensors is not significant enough to make a difference, but for other scenarios involving lighter products (like a bicycle), it might. In such experiments, the compactness of sensor equipment offers an advantage. "Our products are so small they won't create a mass-loading effect that changes the dynamics of the experiment," says Hellsund.

The Anxious Moment

Setting up a digital crash simulation requires a few hours of labor from an expert proficient in the simulation software. Setting up a real-world crash experiment, however, requires much more. "In a typical vehicle test, it takes one to seven days just to prep the car," says Shelly Horvath, marketing specialist at DTS.

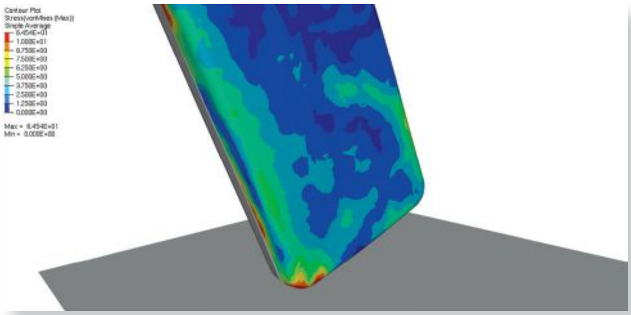
Hellsund explains that in a typical experiment involving a vehicle or an aerial craft, the client uses accelerometers, load cells, pressure sensors and potentiometers to understand how the craft behaves during descent and what forces the manikins are subjected to.

"These experiments are expensive, so everyone is usually gnashing their teeth, double-checking and triple-checking everything before the drop happens," says Hellsund. Because of the cost involved in physical testing, many manufacturers now rely on digital simulation whenever possible. While software-based simulation makes it possible to reduce the number of real-world tests, it doesn't eliminate them altogether.

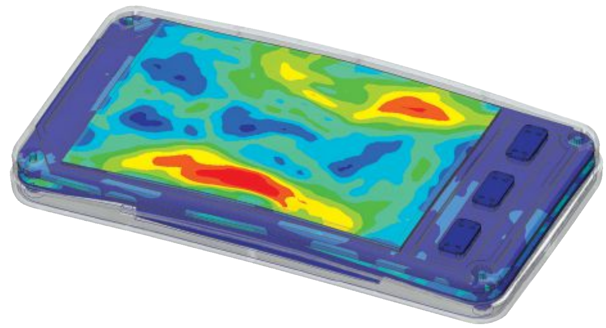
Drop Tests in Pixels

While the variation of drop tests and crash tests is almost infinite, the mechanism and the physics involved are fairly similar across the board. At its core, the test is designed to simulate a specific mass hitting a hard surface at a certain speed. It is one of the repeatable scenarios software developers hope to address using a module, a plug-in, or a standalone product.

SolidWorks Simulation Professional, a package tightly integrated with Dassault Systèmes' SolidWorks CAD program, includes a drop test simulation function. (Those with regular licenses of SolidWorks Simulation may need to pay an additional fee to access the module.) "We packaged a non-linear dynamic problem that was traditionally very complex into a simple, easy-to-use study type. Setting up the problem is as simple as saying, here's my geometry, here's my floor, here's the distance between them, now let me see the results," says Stephen Endersby, product manager at SolidWorks Simulation.



In September 2014, Dell, Intel and Altair worked together to simulate a mobile phone drop test in a virtual environment. The experiment uses Altair's RADIOSS solver to compute the results. *Images courtesy of Altair.*



The Dell-Intel-Altair virtual drop test was designed to verify if adding a damper gasket would reduce stress on a phone design. In this scenario, the gap between the phone shield and carrier plate causes bending and high stress levels in the LCD module in a back drop test.

In the consumer goods industry, the cellphone is a good candidate for virtual drop tests. It's prone to drops. It's made of delicate electronics and a display that can shatter. But you may also perform drop tests involving other products (for instance, laptops and desktop computers) using SolidWorks Simulation Professional, says Endersby. "You should start with a simple model with just a few loads," he says. "Then if the results look right, you build more complexity into it. You shouldn't try to eat an elephant in one bite."

The function, however, may not be suitable for scenarios involving complex geometry deformation from impact that requires secondary meshing during the process. In cases like a helicopter's drop or even a plastic bottle crush, the metal twisting and plastic crumpling behavior may require additional meshing to produce accurate results. Such simulations may be outside the range manageable by SolidWorks Simulation's drop test study. "That's where you're no longer looking at a simple a drop, but a crash with extreme deformation and a high rate of change," Endersby says.

The drop test simulation is "very computation intensive," Endersby says; therefore, developers are looking into supporting clusters in the future. The current version of the solver runs only on a local computer. It's programmed to take advantage of multicore CPUs during meshing and solving. GPU (graphics processing unit) acceleration is not yet supported.

Drop Tests on High-performance Computing

In September of 2014, Dell, Intel and simulation software supplier Altair collaborated to digitally simulate a cellphone drop test ("HPC Gets the Drop on Design Simulation" podcast, *Inside HPC*, September 2014). The project employed 16 Dell PowerEdge HPC Blade servers equipped with Intel Xeon E5-2600 v2 CPUs, running Altair's HyperWorks RADIOSS software. The outcome of the joint study is a benchmark on virtual drop testing titled "Optimized Drop Testing with Dell, Intel, and Altair" (by Fredrik Nordgren, application engineer, Altair; Eric Lequiniou, director of HPC, Altair; and Martin Hilgeman, HPC Consultant, Dell).

"To test performance of the Dell-Intel-Altair solution, engineers focused on a specific use case testing whether the addition of a damper gasket would reduce stress on a phone design. In this scenario, the gap between the phone shield and carrier plate causes bending and high stress levels in the LCD module in a back drop test. The goal was to find an optimized gasket design with ideal characteristic (thickness, size, flexibility, etc.) that minimizes filtered stress in the edge elements of the LCD," wrote the paper's author.

Lequiniou said, "Altair offers a packaged solution called Impact Simulation Director (ISD), developed by the Altair Enterprise Solutions team." The app, according to Altair's data sheet, "automates the laborious, manual tasks associated with model setup, analysis, post-processing and reporting." ISD would allow users to import a CAD model into Altair's HyperMesh, clean up the geometry and generate mesh, assign materials properties, define contacts and boundary conditions, submit the job for processing, and view the results.

Even though the Dell-Intel-Altair drop-test study involved HPC hardware, "It's possible to run [the drop test] on a single workstation or laptop," says Lequiniou. However, HPC makes the process much more efficient. "HPC speeds up the simulation time using multicore, multi-node clusters, especially in the design optimization phase where we ran not only one single model but hundreds of them to automatically find the best version," he says.

To take advantage of HPC, the simulation solver has to be capable of multithreaded workflow. "Our RADIOSS solver is a highly parallel code based on Hybrid MPI OpenMP parallelization. It is optimized to run very efficiently in parallel on large clusters," Lequiniou says.

Pixels And Metal Need Each Other

The advantage of virtual testing is the ability to repeat the same scenario hundreds of times with different variables at a relatively low cost. Setting up the first virtual cellphone drop takes time, effort and expertise, but once the template is established, the same test can be performed on a computer over and over to examine the impact behaviors of cellphones manufactured in different materials, at different heights, with slightly different component placements. If the number of iterations is significant, they could run simultaneously on an HPC cluster.

"You should use digital simulation (1) to guide you while the design is still evolving and (2) to understand the expected failure mode. If you did a physical test and one of your components broke in a way that you didn't anticipate, because you didn't make provisions to measure that breakage, that test could be useless. That means you'd have to redo the same expensive test. So you can use digital simulation beforehand to make sure you understand what you want to measure in the real test," says SolidWorks' Endersby.

Altair's Lequiniou pointed out, "With digital simulation, you get feedback at the early stage of the design on the behavior of the final product without having to wait for a first prototype. Our simulation code gives physically accurate results that match the real behavior of the product. The car industry has been using RADIOSS as the standard for crashworthiness for around 30 years."

But relying on virtual tests to the exclusion of physical tests would be ill advised. "If you're dealing with a new prototype or something you have never physically tested before, you can't tell if your digital model is correct or not unless you do a real experiment," says Hellsund.

The test data also serves as a more reliable foundation for digital simulation, he pointed out. "Usually engineers want to use the [real-world test] data in their finite element analysis to fine-tune their digital simulation," Hellsund says. DTS data recorders can export the captured values in a format digestible in MathWorks, LMS and other engineering simulation software.

Furthermore, Hellsund pointed out the experience of a crash or a drop is more than a set of numbers. It's sensory, augmented with sights and sounds that cannot be expressed as input parameters. "We're always surprised by how violent and unpredictable these tests are," he says. **DE**

Kenneth Wong *is* Desktop Engineering's *resident blogger and senior editor. Email him at kennethwong@deskeng.com or share your thoughts on this article at deskeng.com/facebook.*

INFO → Altair: Altair.com

→ **Discovery Channel, Curiosity: Plane Crash:** https://goo.gl/18JV0W

→ **Diversified Technical Systems:** DTSWeb.com

→ **NASA Sea Knight drop test captured on video:** youtu.be/mYFeTH0Bp6A

→ **SolidWorks:** SolidWorks.com

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Engineering Our Connected Future

Smart devices are demanding a highly collaborative workflow among mechanical, electrical and software engineers.

BY JIM ROMEO

According to Pricewaterhouse Coopers' (PwC) 6th Annual Digital IQ Survey, businesses are gearing up for a fully connected future. Connected objects, using embedded software to create the Internet of Things (IoT) is emerging as an opportunity for smart products everywhere we turn. Harvesting such opportunity will depend on the planning, collaboration and integration between smart product design and embedded software intelligence.

According to the report, 20% of companies are currently investing in IoT sensors, up from 17% in 2014. Today connected sensors are being built into everything from home refrigerators to city refuse bins to vines in "smart" vineyards.

PwC further cites research from Gartner that 4.9 billion connected objects are in use in 2015 — a 30% jump from 2014. This figure is estimated to reach 25 billion by 2020: Twice as many IoT devices talking to each other as there will be smartphones, tablets and PCs. What was still a futurist's dream just a few years ago is now infiltrating every part of business. But this corroboration is not yet fully mature.

Smart Designs, Smartly Planned

To ramp up quickly, many companies are working with outside firms as consultants and to bring in additional software and electronics engineering expertise. But first, device manufacturers need to decide the basic "smartness" characteristics of their device, says Brian Oberholtzer, vice president of Engineering at Zonoff. If the device is to be a consumer IoT device on its own, then the manufacturer might work with a company that has a remote access platform and the ability to deliver mobile apps.

"Such a device also needs to consider how it will be paired with home Wi-Fi in a way that is approachable to end users," says Oberholtzer. "Another option is to support a wireless standard like Z-Wave or Zigbee, and in this case, a different partner may be appropriate as cloud and mobile applications are not needed but true embedded development and protocol expertise is required. If working though this decision is outside of the device manufacturer's expertise, then an appropriate industry expert should be sought out to help determine the kind of 'smart' that the device will have. Power requirements of the device play a big part in the tradeoffs."

The Pearl Thermostat uses a ZigBee HA 1.2 hub to offer remote climate control. ***Image courtesy of CentraLite Systems.***

Building A Smart Culture For Smart Products

Planning so designs are smarter requires somewhat of a culture change. Product designers need to build savvy regarding the capabilities that digital intelligence in embedded software affords. Outside service providers are one way to jumpstart the training and workflow needed for connected products.

Many manufacturing companies have very little experience with software development and aren't fully aware of the importance of some critical features such as logging and auditing, reporting, or malicious use of the app, says Sean Lorenz, director of IoT Marketing Strategy at Xively. There are a number of systems focused on IoT projects, so companies unsure of how to handle these issues are beginning to have a larger pool to select from.

But the culture of collusion and collaboration may be shifting toward joining software developers and design engineers at the hip, as demand for IoT products grows. The staffing firm Adecco Corporation, whose markets include engineering and technical disciplines emphasizes the importance of melding embedded software with traditional engineering designs.

In one of the company's research reports, they write: "A company that wants to move from products to smart, connected products, may need to revamp its technology stack to include not just hardware, but software, and lots of it. They will also need to address the security and infrastructure demands of connectivity."

Integrating Hardware With Embedded Software

Design teams are challenged with building collaboration early on — before progress is made on any engineering design that might make it difficult to include both sensors and embedded software. If the relationship isn't formed early enough, it will be more difficult to retrofit smart capabilities.

Early is better, says John Calagaz, CTO of CentraLite Systems. Embedded software engineers need to be brought into the process early. He says they are the ones who will determine, with the hardware engineers, if the design is possible given the requirements on the design side along with cost.

"A designer can create a really innovative concept, but the embedded and hardware engineers are going to determine which components are needed to make it happen," says Calagaz. "A $50 device could easily become a $100 device if everyone assumes the design can be built as is without any consulting of the embedded and hardware engineers."

This early cooperation is growing and embedded software firms realize the importance of developing their software with a smart product in mind.

"There is definitely growing cooperation between design engineers who design consumer products and design engineers who have, in the past, traditionally designed complex devices like medical instruments, industrial controllers and airplanes," says Oberholtzer. "Embedded software firms are recognizing the need to adjust their tools, and their message, for these other design engineers. And while embedded software companies are changing their products to go into low-power, low-cost consumer products for the IoT, other companies like Apple and Google are also creating their own tools for this market."

Oberholtzer highlights the importance of not becoming too dependent on big names when it comes to considering operating systems and information networks for their IoT devices.

"Lots of companies want into that opportunity because many, many devices will be sold," he says, "and lots and lots of data will be transmitted through them. The device manufacturer can then put the intelligence and monitoring in a hub that connects all the IoT devices. Inside the hub, the manufacturer can decide to use Google or Apple or their own custom OS to control, monitor and monetize the devices and the data."

Engineers need to also consider multiple sources in building the integration between embedded software solutions and devices. Cloud-based solutions as well as mobile technology are key considerations when mapping out smart products.

Oberholtzer says there are a range of companies and services for device manufacturers depending on the kind of device being produced ranging from embedded contractors, existing SaaS (Software-as-a-Service) providers for remote access to devices, to mobile application contractors and user experience consultants.

SATO, a provider of barcode printers, leverages the Xively IoT platform to provide next-generation connectivity. ***Image courtesy of SATO Global.***

"It is often possible to retrofit a smart solution to an existing non-smart product but it obviously can make a better product if the vision for the smart device starts out from early stages of design with the end use cases in mind," he says. Generally, the functionality is determined, hardware is selected and compatible software acts within that hardware. So hardware and software engineering need to be engaged, and meet up early.

"If they're going to be used, embedded software services should be brought in as early as possible," says Bob Zeidman, president, Zeidman Consulting and Technologies. "Right now, the hardware needs to be determined first and the software needs to be developed based on the hardware that is selected. The embedded software developers need to be in on the hardware decisions so that they can confirm that they can meet the device requirements given the hardware choice."

Zeidman cautions that if you choose the wrong hardware at the beginning, then write the software and find that you can't meet the design requirements, you need to redesign the hardware or change the design requirements. **DE**

Jim Romeo *is a freelance writer based in Chesapeake, Virginia, with a focus on business and technology topics. Contact him via DE-Editors@deskeng.com or jimromeo.net.*

INFO → **Adecco Corporation:** Adecco.com

→ **CentraLite Systems:** CentraLite.com

→ **Pricewaterhouse Coopers:** PwC.com

→ **Xively:** Xively.com

→ **Zeidman Consulting and Technologies:** ZeidmanConsulting.com

→ **Zonoff:** Zonoff.com

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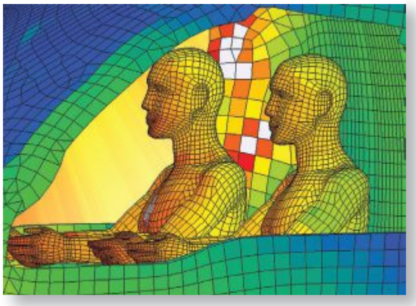
Editor's Picks

by Anthony J. Lockwood

Each week, Tony Lockwood combs through dozens of new products to bring you the ones he thinks will help you do your job better, smarter and faster. Here are Lockwood's most recent musings about the products that have really grabbed his attention.



ThermoAnalytics Enhances and Rebrands RadTherm

Version 12.0 of the software is now called TAITherm.

TAITherm represents the solution's 12th major update. The software, which uses a multiphysics methodology to solve both steady-state and transient thermal conditions, scales to solve fast 1D models and detailed 3D models for virtual prototyping from the beginning of a project through to final validation. This newest release sees enhancements across most of its entire operating areas, such as post-processing, CAE coupling and its Human Thermal Comfort management add-on module.

Also added are distributed computing capabilities for running multi-grid and partial-direct solvers in parallel.

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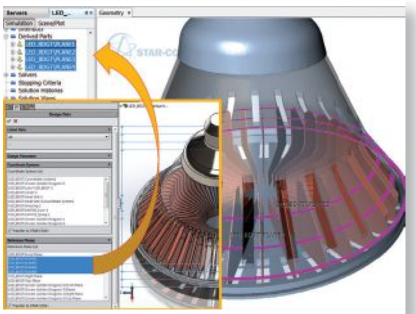

CD-adapco Releases STAR-CCM+ v10.04

The platform now offers computational solid mechanics capabilities.

Version 10.04 of STAR-CCM+ adds a finite element-based stressed solver for engineers who need to run the occasional finite element analysis (FEA). This new computational solid mechanics functionality comes as an operational component of STAR-CCM. No new license required. It uses the same the interface, and it gives you the flexibility to use the right analysis tool on a problem as it warrants.

This release includes a new Adjoint Solver for Coupled Solid Energy that enables sensitivity analysis of solid conduction problems.

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National Instruments Ships Xeon-Based PXIe Controller

Hardware is suited for wireless, semiconductor testing and 5G prototyping.

The NI PXIe-8880 controller features an eight-core, server-class Intel Xeon E5-2618L v3 processor and a full system bandwidth of 24GB/s both ways. NI says that the Xeon CPU in an embedded controller board is an industry first. The NI PXIe-8880 comes with 8GB of memory (upgradable to 24GB) and 24 lanes of PCI Express Gen 3 connectivity to the backplane.

Furthermore, the 18-slot NI PXIe-1085 chassis also features PCI Express Gen 3 technology. It gives you eight lanes per slot for a matched total system bandwidth of 24GB/s.

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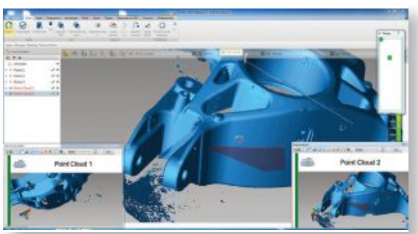

FARO Technologies' CAM2 Measure 10.5 Now Available

3D scanning software also has complementary iPhone and iPad application.

Beginning with CAM2 Measure 10.5, users can connect multiple 3D measurement devices within the same coordinate system and simultaneously scan from each into a single seat of software on a computer. A key feature here is that version 10.5 provides an expanded point cloud capacity that lets users collect over 20 times more data than with previous versions and maintains accelerated processing speeds.

The platform also sees GD&T (geometric dimensioning and tolerancing) enhancements that streamline analysis and visual reporting.

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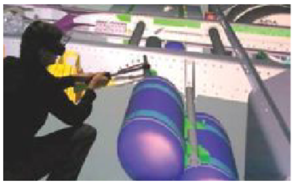
Designing with Virtual Reality

MAN and the University of Applied Science Upper Austria use ESI Group's IC.IDO to efficiently create a truck assembly line.



MAN Truck & Bus Österreich AG strived to create a more efficient design for a truck assembly line. They were interested in anticipating the assembly sequence, looking to improve the assembly process significantly and make the operations faster and more efficient.

Benefits of Virtual Collaboration

MAN was able to simplify the setup process of the assembly line while also making it run more efficiently than ever before. This was possible because the designers, operators and subcontractors were able to exchange views about a 3D prototype before the manufacturing facility was in place. They were also able to reduce the time to launch and the cost by bringing line-testing operations down from two weeks to one day.

"With rapid data preparation in virtual reality workshops, powerful assembly functionalities and user friendliness, ESI's IC.IDO proved to be the right choice for this collaboration. IC.IDO's usability, physical calculation and real-time detection of parts colliding during the assembly process matched MAN's needs. Not to mention, what previously took us two weeks can now be completed in just one day," says Franz Obermair, professor at the University of Applied Sciences Upper Austria.

Background

In a rapidly globalizing market, commercial vehicle OEMs (original equipment manufacturers) and their suppliers face a dynamic business climate. Innovative virtual product engineering technologies have become a precondition to sustain and improve their competitiveness, growth and quality standards.

Virtual reality is making this possible, bringing design, engineering and manufacturing teams together to work on the up-to-date virtual prototype to improve the assembly and disassembly processes.

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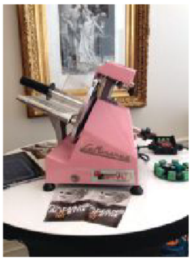
IoT Takes on the Food Industry

The Solair application platform at the heart of the new NEMOSY system was developed and patented by DSC Nexus for the large-scale retail trade.



Develop an add-on to offer a value added service to Minerva Omega Group food machines. That was the challenge that Minerva Omega Group, an Italian company specializing in designing and developing a large range of machines and systems for processing and preserving food products, posed to Solair and DSC Nexus.

Initial Requirements

The industry where the Minerva Omega Group operates is highly competitive. It is a mature market and innovation on existing products, such as meat slicers, has reached its limit. The initial requirement for the Minerva Omega Group was to identify and produce an add-on for their machines to give significant added value and differentiation to put on the table during the negotiation phase. This was the beginning of an idea to add a Wi-Fi monitoring solution to their machines to give the large-scale retail trade a new service to offer. They can now manage machine maintenance dynamically.

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Commentary  by Dr. Royston Jones

Can Simulation Reach its Full Potential?

Simulation-driven design — the philosophy of using simulation tools upfront in the design process to find the ideal design solution fast — is something we talk a lot about at Altair. It's something the Altair ProductDesign team puts into practice every day with clients across industry verticals. In many ways though, this philosophy is something of an ideal. Even in the modern, multi-disciplinary design environments of today's vehicle and aircraft manufacturers, simulation is not seen as a critical path within the conceptual design stages of programs. The reality is that for many companies, design remains king and simulation is there to provide validation only.

I am fortunate that my role at Altair means that I meet design and engineering teams from across Europe's major manufacturers and experience a wide cross-section of attitudes and approaches to the use of simulation today. In recent years, I have witnessed a change in attitudes toward computer-aided engineering (CAE). There is more willingness to explore the potential and use of CAE technology. There is an enthusiasm to apply it more freely. Companies are continuing to take steps toward the simulation-driven design ideal. For me, this is due to a handful of factors.

Simulation-driven design is not yet the standard way of designing products.

Barriers to Upfront Simulation

First, something that's always held CAE and simulation back as an integral part of design processes is the speed in which an analyst can provide results back to program teams. Speed was less of a problem when an analyst just needed to validate performance. However, when you move to a situation where simulation teams are tasked with providing design direction within the early exploration phases of conceptual design, speed becomes paramount. This barrier is being eroded away on an almost daily basis with the advent of ever more powerful and cheaper access to high-performance computing (HPC) resources.

Second, for simulation to play an upfront role, the results have to be accurate. Without accuracy, CAE loses its credibility and with that goes any ability for it to influence design. But modern simulation technologies have addressed this barrier too. Witnessing the accurate simulation of carbon fiber structures deforming on an individual ply level during a crash event or seeing a simulation of an injury to muscle tissue is something we could have only dreamed of just a few years ago; and things will only get better as time goes on.

Lastly, the intelligence of modern-day simulation tools is helping to drive adoption within the early design process. The necessity for many manufacturers to save weight, material and cost to produce products has resulted in an increased adoption of design optimization techniques. Software can provide vital design insights on where material is needed and where it can be removed without negatively impacting performance. These tools offer designers new ways to rapidly explore design concepts for specific methods of manufacture to bring material-efficient, high-performance products to market.

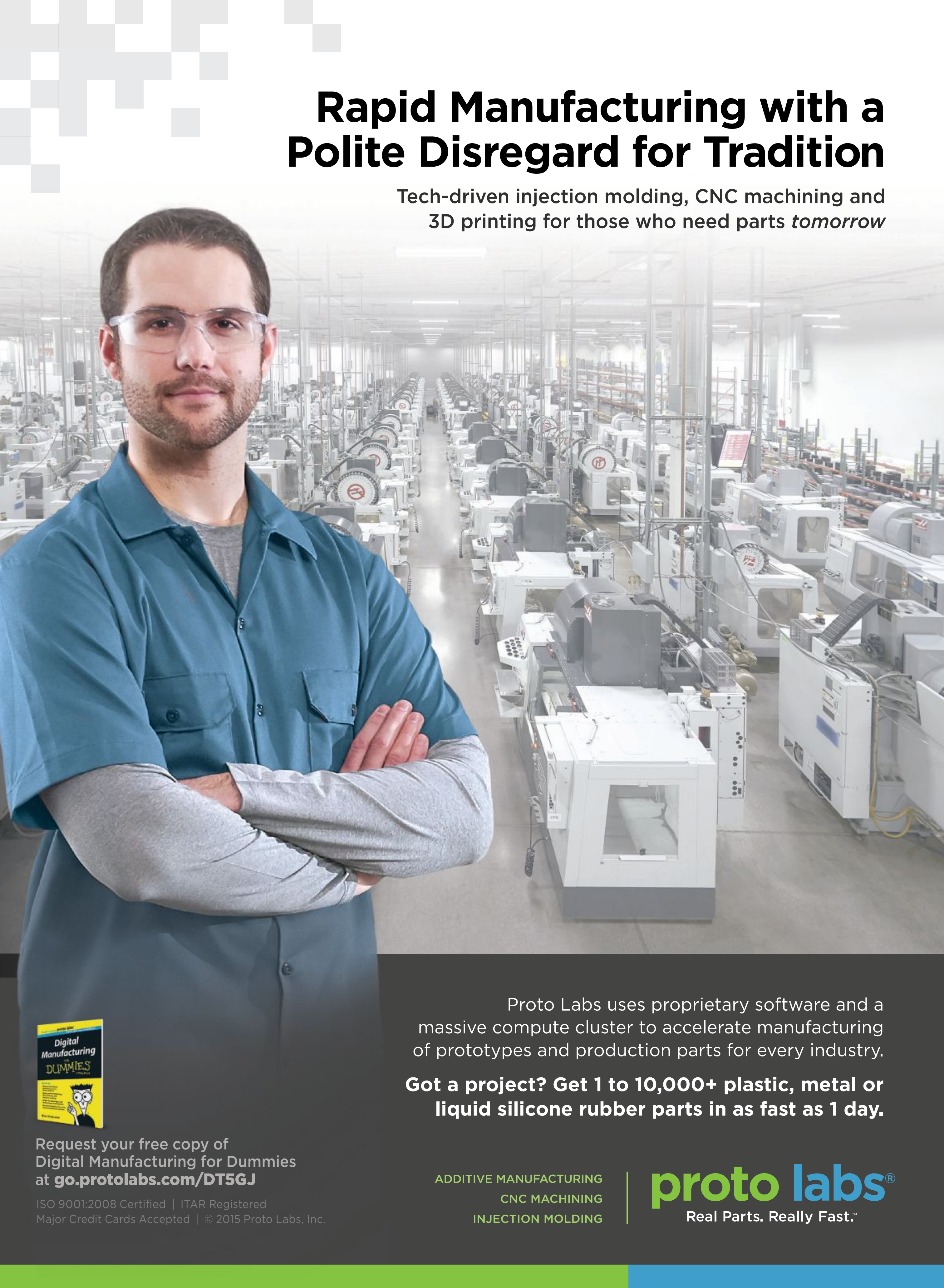
For me, one of the best examples of the advantages of moving simulation techniques upfront in the design process has been the advent of additive manufacturing (AM). In the AM world, the analyst becomes key, producing early concepts for designers to explore and develop; safe in the knowledge that the organic (or bionic) structural design is mass efficient, meets or exceeds the performance requirements and can be manufactured. A simulation-driven design approach in combination with AM offers unprecedented levels of weight and materials savings — demonstrating why simulation is such a compelling technology when used in the early design phase.

Cultural Shift Needed

But even with all this progress, simulation-driven design is not yet the standard way of designing products. Perhaps the final thing holding back its trajectory is the culture ingrained in well-established design processes. Processes that have worked time and time again to produce successful products are not easily changed.

Much of my work involves challenging traditional design practices and showing how a simulation-driven approach, by example, can positively impact competitiveness and profitability. In my view, the key to truly innovative products lies in the closer integration of simulation with design. I'm encouraged to see that barriers have fallen and examples of successful applications of simulation-driven design have increased. We're getting closer to the simulation-driven design ideal. Long may that continue. **DE**

Dr. Royston Jones *is executive vice president of European Operations and global chief technology officer for Altair ProductDesign, altairproductdesign.com. Comments can be sent to DE-Editors@deskeng.com.*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