DE

Technology for Optimal Design Engineering

January 2016 / deskeng.com

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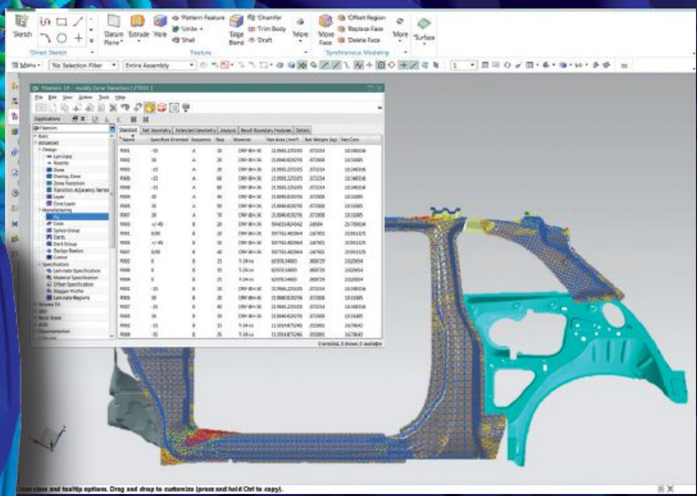

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by Jamie J. Gooch

The More Things Change ...

Twenty years seems like an eternity when it comes to technology. I'm reminded of that as we begin a new year and I flip through the premiere issue of *Desktop Engineering* from 1995. A new product writeup under the headline of "Pentium Notebook" explains the features of an HP OmniBook 5000: a 90MHz Pentium processor, VGA or SVGA display, up to 1GB hard drive and 8MB of RAM — all for just $5,800. A few pages later, a mathematics software review compares Macsyma, Maple and Mathematica, ultimately determining "if you have 8MB of memory or less, Maple is the product you want." A feature titled "New Directions in FEA" says desktop FEA programs will be able to solve several million degrees of freedom problems at the rate of 40,000 DOF per minute "within the next year or so."

Contrast those articles, which were largely about the promise of desktop engineering, to this issue's coverage of software algorithms suggesting designs, photorealistic renderings being used to replace physical prototypes, and reviews of 4K displays and a $5,800 desktop workstation with a 10-core, 3.1GHz Intel processor, 32GB of RAM and more than 2TB of hard drive space. In many ways, the promise in that first issue has been delivered upon. But, as stated in the tagline for the first issue's cover story: "Micros have forever changed engineering, but the big changes have just begun."

Today's engineers need computing horsepower, up-front simulation and collaboration tools more than ever.

Some Technology Constants

Technology has come a long way, but even bigger changes are on the horizon. The coming ubiquity of the Internet of Things (IoT), the widespread commercialization of machine learning, incredible advances in 3D printing and the democratization of simulation and high-performance computing are already revolutionizing the way products are developed. Still, some things don't change. Do any of these words of wisdom from experts interviewed for the first issue's cover story, "Your Changing Desktop," sound familiar?

- "The most critical need in the engineering environment is for continued improvements in simulation so that users can simulate more and prototype less. This will result in reducing the time required to bring new products to market, and in dramatic design and development cost savings." — *Tom Hotchkiss, HP*
- "Faster processors have meant that more software-intensive design tools can be deployed, allowing engineers to work on more complex designs. The simulation capabilities of the faster processors provide better coverage of the design and reduce the debug cycle and the probability of design errors." — *Sam Fuller, Motorola RISC Microprocessor division*
- "Some additional focus should be put on integrating the project and product life cycles, especially for more involved engineering projects — and more and more projects are becoming more involved." — *Yoav Etiel, Bentley Systems*
- "What is needed is better software for coordinating teams of engineers, including geographically dispersed teams." — *Tom Roberts, DEC*
- "Networking has allowed the control engineer to take a general technology and link it to the sensors monitoring the process. This closes the process loop." — *Al Raden, IBM*

So, 20 years ago engineers needed better, faster simulation of more complex designs and technology tools to enable a more collaborative workflow. Technology vendors have delivered all of those things, of course, but those needs are still compulsory to the advancement of engineering.

More is More

Even with the incredible technological advances over the past two decades, it could be argued that today's engineers need computing horsepower, access to up-front simulation, and collaboration tools more than ever. That's why we we've placed more emphasis on access to simulation and optimization recently, called attention to what Big Data and the IoT mean to engineering, broadened our computing coverage, and have begun covering engineering workflows that cross engineering disciplines and departmental borders.

As we begin our 21st year, we look forward to sharing the next revolutionary technological breakthroughs and evolutionary technology updates that will help design engineering teams produce optimal designs. It's going to be a fascinating new year. DE

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

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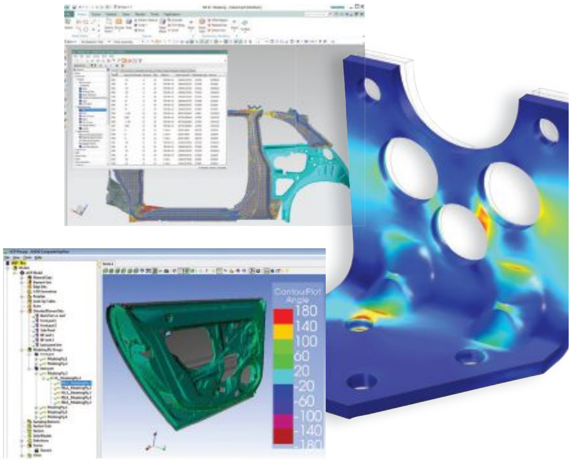

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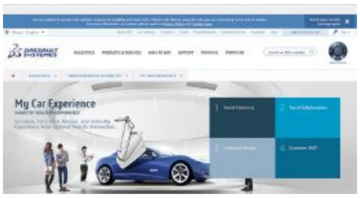

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ON THE COVER: Optimization and simulation software help engineers create more lightweight designs. *Images courtesy of Altair, Siemens PLM Software and ANSYS.*

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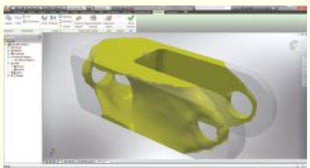

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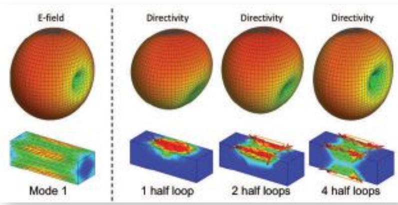

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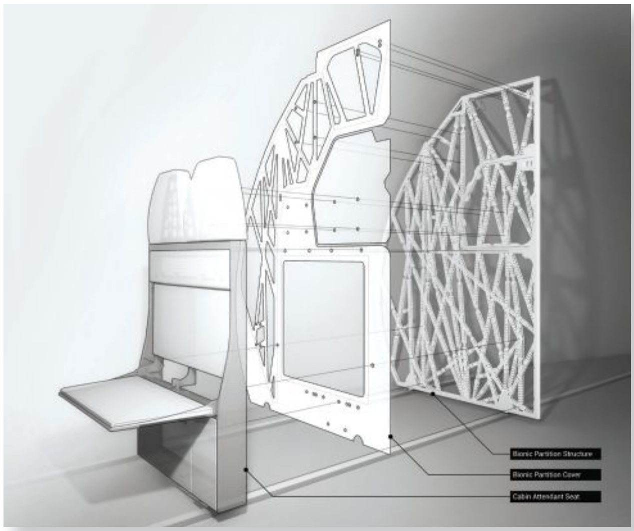
by Kenneth Wong

The Era of Algorithm-Driven Design Begins

Suppose someone develops a kind of intelligent paint. With this medium, the next Rembrandt and Picasso could do away with the tiresome preliminary sketches and form studies. They could simply tell the paint what they want to draw. Whether it's the portrait of an Italian nobleman or a woman's figure in cubic blocks, the paint would automatically generate the best profile. The virtuoso artists would only have to do a few final touchups, like correcting the skin tones here and there and adding some highlights. Such an invention would fundamentally change the relationship between the artists and their medium. Alas, the existence of intelligent paint is purely hypothetical.

Yet, a comparable shift is about to happen to the design community. As I see it, the new breed of software that enables algorithm-driven shape exploration is the equivalent of intelligent paint. With built-in logic to evaluate and generate topology, the software behaves more like AI (artificial intelligence) and less like a geometry-sculpting program.



This Airbus partition is conceived using custom algorithms that generate cellular structures and bones. The structure is stronger and more lightweight than would be possible using traditional processes, according to the joint announcement by Autodesk and Airbus. ***Image courtesy of Autodesk.***

Generative Design

At last month's Autodesk University Conference (AU 2015, December 1-3, Las Vegas), Autodesk CTO Jeff Kowalski declared: "Technology takes a quantum leap from passive to generative." The year before that, at AU 2014, Kowalski began using the term "generative design" to refer to a process that "starts with your goal. Then it explores all the possible permutations of the solution through successive generations, until the best one is found."

The project that brought this vision to reality is the Autodesk-Airbus collaboration to design a new airline cabin partition. The ultra-thin, lightweight structure must also hold a foldout seat that can accommodate the weight of two crew members during takeoff and landing. In a blog post detailing the project, Autodesk wrote: "Dubbed the 'bionic partition,' the component was created with custom algorithms that generated a design that mimics cellular structure and bone growth, and then produced using additive manufacturing techniques. This pioneering design and manufacture process renders the structure stronger and more lightweight than would be possible using traditional processes."

With simulation and analysis software, the designer provides a fairly detailed 3D model and a series of inputs (such as loads, pressures, contact points and material properties), and asks the software: "What will happen to my design under these conditions?" With algorithm-driven design, the designer designates a region for shape exploration and a series of inputs, then asks the software: "What is the best topology that can stand up to these forces?"

Though a relatively new approach in manufacturing, algorithm-driven geometry is quite common in architecture, especially in large-scale commercial projects and iconic landmarks. Bentley Systems, a rival of Autodesk in architecture, construction and engineering (AEC), has cultivated a robust user community around its GenerativeComponents software. Grasshopper, a plug-in for the surface-modeling program Rhino, extends GC's reach with an interface that's more visual, less script-driven.

Topology Optimization

In my view, the emerging topology optimization packages also manifest algorithm-driven design. Altair's solidThinking Inspire, TOSCA Structure from Dassault Systèmes, and GENESIS from Vanderplaats Research & Development fall into this class, for example. They're usually deployed as lightweighting solutions to identify the lightest possible design to improve fuel economy in automotive and aerospace industries. Since topology optimization is an offshoot of finite element analysis

(FEA) solvers, it will likely become a feature of simulation software packages in the near future. But Shape Generator, which made its debut in Autodesk Inventor 2016 R2, pushes the envelope further. It brings topology optimization to the CAD modeling phase.

The shift from human-conceived design to algorithm-driven design is a tectonic shakeup.

If you're an artist with self-doubt, an invention like intelligent paint would wreak havoc with your self-esteem. After all, if paints can automatically generate portraits or landscapes, what is the purpose of the artist? Algorithm-driven design, on the other hand, isn't the death knell for engineers and designers, because computer-proposed shapes — or algorithm-driven geometry — are seldom suitable for manufacturing as-is. It still takes the software skill, design intuition and industry experience of an engineer to transform the bone-like structure or the jagged lump of geometry into something fit for machining, injection molding and mass production at a reasonable cost.

Even if the design is destined for 3D printing — a method that transcends the classic manufacturing constraints — an engineer must intervene to improve the computer-generated design's aesthetics. Most people I know wouldn't want to wear a bicycle helmet that looks like a crater from Mars or drive a car that resembles a prehistoric animal's ribcage, which is usually what you get when you ask a piece of code to spit out a mathematically optimal shape. The software can evaluate stress fields and structures for efficiency, but it's not programmed (not yet, at any rate) to evaluate beauty — a subjective human concept.

Still, the shift from human-conceived design to algorithm-driven design is a tectonic shakeup. It's bound to rattle many established workflows, processes and deep-rooted thinking in our industry. We can only speculate on how Rembrandt and Picasso might have reacted to a form of self-drawing paint. But we're about to witness how the designers and engineers will react to software that behaves a bit more like humans.

By the way, this column is not algorithm-driven. It's written by yours truly — every word of it! **DE**

This commentary is the opinion of **Kenneth Wong,** DE's *resident blogger and senior editor. Email him at kennethwong@deskeng.com or share your thoughts on this column at deskeng.com/facebook.*

by Tom Kevan

The IoT Redefines the Sensor

The Internet of Things (IoT) pushes measurement analytics to the edge of the network, redefining the sensor's place in the electromechanical ecosystem. No longer a discrete component working in isolation, the sensor interacts with computing and communications components to provide intelligence via two-way communications. As a result, deploying sensors in the IoT presents different challenges than those encountered when integrating sensors into traditional network-edge devices, placing greater demands on traditional practices and requiring new design and test approaches.

To perform their functions, most IoT sensor nodes combine a sensor front-end, signal conditioning, power supply, microcontroller and back-end communications. For the engineer, the challenge is to ensure that not only do these components work well together, but they also work with other connected "things," creating harmony from diversity.

Engineers must view sensors as a critical part of the larger whole.

To meet this challenge, engineers must adopt a systems engineering perspective, looking beyond individual components and viewing the sensor as part of a larger whole. Using this perspective, engineers must determine how the sensor fits and interacts with the other components in the node. This demands that mechanical, electronic and software engineers work together, viewing the system holistically to ensure the node meets performance specifications.

Fitting More Into Less

In addition to making all of the components work well together, design engineers must also fit more and more functionality and components into smaller spaces. These design demands place a premium on miniaturization and packaging technologies.

For example, engineers have traditionally considered microcontroller and wireless transceiver requirements separately, but for an IoT system, the selection of these two components must be considered together. Instead of using discrete components, designers now have the option of using a system on chip (SoC) components that combine transceivers and microcontrollers. These devices often include extra memory and processing power, saving space and reducing cost and power consumption.

Another option is micro-electro-mechanical systems (MEMS) technology, which has evolved from miniaturized, single-function systems into complex integrated systems. The latest generation of these systems brings together sensing, data processing and actuation, enabling them to handle a number of IoT functions.

The adoption of MEMS and SoC integration approaches can simplify the development process. They do, however, make new demands on design, prototyping and testing tools.

The Cost of Openness

Engineers must also ensure reliable communications. IoT edge nodes communicate over physical layer protocols, including a wide variety of wireless standards, ranging from Bluetooth to cellular, constantly pushing the limits of range and throughput. The challenge here is that no one standard meets the requirements of all applications. As a result, engineers have to select the technology that delivers the required levels of performance, coming to terms with interoperability hurdles and ambient interference. To meet these needs, they can turn to tools and platforms that analyze RF (radio frequency) signals and communication protocol exchanges.

The downside of wireless communications is that they open the nodes to security threats. One of the biggest challenges of providing security for the small endpoints of the IoT lies in the fact that traditional techniques of isolating the nodes often do not work, and hardware-based security cannot always be applied. Engineers do, however, have the option of turning to software-based security solutions.

Less is Better

The power consumption design criterion for IoT sensor nodes has one rule: Do more with less. This means that the node must be able to sense a physical property, perform analytics and transmit data to the Internet on a significantly reduced power budget, regardless of the power source technology.

This calls for hardware- and software-based power management. To a large extent, the solution lies in a combination of ultra-low-power optimized software that supports a variety of power-saving and sleep modes and energy-efficient hardware (such as point-of-load and fanless, conduction-cooled power supplies).

Many engineers designing IoT devices may not have a depth of knowledge in all the fields touched by the design process. As a result, designers will require intuitive, easy-to-use test and prototyping systems that provide a holistic development perspective and enable shorter design cycles. **DE**

This commentary is the opinion of **Tom Kevan**, *a freelance writer/editor specializing in engineering and communications technology. Contact him via DE-editors@deskeng.com.*

Systems-Level Optimization

When engineers hear the term "optimization," the first thing that comes to mind is usually structural (geometry) optimization — most likely the type called topology optimization. But for any product with a sophisticated functional architecture, optimization technology offers great benefit when used early in product development to optimize the functional systems models that are created and refined before geometry definition begins.

The mistaken assumption that "optimization" must mean geometry optimization is grounded in a misconception that shows up in many discussions of how to simulate early in product development, which tend to fixate on finite element analysis (FEA). The weakness of this view is that it overlooks the power of systems modeling for studying, exploring and optimizing designs at the beginning of projects — when product geometry is not yet available for 3D CAE (such as FEA or computational fluid dynamics) and engineering decision-making can have its greatest impact and leverage on project success.

Before Geometry: Systems Modeling Software

Systems modeling software consists of tools and languages for systems engineering: the specification, analysis, design, verification and validation of systems and systems-of-systems. In discrete manufacturing, systems engineering is the coordinated specification through validation of complex physical systems across multiple domains — mechanical, electrical, electronic, hydraulic, thermal, control, electric power and others.

Systems modeling software is used early in engineering projects to make a product's most crucial functional and architectural decisions. For complex architecture products, design exploration and optimization software can have its greatest impact by being used to optimize the functional systems models created during conceptual and preliminary engineering with tools such as Dassault Systèmes' Dymola, Maplesoft's MapleSim, MathWorks' Simulink, PTC's Integrity Modeler, Siemens PLM Software's LMS Imagine.Lab Amesim, or the Modelica tools and libraries from Modelon and others.

Design Exploration and Optimization of a Hybrid Electric Vehicle's Powertrain

While design exploration and optimization promises great benefit for aircraft, space systems, defense systems and any other industry whose products have complex multi-domain architectures, some of its first adopters have been automotive manufacturers pressed to meet the engineering challenges of powertrain electrification. One example is an automotive original equipment manufacturer where design exploration and optimization software was used with systems modeling and simulation software to optimize performance of the combined electric-and-combustion propulsion system in a new hybrid electric vehicle (HEV).

A key challenge in HEV powertrain development is to maximize fuel economy while complying with mandated emissions targets — two competing or conflicting performance objectives. In particular, the "traveling performance," or difference between the actual and legally mandated emissions levels, needs to be minimized to some extent to ensure robust compliance with those mandates. This is an ideal task for design exploration and optimization software, which was used to automate the traditional "guess-and-correct" approach to simulation-based design, helping engineers evaluate and balance the tradeoffs between maximizing fuel economy and maintaining emissions compliance.

In this project, Noesis Solutions' Optimus design optimization and process integration software was used in conjunction with Maplesoft's MapleSim multi-domain systems modeling and simulation software. First, engineers used the optimization software's design of experiments (DOE) and response surface modeling (RSM) capabilities to identify the best possible tradeoff between the fuel-economy and traveling-performance objectives by varying and balancing three key variables in the powertrain systems model:

1. Number of battery cells (20 to 60)
2. Engine speed (2000 rpm to 5000 rpm)
3. Battery charge level that initiates battery recharging by the combustion engine (10% to 90%)

Then the optimization software's multi-objective (Pareto) optimization capability was used to identify two separate design optima: the fuel-economy optimum (11.8 km per liter/33.3 miles per gallon — 39% better than the initial baseline design) and the traveling-performance optimum, a unified measure of pollutant concentration resulting from a formula whose inputs are the concentration levels of several different compounds in combustion engine exhaust (2,477 — 22% better than the initial baseline design). Because these optima were at opposite endpoints of the "Pareto front" of possible tradeoff solutions, a compromise "Pareto-optimum" design needed to be found in between.

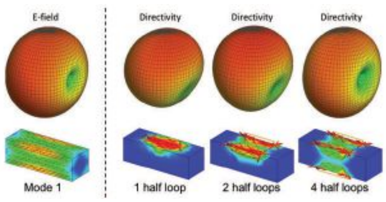
With both objectives equally weighted, the resulting single-tradeoff HEV system configuration yielded fuel economy of 11.3 kilometers per liter (31.9 miles per gallon) and traveling-performance value of 2,970. With these values, engineers improved fuel economy an impressive 21% and traveling performance (emissions compliance) by 15% over the initial design. DE

This commentary is the opinion of **Bruce Jenkins**, *president of Ora Research (oraresearch.com), a research and advisory services firm focused on technology business strategy for 21st-century engineering practice.*

Altair Announces FEKO Competition Winner

Ting-Yhen Shih, a PhD student from the University of Wisconsin-Madison, is being awarded first place in the Altair FEKO Student Competition for his work on platform-mounted HF antennas.

The competition supports engineering education and academic excellence for students interested in antennas, microwave devices, bio-electromagnetics, electromagnetic compatibility and other electromagnetic fields.



Shih's entry, titled "Design of Platform-Mounted HF Antennas with Enhanced Bandwidth Using the Characteristic Mode Configuration in FEKO," develops a method to efficiently approach the bandwidth limitation of a platform mode. This creates new bandwidths that stand-alone antennas were not able to achieve previously.

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Luxion, Onshape Partner for KeyShot Connection

The KeyShot Connection plug-in lets users make photorealistic renderings and animations of their Onshape documents. The integration enables users to connect to their Onshape account from inside KeyShot, share Onshape documents with any changes and update files without losing any material, lighting or animations setup in KeyShot.

To access the capability within KeyShot, an option for "Connect to Onshape" is added to the menu after installation. While browsing, Part Studio or Assembly is selected and brought into KeyShot with the click of a button, with the model structure, part and assembly names all maintained. (KeyShot Pro adds the ability to import NURBS data for perfectly smooth, rounded surfaces.) After materials, environments and textures are added in KeyShot, the scene may be saved and uploaded directly to an Onshape document for others to make updates.

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National Instruments Releases Trend Watch

A new report from NI examines a range of topics focused on the Internet of Things (IoT) and its impact on data management, according to the company.

The report includes the following topics:

- Prototyping Takes 5G From Concept to Reality
- Big Analog Data of the Future: From the Edge to the Enterprise
- It's About Time: Evolving Network Standards for the Industrial IoT
- Testing the Big Bang of Smart Devices
- The Consumerization of Software

"As the world becomes more connected, the incredible amount of real-world data available today promises engineers and scientists great insight, but getting that insight can be a challenge," said Eric Starkloff, NI executive vice president of global sales and marketing.

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Technical Documentation Application Launched

Built on the Aras Innovator platform, the Technical Documentation application uses PLM content during the authoring process to reduce rewriting and error. Document revisions and engineering change orders automatically trigger updates, improving accuracy, Aras states.

Technical Documentation was built in partnership with Orio AB and is a Web-based solution.

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Pasternack Adds Flexible Waveguides

Flexible Waveguides, according to the company, act as a malleable conduit in waveguide systems where there is no option for a rigid waveguide section. Ideal for test labs or prototyping, these waveguides can easily be flexed and manipulated, the company states. They are available in 12-, 24- and 36-in. configurations.

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Speed v10.06 Now Available

CD-adapco, a provider of CFD (computational fluid dynamics) software, has released SPEED v10.06, the latest version of its electric machine design solution. This iteration, the company says, offers more tools for intelligent and automated electric machine design.

Version 10.06 has tighter integration with HEEDS MDO, enhanced design exploration capabilities and a number of refinements and bug fixes.

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Graebert GmbH Ships ARES Commander 2016

ARES Commander DWG-based software is available in 14 languages and on Windows, Mac and Linux systems.

Some of the new features in the software include:

- Quick Input: Gives a command entry interface near the pointer.
- Annotation Scaling: Adjusts the size and scale of dimensions, texts, hatches and blocks to the scale of each viewport.
- Dimension Location Snap: Forces dimension lines to be placed at specified distances from measured linear entities and between successive dimension lines.
- LayerState Manager: Creates and names different scenarios for user layers and eases switching between them.

The company has also stated that ARES Commander 2016 can be purchased as a perpetual or annual (12 month) plan. Additionally, any license of the software includes a 12-month subscription to ARES Touch mobile CAD.

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AMD Announces FirePro W4300

The new FirePro W4300 graphics card is suited for CAD performance in both small form factor (SFF) and tower workstations. It integrates a GPU (graphics processing unit) with 4GB of GDDR5 memory and a low-profile design.

It is optimized for the latest CAD applications, the company says. These include AutoCAD, Inventor, Revit, SOLIDWORKS, Creo, NX and more. Compatibility with Eyefinity multi-display technology allows the use of up to six high-resolution displays.

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EnvisionTEC Expands Micro Plus Line

The Micro Plus is available in two variations, the Micro Plus Hi-Res and Advantage. This desktop 3D printer has a new body style, touchscreen and an integrated embedded PC with Wi-Fi connectivity.

The Hi-Res provides a build envelope of 1.8x1.1x3.9 in. and a resolution of 30 microns. The Advantage has a dynamic Z resolution that varies between 25 and 75 microns with a build envelope of 2.3x1.8x3.9 in.

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Globalscape Reveals WAFS Version 5

The latest version of WAFS (Wide Area File Services) has updates to stability, performance and security. The software streamlines enterprise collaboration and decreases bandwidth usage.

Version 5 highlights include:

- Eight times faster upload and 10 times faster download performance.
- Increased transparency of file replication activities.
- Reduced bandwidth for data transfers.
- Enhanced synchronization engine for file collaboration.

"As work environments become increasingly distributed, real-time collaboration on large, critical files such as spreadsheets, CAD drawings, engineering blueprints, or MRI images is an ever-more vital business imperative. With WAFS 5, distance and file size is not an issue. Complex files can be sent over a WAN at LAN speeds and are accessible to end users across multiple offices around the world," says Greg Hoffer, vice president of Engineering at Globalscape.

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Arena Solutions Supports IoT Product Capabilities

Arena Solutions has announced that more than 100 customers are already using Arena PLM for incorporating Internet of Things (IoT) capabilities into products.

Some current companies using Arena PLM for IoT are i4c Innovations and Totus Solutions. According to the company, i4c Innovations is improving product cycle time by up to 25%; speeding engineering change order cycle time by more than 75%; reducing scrap rework by up to 50%; and increasing supply chain collaboration. Totus Solutions, a provider of security lighting systems, is using Arena to accelerate engineering change orders by up to 100%; cut scrap and rework in half; and increase supply chain collaboration.

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Razorleaf Introduces Cloverleaf Platform

Cloverleaf is an open integration platform designed to support implementation, migration or upgrades of PLM applications and databases. Clover's capabilities exchange data with systems outside of PLM such as ERP (enterprise resource planning), MES (manufacturing execution systems), 3D hardware, industrial automation and more.

The platform operates using industry standard connection methods including SOAP, Web services and direct database connections. Third-party microservices let users move files, renditions and business data in the correct format. It can be paired 1:1 or 1:many endpoints, offering scalability, the company says.

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Shed Weight Sooner

Use structural simulation software early for optimum lightweighting.

BY PAMELA J. WATERMAN

Product optimization begins in the design process but doesn't stop with geometry: Material choices and manufacturing options are increasingly critical trade-off parameters. In addition, an optimization process should account for the manufacturing approach (mill, cast, stamp, layer) and possible subsystem assembly options (weld, rivet, glue). Making wiser decisions before a part or assembly is ever handed over for refined structural analysis is key to producing improved designs. Check out these recent and upcoming improvements in simulation tools that do just that.

More Options in Your Own Toolbox

Major players in both the CAD and CAE worlds have been tackling this faster/better challenge from various directions. "I see a very large focus on both geometry and materials together," says Doug Neill, vice president of Product Development at MSC Software, "and both have challenges in the current engineering workflow. Technology is out there that helps, but nobody yet has the perfect push-button solution — including us — that makes it trivially simple to do lightweighting quickly and easily."

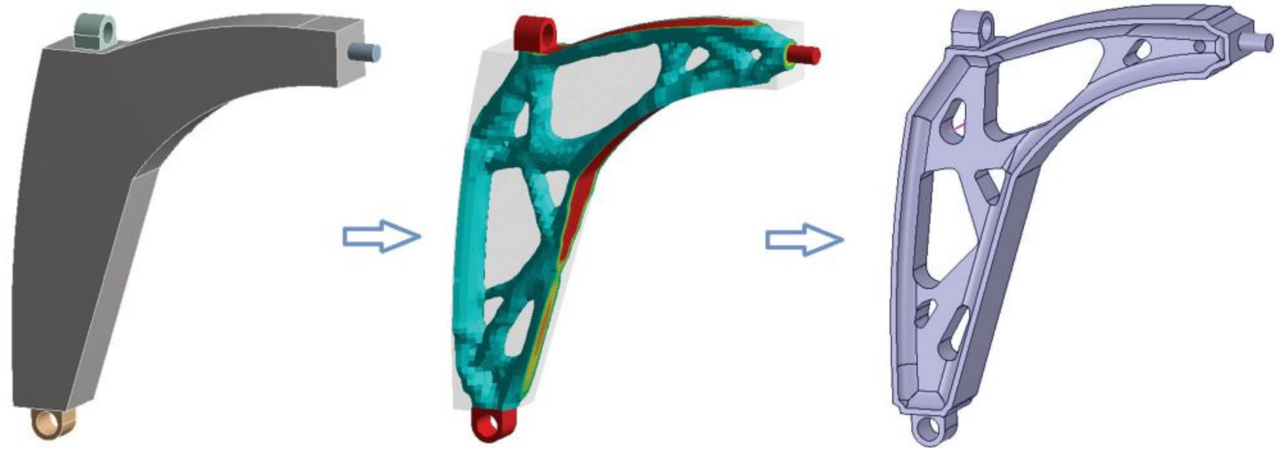
Neill breaks down typical lightweighting approaches into three categories: Changing geometry to replace an existing component with a lighter one; using 3D printing to produce a more efficient structure; and specifying a different material that may not itself be lighter but is stronger, so less is needed.

MSC Nastran and MSC Nastran Desktop Structures both support topology optimization for exploring design options. Neill says such topology software will tell users the most efficient place to put material, but he adds: "It's a proposal, and it doesn't say that the result will satisfy buckling criteria, non-linear contacts, failure mechanisms and even sometimes static strength."

On the other hand, he explains: "Shape optimization has the ability to take more geometric concepts like parametric CAD and represent changes in those parameters in finite elements and do shape changes." Neill says a third company offering, MSC Apex, represents current corporate philosophy: Geometry is great, but it needs to be in a CAE tool. Rather than trying to put physics into a CAD package, MSC Software is putting geometry, topology optimization and shape optimization into a CAE package.

Neill's last observation is that currently, people doing topology optimization are almost always looking to replace metallic, homogeneous isotropic materials with inhomogeneous, anisotropic materials including those created by layered (additive) manufacturing. A real solution for that type of optimization is not yet available in one environment, though MSC Digimat software addresses the angle of composite material simulation.

Similar thoughts are echoed at Siemens PLM Software,

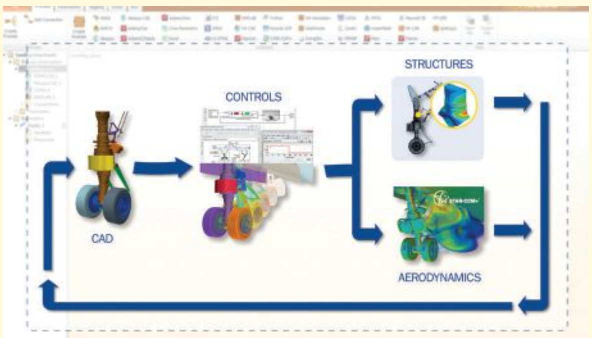


Optimal topology design of an automobile upper control-arm. The left part shows the initial design. The middle version shows the topology optimization results obtained with GENESIS Topology for ANSYS Mechanical (GTAM) from Vanderplaats Research & Development. The part on right shows the final CAD model cleaned up using ANSYS Space Claim. *Image courtesy of Vanderplaats Research & Development.*

Optimization is Their Business

Red Cedar Technology, a wholly owned subsidiary of CD-adapco, is all about optimization; so is David Vaughn, global vice president of marketing at CD-adapco, who comes from a background of light-weighting for aerospace applications. "Simulation tools have reached a level of maturity that allows us to consider all the engineering disciplines together," he notes, "and it's the exception that you can only look at weight reduction without considering the constraints of interactions with other disciplines."

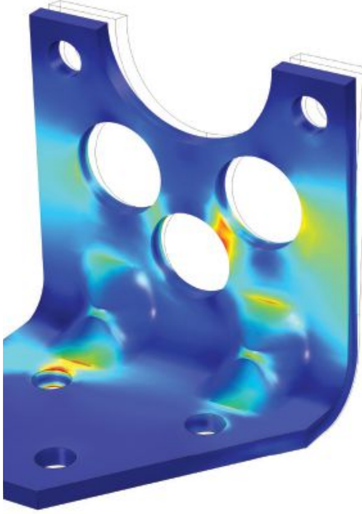
Red Cedar's flagship stand-alone package, HEEDS Multidisciplinary Design Optimization (MDO) software, integrates with all popular CAE applications. Vaughn says this fits well into the company's mission to provide tools that are not only used for validation after the design is finished; instead, engineering simulation and optimization algorithms need to provide a steady stream of data that flows throughout — available iteration after iteration.



Workflow to improve/reduce weight of a landing gear component, performed with CD-adapco analysis and Red Cedar Technology optimization software. ***Image courtesy of CD-adapco/Red Cedar Technology.***

Vanderplaats Research & Development (VR&D) offers a range of CAE-independent tools that include structural analysis and optimization, addressing the needs of both designers and analysts. President Juan Pablo Leiva says that their GENESIS package can work on the three different types of optimization that assist in light-weighting: topology (targeted to preliminary design); shape (which locates nodes in a finite element model and supports freeform optimization); and sizing (to zero in on dimensions such as sheet metal thickness once shape has been established).

"In GENESIS," Leiva explains, "you can do both topology and shape at the same time. We are starting to (change) who is part of the early design — the designer or the engineer? Traditionally the designer gave the original shape and the engineer just verified. Now the engineer can tell the designer, if you make more shape changes or holes, the structure will be more efficient."



Shape optimization with COMSOL Multiphysics and its optimization module, where the weight of a mounting bracket is reduced. An upper bound is placed on the maximum stress allowed for the static load case, and a lower bound on the first natural frequency. ***Image courtesy of COMSOL.***

where Edward Bernardon, vice president for Strategic Automotive Initiatives, agrees that optimization is not just about geometry. He gives the example of car companies needing to reduce frame weight for better fuel economy: "The packaging/styling guy says 'this is the shape I have to have more or less (say, for a four-seater). I'm going to give you X dollars per pound to reduce the weight of this car. You can use steel, composites, magnesium, aluminum; you can glue it, rivet it, weld it, whatever you want.'

"So," Bernardon explains, "the choice the engineer has to make is, 'what material do I put where, and what's the shape that achieves the stiffness I want?' You need this information at a high level and at a detailed level.

"Ideally, you'd love to have tradeoffs of cost against the material you use, where you put cut lines, and how you join them, all in one place," he continues. "This could be the CAD system, which allows you to trade off packaging, cost, manufacturability and the input you get from the analysis tools, such as strength. But you need it for composites, steel, magnesium casting, etc. There's no software that (currently) solves this problem — not ours, nor anybody else's. Some of these tools exist but they're not really at the fingertips of the designer. A tool like that is maybe five or 10 years into the future."

What Siemens PLM Software does offer are pieces of this tool, such as FiberSim for composite design and the NX CAD/CAE family for design, simulation and manufacturing. "We see the opportunity to take some of these workflows that traditionally have been in the analyst's domain and make them available in a format that is consumable for designers. The only way to really make that happen is if you are working in the same environment that the designer does," says Ravi Shankar, director of Simulation Marketing at Siemens PLM Software. He notes that NX offers that ability: the analyst can create a workflow that designers can execute in their own environment, or the designer can start to do some CAE work to get some up-front feedback on their design.

Especially in the automotive and aerospace industries, ANSYS users have also been working for decades to reduce part weight. "There are two things to do: Optimize all components for light[er] weight and use a different material like a composite," says Sandeep Sovani, global automotive director, ANSYS.

To optimize components, Sovani says analysts have traditionally used FEA (finite element analysis) and CFD (computational fluid dynamics) tools, including the individual multiphysics solvers within the ANSYS Workbench platform. In 2015, the company added ANSYS Integrated Multiphysics (AIM) to Workbench, offering a simulation environment designed for engineers of all skill levels that includes templates, automated processes and an intuitive user interface.

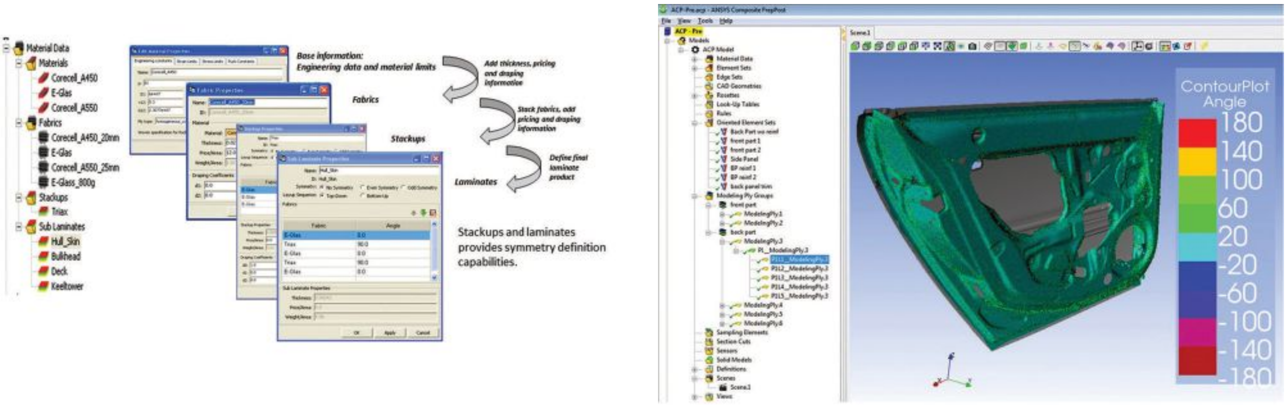
Another ANSYS optimization product within Workbench is Genesis Topology for ANSYS Mechanical (GTAM), developed as a vertical customization in collaboration with Vanderplaats Research & Development (VR&D). "A lot of parts are overdesigned simply because [otherwise] very complex geometry would be needed for creating components that are structured along stress lines. Topology optimization supports just that: With GTAM, the region to be optimized is identified and Genesis runs in the background. This workflow could have been done without the GTAM function, but it would have been more cumbersome," notes Sovani.

Lightweighting through use of composites is also supported by ANSYS with its Composite PrePost software. This tool analyzes part performance when different composite stacking and orientations are considered. It is designed to work with ANSYS Mechanical but can write to other analysis packages, too.

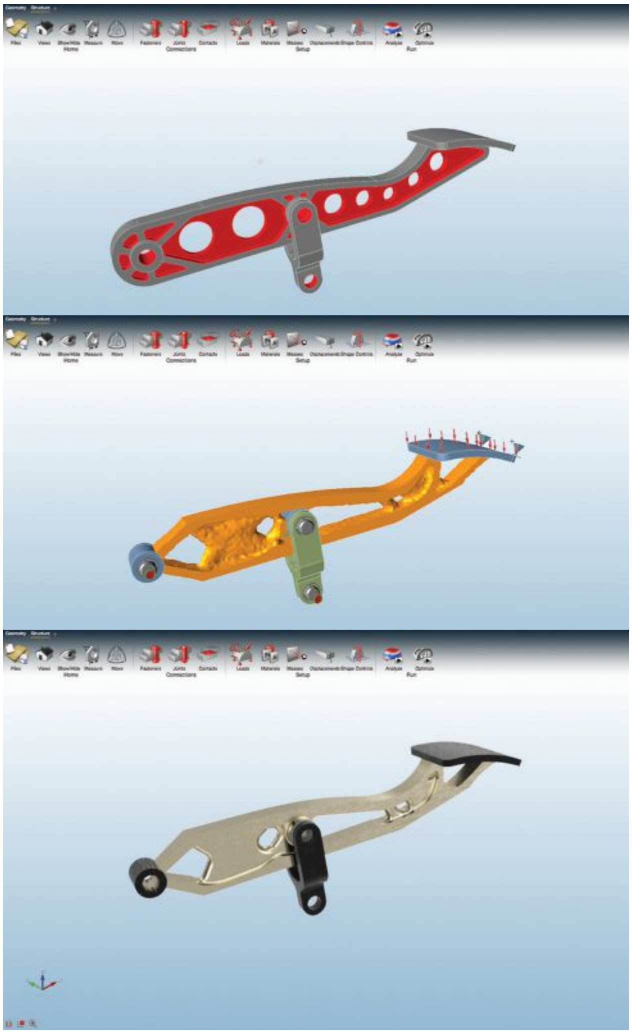
Experts at COMSOL suggest three ways to optimize a mechanical design for lighter weight, offering something for all levels of engineer, notes Walter Frei, COMSOL application engineer. "The first would be for users already working with a CAD program such as SOLIDWORKS or Inventor for which we have a COMSOL LiveLink program," he says. "For example, for pure structural analysis, you could use the core COMSOL Multiphysics package with a LiveLink product as well as the Optimization Module. You'd then tell the COMSOL software, these are the SOLIDWORKS, etc. dimensions (such as multiple hole radii) that can be changed, and pass those to the Optimizer. Say, 'minimize the weight, constrain the stresses to not be above a certain value or keep the eigenvalues within a certain range.' That's the easiest to do.

"The second level up," says Frei, "is shape optimization, which is little bit more involved." He points out you can't always just cut a hole in the part to remove weight; identifying a different cutout shape (which could even be defined by a function) requires a geometry-deforming capability. "With this, the user has to put some thought into things ahead of time," he says, "providing the optimizer some more inputs, but it gives you more flexibility."

Not surprisingly, the third COMSOL option is topology



Vehicle door-panel design defined for composites, using ANSYS Mechanical and ANSYS Composite Prepost software. Design improvements for lightweighting are simplified with stack-up and lamination layout capabilities. *Images courtesy ANSYS.*



Lightweighting performed on a brake pedal: original design (top), design analyzed for load-bearing paths using solidThinking Inspire software (middle) and final CAD design of part refined for efficient manufacturing (bottom). *Images courtesy of solidThinking.*

optimization, where users don't even start with a CAD model but rather with a "block" of specific material. Given certain constraints plus loads defined at several points, COMSOL software identifies where material could be removed. Frei notes that this is the approach that is generally used very early in the design process and can be very powerful.

Frei adds that you can absolutely optimize both geometry and material. "To COMSOL," he notes, "there really is no difference between the two. Often the material is based on other constraints, such as monetary, that have nothing to do with lightweighting."

Within the continually evolving Dassault Systèmes (DS) 3DEXPERIENCE portfolio, users of the SIMULIA product line can find a number of optimization functions moving up front and available to the designer. Over the years, acquisitions such as Isight for parameter optimization and Tosca for topology optimization, now brought into the 3DEXPERIENCE platform, show how much the company is expanding the value of simulation activities to tasks outside of the classic analyst group.

"We're not trying to turn everyone into a simulation expert, and not everyone will be creating methods for topology. We want to make Abaqus and Tosca technology available in the right way: The designer is capable of describing the desired aspects — 'minimize the weight' — the analyst would fine-tune the resulting model, and vice versa," says Dale Berry, senior director of SIMULIA Growth.

Michael Werner, formerly with Tosca and now a SIMULIA portfolio technical specialist, explains that optimization really helps build a bridge between the CAD and CAE communities. In the Tosca package, new features include optimizing structures with sheet-type geometry; methods for optimizing internal lattice structures for 3D printing are also in the works. He adds: "We're developing targeted apps for both the designer and the analyst, and bringing Tosca closer to the Abaqus user base."

Optimizing in a Pre-CAD Step

The first 2016 subscription update of Autodesk Inventor addresses the goal of creating the lightest strongest part available. It employs a new technology called Shape Generator that uses

Four stages of lightweighting a bracket: simulation and analysis performed with the new Shape Generator feature in Autodesk Inventor. Users define part material, apply loads, identify fixed points and enter a value for the amount of mass to be removed. ***Image courtesy of Autodesk.***

shape topology optimization, and does so early in the process.

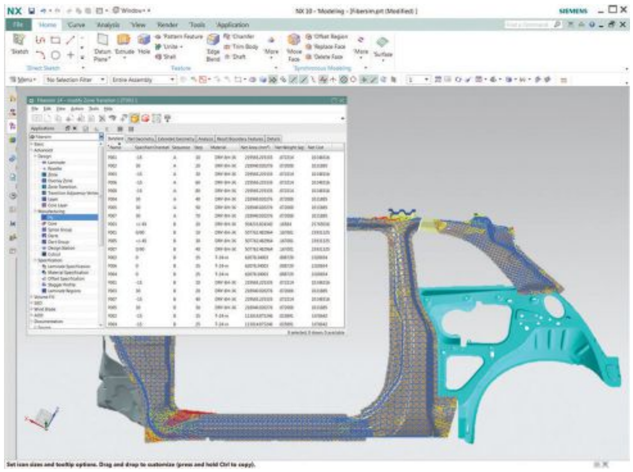
To lower part weight, "You could probably iteratively try a lot different things, but that's just 'whatever is in my mind, based on my experience,' and oftentimes you get to a point where it's good enough — as light as I can get it," says Derrek Cooper, director of Product Management at Autodesk. "This was the catalyst for Shape Generator: Instead of having the simulation folks doing optimizing in an isolated workflow, could we, in two or three clicks, help designers come up with the idealized shape?" He calls this conceptualized optimization, accelerating users to get to something that can be fine-tuned.

To invoke this Autodesk Inventor feature, designers specify material, maximum build volume (or general part shape), known contact points and all expected loads, then define a goal such as "reduce mass by 30%." Clicking on "Generate Shape" then produces an STL file that could go right to a 3D printer, or into a CAD program for further geometry refinement. Cooper notes you can create a range of parts depending on the chosen material.

Creating structurally efficient designs up-front is also the main principle behind Inspire software from solidThinking, a wholly owned subsidiary of Altair. Dedicated to upfront (pre-CAD) design guidance, solidThinking's Inspire generates a series of material layouts within a maximum allowable package space that will handle the required loads. "Traditionally the analyst would do a very detailed analysis and say to the designer, 'I want a couple of changes', then they go back and forth. There are a lot of communication gaps and frustration, so this is exactly what we've changed," says Jaideep Bangal, senior application engineer at solidThinking.

The philosophy driving solidThinking is that design engineers should use the same kind of technology as the analyst to create a concept upfront that is structurally correct, using a solver that is mathematically correct but very easy to use. "This solver (in Inspire) doesn't have all the knobs and tweaks as for the analyst," says Bangal, "but it gets you to 99% of the goal. You don't have to go back and forth (with an analyst), which means in an hour or so, you get many possible concepts."

These concept models may display a very organic appearance, and are therefore presented as raw polygon forms that can be brought into any CAD tool and refined for manufacturability. Last year, Inspire added analysis and topology optimization tools that support assemblies such as fasteners, joints and contacts. New to Inspire 2016, users can perform buckling analysis,



The weight of each defined layer of a composite is identified for a vehicle's "B" pillar design, specified with Siemens Fibersim software, for a model analyzed with Siemens NX 10 software. ***Image courtesy of Siemens PLM Software.***

define dynamic loads (acceleration), set temperature values as a boundary condition, and specify sheet metal materials (a request by many automotive customers). Bangal adds that the next big thing will be evaluating and suggesting structures for alternative manufacturing possibilities like 3D printing. **DE**

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.*

INFO ➜ ANSYS: ANSYS.com

➜ **Autodesk:** Autodesk.com

➜ **COMSOL:** COMSOL.com

➜ **Dassault Systèmes' SIMULIA:** 3ds.com/products/simulia

➜ **MSC Software:** MSCSoftware.com

➜ **Red Cedar Technology:** RedCedarTech.com

➜ **Siemens:** Siemens.com/plm

➜ **solidThinking:** solidThinking.com

➜ **Vanderplaats R&D:** VRandD.com

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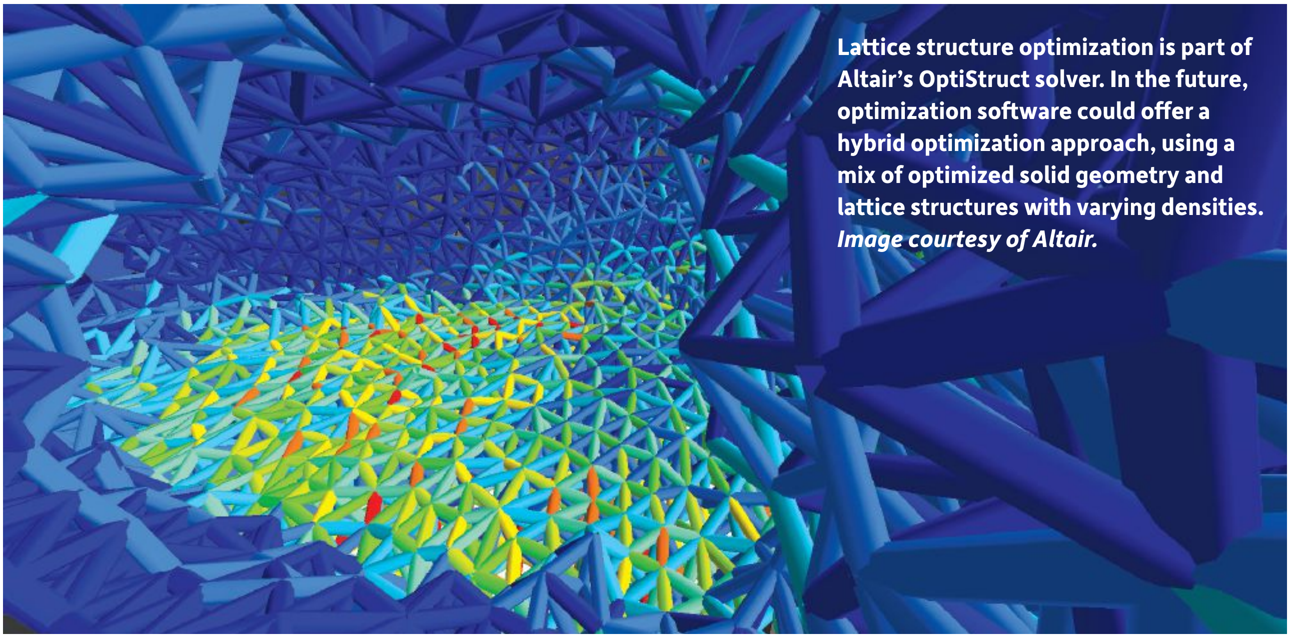
Your Software Respectfully Suggests a Design Revision

With optimization, software evolves from a passive tool to an active design partner.

BY KENNETH WONG



Lattice structure optimization is part of Altair's OptiStruct solver. In the future, optimization software could offer a hybrid optimization approach, using a mix of optimized solid geometry and lattice structures with varying densities. ***Image courtesy of Altair.***

For years, design engineers used a mix of vocational training, aesthetic preferences and professional know-how to generate early concepts for a product. Then, these ideas were put through digital simulation and physical tests to identify the most promising candidates. But the advent of topology optimization turns this workflow on its head.

Using stress, load, material and other boundary conditions as input, the engineer can (in a manner of speaking) ask the optimization software to mathematically compute and generate the optimal shape. The role of the software is fundamentally changed, from a mindless geometry-sculpting tool to a design engine with its own modeling logic. From time to time, even experienced designers are surprised by the elegance, simplicity or sophistication of the so-called optimized shape proposed by the software.

Previously, the designer's job was to conceive and perfect the product's shape. With topology optimization, they must learn to shepherd the computer-aided shape exploration process instead. It's a new way of using software. In fact, the verb "use" is not quite accurate here. From now on, the conceptual design phase will be driven by a partnership between human intellect and programming code, between the designer and his or her software.

Trimming Fat and Growing Bones

Under the hood, topology optimization software uses the same principles — and often the same solvers — found in finite element analysis (FEA) and simulation software. For instance, Autodesk's Shape Generator feature in Autodesk Inventor 2016 R2 (released October 2015) relies on Autodesk's Nastran FEA solver. solidThinking Inspire, an optimization package from Altair, uses Altair's OptiStruct solver, also found in the company's higher-end HyperWorks software suite.

Generally, this is the software-driven optimization workflow: (1) The software runs FEA to identify the stress and load concentration in "the design space," the region designated as the boundary for shape exploration; (2) it derives a new (lighter) shape by removing materials in the areas unaffected by stress. In doing so, the software preserves sufficient structural strength to counteract the anticipated load without excess material.

In addition to Inventor's Shape Generator, Autodesk also offers lattice-structure optimization with Autodesk Within, an offspring of the company's Dreamcatcher research initiative. At a briefing with the media at Autodesk University (AU) 2015, Lance Grow, director of Autodesk's Product Design Product Line Group, summed up the distinction between the two: "[Autodesk Inventor's] Shape Generator removes materials from an existing part based on load properties. With Autodesk Within, the software grows materials [to counteract the anticipated load] based on a variety of algorithms."

The technical terms and industry nomenclature can be confusing, but if you'll tolerate some butcher shop expressions, look at it this way: Autodesk Inventor's Shape Generator uses FEA to trim excess fat from your geometry; Autodesk Within uses algorithms to generate the optimal skeleton structure for your product. Both are examples of computation-driven optimization.

A Hybrid Optimization Approach

Manoj Mahendran is an application engineer and support specialist at Phoenix Analysis and Design Technologies (PADT) who produces optimization tutorial videos for his employer's YouTube channel. PADT uses Genesis software from Vanderplaats Research & Development for optimization. PADT offers engineering, simulation and rapid prototyping services. It's also a reseller of ANSYS products.

"There's a significant drive to incorporate lattice structures into optimization, into geometry modeling, because now they can be printed with 3D printers," says Mahendran. It's conceivable that, in the not-so-distant future, the two types of optimization — removing excess materials from geometry and generating bone-like structures to add strength — would converge. Such a combination represents the ideal in computation-driven design.

The latest version of Altair's OptiStruct solver (released in February 2015) includes the ability to automatically generate lattice structures. "In the future, we will have lattice structure in our Inspire software," says Jaideep Bangal, senior application engineer at Altair's solidThinking Inspire. This could result in shapes with "some part in lattice, some part in solid, because that's what the design needs," he adds.

The Optimal Stage for Optimization

The introduction of optimization raises questions about where in the product development process it belongs. Advocates suggest it should take place early in the design cycle. After all, you do not want to spend too much time and effort refining and testing a non-optimal concept that invites costly revisions.

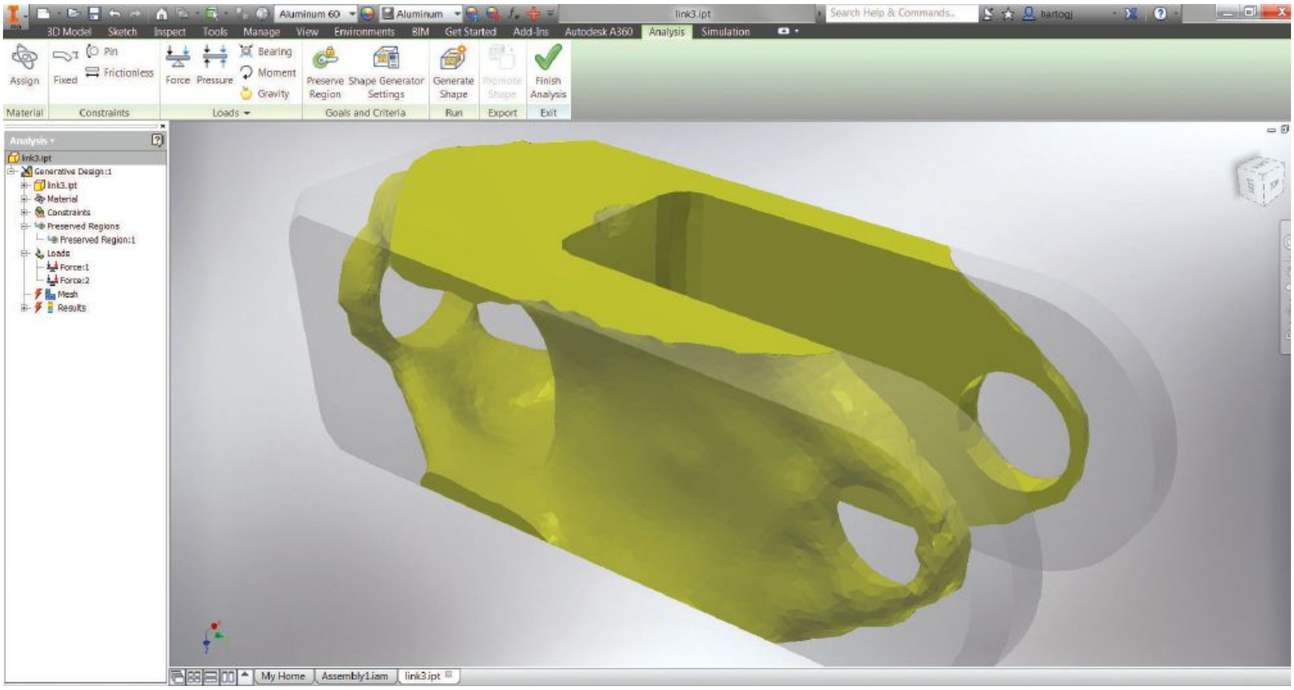
"[Optimization] is a lot simpler to do in the beginning stage. So if you're going to optimize an L-shape bracket, just make two square boxes — don't spend time detailing the model. Chances are, you won't end up using the same model you started with," says Mahendran.

The design engineer's default tool is usually a CAD program. Such programs are the standard tool for sculpting out detailed mechanical parts and assemblies. But in topology optimization, the designer enlists the software's help to determine the best shape. Therefore, Altair's Bangal argues: "Topology optimization should take place before the CAD modeling phase."

Rani Richardson, a CATIA business experience consultant for Dassault Systèmes, points out: "Starting the process with an optimized detail design brings a lot of advantages to the designer, including decreasing the part lifecycle, removing material where it is not needed while retaining restraints like strength or stiffness. Once designed, a variety of functions and constraints are available for static and dynamic problems. [In Dassault Systèmes SIMULIA's TOSCA software], multiple load cases and nonlinear analysis are supported and manufacturing constraints can be applied, ensuring the part can be fabricated."

Traditionally, a novelty tool or a new approach is first entrusted to a smaller circle of experts. The technology is recommended for wider adoption only when it reaches maturity, after it has gone through several generations of trials and errors. Yet, Bangal and his colleagues firmly believe topology optimization should be in the hands of design engineers.

"Computational fluid dynamics (CFD) or FEA is very mature as a workflow, but topology optimization is new to design



In Autodesk Inventor 2016 R2, Autodesk introduces Shape Generator, a CAD-embedded topology optimization function. *Image courtesy of Autodesk.*

engineers," says Bangal. The trick is to hide the complexity of topology optimization behind a simple user interfaces. For Bangal and his colleagues, the answer is solidThinking Inspire, a topology optimization package with a low learning curve.

CAD-embedded Optimization

At the present, topology optimization usually takes place in simulation software programs or in special optimization software packages. However, by introducing Shape Generator in its mainstream CAD program Autodesk Inventor, Autodesk has ushered in CAD-embedded optimization.

Parameter Optimization vs. Topology Optimization

Both parameter optimization and topology optimization employ FEA and CFD solvers to compute the best design alternative. However, the type of answer sought by the user is quite different in each case.

In parameter optimization, the user has already determined or selected a certain shape for the product. He or she is merely using the software to identify the best value or measurement for a specific region of the geometry (for example, the thickness of an electronic unit's housing).

In topology optimization, the user defines the rough design space; provides the software with the anticipated stress, loads, pressure, anchor points and joint types; and the software computes the mathematically optimal shape.

In parameter optimization, the answer sought is usually a set of numeric values. In topology optimization, the answer is usually provided in the form of a mesh model.

"Topology optimization has been around, used mainly by the analysts community with CAE tools or special tools. What's different about [Shape Generator] is that it's integrated into a mainstream CAD platform. Our approach is to put it in CAD so it can benefit the conceptual design phase," notes Jonathan den Hartog, product manager for Autodesk Inventor.

FEA was once the restricted domain of simulation software, but over the years, CAD vendors incorporated simple stress analysis tools into the CAD modeling environment. CAD-embedded FEA is now a standard feature in packages like Autodesk Inventor, SOLIDWORKS, Solid Edge and PTC Creo. While sophisticated simulation tasks (for example, dealing with multiphysics phenomena or anisotropic composite materials) are still relegated to specialists using high-end simulation programs, CAD users' familiarity and comfort with simple (usually linear) stress analysis is growing. The introduction of topology optimization in CAD software could follow the same pattern in the coming years.

In a presentation to the media at AU 2015, David Benjamin, founding principal of The Living, a design studio Autodesk acquired, said: "We've been exploring [computation-driven optimization] technology's role and also talking to engineers. It's still too early to know what specialty is needed — or not — to use such a tool. But the framework and the specific techniques and the algorithm could be put inside a whole range of software. Some novice users may provide a series of input and let the software suggests some shapes. At the other end of the spectrum, even the most advanced users with great creativity and intuition can still benefit from such a tool."

The Role of the Coach

Can optimization be self-taught? Can you learn it by diving into the software on your own, the way some learned to swim? It's possible, but perhaps not the best approach, according to PADT's Mahendran.

"I feel that the first exploration should be done with an expert looking over the [newbie's] shoulder," he says, "People often bite off more than they can chew — or more than the software can chew." He advises: "Try to crawl before you run. Don't start off with a million-mesh topology. Try it with first a low-polygon optimization."

The software tools that target designers and engineers tend to have simpler interfaces with fewer inputs. Still, points out Mahendran: "You're trying to approximate the real world as much as possible, but in some situations, you have to make assumptions that have tradeoffs." It's difficult for a novice user to understand these tradeoffs without an expert's guidance.

The Cost of Geometry

Traditional manufacturing methods are designed to cut and mold symmetrical, circular and rectangular features. The simpler it is to produce, the less it costs. However, computation-driven geometry often results in organic shapes, involving asymmetrical patterns, uneven corners and fossil-like structures. Such shapes typically cost more to produce using current technologies and materials.

"If a part weighs 50% less, but costs 100% more to manufacturer, is it really helping you? We have solutions that can shave off weight to the decimal point, but that doesn't mean it's the right approach for everyone," notes Mahendran.

solidThinking's Inspire addresses this dilemma with the option to add manufacturing constraints. By specifying the preferred manufacturing method, an Inspire user can instruct the software to restrict the optimized shape to geometric features compatible with the chosen manufacturing method.

At the present, standard manufacturing procedures — such as machining, injection molding and stamping — still remain the most economic options for large-volume production. However, new additive manufacturing methods — specifically, 3D printers capable of printing in metal — may soon remove the cost associated with shape complexity.

"Before, if the optimized topology is a natural [organic] shape, it cannot be manufactured in injection molding or machining. Now, with 3D printing, you can forget about manufacturing constraints," says Altair's Bangal.

This development can have a profound impact on the way our products look. "The cost consideration that works against the optimized shape will eventually go away, because of 3D printing," says PADT's Mahendran. "Organic structure in product is something that will come about soon. When metal 3D metal printing becomes accessible to most engineering firms, these shapes will become more widespread."

However, it's a mistake to think of topology optimization is a fully automated process that can be delegated to the software. You still need an engineer to intervene and use his or her judgment, especially when it comes to manufacturing.

With CAD software, you use it like a knife or a drill: You decide where to cut and drill; the software does your bidding. With topology optimization, the software is a partner in the decision-making process. You ask the software: "Where should we cut meat to make it lean? Where should we grow bones to make it strong?" The proposed optimal shape sometimes confirms your intuition; other times, it surprises you with a solution you haven't thought of. It's beginning to act more like a sentient design collaborator and less like a primitive chiseling tool. **DE**

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

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Design Freedom with New Constraints

The marriage of 3D printing and optimization software is giving rise to a new generation of lighter, visually compelling designs — but not without constraints.

BY BETH STACKPOLE

The dynamic duo of 3D printing and new optimization software is giving engineers the freedom to design and produce organic shapes and lightweight structures that raise the bar on ingenuity while delivering unprecedented savings. Yet to fully reap the benefits of this nicely matched pair, engineers need to master a set of new constraints to ensure designs can be produced in a reliable, cost-effective fashion.

Advances in 3D printing technology — from new materials to higher resolution output capabilities — coupled with topology optimization and other design software improvements are empowering engineers to come up with freeform shapes and complex lattice structures that challenge conventional design limitations. These next-generation designs are not only visually compelling, they are typically more aerodynamic, weigh less and boast fewer parts than designs crafted with traditional CAD tools for output using mainstream manufacturing practices.

Stratasys Direct Manufacturing's Direct Metal Laser Sintering (DMLS) offerings are helping optimize structures for aerospace applications, including this lighter weight bracketed part. ***Image courtesy of Stratasys.***

While traditional boundaries don't necessarily apply in the world of 3D printing, engineers expecting an unfettered design environment will be in for a surprise. "In general, the talk about 3D printing technology delivering design freedom without the constraints of traditional manufacturing is true, for the most part," says Tim Thellin, director of Software and Productivity Tools for Stratasys Direct Manufacturing. "If you know you're building a part with an additive manufacturing process, you don't have to worry about undercuts, fillets or internal channels that go deep inside the part. Yet there are different constraints driven by the technology you're using and the materials you are building with."

Out With the Old, In With the New

For many 3D printing or additive manufacturing (AM) technologies, the biggest constraint is optimizing designs to minimize or eliminate support structures needed during the actual build process. With certain AM technologies, specifically Direct Metal Laser Sintering (DMLS), there are structural checks to ensure the technology used to build up the

Altair's topology optimization software has a symbiosis with additive manufacturing, maximizing design freedom to create complex, freeform "bionic" structures. ***Image courtesy of Renishaw.***

part doesn't actually create stresses that result in part deformation, and ultimately, a bad build. Optimizing a design for the materials used or for proper orientation on the build platform are other factors that need to be considered early on in the process, and there are myriad other constraints that may seem foreign to engineers acclimated to traditional manufacturing processes like casting, injection molding and stamping, experts say.

"Design for 3D printing is still in early adulthood," notes Craig Therrien, senior product portfolio manager at Dassault Systèmes' SOLIDWORKS. "People think that a 3D-printed part will have the same properties as a casted or forged part, but it doesn't." Because 3D printing instills different mechanical properties on a part, it is not an exact science, and Therrien says many engineers compensate by overdesigning the part in the hopes of adding rigidity — a tactic that minimizes the lightweighting advantages that make 3D printing such a draw in the first place.

Support structures, in particular, seem to present the biggest design challenges to customers, says Eric Utley, applications specialist at Proto Labs, a digital manufacturing source for custom prototypes and low-volume production parts. Commonly used in AM processes, especially metal technologies, supports are typically scaffold or lattice-type structures required at certain angles to hold a part up as the detailed features are being built. Designing a part so that it steps up incrementally and can be self supporting (instead of featuring long bridges or overhangs) is something engineers untrained in 3D printing techniques don't necessarily understand, Utley says.

Likewise, untrained engineers may design parts with volumes that inadvertently trap powder material from the 3D printing process or have supports that are difficult, if not impossible, to remove. "These constraints are commonplace with organic shapes and with metal AM practices," Utley says. Education and consulting services are key, he says. "You need to think about

Stratasys' sparse fill capabilities for its Fused Deposition Modeling (FDM) technology create a honeycomb structure critical for lightweighting parts and accelerating build times. *Image courtesy of Stratasys.*

support structures as you're designing. You need to consider what material you want and then look at which 3D printing technology builds in that material. Next you figure out the limitations and design around it. It's going to be different for each of the 3D printing technologies in terms of what can get by and what can't," Utley explains.

Designs that prevent easy support removal, build orientations that don't work within the build platform, trapped volumes, and issues surrounding wall thicknesses are the biggest mistakes made by BasTech customers, notes Scott Young, engineering manager for the company, which provides AM services. Helping customers work around these inherent design flaws isn't the problem, Young says, but companies would be better served addressing the issues at the onset of design to avoid additional costs. "It would make life a lot easier and less costly in the end," he says. "If designers understand things upfront, we can optimize the process and everything goes more smoothly."

Companies like GE Aviation and Alcoa, which are investing millions of dollars to ramp up their internal AM expertise and perfect 3D printing expertise, are already seeing results. In one of the more highly touted examples, GE completely redesigned its fuel nozzles (19 of them to be exact) on its LEAP engine for Direct Metal Laser Melting (DMLM) processes using EOS systems. The result is a nozzle that is now a single part instead of 20 parts machined together, and it's far stronger than its predecessor made with traditional subtractive manufacturing processes. "You have to leave behind conventional thoughts and structures when you think in terms of designing for AM," says Andy Snow, senior vice president of EOS North America, which offers consulting services in how to design for its AM technology.

Software to the Rescue

In recognition of the skills gap, design tool makers 3D printer manufacturers, and simulation software providers are stepping up efforts to provide new services and products to make it easier to design for AM much like any design for manufacturability effort. Stratasys Direct Manufacturing, for example, leverages the Insight software, which automatically slices models to generate support structures and material extrusion paths while also allowing engineers to optimize build orientation for maximum strength. Stratasys' Fused Deposition Modeling (FDM) technology also allows for sparse fills, a way to print out hollowed or partially filled models optimized to meet cost and weight reduction targets, Thellin says.

There's lots of activity on the CAD and simulation front. Altair's topology optimization tools, Inspire from solidThinking Inc. and OptiStruct, are instrumental for creating the organic shapes that AM practices enable, according to Ming Zhou, Altair's senior vice president of FEA (finite element analysis) and Optimization. To help engineers effectively integrate topology optimization into the early AM design process, Altair has partnered with Materialise to offer its 3-matic STL software to HyperWorks users, allowing them to make design modifications directly on STL, scanned and CAD data in preparation for 3D print-

Toshiba Prototypes Metal 3D Printer

Toshiba Machine, a subsidiary of Toshiba, has become the latest additive manufacturing (AM) outsider to announce it will be moving into the 3D printing arena. It already has a working prototype and claims it will be ready for a 2017 launch date.

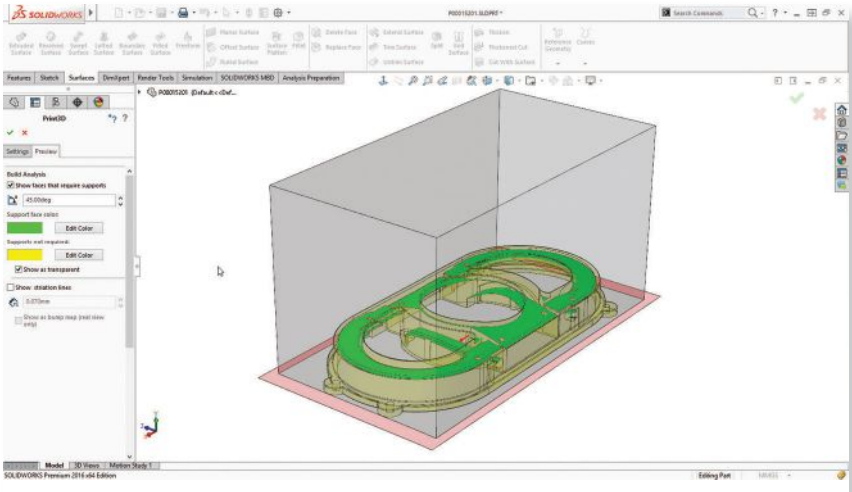
The company is staking its claim in AM through speed. It has developed a metal printing process it calls laser metal deposition, which uses a laser in tandem with powdered material deposition to build layers. That's pretty standard as far as metal printing processes go, but Toshiba Machine claims its prototype is over 10 times faster than existing AM systems.

ing. Moving forward, Zhou says Altair is working to evolve its optimization algorithms to consider overhang angle constraints, supports and print orientation, as well as simulation of printing processes to analyze thermal and material effects. "We're trying to bring additional cost components into optimization," he says.

Two of this year's major CAD releases, Autodesk Inventor 2016 and SOLIDWORKS 2016, also feature advances aimed at simplifying design for 3D printing. For example, Autodesk Inventor 2016 and Fusion 360 include 3D Print Studio, a dedicated 3D printing environment that lets users optimize model orientation (even split it in two) for a variety of supported 3D printers. Autodesk also has a lot going on in the area of topology optimization as part of its vision for what it calls "generative design — the concept of starting with a goal and exploring all the possible permutations of the solution until the best one is found." Shape Generator, available in the latest Inventor update, is a topology optimization function embedded directly in the CAD environment, and Autodesk Within, which automatically generates lattice structures that fit user-defined volumes, is being specifically positioned to help optimize designs for AM.

SOLIDWORKS 2016 now features the Print3D Property Manager Settings tab that enables engineers to change model scale or reorient models to fit in a build volume. A preview tab also lets users run a preview analysis to identify faces that require supports during 3D printing, and the software will display striation lines resulting from layering so users can determine whether the print resolution is optimized enough for the desired output, according to Therrien.

Beyond these capabilities, Therrien sees simulation software evolving to help engineers check the function of a 3D-printed part much like they do now for an injection molded part. "One of the next steps is verifying what we are making because 3D printing is repeatable," he says. "That's something that will come in the future."



SOLIDWORKS 2016's Print3D PropertyManager Settings tab includes the ability to change the model scale and to reorient the model to fit the print volume. *Image courtesy of SOLIDWORKS.*

One company looking to the future of AM is 3DSim. The startup is leveraging years of research work in AM along with supercomputing capabilities to provide fast and actionable insight into metal 3D printing processes. The idea, according to CEO Brent Stucker, is to help organizations eliminate the waste and reduce the costs of AM practices by predicting residual stress and strain, minimizing the amount of support materials and post-processing finishing work. ExaSim, targeted for release in the second half of 2016, is a whole new set of simulation tools targeted at the machine operator and designed as a guide for helping them build a part properly. The software, which will run in the cloud, takes some of the mystery out of 3D printing processes.

"It takes a long time for someone to learn the physics of what's going on," Stucker explains. "Every time you put new geometry on a new machine and create a new scan pattern or vector, you produce a different microstructure and you can't treat it as a black box."

With ExaSim, Stucker is trying to turn what seems like a random process into something repeatable. "People spend a lot of time on trial and error experiments to try to satisfy their curiosity or to get a part qualified," he says. "We're trying to achieve a dramatic reduction in that time." **DE**

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INFO ➔ 3DSim: 3DSim.com

➔ **Altair:** Altair.com

➔ **Autodesk:** Autodesk.com

➔ **BasTech:** BasTech.com

➔ **EOS North America:** EOS.info

➔ **Materialise:** Materialise.com

➔ **Proto Labs:** ProtoLabs.com

➔ **solidThinking:** solidThinking.com

➔ **SOLIDWORKS:** SOLIDWORKS.com

➔ **Stratasys Direct Manufacturing:** StratasysDirect.com

➔ **Toshiba Machine:** Toshiba-Machine.com

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Keep Current to Maximize Simulation

Benchmark tests show more than 9X time savings in simulation runs using Autodesk CFD 2016 and current Dell Precision workstation vs. an older setup.

By now, most engineers are well versed in the virtues of computer-aided engineering (CAE) software. They know simulation helps analyze and predict product performance in the virtual world, minimizing the need for building costly prototypes. They are aware that use of simulation is crucial for identifying weaknesses in potential designs, for the selection of materials, and as a means of optimizing products to hit specific cost and lightweighting targets.

What engineers are now starting to recognize is that use of simulation early on and throughout the development cycle elevates that value proposition even further. Through investment in analysis tools that are readily accessible to mainstream engineers — not just simulation specialists — engineering organizations can get greater mileage out of simulation practices, exploring many more design concepts in richer detail. At the same time, they can predict the implications of design changes quickly, circumventing (or at least, condensing) the traditional, highly iterative cycle of building and testing physical prototypes.

Early Analysis Yields Optimal Design

The case for ongoing simulation gets even better when the practice is used to zero in on potential problem areas in the early design stages. This allows engineering teams to make adjustments far more easily and protects them from costly missteps that can lead to major product delays or the expense of scrapping physical prototypes and manufacturing tooling on the heels of late-stage design changes. Simulation also plays a key role in allowing engineering teams to validate designs before testing, once again limiting reliance on physical prototyping and helping to shorten product development cycles and accelerate time-to-delivery.

> **“Autodesk CFD gives us a better understanding of product performance and in turn, allows us to develop cost-effective, innovative and more reliable designs in less time … ”**
>
> ***— Bruno Fairy, Parker Hannifin***

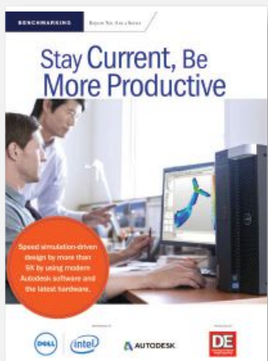
While there is no disputing the role simulation plays in advancing the full spectrum of design practices, its benefits can be severely undermined without an investment in the proper hardware and software platform. What engineers might not realize is that simulation software and hardware technologies are evolving at a rapid pace. Today’s modern workstations from Dell and Intel® come standard with such state-of-the-art capabilities as multi-core processors, solid-state drives (SSDs), and high-end graphics processing capabilities, which provide a powerful platform for CAE applications and large-scale simulation models, making a world of difference in their performance. At the same time, CAE software is also undergoing significant improvements, bringing new solvers, algorithms, intelligent memory management techniques, and support for parallel processing to

Engineering Productivity Pays the Price of Falling Behind

To learn more about how the latest Dell Precision workstations and software combine to speed your simulation and optimization workflow, download “Stay Current, Be More Productive,” the fourth in a series of *DE* benchmarking reports sponsored by Intel, Dell and independent software vendors.

Each benchmarking study pits older 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 Autodesk’s case, the new hardware and latest software completed some tasks more than 9X faster.

Download “Stay Current, Be More Productive” here: deskeng.com/de/benchmark4.



deliver faster and more reliable performance for both pre- and post-processing functionality.

Improvements Speed Simulation

Autodesk Simulation, as part of the company's Digital Prototyping solution, offers a portfolio of mechanical, computational fluid dynamics (CFD), composite, structural, and plastics simulation capabilities that have been optimized to exploit modern hardware for optimal performance. The latest versions of Autodesk CFD 2016 and Autodesk Nastran 2016, include algorithm enhancements, meshing improvements and across-the-board solver upgrades that deliver a higher level of performance for both routine and complex simulation tasks.

As the benchmarking results show, Autodesk CFD 2016 running on a modern workstation with dual, multi-core processors (up to 10 cores) will run certain large-scale fluid and thermal analyses more than 9x faster than on a three-year-old workstation. Read the report at deskeng.com/de/benchmark4 to see how much faster different CFD and Nastran problems can be solved via the latest version of Autodesk Simulation running on a modern Dell Precision workstation.

Stay Current to Compete

Widespread use of simulation is a critical component of design success. Companies that remain at a standstill with simulation or haven't made a commitment to keeping hardware and software up-to-date are at risk of losing their competitive edge by constraining their design practices, which results in sub-optimal products.

Companies will be hard pressed to accommodate increasing product complexity or meet demands for lighter weight, cost-optimized structures without expanding use of simulation throughout the product design lifecycle. Substandard simulation practices also make it more difficult to make ongoing improvements to existing offerings, let alone delve into the exploration needed for launching new categories of products.

Although there are obvious costs associated with hardware and software upgrades, those investments are far outweighed by the resulting benefits of infusing simulation into design practices at both large and small enterprises. Widespread use of simulation has productivity benefits for individual engineers who are empowered to solve tougher design problems in less time. That has huge repercussions. Just imagine what it would mean if you get to market ahead of your competition. What would pulling in a car model a year early, for example, mean for a company's revenue?

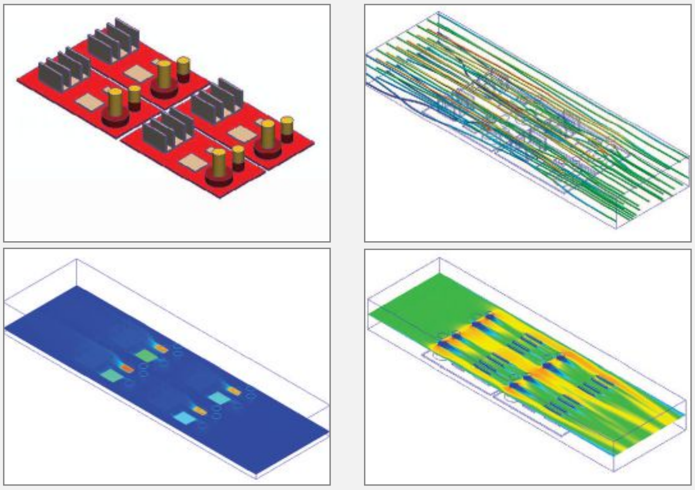
For more information, download the full "Stay Current, Be More Productive" benchmarking report for free at deskeng.com/de/benchmark4.

Complex Analysis Results

Autodesk, Intel and Dell collaborated with *DE* to explore the impact of outdated software and hardware on present-day simulation studies. The partners conducted a benchmark study on both Nastran and computational fluid dynamic (CFD) analysis problems.

Six Nastran analyses were benchmarked, showing a 1.8X to 6.4X solve time reduction using the newer hardware and software. The CFD results were even more impressive, with solve time savings from 2.36X to 9.39X on increasingly large model element counts using Autodesk CFD Flex 2016 on older and current hardware.

The most impressive results involved a large coupled analysis to consider both fluid velocity and thermal properties. The 3D heat transfer analysis of a circuit board with heat generation applied to various chips being cooled with external air at room temperature was studied. The more complex analysis was able to leverage the multiple cores and processors of the new workstation to achieve dramatic speed increases, particularly with the largest number of elements and nodes, as shown below.

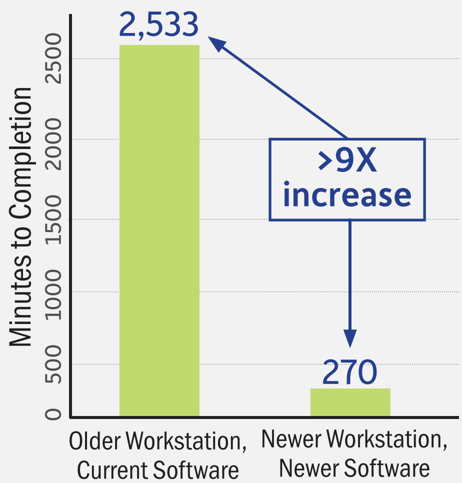


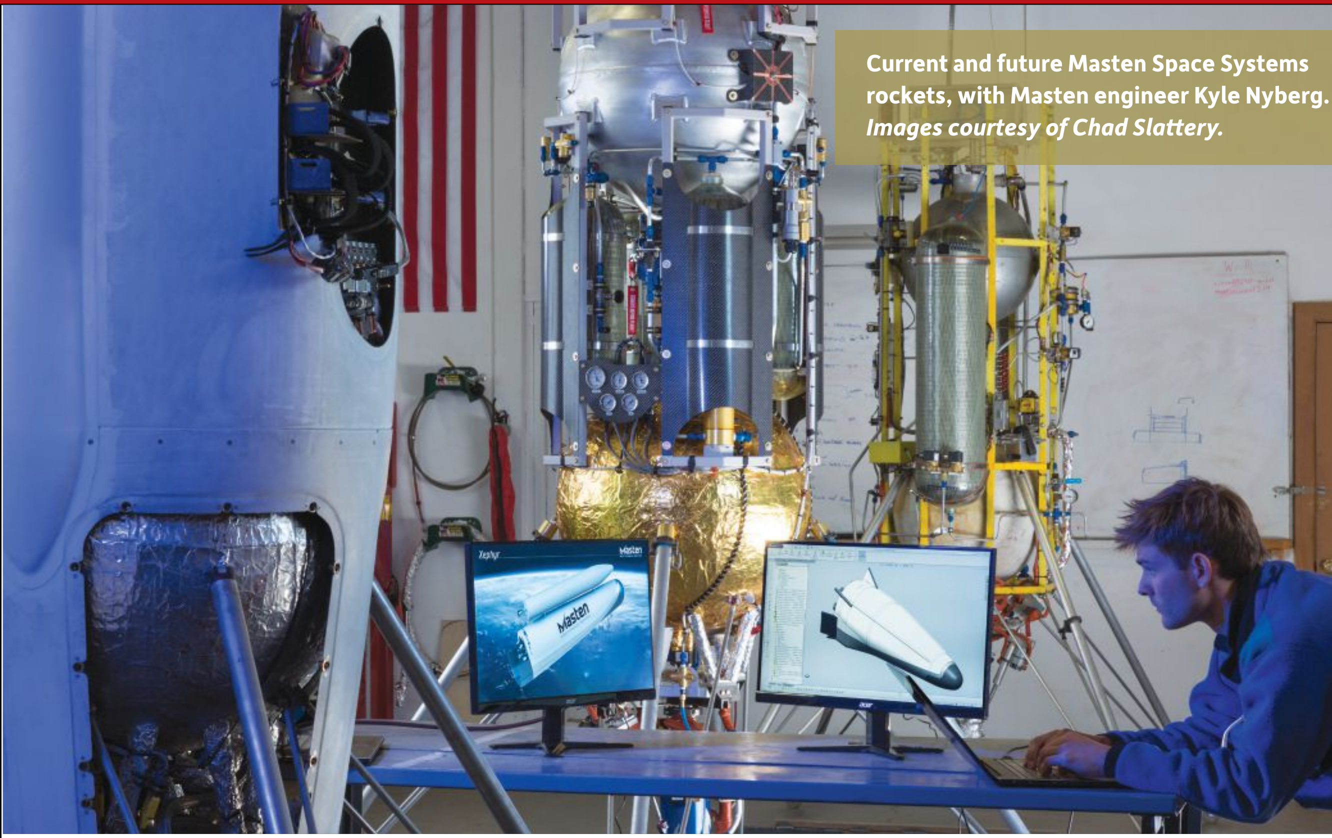
Fluid / Thermal – Large

Elements: 14,440,153
Nodes: 2,806,317

Solution times:
Three-year-old workstation and current software: 2,532.8 minutes
Current workstation and current software: 269.7 minutes

Total Speedup: 9.39x





Current and future Masten Space Systems rockets, with Masten engineer Kyle Nyberg. ***Images courtesy of Chad Slattery.***

Supercomputers Lower the Cost of Space Access

DARPA and Department of Defense supercomputers help Masten Space Systems calculate aerodynamic effects on designs for low Earth orbit launchers.

BY MICHAEL BELFIORE

When Dave Masten traded the life of a Silicon Valley coder for that of a self-taught rocketeer in Mojave, CA, he didn't start with much. But, with three other renegades and a portable test stand towed by a pickup, he set up shop in a World War II-era hangar at the Mojave Airport, building rocket engines and vertical takeoff/vertical landing vehicles to go with them.

Eleven years later, the company that bears Masten's name has a solid business testing hardware and software designed for planetary landers. Low and slow is the name of the game here, as customers including NASA and Draper Laboratories use Masten Space Systems rockets as testbeds for their own technologies designed to help rocket-powered landers touch down safely on airless worlds like the moon or in the rarified atmosphere of Mars.

While those testbed vehicles have been the company's bread and butter for more than a decade, Masten's vision has always been to reach space from Earth. And to do that, it will have to build rockets that go faster. Much faster. Fast enough, in fact, to require Masten engineers to spend significant resources on calculating the effects of aerodynamic forces on their designs or see them disintegrate in the more-than-gale-force winds of hypersonic flight.

Now, with a new contract in hand from the Defense Advanced Research Projects Agency (DARPA), they are finally getting the chance to do so.

A Boost from DARPA

"Aero is a factor and we have to account for it, but it's not been the primary research or testing goal," says Sean Mahoney, who now runs the company that Dave Masten founded. (Masten now serves as CTO of the company.)

What the company has lacked in aerodynamics expertise, it has more than made up for in experience building reusable rockets that can fly frequently and affordably — just the qualities DARPA program manager Jess Sponable wanted for his XS-1 program.

In June 2014, Masten Space Systems won a $2.99 million contract from DARPA to design an experimental spaceplane, to be called the XS-1. Aerospace giants Boeing and Northrop Grumman were also funded to create competing designs.

The XS-1 program, run by Sponable, seeks to foster the creation of an unmanned launcher the size of a business jet that can hit 10 times the speed of sound and reach the edge of the atmosphere. From there, the XS-1 will launch an upper stage capable of sending a 3,000- to 5,000-lb. payload into low Earth orbit. The XS-1 envisioned by Sponable should be able to launch 10 times in as many days and cost no more than $5 million for each satellite launch. That dollar amount isn't arbitrary; it's about one-tenth the cost of current launch systems.

Hypersonic speed isn't a necessity for vehicles that serve as the first stage of a satellite launcher. Instead, the requirement that the XS-1 achieves Mach 10 flight is designed to enable further research into — as the DARPA solicitation put it — both "next-generation space launch and global reach aircraft." It also significantly increases the aerodynamic challenges that must be solved in designing the craft.

To help solve those challenges, Masten brought in aerodynamicist Allan Grosvenor to serve as senior engineer and aerodynamics lead. It's his job to manage the effort to enable the Masten XS-1 design to survive atmospheric flight at Mach 10.

Masten rocketeers Ellen Moyer and Wyatt Rehder prep Masten's Xodiac rocket for flight.

Simulating Hypersonic Flight

Overseen by Dennis Poulos, program manager for the XS-1 program at Masten, the engineering team builds individual components of the design using SOLIDWORKS. Grosvenor pulls what he needs from there to do the computational fluid dynamics (CFD) analysis needed to simulate the aerodynamic forces that will be experienced by the vehicle after it is built.

"I get the vehicle outer mold line (OML) along with the aerodynamic control surfaces, and then I put that into the CFD-related codes that I'm using," says Grosvenor. "I'm able to actually reverse-engineer that OML into a parametric model, which is important for vehicle design studies focused on evolving aerodynamic performance and controllability."

For example: "We're using CFD to generate aerodynamic forces and moments that are then used for evaluating performance and controllability. We're also generating loads and heating maps all over the vehicle as well as hinge moments on the aerodynamic surfaces," says Grosvenor.

To get the data, Grosvenor logs onto supercomputers at the Department of Defense High-Performance Computing Centers via his MacBook Pro laptop. "I can't say enough about what an enabler having access to those systems is for a small company trying to do this kind of project," said Grosvenor. "If we did not have the ability to run these kinds of jobs on these kinds of systems, it would radically change what would be feasible for us to contemplate and the way we go about doing it."

Although Grosvenor has to share time on the supercomputers with other users, he says the power available to him lets him get far more analysis done in much less time than would be possible otherwise. A typical job might run overnight, giving him calculations on aerodynamic loads and heating from air friction for every 20 seconds of a simulated XS-1 flight for a variety of design iterations.

Grosvenor accesses several supercomputers. They include a Cray XE6 known as Garnet, a Cray XC40 known as Excalibur and a Cray XC30 called Lightning. He also uses an SGI ICE X called Spirit. CFD tools provided by NUMECA running on Linux crunch the numbers.

Once he has the data back from the supercomputers, Grosvenor feeds it to team members working on the affected portions of the vehicle design in progress, which allows them to adjust their own work for maximum performance of the vehicle.

Looking to the Future

The entire Masten team now numbers 30 people, and the company is actively growing. Ramping up for the XS-1 program, says Mahoney, has people "stacked on

Masten rockets from left to right: Xaero-B, Xodiac and Xombie.

top of each other" in their current space. "We'll be adding some more physical space soon."

Masten's work on the XS-1 design will soon move to wind tunnel testing of scale models at a facility that has yet to be determined. Soon afterward, in mid-2016, the Phase 1 portion of DARPA's XS-1 program for which Masten was awarded its contract will conclude. And Masten Space Systems will pull hard to land the XS-1 Phase 2 contract.

For Phase 2, DARPA will select only one contractor to actually build the XS-1. After Masten and its competitors submit their applications, DARPA expects to make the decision on who will build the vehicle by September of 2016.

If all goes well, in 2019 the XS-1 will undergo flight testing for Phase 3 of the program, during which it will have to demonstrate all of the capabilities requested by DARPA, including flying 10 times in 10 days and launching a satellite. DARPA has made available a total of $140 million for Phases 2 and 3.

Once the vehicle design has been validated through flight tests, DARPA will hand off the project, along with the building of operational vehicles to other organizations, just it has done for countless other projects throughout the agency's more-than-50-year history.

In the meantime, Masten Space Systems continues its work with the landers that put it on the aerospace testing map.

On a recent fall afternoon, the Masten team prepped its Xodiac lander for a test flight in support of internal research and development in advance of flying the vehicle for a customer. "We're out there on a very frequent basis," says Mahoney. That rocket and the two others the company routinely flies still fit on trailers, just as Masten rockets have done since Dave Masten founded the company in 2004.

It's all part of a design philosophy that calls for frequent flights and rapid turnaround times for each vehicle; a philosophy that may soon get Masten Space Systems into orbit. **DE**

Michael Belfiore's *book* The Department of Mad Scientists *is the first to go behind the scenes at DARPA, the government agency that gave us the Internet. He writes about disruptive innovation for a variety of publications. Reach him via michaelbelfiore.com.*

INFO → **Cray:** Cray.com

→ **DARPA:** DARPA.mil

→ **Masten Space Systems:** Masten.aero

→ **NUMECA:** Numeca-usa.com

→ **SGI:** SGI.com

→ **SOLIDWORKS:** SolidWorks.com

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

A New Storm

The Digital Storm Slade PRO is an entry-level workstation with a range of options. It features front-mounted fans and a sleek case that opens to reveal access to drive bays. *Images courtesy of Digital Storm.*

The Digital Storm Slade PRO is an updated version of a very good system.

BY DAVID COHN

Digital Storm recently sent us a new version of its Slade PRO workstation, an updated version of its custom-built workstation that we previously reviewed (see deskeng.com/de/?p=18220). The Fremont, CA-based company originally focused on producing fast gaming computers but has been selling custom-built workstations to engineering professionals for several years.

While the Slade PRO is Digital Storm's entry-level workstation — with a starting price of $1,592 — it is available in multiple configurations ranging from a single Intel Core i7 CPU to systems with dual Xeon CPUs and multiple NVIDIA GPUs (graphics processing units). Other Digital Storm models offer similar wide ranges of options, but are based on larger cases.

Like its predecessor, our new Slade PRO came enclosed in some rather unique packaging with a foam block inside the case to help prevent components from being dislodged during transit. In spite of this, when we opened the case to remove the foam, we noted that the hard drive was partially dislodged from its cage. But unlike the evaluation unit we received last year, the drive was still connected and everything worked properly. It was a simple matter to reseat the drive. Although this was the result of careless handling by the shipping company, it is something seen repeatedly by both *DE* and Digital Storm customers.

Digital Storm is not really a manufacturer — it is a system integrator, assembling computers from an assortment of readily available components. For example, the Slade PRO comes housed in a large, black aluminum and steel ATX mid-tower case measuring 8.7x20.9x19.5 in. (WxDxH). However, that case is actually an Obsidian Series 550D manufactured by Corsair, available online for $143. What Digital Storm adds is skilled assembly, extensive testing and a single point for support and service should it be needed.

This is the same case we saw when we reviewed last-year's version of the Slade PRO. As such, it provides excellent noise reduction and sound isolation, thanks to front and side panels lined with sound-damping material and front air intakes angled away from the front of the case. But as noted last year, the case is a bit quirky, with two front-mounted intake fans and one rear exhaust fan. There are also removable plastic panels on the top and left side that can accommodate two additional fans each, but adding fans in these locations would likely increase the sound level. Removable magnetic dust filters protect the top, front, and side air intakes. There is also a slot-mounted filter on the bottom of the case that often slid out when we moved the system. Although the

Single-Socket Workstations Compared

		Digital Storm Slade PRO one 3.1GHz Intel Xeon E5-2687W v3 10-core CPU, NVIDIA Quadro M4000, 32GB RAM	Computer Direct Volta Pro one 4.0GHz Intel Core i7-4790K quad-core CPU, NVIDIA Quadro K5200, 16GB RAM	BOXX APEXX 2 2401 one 4.0GHz Intel Core i7-4790K 4-core CPU over-clocked to 4.5GHz, NVIDIA Quadro K5200, 16GB RAM	Xi MTower PCIe one 3.7GHz Intel Core i7-5930K 6-core CPU over-clocked to 4.32GHz, NVIDIA Quadro K5200, 16GB RAM	Lenovo P300 one 3.6GHz Intel Xeon E3-1276 v3 quad-core CPU, NVIDIA Quadro K4000, 8GB RAM	HP Z1 G2 one 3.6GHz Intel Xeon E3-1280 v3 quad-core CPU, NVIDIA Quadro K4100M, 16GB RAM
Price as tested		$6,187	$4,441	$5,111	$4,985	$2,072	$5,918
Date tested		10/18/15	7/12/15	2/4/15	12/13/14	11/9/14	5/3/14
Operating System		Windows 10	Windows 7	Windows 7	Windows 8.1	Windows 7	Windows 8.1
SPECviewperf 12	higher						
catia-04		78.54	103.66	100.40	98.53	38.19	42.23
creo-01		65.60	91.62	77.69	86.66	34.31	30.28
energy-01		6.31	3.73	3.61	3.49	0.65	1.74
maya-04		63.79	75.92	74.68	72.18	32.31	33.79
medical-01		25.99	31.33	30.01	28.84	12.38	10.34
showcase-01		42.26	49.76	49.76	48.98	22.64	21.12
snx-02		74.62	152.32	83.03	150.42	36.79	40.37
sw-03		110.74	134.67	130.28	126.08	69.37	38.66
SPECviewperf 11	higher						
catia-03		76.76	134.82	131.40	99.71	67.84	63.80
ensight-04		113.47	145.75	152.22	148.83	48.80	61.56
lightwave-01		71.75	109.59	107.01	100.99	88.54	82.76
maya-03		162.38	131.43	245.35	99.44	132.59	128.09
proe-05		13.98	28.51	27.19	18.19	21.34	17.18
sw-02		64.18	97.48	96.35	88.99	72.05	67.75
tcvis-02		59.98	108.24	106.96	78.64	55.66	58.99
snx-01		113.28	135.41	137.53	134.51	53.24	65.58
SPECapc SolidWorks 2013	higher						
Graphics Composite		2.16*	11.24	10.27	8.82	6.29	5.67
RealView Graphics Composite		2.77*	13.32	12.08	10.03	6.88	6.16
Shadows Composite		2.80*	13.37	12.12	10.05	6.89	6.13
Ambient Occlusion Composite		6.44*	28.08	24.55	17.58	9.65	8.48
Shaded Mode Composite		2.10*	11.25	10.25	8.95	6.17	5.55
Shaded with Edges Mode Composite		2.21*	11.22	10.30	8.69	6.41	5.79
RealView Disabled Composite		0.80*	5.69	5.37	5.28	4.39	4.08
CPU Composite		3.39*	4.87	4.87	4.50	4.18	3.12
Autodesk Render	lower						
Time	seconds	47.33	50.83	41.88	42.33	64.08	45.00

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

*** Results may be an anomaly due to the operating system and application software versions used.**

entire system weighed just 35.25 lbs., moving it was hampered by a lack of any type of handle or other grip point.

Lots and Lots of Options

The front of the case presents a monolithic appearance. Initially, all that is visible is a brushed aluminum panel housing headphone and microphone jacks, a small reset button, a large round power button, and a pair of USB 3.0 ports. This panel is a cutout in a large door that can swing open from either side or be removed. This door concealed four 5.25-in. drive bays. The top bay contained an ASUS Blu-ray player/DVD writer combo drive (a $77 option) while the bottom bay housed a media card reader with five slots plus a USB 2.0 port (adding $19).

Removing the left side panel revealed a spacious and well-organized interior. In addition to the front panel drive bays, the Corsair case provides six internal tool-free drive bays that can accommodate either 3.5- or 2.5-in. drives. This time around, our Slade PRO came with a 400GB Intel 750 Series PCIe card-based solid-state drive (SSD) as the boot drive, installed in one of the available expansion slots, and a 2TB Western Digital Black Edition 7200 rpm data drive in one of the internal drive bays. Although a 2TB hard drive comes standard in the base configuration (which also includes a cage-mounted 250GB Samsung SSD) the storage drive in our system was a $66 upgrade while the 400GB card-based SSD added another $348. Other, larger capacity SSD and standard hard drives are available.

As we learned last year, the Slade PRO is actually available in multiple configurations — now a total of eight variations — that can then be customized by choosing from an array of options. For example, the $1,592 entry-level system comes with a 4-core CPU, 16GB of memory, an NVIDIA Quadro K620 GPU, a 250GB SSD and 2TB hard drive. Other systems start with 6-core, 8-core, or 12-core Xeon processors at $2,571, $3,932, or $5,334, respectively — or you can configure systems based on dual Core i7 or Xeon CPUs. And while all Slade PRO systems start out with the same case, you can choose different cases and spend hundreds of dollars for exotic paint jobs.

Our Slade PRO system contained an ASUS X99-E WS motherboard based on an Intel X99 chipset (actually a $338 upgrade from the base motherboard, and Digital Storm offers three other motherboard options). This ASUS motherboard provides eight memory sockets, supporting up to 256GB of memory using 32GB DIMMs (dual in-line memory modules). Our unit came with 32GB of DDR4 2133MHz ECC registered RAM installed using four 8GB 288-pin Samsung DIMMs, the same as the base configuration. There are also seven PCIe 3.0/2.0 x16 slots. Our

SHOULD YOU BUY IT OR BUILD IT YOURSELF?

System integrators assemble computers using parts that are readily available, begging the question: Does it make sense to have Digital Storm assemble the system or would you be better off buying all of the components and building it yourself? Because we knew exactly what components went into our Slade PRO evaluation unit, we were easily able to price them online from a number of well-known retailers. Here's what we came up with:

Corsair Obsidian 550D case	$143
Intel Xeon E5-2687W v3 CPU	$2,100
ASUS X99-E WS motherboard	$519
Samsung 2133MHz ECC memory (4x8GB)	$360
750W EVGA SuperNOVA power supply	$150
USB 2.0 Digital Media Card Reader	$8
ASUS Blu-ray & DVD 12X Writer/Reader optical drive	$92
Intel 750 PCI-E 400GB SSD	$360
Western Digital 2TB Black Edition hard drive	$117
NVIDIA Quadro M4000 graphics card	$889
Corsair H80 liquid CPU cooler with 120mm radiator	$90
Windows 10 Professional 64-bit (OEM version)	$140
Logitech MK200 keyboard and mouse	$20
TOTAL	**$4,988**

That means, if you bought all of the parts and built it yourself, you could assemble the identical system for around $5,000, saving 20%. Of course, that assumes that you have the requisite skill, confidence and time to do it yourself. For the level of performance our Slade PRO achieved and the peace of mind of knowing that when the system is delivered to your door it is guaranteed to work and is supported by lifetime customer care, you may well decide that the extra $1,200 is money well spent.

system came with an NVIDIA Quadro M4000 graphics board instead of the K2200 included in the base configuration, adding $451 to the base price. The M4000 is a new card recently released by NVIDIA and based on the company's newest Maxwell 2 GPU. The M4000 includes 8GB of GDDR5 memory and 1664 CUDA (compute unified device architecture) cores and provides four DisplayPort connections. The board requires a single expansion slot, although its stereo connector uses an additional rear panel knockout and its 120-watt power consumption requires an auxiliary power connection.

While Digital Storm's website lists systems based on 4-core, 6-core, 8-core, and 12-core CPUs, our evaluation unit came with a 10-core Intel Xeon E5-2687W v3, a processor with a 3.1GHz clock speed, 3.5GHz maximum turbo speed, and a 25MB cache. This CPU added $2,241 to the base price of the company's 6-core Xeon system. Cooling is provided by a Digital Storm Vortex liquid cooling system (actually a branded version of the Corsair H80), but again Digital Storm offers a myriad of other options. Users can also have their systems configured with internal lighting, additional airflow controls and other modifications. The system comes with a 750-watt EVGA SuperNOVA power supply, but again, there are no fewer than 11 other options.

The rear panel offers eight USB 3.0/2.0 ports, two USB 3.1/3.0/2.0 ports, two RJ-45 network jack, two eSATA connections, one optical S/PDIF output port, five audio jacks (separate microphone and line-in jacks as well as line-out, rear, and center/sub-woofer channels), a USB BIOS flashback button, and a Q-Code Logger button, all supported by the ASUS motherboard.

Very Good Performance

With its fast 10-core CPU and powerful new graphics card, we were quite anxious to see how well the new Slade PRO would perform. On the SPEC Viewperf tests, the system held its own and outperformed its predecessor.

Although the results on the SPECapc SOLIDWORKS 2013 test proved quite disappointing, those results may be an anomaly due to the operating system used rather than the actual performance of the workstation. The Slade PRO was the first system we have tested that came with Windows 10, and although SOLIDWORKS seemed to run fine, our research indicates that only SOLIDWORKS 2014 and newer are supported on this new OS.

We also ran the SPECwpc benchmark, and here the Slade PRO turned in some of the best results we've recorded to date for a system equipped with a single CPU. Similarly, on the AutoCAD rendering test, a multi-threaded test on which faster systems with more CPU cores have a distinct advantage, the Slade PRO completed the rendering in just 47.33 seconds — quite fast — but nearly 10 seconds slower than last year's Slade PRO, which still holds the record for a single-socket workstations.

As we've stated, Digital Storm pre-loaded Windows 10 Professional 64-bit, for which it charged a $52 premium over the Home edition. One year of McAfee AntiVirus Plus was also included. Because configuring a Digital Storm system is truly an a la carte process (and we did not request any additional options other than those already mentioned), our system came without a keyboard or mouse. Assuming that most users would likely need these, we added a Logitech Media Combo MK200 keyboard and mouse (a $24 option) when we priced the system using the company's configuration website.

Digital Storm backs its computers with lifetime customer care and a three-year limited warranty that covers labor costs for three years and defective part replacement for one year, something that we found a bit curious because many of the components included in the system have longer warranties. Warranties of up to six years, including four-year part replacement, are also available.

Because our system priced out at more than $6,000, it qualified for a $200 discount, free ground shipping, and an extra year of warranty coverage. While that offer was only good for a limited time, other offers may become available.

Like its predecessor, the new Digital Storm Slade PRO performed flawlessly throughout our review process, and generally outperformed last year's version. But there is nothing "bleeding edge" about the Slade PRO and you could build the same system yourself for less. Its lack of ISV (independent software vendor) certification makes us wonder whether it is appropriate for mission-critical engineering applications. That said, the Digital Storm Slade PRO remains a well-built system based on excellent components that offers a lot of bang for the buck. DE

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INFO → Digital Storm: DigitalStorm.com

Digital Storm Slade PRO

- **Price:** $6,187 ($1,592 base price)
- **Size:** 8.7x20.9x19.5 in. (W xDxH) tower
- **Weight:** 35.25 lbs.
- **CPU:** One Intel Xeon E5-2687W v3 (10-core) 3.1GHz
- **Memory:** 32GB DDR4 2133MHz ECC RAM (up to 256GB supported)
- **Graphics:** NVIDIA Quadro M4000
- **Storage:** 400GB PCIe card-based Intel 750 SSD, 2TB Western Digital Black Edition 7,200 rpm
- **Optical:** ASUS Blu-ray player/DVD writer
- **Audio:** Onboard integrated high-definition audio
- **Network:** Integrated 10/100/1000 LAN with two RJ45 jacks
- **Other rear panel:** Eight USB 3.0/2.0, two USB 3.1/3.0/2.0, two USB 2.0, optical S/PDIF, two eSATA
- **Keyboard/Mouse:** Logitech Media Combo MK200 keyboard and mouse (included for pricing purposes)

Another Picture Perfect Pair of Displays

The 27-in. BenQ BL2711U and 32-in. BenQ BL3201PH both offer feature-rich 4K (3840x2160) resolutions at affordable prices. *Image courtesy of David Cohn.*

Two new BenQ monitors deliver affordable 4K resolution.

BY DAVID COHN

Last year, BenQ sent us a pair of its new monitors aimed specifically at users of CAD/CAM software (see deskeng.com/de/?p=20372). The Taiwanese firm, originally spun off from Acer in 2001, was not very well known in the engineering market despite selling LCD monitors, digital projectors, digital cameras and mobile computing devices for more than a decade. With the introduction last year of its BL-series of monitors, however, that lack of name recognition is rapidly changing. A year later, BenQ is back with updated versions of these two displays: the 27-in. BenQ BL2711U and the new BenQ BL3201PH.

Outwardly, both monitors appear quite similar to their predecessors, but this time around BenQ ups the ante, delivering a pair of panels with 4K (3840 x 2160) Ultra HD (ultra-high definition) resolution at price points that will not break the bank. Both monitors are based on LCD panels manufactured by AU Optronics (AUO) and both now use IPS (in-plane switching) technology to achieve wide viewing angles (178° in both horizontal and vertical viewing directions), response times as low as 4 milliseconds gray-to-gray (the time it takes to change a given pixel from gray to a different color and then back to gray), and a claimed 100% sRGB color gamut. The only significant difference between these two monitors is their size. The 27-in. BL2711U has a 0.155mm pixel pitch and a brightness of 300 cd/m2 while the 32-in. BL3201PH has a pixel pitch of 0.185mm and a brightness of 350 cd/m2. Both have a 1000:1 contrast ratio.

In addition to the power cord, BenQ also provides six cables: DVI-D dual-link; DisplayPort (a DisplayPort to min-DisplayPort in the case of the BL3201PH); HDMI; USB 3.0 input; a power cord; and an audio cable to connect the computer's audio port to the monitor's built-in stereo speakers when using DVI (audio is carried as part of the signal when connected using DisplayPort or HDMI). It took just a few minutes to assemble each display by placing the panel face down on a flat surface, attaching the monitor stand to the monitor base and tightening the thumbscrew on the bottom of the base, and then aligning the stand arm with the monitor and locking it into place. Before attaching the monitor to its stand, we noted the standard 100mm VESA mounting holes that enable the panels to be wall mounted or attached to other supports.

> **"4K Ultra HD" is the terminology to be used by the Consumer Electronics Association (CEA) and its members to describe the emerging category of display products with more than 8 million pixels – four times the resolution of Full HD.**
>
> ***— CEA***

The 27-in. BL2711U weighs 17.6 lbs. (including the stand). The panel itself measures 25.1x15.1x2.7 in., has a height adjustment range of 16.1 to 21.6 in., and needs a space 9.4 in. deep. The 32-in. BL3201PH weighs 28.6 lbs., has a panel measuring 29.1x17.2x2.5 in., a height adjustment range of 19.3 to 25.1 in. and is 9.1 in. deep.

The stand included with each monitor provides a very stable support and allows the displays to be swiveled 45° both to the left and the right and to be tilted from -5° to +20°. The panels can also be pivoted 90° from landscape to portrait mode. Cables can be neatly routed through a hole in the center of the lower portion of the stand.

Controls and Inputs

Both displays sport panels with a 16:9 aspect ratio surrounded by a thin black bezel. A power button located in the lower-right corner glows white when the screen is active and amber when in standby mode. Five adjacent touchpad buttons with LED indicators let you access controls using the on-screen display (OSD). The LEDs in these touch-sensitive buttons light up as your finger approaches and the OSD is very intuitive. Both monitors also offer picture-in-picture and picture-by-picture modes, enabling you to display images from two different computers on screen simultaneously.

Each monitor also features a full range of input ports, including dual-link DVI, DisplayPort and HDMI video inputs, while the D-sub (VGA) ports found on last year's models have been eliminated. Each also includes a USB 3.0 input port and an audio line-in jack. On the BL2711U, all of these connections are located on the bottom of the rear panel along with an AC power connector, a master power switch, audio input jack, DVI-D, two HDMI ports (one supporting HDMI 2.0 only), DisplayPort, USB 3.0 input port, and two USB 3.0 output ports. There is also a pair of USB 3.0 ports on the left side of the bezel along with a headphone jack. A blue headphone hook extends from the rear of the monitor stand. The BL2711U also includes a pair of built-in 3-watt stereo speakers that mute when you plug in headphones. And, sound quality using the built-in speakers was quite good.

On the BL3201PH, the connections are a bit more spread out. The USB 3.0 input port, a mini-USB port (for the OSD controller), three USB 3.0 output ports, and an audio line-in jack as well as the AC power connector and master power switch are located on the bottom of the rear panel. But the five video inputs — DVI-D, two HDMI ports, a DisplayPort, and a mini-DisplayPort — are located on the right side of this panel where they are much more easily accessed. A panel on the lower-right edge of the bezel provides easy access to a pair of USB 3.0 ports, a headphone jack, and an SD card reader. Other than the difference in size and port locations, the BL3201PH's vertical stand is silver aluminum whereas the BL2711U's is black, and the built-in stereo speakers in the 32-in. monitor are rated at 5 watts.

Both BenQ monitors also feature an ambient light sensor built into the center of the bezel below the panel, enabling the display to automatically adjust its brightness as the surrounding lighting conditions change. Additionally, there is a human motion sensor (BenQ refers to this as an "ECO sensor") that can turn the screen off when it senses that no one has been in front of it for 40 seconds and automatically turn the display back on again when it senses motion.

The BL3201PH includes the same unique OSD Controller we first encountered with the BL3200. This small puck-shaped device, which connects to the min-USB port, provides a collection of buttons that enable users to access and navigate the OSD rather than using the buttons on the bezel. When not being used, the controller fits into a round indentation in the monitor stand.

BenQ also includes Display Pilot (from Portrait Displays Inc.), software that automatically detects when the display is pivoted between landscape and portrait mode and matches the on-screen image to the new orientation. Display Pilot also includes an application tuning feature that, once configured, automatically assigns picture modes so that the display takes on color temperature, brightness, and contrast settings that best match the program your are using. For example, when using CAD software, the monitor can switch to CAD/CAM mode. Picture modes include sRGB (for matching colors to devices such as printers and digital cameras), Animation, Presentation, Movie, Photo, Reading (for eBooks and documents), Eco (to lower brightness and conserve power), and M-book (to minimize differences between the monitor and a connected MacBook. You can also use the Display Pilot software to control the ambient light sensor and ECO sensor, set a pop-up message to display at pre-defined intervals to remind you to rest your eyes, set a timer to automatically power off the monitor in power saving mode, span the Windows task bar across multiple monitors, and display the recommended resolution whenever a new input source is detected.

Impressive Performance

We used DisplayMate from DisplayMate Technologies to help evaluate the visual quality of each monitor. DisplayMate uses a series of test patterns both to help users fine-tune the image and to uncover any picture quality problems or video artifacts that might otherwise go unrecognized. Both BenQ monitors displayed excellent color and gray scale and showed absolutely no pixel defects. We were able to read text down to 6.8 points even at different intensity levels and the fast response time resulted in no image smearing when viewing full-motion video.

We were very impressed with the performance of both of these displays. We were also impressed with their price. The BL2711U has a suggested retail price of $679, a bit less than its predecessor, although the best street price we found was $630, a bit more expensive than similar 4K 27-in. displays from Acer, Dell and LG but less those from HP, NEC and Viewsonic. The 32-in. BL3201PH has a suggested retail price of $999, but a street price averaging $100 less, quite a bargain for a display of this size. Both monitors are backed by a three-year warranty that covers parts and labor. Once again, BenQ has delivered a pair of great monitors that deserve a place on the desk of any CAD user. **DE**

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BenQ BL3201PH 32-in. IPS Display

- **Price:** $999 MSRP ($899 street price)
- **Size:** 32-in. (diagonal)
- **Display type:** IPS LED backlit
- **Screen dimensions without stand (WxHxD):** 29.1x17.2x2.5 in.
- **Physical size with stand at highest setting (HxWxD):** 29.1x25.1x9.1 in.
- **Weight:** 28.6 lbs.
- **Native resolution:** 3840x2160 pixels @ 60Hz
- **Display area:** 27.9x15.7 in.
- **Horizontal frequency range:** 30kHz – 83kHz
- **Vertical refresh rate:** 50 Hz – 76 Hz
- **Aspect ratio:** 16:9
- **Pixel Pitch:** 0.185 mm
- **Dot/Pixel per Inch:** 137.68
- **Brightness:** 350 cd/m2
- **Contrast ratio:** 1000:1
- **Response time:** 4ms (gray to gray)
- **Number of colors:** 1.07 billion
- **Color gamut:** 100% sRGB
- **Power consumption:** 79 watts typical, 0.5 watts standby
- **Video input ports:** DVI-D dual-link, DisplayPort 1.2, mini-DisplayPort 1.2, 2 HDMI
- **I/O ports:** USB 3.0 in, five USB 3.0 out, one mini-USB out, audio line-in, headphone jack
- **Other features:** Tilt/swivel base, portrait/landscape pivot, built-in 5W stereo speakers, Kensington lock slot, OSD controller, SD card slot
- **Cables included:** AC power cord, DVI-D dual-link, DisplayPort to mini-DisplayPort, HDMI, USB 3.0, audio
- **Warranty:** Three years parts and labor

BenQ BL2711U 27-in. IPS Display

- **Price:** $679 MSRP ($630 street price)
- **Size:** 27-in. (diagonal)
- **Display type:** IPS LED backlit
- **Screen dimensions without stand (WxHxD):** 25.1x15.1x2.7 in.
- **Physical size with stand at highest setting (HxWxD):** 21.6x25.1x9.4 in.
- **Weight:** 17.6 lbs.
- **Native resolution:** 3840x2160 pixels @ 60Hz
- **Display area:** 23.4x13.2 in.
- **Horizontal frequency range:** 30kHz – 140kHz
- **Vertical refresh rate:** 30 - 76 Hz
- **Aspect ratio:** 16:9
- **Pixel Pitch:** 0.155 mm
- **Dot/Pixel per Inch:** 163.18
- **Brightness:** 300 cd/m2
- **Contrast ratio:** 1000:1
- **Response time:** 4ms (gray to gray)
- **Number of colors:** 1.07 billion
- **Color gamut:** 100% sRGB
- **Power consumption:** 42 watts typical, 0.5 watts standby
- **Video input ports:** DVI-D dual-link, HDMI 1.4, HDMI 2.0, DisplayPort 1.2
- **I/O ports:** USB 3.0 in, four USB 3.0 out, audio line-in, headphone
- **Other features:** Tilt/swivel base, portrait/landscape pivot, built-in 3W stereo speakers, Kensington lock slot
- **Cables included:** AC power cord, DVI-D dual-link, DisplayPort, HDMI, USB 3.0, audio
- **Warranty:** Three years parts and labor

INFO ➜ BenQ: BenQ.us

➜ DisplayMate: DisplayMate.com

CHAPTER 6 EXCERPT

Go Mobile

Performance improvements have put laptops on par with desktop systems for some engineering applications.

The Dell Precision mobile product family includes the new Precision 7710 and 7510 mobile workstions with Intel's new mobile Xeon processors. *Image courtesy of Dell.*

Memory-intensive engineering and analysis work requires a lot of computer horsepower. Traditionally, that has meant a certified tower-style workstation, but that is slowly changing. Interest in mobile workstations for engineering applications is increasing, and will likely be further boosted by new processor developments. In the second quarter of 2015, for example, mobile workstation shipments rose 5.4% year over year while desktop shipments declined over the same period, according to IDC, and mobile workstations account for nearly 30% of overall certified workstation sales.

The release of Intel's mobile Xeon CPUs for laptops is expected to open up that market even further. The 4-core CPUs support vPro business management features, along with error-correcting code (ECC) memory and other features on par with the Xeon desktop chips.

"The OEMs (original equipment manufacturers) we work with see that there is a market for portable, business-class devices that can be used for CAD, rendering, and other applications," says Chris Silva, director of marketing for premium notebooks at Intel. "What was missing was an industry-grade branding and capabilities that the Xeon name provide."

"The Xeon brand is really well known in enterprise spaces, and is synonymous with higher end desktop workstations," adds Scott Ruppert, worldwide workstation portfolio manager at Lenovo. "There's a recognition by customers that it provides stability and quality."

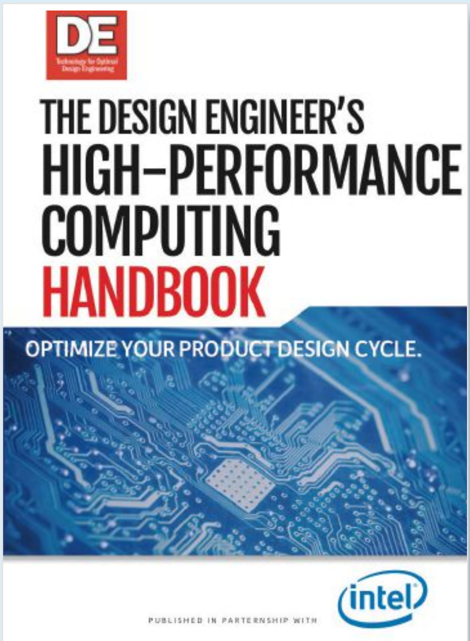
It will also likely provide a performance boost for mobile users. "We're seeing 15 and 20% improvements in overall performance with the new CPUs," says Scott Hamilton, Precision specialist at Dell. "The Xeons are now just as fast if not faster on the mobile side as the Core i7 proces-

How the HPC Handbook Works

The Design Engineer's High-Performance Computing Handbook is a multimedia resource consisting of magazine article excerpts; the hpc.deskeng.com website that is full of videos, case studies and research; e-newsletters; and regularly released chapters that are free to download. Once you download a chapter, you'll be alerted when new chapters are ready. Each chapter takes a detailed look at a computing topic important to design engineers. The chapters include pictures, charts, definitions and links to additional information.

The HPC Handbook site is the hub of information for high-performance computing in design engineering. The HPC Handbook is available for download on the site, and the site is constantly updated to include the latest HPC educational resources that are pertinent to design engineering teams. It is divided into sections on Workstations, Clusters/Servers, Cloud Computing and Software, each of which contain the best information available on the Web from *DE* and beyond.

Check it out at hpc.deskeng.com.



Lenovo's ThinkPad50 (pictured) and ThinkPad70 feature Intel's new mobile Xeon processor and a new FLEX Performance Cooling system with a dual-fan design. *Image courtesy of Lenovo.*

The HP ZBook Studio is the company's first quad-core workstation Ultrabook. It can be equipped with Intel's new Xeon mobile processor and up to 32GB of RAM. *Image courtesy of HP.*

sors. Support for ECC is also important for people who are doing analysis work, because it guarantees the reliability of the calculation."

Dell is offering its new Precision 7710 and 7510 mobile workstations with the mobile Xeons, and a choice of NVIDIA Quadro M or AMD FirePro GPUs (graphics processing units), as well as options for Intel's integrated graphics.

Most of the other major manufacturers have now announced mobile workstations featuring the Xeons, including Lenovo's ThinkPad P50 and P70. The 17-inch P70 includes a 2TB hard disk, 1TB PCIe SSD, and a DVD-RW that can be replaced with an additional 1TB hard disk or smaller SSD. HP has announced the HP ZBook Studio, its first quad-core workstation Ultrabook, dual 1-TB HP Z Turbo Drive G2, dual Thunderbolt 3, dual cooling fans and an optional 4K display.

"Xeon provides good performance with extra added reliability," says Josh Peterson, director of Worldwide Product Management, Workstations at HP. "It will take time for customers to understand what Xeon really means for the mobile space, but it is proliferating beyond the desktop."

Mobile Workstations Catch Up with the Desktop

Graphics, CPUs and storage have all advanced to the point that users are seeing significant productivity gains with mobile workstations. In fact, they are powerful enough to serve as desktop replacements for some applications. Intel's Iris Pro also provides sufficient entry-level graphics capabilities for mobile users with lighter loads. OEMs offer docking solutions that can help provide more flexibility for notebooks, as well as Thunderbolt capabilities and access to high performance storage.

Desktops still have an edge, particularly for applications that need a significant amount of computing power. Simulation, analysis and rendering benefit from the higher core counts on these systems. "For GPU computing, you can also put more robust graphics cards in the towers, and more of them. You can offload some of the compute onto those cards," Hamilton says.

Mobile workstations are generally limited to four cores and around 64GB of memory. That's enough to support the typical engineer, but there's little room for expansion. "You can upgrade the memory if you didn't already fill up those slots, but the configurability is much more limited with mobile workstations," Peterson says.

Even with these limitations, many engineers use mobile workstations to replace towers. Others use both types of hardware.

"You can get the power of a desktop in a mobile form factor now," Ruppert says. "The capabilities have really gone up a notch. If the horsepower in the mobile workstation fits the user's needs, they may just invest in a couple of monitors and a docking station on the desk, maybe get the same thing at home, and keep that single device with them."

Many users still have both types of machines, and Silva says that roughly 60% of notebook users also have a desktop. Some companies are still reluctant to allow team members to take design files on the road (or home) because of intellectual property concerns. In those cases, the mobile workstations may be used to remotely access the desktop system.

"You still get the biggest bang from a tower workstation, but with the versatility of being able to take that work mobile, we are seeing customers move to that platform," Peterson says.

As mobile workstations add compute power, it's been easier for certain types of users to shift their work completely to a mobile device. With faster CPUs and GPU-enabled applications, some analysis and simulation work can even be done on these mobile workstations.

"Mobile graphics have definitely taken a big step forward and are keeping up with desktop systems," Ruppert says. "So a lot of the things that used to require a desktop can now be done on a mobile workstation."

"Each year there is a little better performance, and this generation of workstations is a big step because of the Xeon and ECC support," Peterson says. "Depending on the applications they are using, we are seeing more customers move from desktop to mobile."

In addition, mobile workstations can be augmented with separate rendering appliances or cloud-based storage and computing resources.

CHAPTER 7 EXCERPT

Computing Options

A look at engineering computing options from some of the industry's top providers.

As an engineer, the way that you work is changing – technology is letting you create more detailed CAD models, simulations and generate more data than ever before. However, this new standard may be draining outdated computing resources that are several years old, as companies evaluate ROI (return on investment) for computing hardware approximately every three years.

"[Workstations] will live for about two to three years, but they're never really stagnant. [Users] will always want the latest graphics cards or CPUs," says Josh Peterson, director of Worldwide Product Management, Workstations at HP.

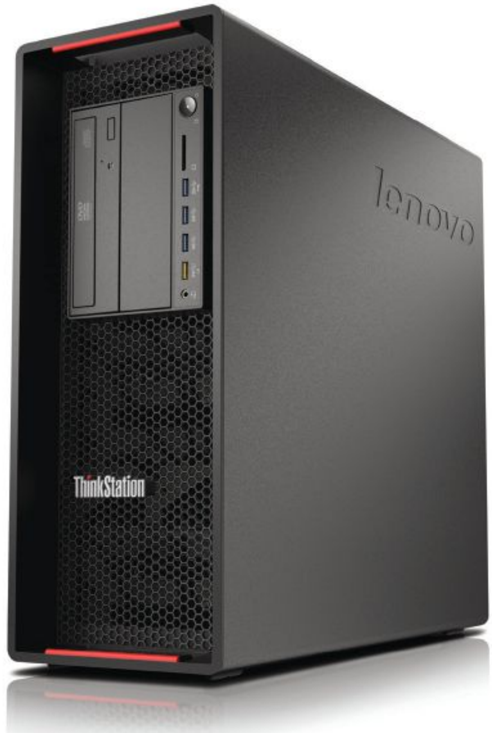
New processors with higher core and thread counts means more computing power to address challenges such as long simulation completion times and complex system modeling. It also signals an opportunity for computer original equipment manufacturers to launch new products, ensuring you have the latest technology at your desk.

Computing Comes in Many Forms

The most common workstation form factors are mobile, small form factor (SFF) and tower configurations. Mobile workstations, while they look like a consumer-level notebook, are packed with higher-end components. Chapter 6 of the HPC Handbook focuses on mobile workstations.

Desktop systems, which are able to offer more memory, processing cores and customization, are often offered in small form factor and tower. An SFF system is designed to minimize the volume of a desktop computer. With minimal components and a smaller chassis, these systems can still be used for ISV (independent software vendor) certified applications and virtual environments. The tower form factor gives the largest capacity for components, disk drives and expansion slots. It is also seen in variant forms such as the minitower.

Aside from the physical shape of the workstation, considering the performance under the hood is key. Vendors often have a portfolio consisting of entry-level, mid-range and high-end options. These systems have different capabilities (and price tags) for processing power, memory and graphics. While engineering software may run more efficiently on a workstation, that doesn't mean a system with the maximum memory, graphics and the highest level CPU is suited for your engineering work. Generally, entry-level workstations can be more suited for day-to-day CAD work, while high-end workstations can be outfitted with multiple CPUs and GPUs for intensive CAE.



The ThinkStation P700 from Lenovo features built-in Flex Bays that allow users to include the components you need such as hard drives, media card readers or FireWire. *Image courtesy of Lenovo.*

Your investment in a workstation depends on how compute-intensive your engineering work is, or how many applications you are running all at once. According to an article in the July 2014 issue of *DE*, "Simulation applications require different types of processing power than CAD or CAM uses, and in many cases what makes one application perform well may hinder another. The trick here is to understand what types of components and add-ons offer the best performance increases for an applica-

HP's z230 family of workstations is available in small form factor and tower cases, with Intel Core or Xeon processors. *Image courtesy of HP.*

The Dell Precision line of desktop and mobile workstations includes the new Tower 3000 series with up to 64GB of DDR4 2133 MHz memory. *Image courtesy of Dell.*

tion, while still keeping things affordable. It all comes down to making the right choices."

Beyond desk-based systems, there are also virtualized or cloud-based offerings for more computer power.

Virtual desktops, as covered in chapter 4 of the HPC Handbook, "duplicate the functions of powerful professional workstations in a virtual environment." This can be via the cloud, data centers and on- or off-site servers. While users will have access to an interface through a desktop connection, all of the heavy computing is done virtually through the aforementioned hardware.

Server form factors are split into rack-based and blade servers. The main differentiator between these options is scalability and how data is processed. Rack servers are designed to operate as a standalone machine and range in size depending on how many units are installed. Blades contain multiple physical servers within one unit, usually come in 4 or 8 unit configurations, and each blade runs like an individual computer.

While more technology for high-performance applications is becoming available, you or your company may not be able to immediately be able to invest in lots of IT infrastructure. This is where cloud services, private cloud appliances or full cloud solutions may be a viable option for compute-intensive applications such as CAE.

"While [cloud] appliances are powerful systems, they aren't clusters — which can have far more horsepower, but can sometimes demand larger and more complex IT management resources," notes *DE* contributing editor Peter Varhol. "For larger engineering organizations, they won't replace traditional clusters from a sheer performance standpoint. Where they can make a difference is in smaller groups that are using individual workstations, or for groups that cannot fully utilize a cluster. Private clouds can also be useful in larger groups that have occasional needs for more computing horsepower than their cluster can provide."

Offerings for turnkey cloud appliances are available from companies such as BOXX Technologies, Rave Computer and Altair HyperWorks.

Several companies have also emerged to offer virtualized applications for CAD and CAE. These organizations will offer high-performance computing resources as a service, so engineers can simply pay for just what is necessary. Some currently available applications for CAD include Onshape and Autodesk Fusion 360; virtualized CAE is offered by UberCloud, Rescale, Ciespace and others.

Learn More

To learn more about mobile, desktop and cloud-based engineering computing options, download *The Design Engineer's High-Performance Computing Handbook,* which has just been updated with two new chapters covering those topics. The full version of chapters 6 and 7 include specs on the latest hardware, a discussion of graphics and expert industry analysis.

This free resource, brought to you be *DE* in partnership with Intel, is available at hpc.deskeng.com/download.

Photorealistic Rendering Grows in Importance

Software and techniques for photorealistic virtual prototypes have developed beyond simple images.

BY MARK CLARKSON

Consider how much cheaper, easier and faster it is to make a picture of a car (or a shampoo bottle) than to build a physical prototype. It's easy to see why the idea of replacing prototypes with renderings would be attractive to automobile (and bottle) manufacturers. But, if a rendering is going to replace a real-world prototype, it has to resemble the real world as closely as possible. It must be reliably predictive.

We've always accepted that premise when it comes to, say, weight or material strength. No one wants a CAD system that gets basic measurements wrong. Photorealistic renderings — pretty pictures — seemed less important. Those "pretty pictures," however, are becoming ever more useful in the design process. Manufacturers want to predict, not only the gross physical attributes of the final product, but also its look and feel. To do this, they need renderings that not only look nice, but also accurately reflect physical reality.

Flipping to Reality

Physics-based techniques to accurately calculate the movement of light in, on and through various materials have been around for years — decades even — but until now, hardly anyone had sufficient hardware horsepower to do much with them. Consequently, rendering has traditionally involved some degree of … well, "cheating."

Rendering algorithms can be focused obsessively on speed and efficiency, often at the expense of physical verisimilitude. The question was, how few calculations can we perform to produce an acceptably accurate rendering? Can we fool the eye into seeing a reflective object, without following every photon through the scene? Sure we can, and it's much, much faster than actually performing the computations necessary to calculate physically accurate reflections.

As rendering applications became more sophisticated, and our expectations of the final renders grew ever higher, the tricks got harder and harder to pull off. Finally, a few years ago, things began to flip. "We said, 'forget about the tricks,'" says Phillip Miller, head of Advanced Rendering Solutions, NVIDIA. "Instead of doing all these CG (computer graphics) approaches, let's use real physics. You get predictable results and, suddenly, [the program's] easier to use, because it's working like the world around you. You put lights where they're supposed to be and you get the right results."

The problem has always been one of horsepower, but computing horsepower is cheap and getting cheaper. Consequently, in recent years, renderers have begun to sport physics-based lighting, lenses and materials.

A Workstation is Probably Enough

Extra computing horsepower is perhaps most immediately obvious on your desktop workstation. "In the past," says Matt Moy, product specialist at Rave Computer, "to work with large sets of data you'd have to log time on a large, expensive cluster. With the advent of GPU (graphics processing unit) computing, we can pack the [same amount] of computing power into a personal workstation." Rave specializes in building high-performance workstations, which Moy is quick to point out entails more than stuffing a cabinet with the fastest, most over-clocked components. "We've very carefully integrated the best of breed components in every category," says Moy.

Effective cooling is key. The hotter the machine gets, the faster the fans spin and the louder and more annoying it becomes. Worse, heat can slow things down as components react to the high temperatures. Intel's Turbo Boost feature, for example, allows the CPU to run at faster than its nominal clock speed. This increase, though, is limited by the processor's power draw and temperature. If it gets too hot, it slows down.

Rave's cooling design, for example, creates positive pressure inside the chassis. This not only prevents hot spots, but keeps dust from sneaking in through DVD drives, ports and whatever other cracks it can find.

When a Workstation Isn't Enough

Sometimes, a workstation is inadequate or inappropriate. If you need to plug in some more power, that's increasingly doable. Specialty computer maker BOXX Technologies, for example, makes the renderPRO, a plug-and-play turbo booster with twin

CPU or GPU Rendering?

There are two rendering claims that come up again and again in the industry. The first is that CPUs are better for rendering, especially ray tracing, primarily because the amount of available RAM and chip architecture. And, second, that GPUs are better for rendering, especially ray tracing, primarily because of massive parallelism and chip architecture.

"In practice," says Niles Burbank, senior product manager at AMD, "it boils down to what your preferred software package supports."

True. But, while some renderers are still CPU oriented, there's no denying the general industry-wide movement toward leveraging the massive parallelism of GPU cards. GPUs offer attractive amounts of computing power, along with easy scalability. It's comparatively easy to upgrade your processing power by plugging in an additional GPU card or two.

There are problems, of course. "There is a very well-established infrastructure of tools and applications that take advantage of [x86 CPUs], which is not as mature on the GPU side," says Burbank.

A CPU-oriented renderer can't be "ported" to the new GPU environment. The underlying algorithms must be completely re-thought to leverage all the processor cores.

"Applications have been parallel before," says NVIDIA's Phillip Miller, "but we're talking about a different scale. We want hundreds of thousands of processes. In ray tracing, we want a million rays in flight. You have to change the way your application is designed to take advantage of that."

Another oft-cited limitation of GPUs is their comparatively small RAM. Most cards top out at 12GB, which limits the size of scenes you can load and render. "While 12GB may not be enough for some," says Rave's Matt Moy, "every time they increase the frame buffer on these cards, they're opening the door to more and more people."

Intel Xeon processors. Plug it into your workstation or laptop and reap instant rewards from its fast RAM and 28 CPU cores.

Taking a different tack, graphics card manufacturer NVIDIA makes the Visual Computing Appliance (VCA), which focuses, unsurprisingly, on GPU power. In addition to its 20 CPU cores, the VCA holds up to eight double-width cards, each with thousands of cores. NVIDIA's Quadro M6000, for example, packs 3072 CUDA (compute unified device architecture) cores.

"When you're talking about performance increases of this magnitude," says Miller, "it completely changes the game. What used to take a coffee break is now interactive. What used to take overnight now takes a coffee break." Need even more power? You can link multiple VCAs together.

NVIDIA's VCA (visual computing appliance) can provide extra GPU computing power for rendering applications. ***Image courtesy of NVIDIA.***

"Honda has 30 machines of this configuration, working together," says Miller. That's nearly three-quarters of a million cores. Honda's VCA cluster produces what Miller characterizes as "interactive reality."

"They use it for final quality control to examine every piece of the car before it goes to manufacturing," Miller says.

This kind of setup seems pretty expensive — and it is — until you realize that a physical prototype costs Honda between half a million and a million dollars. "They saved multiple prototypes within the first few months of operation," says Miller. "That more than paid for their investment."

Miller points to an example of a taillight. "Honda thought it was designed correctly but, when they previewed it, they realized that the red was bleeding into the white. Had they built it, they would have had a problem, but they corrected the issue before the plastic parts were even made."

That anecdote hinges on physically realistic, predictive rendering results. A shortcut to fool the eye into seeing realism no longer cuts it. We need results we can trust, even in our "pretty pictures." **DE**

Contributing Editor **Mark Clarkson** *is* DE's *expert in visualization, computer animation, and graphics. His newest book is Photoshop Elements by Example. Visit him on the web at MarkClarkson.com or send e-mail about this article to DE-Editors@deskeng.com.*

INFO → **AMD:** AMD.com

→ **BOXX Technologies:** BOXXTech.com

→ **NVIDIA:** NVIDIA.com

→ **Rave Computer:** Rave.com

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A Growing System for IoT

Developing smart, connected devices demands a broader system scope.

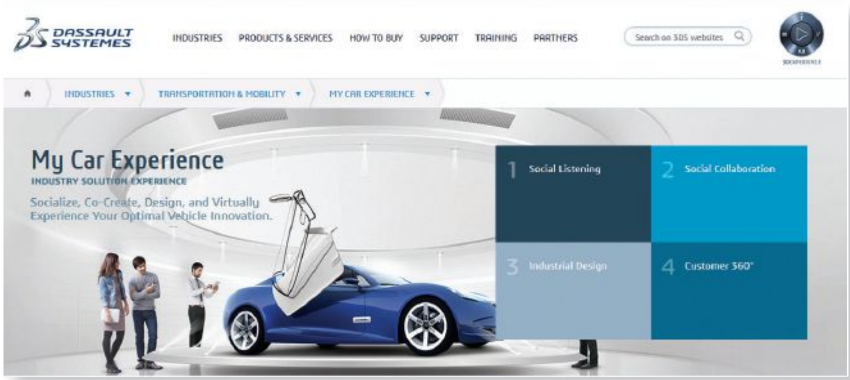
BY KENNETH WONG

About a decade ago, product lifecycle management (PLM) was the manufacturing industry's ultimate business transformation goal. The approach, which called for data consolidation and process re-engineering, spawned a new industry of software and services. But these days, the PLM market leaders are setting their sights on something else.

In analyst CIMdata's annual PLM market reports, three names together consistently account for the biggest segment of the revenue pie: Dassault Systèmes, PTC and Siemens PLM Software. However, the industry is growing its focus on trends beyond PLM. In the last five years, PTC executed a rapid succession of acquisitions (MKS in 2011, ThingWorx in 2013, Axeda in 2014, ColdLight and Vuforia in 2015) aimed at the design and development of smart, connect devices.

Dassault Systèmes went through a vigorous rebranding campaign, billing itself as the 3DEXPERIENCE company. Describing its offerings, Dassault Systèmes writes, "[The] 3DEXPERIENCE platform allows simulation of IoT (Internet of Things) devices in a virtual environment to discover every scenario before we use the products in real life."

As a division of Siemens, Siemens PLM Software remains focused on manufacturing-related technologies. Even so, in a nod to the growing importance of embedded software in industrial IoT, Siemens PLM recently acquired Polarion, an application lifecycle management (ALM) vendor. It also expanded its reach into test management by acquiring LMS International NV in 2012, and into enterprise manufacturing execution systems (MES) software by acquiring Camstar in 2014, which included the company's Omneo Big Data analytics platform.



Dassault Systèmes' auto industry solution, the My Car Experience platform, includes social listening, to "compile, analyze and share industry trends and customer perspectives." ***Image courtesy of Dassault Systèmes.***

In the words of Monica Menghini, Dassault Systèmes' executive VP and chief strategy officer: "The consumer's journey is the new product" (3DEXPERIENCE Forum, San Francisco, November 2015). If we accept the premise that the product is not just the tangible object sold to the consumer but the overall consumer experience, the so-called system expands considerably. It would encompass online product configurators, predictive analytics based on field data, apps and post-sales services. Simulation would include not only the product's electromechanical behaviors but also the software-triggered operations and the consumer's interaction. The system demanded by the IoT may be far broader than what the current system engineering and PLM tools tackle.

Designing the Experience

A car as a product is an electromechanical system that runs on fuel. On the other hand, a car as a driving experience (to borrow BMW's words "the ultimate driving experience") demands much more. The in-car multimedia console, Wi-Fi connectivity, automatic firmware updates, onboard navigation, voice response, semi-autonomous braking and parking, even the online customization interface with instant previews and the post-sales services are all part of the consumer's journey — an example of the type of "experiences" that Dassault Systèmes believes its customers will package and sell.

The key to designing the experience is systems engineering — a strategy that demands collaborative and simultaneous development of control software, hardware and anything else in-between. It even includes listening to the consumer chatter — positive and negative — about similar classes of products or competitor products. Dassault Systèmes' My Car Experience, a set of offerings that cater to the auto industry, includes Social Listening, described as a way to "collect and analyze pertinent customer perspectives and requirements to align and enhance your vehicle development."

Virtual Avatars in AR Apps

At its LiveWorx Conference in May 2015, PTC put on a show to demonstrate the concept of a digital twin: A virtual replica that mimics and records the operations of a real product in the field. Using a mountain bike from Santa Cruz Bicycles equipped with sensors, Mike Campbell, PTC's executive vice president of Digital Twin, showed how a digital 3D model of the bike could faithfully duplicate the operations of the real bike in real-time. The experiment was made possible by streaming sensor data from the physical bike to the ThingWorx dashboard, which drove the 3D CAD model. Therefore, the digital bike's wheel speed, pedal action, suspension operations and steering angles accurately reflected those of the real bike.

In the demonstration, PTC presenters used an AR (augmented reality) app on an iPad to display the sensor data collected from the bike. But the company's recent acquisition of Vuforia from Qualcomm suggests that the interaction with digital twins could become much more interactive and sophisticated.

Systems on the Screen

Some in the industry think that specific industries already have a headstart in system-level thinking. "Aircraft are complex systems, an integration of code, machine, and platform that's very mature," says Michel Tellier, VP of Aerospace & Defense at Dassault Systèmes. "Before, software development, structural design, and system design took place in their own toolsets, within their own processes — almost a parallel development of separate systems. They worked somewhat autonomously, then came together much later in the development cycle. But that's no longer a viable approach."

One of the hurdles to a systems-level design approach is visualization. Displaying a complex system like an aircraft with all its internal components and layers of engineering data requires robust hardware and graphics acceleration. The demand is much greater for simulating such a system as a detailed 3D assembly model.

"It's not so much loading the data, but about not taking a week to load," said Tellier. "Thirty years ago, it took dedicated hardware, dedicated software, machines and networks to make it possible. Now, we can do it on the desktop — at least for structures." The 3DEXPERIENCE platform, Tellier said, is designed specifically to allow engineers to work with large-scale digital mock-ups of systems — "functional mock-ups" as he calls them.

A "system" is a construct or collection of different elements that together produce results not obtainable by the elements alone. The elements, or parts, can include people, hardware, software, facilities, policies and documents; that is, all things required to produce system-level results.

— NASA Systems Engineering Handbook, SP-2007-6105, Rev1

Big Data Mining

The vast volume of data collected by IoT devices is both a blessing and a curse. Enterprising businesses could use the data to predict imminent failures and proactively offer replacement parts or maintenance services. But to do that, they would need a way to extract useful patterns out of the data.

With its acquisition of ColdLight, PTC now has a solution for machine learning and predictive analytics. Explaining its strategy, PTC writes: "When combined with PTC's ThingWorx IoT platform, ColdLight's Neuron will automate the analysis of data from things to address a range of important challenges. These challenges include detecting failure patterns from data, modeling correlations, predicting failures, prescribing remedies and prioritizing recommendations against cost constraints."

"Sensor data by itself creates value, but that value is magnified dramatically when companies use predictive analytics to process that data into many forms of actionable knowledge that can transform the way they do business, " says Jim Heppelmann, president and CEO of PTC.

There are also opportunities in Big Data. "People can then work with not only data from engineering knowledge but also with usage data collected from the field," says Olivier Sappin, VP of Transportation & Mobility Industry at Dassault Systèmes.

Dassault Systèmes owns the enterprise search engine EXALEAD, which it acquired in 2010. EXALEAD has been integrated into its PLM offerings to power search and sort functions. IoT presents another chance to deploy it.

The New Game

The art and science of product development in the past revolved around shapes and electromechanical operations, designed and tested in geometry modeling and simulation software. The process — a mix of synchronous and asynchronous collaboration — is managed in PLM. But embedded software, apps and connectivity add new layers of complexity.

Not all of the IoT features — or experiences — can be conceived and simulated in the current generation of system engineering and PLM software. With acquisitions, new products and new strategies, some leading PLM vendors are lining up the chess pieces to do battle for IoT market share. So far, they have solutions that tackle different aspects of IoT product development. But their aspiration is clearly to become a one-stop shop with an IoT system engineering solution. **DE**

Editor's Note: Some parts of this article originally appeared in DE *Senior Editor* **Kenneth Wong's** Virtual Desktop *blog post on the Dassault Systèmes 3DEXPERIENCE Forum. Read it at deskeng.com/virtual_desktop/?p=11233.*

INFO → Dassault Systèmes: 3ds.com

→ PTC: PTC.com

→ Siemens PLM Software: Siemens.com/plm

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.

BOXX Technologies Introduces renderPRO 1

Company calls it the world's smallest desk-side rendering system.

The renderPRO 1 is a dedicated rendering and simulation workhorse in a compact and portable form factor. With it, users can offload compute-intensive simulation and rendering jobs from their workstation and let it do the heavy lifting. In other words, it's a computer that gives users CPU cores with minimal other stuff that they already have with their workstation. And that means users can have 3ds Max, KeyShot and the like processing while they're still beating on their workstation.

It accommodates a single Intel Xeon E5 v3 processor family member — up to 18 cores and 36 threads — and up to 64GB of RAM.

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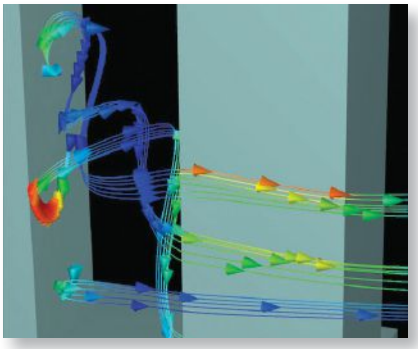

Coolit and CoolitPCB Version 15 Now Available

The software is suited for both veteran and novice thermal designers.

Daat Research's Coolit is suited for predicting airflow and heat transfer in electronic equipment. CoolitPCB lets users run printed circuit board (PCB) thermal analyses.

Speed improvements are highlighted in version 15 of Coolit and CoolitPCB, especially when working with complex CAD-imported objects, according to the company. Solver solution times are up to 40% faster than previous versions. Other improvements in v15 include Joule heating, support for circular and oval PCBs, a streamlined user interface for fan modeling and increased convergence rates for free convection flows.

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CorelCAD 2016 Ships

Corel Corp. is also releasing a mobile application for Android devices.

For years, CorelCAD has been known for its excellent support for native DWG file formats, which is one obvious reason why many outfits use it for CAD file collaboration in-house and with clients.

CorelCAD 2016 seems to offer all sorts of enhancements that make it productive and easy for you to use. Take its new Quick Input feature. It lets users set up a command interface in projects using their cursor in the drawing area.

Annotative Scaling is also available. Here, users can keep text viewable no matter how small or large they make design elements.

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Autodesk Launches HSMWorks for SOLIDWORKS 2016

HSM CAM technology serves as the application's base.

The HSMWorks family comes in Professional and Premium editions. Both versions offer users of SOLIDWORKS a familiar palette of integrated CAM tools. They have full associativity with SOLIDWORKS models, and they support multiprocessor and multicore computing environments. There are features like stock, toolpath and milling machining simulation as well as the stuff needed for operations like drilling, counterboring and tapping operations. HSMWorks 2016 updates include SOLIDWORKS 2016 support, user experience improvements and better defaults management.

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Simulating and Modeling "Monodzukuri"

JFE Techno-Research mobilizes simulation for Japanese-style manufacturing.

BY KUNINORI MASUSHIGE & YUKA TAKAHASHI
CD-ADAPCO

JFE Steel Corporation, a long-standing entity in the steel industry, boasts the world's fifth-largest scale in terms of its crude steel production. JFE Techno-Research Corporation, a member of the JFE Group, undertakes fluid analysis, structural analysis and other arms of the JFE business, including evaluation, investigation and examination of materials. They cater to steel plants, environmental engineering and other areas within the group, and are also actively contracting for business outside the group.

The strengths of JFE Techno-Research focus on the following two areas:

1. The ability to propose solutions not only based on analysis, but also based on experience cultivated over several years in the steel industry,
2. The packaging of proposals with testing results: The Solution Division (Kawasaki) comprises of the CAE Center, the Sensing & Visualization Analysis Center, Structure Performance Department, Material Performance Evaluation Department, Equipment & Process Technology Department and other specialized testing and analysis divisions.

JFE Techno-Research offers interpretation of analysis results, guidelines for design improvements and consulting related to all aspects of "Monodzukuri" (Japanese-style manufacturing).

Partnering with Measuring Division for Verification

The single greatest challenge in engineering simulation is the verification of the numerical results. Correlation of numerical analysis with physical testing improves the accuracy of the final results. The target in normal flow analysis at JFE is an accuracy of ±3% when compared to test results. However, for more complex models that include chemical reactions, multiphase flow and other phenomena, the analysis accuracy typically swells to around ±10%.

"While our target is ±3%, with staffers who have built up a certain degree of experience, it becomes reasonably possible to tell whether or not the outcome is appropriate by examining the results," notes Toshiki Hiruta, director of the CAE Center.

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Direct Digital Manufacturing Takes Flight with the Air Force

Fused Deposition Modeling helps an Air Force contractor cut costs and production times.

Based at Sheppard Air Force Base in Wichita Falls, TX, the Trainer Development Flight (TDF) facility designs, develops and manufactures trainers and training aids for the Air Force and all branches of the Department of Defense (DoD) as required.

The trainers and training aids may be either original products or replicas of existing ones, depending on the training need. Some devices are not required to be working units, so it usually isn't cost-efficient to purchase the actual item. For most training applications, it's more economical to train students on replicas, instead of the often extremely expensive equipment.

The TDF uses direct digital manufacturing to fabricate a majority of its training products. To do so, it employs four FDM (Fused Deposition Modeling) additive fabrication machines with AFSO 21 (Lean) processes incorporated into the overall process.

"Because most of our projects are either one-of-a-kind or very low volume, conventional methods become very expensive," says Mitchell Weatherly, chief of the TDF. "Only about 10% of our work is for prototyping, and 90% is production."

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Commentary

by Michael Neal

DAQ Software: Expect More

We have entered the "Age of Data." The amount of data being collected is growing at an explosive rate as companies rely more on data to make business decisions. Engineers require reliable, accurate and user-friendly data acquisition (DAQ) systems to meet this need. However, innovation in the data acquisition market has not kept pace with this unquenchable thirst for data. Data acquisition tools must evolve to better address the demands of the growing population of users who need data to inform their design decisions. These tools are lacking in two critical areas: providing simple yet flexible software and simplifying measurement system setup.

Today, users must choose between limited configuration software, which helps with basic data recording but cannot be modified to meet application requirements, or their own custom data acquisition applications that must be programmed from scratch. Hardware vendors provide software with the bare essentials for recording data from devices, but they push users to a different programming tool when they face challenges beyond the original software's capabilities. This is an unnecessary trade-off; data acquisition software should evolve to span configuration and customization. In a 2013 National Instruments Global DAQ Value Research survey of 3,800 engineers, 27% identified that developing software for their application was the most time consuming part of their task, while 21% spent most of their time struggling with system setup.

Today, users must choose between limited configurations or completely custom applications.

Software Extremes

Engineers use two types of data acquisition software at opposite ends of the spectrum: the fixed-functionality configuration-based measurement software included with data acquisition devices and the custom software applications users code to control their devices. Fixed-functionality software is good for setting up a quick, simple measurement to configure basic settings like sampling rate. But custom software applications give users the power to program any functionality if they have the know-how and patience.

Users who want a typical data acquisition application for acquiring and saving data, with minor modifications like basic conditional logic, are forced to choose between these two extremes. As soon as their needs extend beyond the software that ships with their hardware, they must make the leap to the opposite extreme: a custom, programmed solution.

There is no reason that data acquisition software can't evolve to better fill this gap. Software that offers a continuum from configurable measurements to customization through programming would increase efficiencies and remove the trade-off between ease-of-use via configuration and flexibility via programming.

System Setup Time Sink

When building a measurement system, setup is time-consuming, and an incorrect setup can introduce errors that may be hard to debug. Today, engineers can choose from a variety of systems featuring flexible, modular data acquisition hardware that they can adapt and reconfigure to meet changing I/O (input/output) and sampling needs. This is highly beneficial to users who face evolving system requirements, but the flexibility of the system complicates system setup.

Consider a device with a single function like a handheld device for measuring temperature. When using this device, the risk for error in setup is low. Conversely, a modular data acquisition system features a range of I/O options and provides many different measurement combinations. This flexibility helps lower total system cost since the same set of hardware can be adapted to serve a range of applications. But with that comes more configuration options that can complicate system setup.

Today, the software packaged with data acquisition devices does little to help users understand and document system connections such as wires between sensors. Better data acquisition software could reduce system setup complexity through improved system visualization, recommendations for correct wiring, and better checks for channel configuration.

Expect More

Data acquisition plays a critical role in driving innovation and discovery. Engineers rely on acquiring the right data to support design decisions, and advances in software could have a tremendous impact on improving their efficiency. To achieve this, data acquisition software must evolve to fill the gap between limited configuration software and flexible (but costly to build) custom programmatic solutions without increasing system setup complexity. To keep pace with the growing demand for data, it's time to demand more from the software we use to acquire it. **DE**

This commentary is the opinion of **Michael Neal,** *software product manager, National Instruments (ni.com). You can send comments to him about this article via de-editors@deskeng.com.*