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OMEGA®

by Steve Robbins

Engineering Bionic Benefits

It was back in 2009 at National Instruments Week in Austin, TX, when I witnessed Tim Dehne, vice president of Engineering for NI, pilot a wheelchair around the ballroom floor during the keynote speech using only his thoughts. I have to say I, like everyone else in the room, was blown away.

The control system for the wheelchair was developed by students at the University of Illinois at Urbana-Champaign. The device enables thought-based control of the chair. Wearing a sensor around a subject's neck, the LabView system acquires impulse signals from the nerve that runs from the brain to the vocal cords. An algorithm processes the nerve signals and generates the appropriate control instructions to the wheelchair. Read more here: http://goo.gl/fuvKq.

Rapid Development

This spring, I was at the SME Rapid Expo in Atlanta. EOS, developer of laser sintering additive manufacturing systems, presented Dean Kamen to speak about a project funded by the Defense Advanced Research Projects Agency (DARPA). He talked about DARPA wanting to develop a neutrally controlled prosthetic arm for amputees.

> **Think of the tools we use, and how they would change if they were controlled intuitively.**

Kamen's company, DEKA Research and Development Corporation, has received an award from DARPA to design an advanced prosthetic arm and hand. DEKA solved the mechanical aspect of the design. I was impressed with how they used additive manufacturing to create a complex, high-quality base mount for all of the servo motors, electronic control systems and moving mechanical parts. The prosthetic arm is customized for each individual user, including a functional cosmetic covering.

During the talk, Kamen showed a video of the prosthetic being tested by a man who had lost both arms. He was able to feed himself and could pick up a glass of water. Again, everyone was blown away.

This September, one of the DARPA-funded prosthetic arms was controlled by a man with tetraplegia via his brain signals. Researchers from the University of Pittsburgh Medical Center and Caltech will be conducting pre-clinical trials using brain-controlled prosthetic arms by five volunteers who have spinal cord injuries.

Air Force Tech Sgt. Joe Deslauriers is learning the intricacies of his new arm. The DEKA arm has 10 degrees of movement. *Photo courtesy of Rob McIlvaine.*

Multi-disciplinary Design

The engineering work that has gone into these projects requires the coordination of a lot of engineering and other disciplines: medical, neural, control, embedded electronics, software, mechanical, materials, programming, signal processing, power management, and many more. They all have to integrate for the design to succeed. It is amazing that all of these scientists, programmers, engineers, companies, universities, and agencies — all in different locations — could collaborate successfully to create this project.

DARPA has succeeded in moving the project close to completion and into the hands, literally, of the people who need the technology. It is going to be available to arm amputees in the very near future, if the Food and Drug Administration moves quickly. But where is this going to end up? Thought-controlled appliances? Cars? This innovation is mind boggling.

While the Six Million Dollar Man may not be in our immediate future (and would cost a lot more than $6 million), bionic technology may soon become part of our everyday lives. Think of the tools we use, and how they would change if they were controlled intuitively by using just our thoughts. Think of the innovation that is happening with mechanical devices that could operate in harsh environments, with great dexterity. Think of all the times in our lives that we have wished for another hand. **DE**

Steve Robbins *is the CEO of Level 5 Communications and editorial director of* DE. *Send comments about this subject to DE-Editors@deskeng.com.*

DE November 2012 VOLUME 18/ISSUE 3

COVER STORY

Cloud Computing Accelerates Design

SIMULATE

ON THE COVER: Cloud computing services allow engineers to use them as needed. *Image courtesy of HP.*

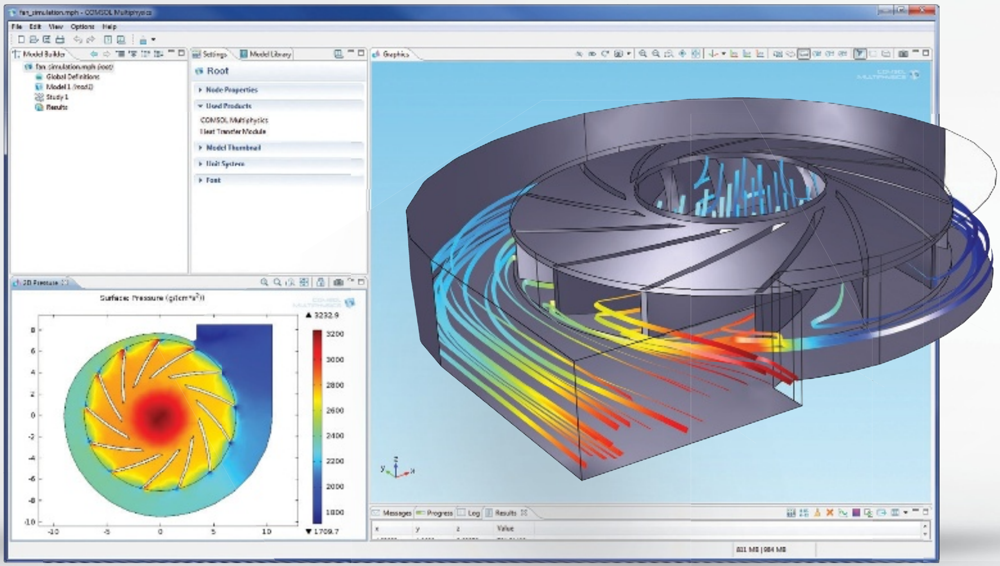
PROTOTYPE

DESIGN

TEST

FOCUS ON ENGINEERING COMPUTING

ENERGY: In a high-power burner, up to 40% of the energy required to run the system is consumed by the fan. This model shows the velocity vector and pressure drop of the flow into the impeller and housing of a burner ventilation fan. Model courtesy of Gianluca Argentini, Riello Burners, Italy.



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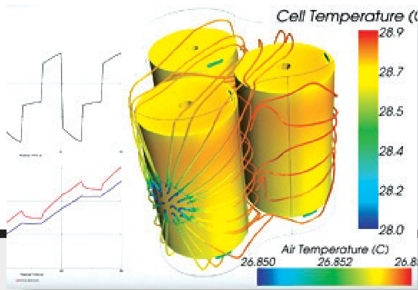

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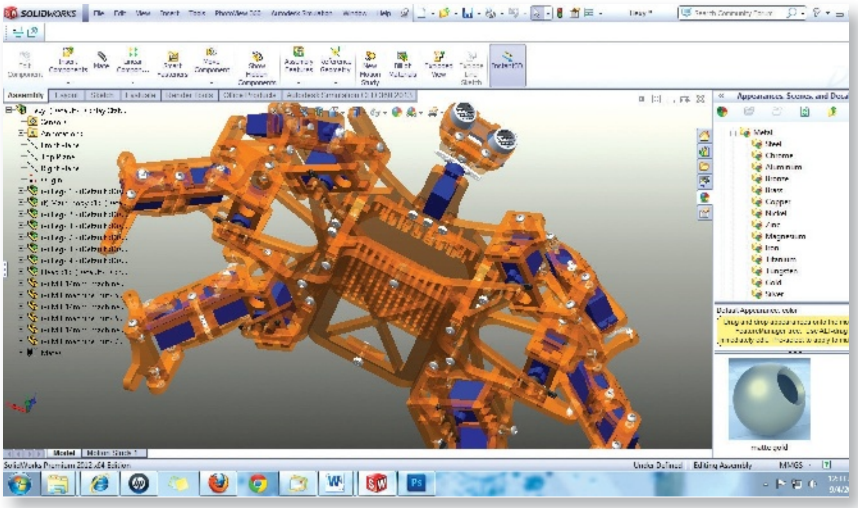
by Kenneth Wong

Crowd-financed, 6-legged Crawlers

Artisan's Asylum, a community craft center in Somerville, MA, is the birthplace of two six-legged robotic crawlers. Hexy, with round eyes that make him look like Pixar's character WALL-E, is roughly the size of a tabletop inkjet printer (a little bit larger when its jointed legs are extended). It's the offspring of ArcBotics, a group of robotic students who hope to become "the IKEA of Robotics." They want to produce robots you can assemble from kits. True to its open source philosophy, ArcBotics shares the CAD assembly of Hexy with the public. Stompy, a much larger variation, is an 18-ft.-tall robot, capable of carrying humans on its back.



Hexy, a crowd-funded, six-legged robot created from a Kickstarter campaign, is shown here as a SolidWorks assembly.

Like Hexy, Stompy is the product of students who were in a robotic engineering class at Artisan's Asylum. In fact, Gui Cavalcanti, the lead for Project Hexapod, is an instructor for the class. Joe Schlesinger from Hexy's team was also involved in the development.

Hexy and Stompy are designed in SolidWorks. While designing the six-legged mechanical crawlers in pixels and bytes cost little to nothing (other than the cost of CAD licenses), physically prototyping them does come with significant cost. This is where Kickstarter kicks in, so to speak.

The hexapod makers launched their fundraising campaigns at the crowd-sourced financing portal, appealing to the public to help them bring their concepts into reality. ArcBotics had hoped to raise $13,000. They took in $168,000. Stompy's fundraising target was $65,000; it brought in $97,000.

The name Stompy, chosen in a voting process, won over Fluffy, recalled Cavalcanti. It seems a better fit for a hexapod with legs made up of about 90 waterjet-cut steel pieces, and a chassis made up of another 100 distinct pieces. In total, Stompy will likely be put together in 650 machined pieces.

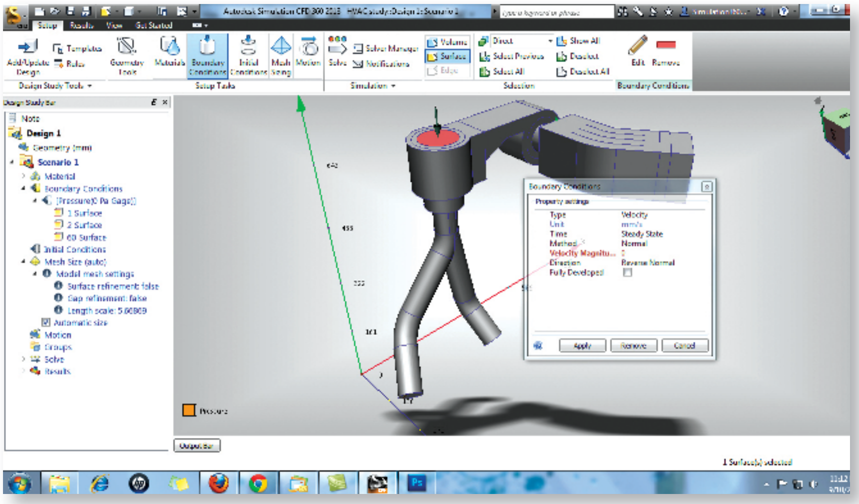
Because Stompy is expected to carry passengers, its creators did extensive finite element analysis (FEA) tests in SolidWorks Simulation to study the effects of the anticipated load on its legs. "[Stompy's shape] is designed to have the lightest, strongest legs it can, which is why they kind of look like excavator arms," Cavalcanti explains.

Both Hexy and Stompy are comprised of a number of electrical subsystems. To program and test Hexy, its team used Arduio, an open-source electronics prototyping platform. Because Stompy's electrical operations are programmed in Python, Stompy's team used a custom simulation environment built in PyODE, an open-source, Python-based physics engine.

Autodesk Launches Pay-as-You-Go Simulation

Debuting under the Autodesk 360 brand for cloud-related products, Autodesk's new offering consists of three simulation software modules for desktop installation: mechanical, injection molding (Moldflow) and fluid flow (CFD). But its advantage is in the integration of cloud-hosted computing horsepower, delivered at the point where you need it.

Simulation 360 is bundled with Autodesk Inventor Fusion, a direct-editing program. The installation places quick-launch buttons in your CAD programs for initiating design studies. The program comes with a lightweight app for viewing your simulation results.



Autodesk's Simulation 360 (CFD module shown here) is augmented with on-demand cloud solving.

The setup process is fairly standard, with prompts and dialog boxes to define loads and boundary conditions. With CFD and mold simulation, meshing takes place in the cloud; with mechanical simulation, meshing takes place on your local machine.

Once you hit Solve, the software's cloud-integrated solver checks your mesh, queues the job and processes it in the cloud. Because simulation tends to consume all available CPU power (and then some) in a standard personal computer, running a simulation has become synonymous with an idle machine. But not so with Simulation 360's cloud-hosted solving. A standard simulation with about 100 iterations is complete in less than a minute, and your local machine remains active during the session.

Your results can be saved as an animation or a dynamic image (one that you can later rotate and view from multiple angles in the lightweight viewer). You may also export a static image to show stress and temperature distribution or deformation.

Simulation 360 modules are not lightweight desktop clients; each amounts to a gigabyte-size installation. Still, the technology points the way to mobile app-driven simulation. If the heavy lifting can be done in the cloud, all you need is a lightweight device to send input values and execution commands, and view the simulation results afterward.

Autodesk is marketing Simulation 360 as a standalone solution—you do not need to be on Autodesk subscription to get access to it. Configurations are as follows:

- Autodesk Simulation 360 includes Mechanical and CFD capabilities, 120 jobs for $3,600/12 months.
- Autodesk Simulation 360 Unlimited includes Mechanical and CFD capabilities, unlimited jobs for $7,200/12 months.
- Autodesk Simulation 360 Ultimate includes Mechanical, CFD and Moldflow capabilities, 120 jobs for $10,000/12 months.
- Cloud Capacity Pack offers 10 jobs (approximately 1 month of usage for $10).

by Kenneth Wong

SolidWorks 2013 Highlights: Conic, Intersect, Dashboard and More

In early September, SolidWorks opened its new office in Waltham, MA, to members of the press for a preview of its upcoming release, SolidWorks 2013. Despite rivals' flirtation with direct editing, SW remains a history-based program. On the other hand, it has launched the long-awaited mobile version of eDrawings.

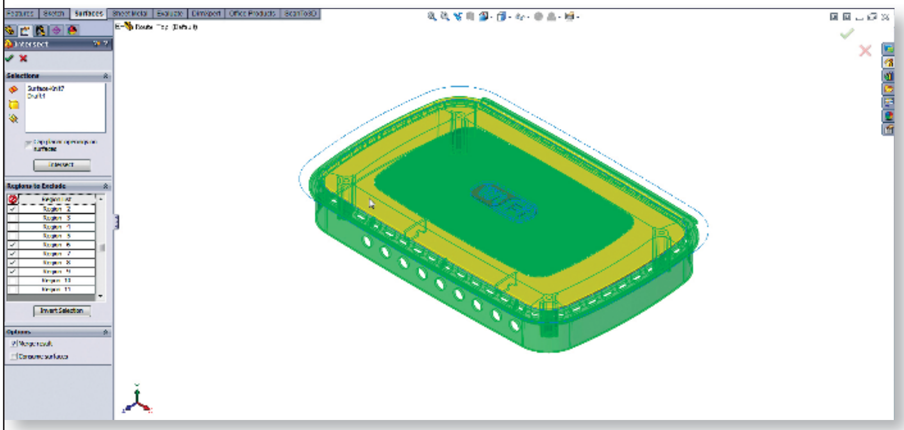
Many would agree that the step-by-step approach required in history-based modeling hinders quick concept exploration—driven by impulse, marked by swift changes. For that, SolidWorks is suggesting the next-generation product currently under development is a better fit.

A Brief Preview

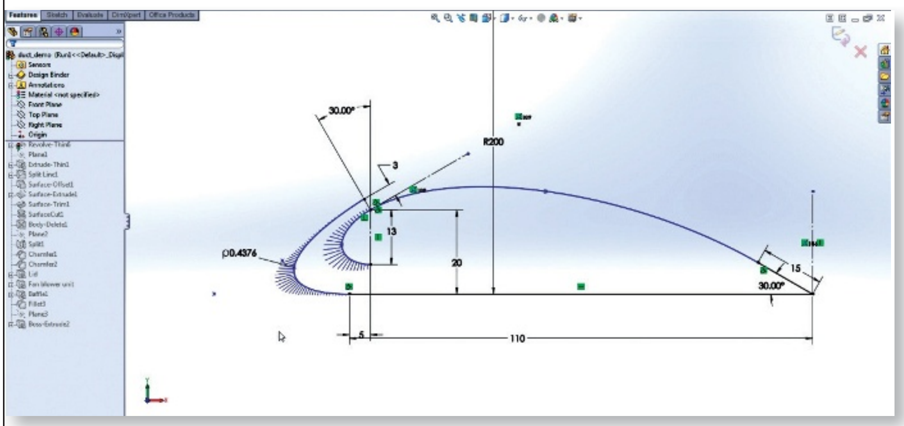
"I know I need to give you something on the next-generation product, so I'll tell you this, and that's it—nothing more," said SolidWorks CEO Bertrand Sicot. He revealed that the new product will:

- focus on mechanical concept design;
- be unveiled at SolidWorks World 2013; and
- complement the existing SolidWorks (neither a replacement for nor a competitor to the current product).

The most significant features debuting in SW2013 include conic-shape creation, the Intersect command, and the Dashboard.



In the upcoming SolidWorks 2013, you'll have the option to use the Intersect command to subtract and add materials at the same time.



SolidWorks 2013 introduces Conic sketch, driven by end points and rho value.

Conic Sketcher

MCAD programs are made for drawing perfect arcs, lines and circles, but they're not quite adept at irregular shapes. To create those, most MCAD programs borrow the spline curves from surface modeling programs. In SW2013, the software gives you Conic sketcher, driven by end points and rho value. This, according to the company, will let you draw elliptical, parabolic or hyperbolic curves.

Intersect Faster

The new Intersect button operates like a Boolean command you can execute to subtract and add materials at the same time. It can be used on a mix of surfaces, solids and planes. Once you've identified the intersection of multiple objects, you may specify what volume to keep and what to discard. This is expected to dramatically speed up operations that previously require two or more steps (a trim followed by an add, for example).

Dashboard Overview

For CAD admins, the Dashboard will provide a comprehensive view of software performance, crash frequency, possible causes, and workstation statuses. Think of it as a network administrator's system monitoring window, configured specifically for SolidWorks installations and instances in a company. The Dashboard will be hosted on the SolidWorks Customer Portal, controlled by password.

Other improvements slated for SW2013 includes patterns with varying dimensions (a handy way to create, for example, a series of slots with varying lengths); an enhanced version of the cost-estimation module (it now supports multi-body parts); sub-model analysis (to perform analysis on a selected portion of the model only); and more.

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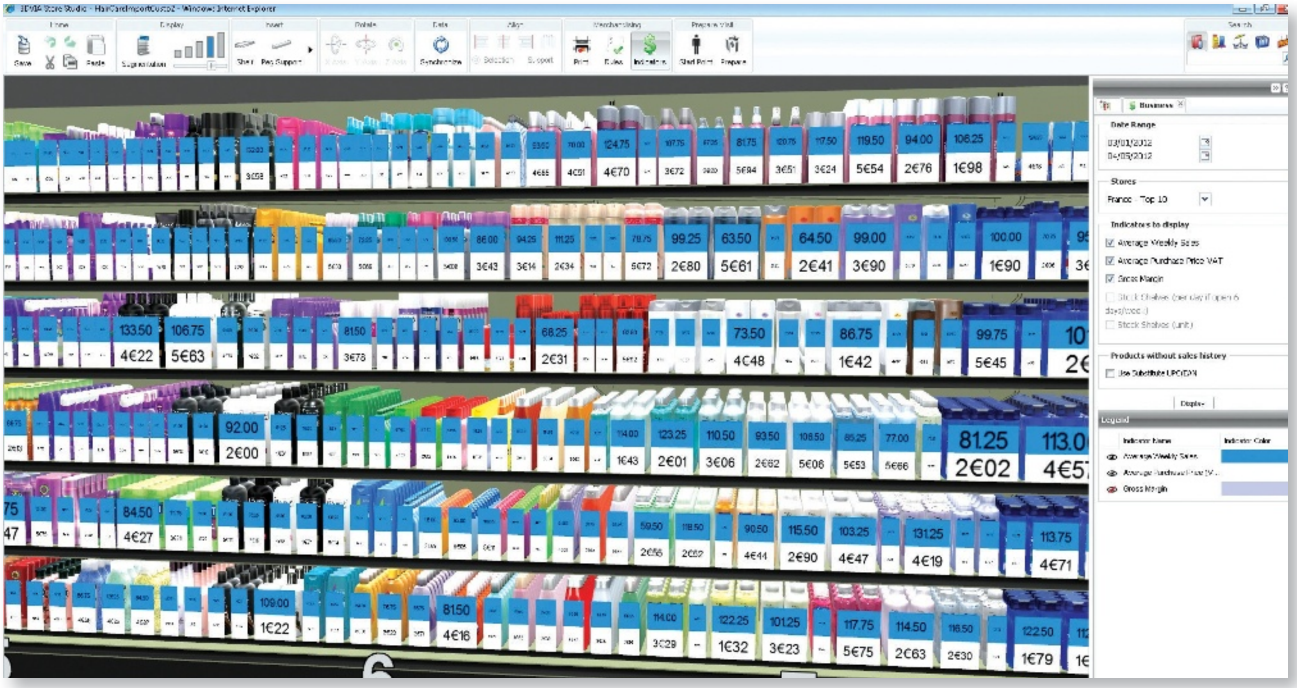
by Kenneth Wong

Perfect Shelf to Design REAL Shopping Experience



With Dassault's Perfect Shelf, retail space designers can try out different shelf placement strategies in a digital environment.

In mid-September, Dassault Systèmes launched Perfect Shelf, an addition to its consumer packaged goods (CPG) solutions. Perfect Shelf, according to Dassault, provides "realistic views of retail aisles, including shelves, fixtures, products, lighting and promotional materials—allowing the shopping experience design process to take place significantly faster, with greater extent and flexibility and at lower cost."

Rosemary Grabowski, Dassault's global marketing director, CPG-Retail, explains that Perfect Shelf is "a new solution for CPG and retail companies … It is not targeted at any specific skill level, but is created with ease-of-use for non-experts in mind." This is a departure from the markets served by Dassault's high-end modeler CATIA and its mainstream mechanical modeler SolidWorks. It's much closer to the consumer-friendly territories served by Dassault's 3DVIA product line.

Perfect Shelf is expected to be an economically viable method to test out space planning in retail venues. Mall designers might use the product to digitally try out various strategic merchandise placements, examine visibility of promotional signs, and understand (to an extent) consumers' eye levels and reaches. In doing so, the designer can avoid the prohibitive cost of deploying actual shelves and sample products to create a mockup of the store. To take advantage of Perfect Shelf, the user will need to invest in creating or acquiring 3D digital content that accurately reflects the real products that must go on the shelves.

In the announcement, Dassault stated, "Product shelving quality is a critical factor tied to every consumer's shopping experience. Both CPG Brand Manufacturers and Retailers want to ensure that every consumer, in every store can find what they want, when they want it—and do so quickly and easily. Delightful consumer experiences keep them coming back again and again to their favorite stores." **DE**

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

Intel Previews Digital "Moore's Law" Radio

Moore's Law says that the number of transistors on a chip will double about every two years, but other technologies progress at a slower rate, including Wi-Fi. The problem: limitations in analog radio technology and inefficient use of power.

Intel Labs has been researching how to create fully digital radio technology, and has finally had some success. The company recently demonstrated a completely digital Wi-Fi unit that fits on a single chip.

Intel claims the chip will be cheap to manufacture, which means it should start appearing as part of mobile devices in the not-too-distant future. By moving Wi-Fi to digital (or Wi-Gig, as Intel is calling it), using a mobile device will consume less power and increase bandwidth to, according to the company, more than 5 gigabits per second.

MORE ➜ engineeringontheedge.com/?p=2701

Hoverbike Takes Flight

A California firm is hoping its new hoverbike design could lead to new methods of low-altitude flight and cargo transportation. Aerofex has updated a 1960s-era design idea by stabilizing it.

Long in development, test videos of the hover vehicle (operating on a dry lake bed in the Mojave Desert) have finally emerged. The driver controls movement and direction by leaning. So far, test runs have achieved speeds of 30 mph at a height of 15 ft.

Aerofex founder Mark De Roche says the technology could be used for search and rescue vehicles, defense technology, cargo transport, and as a launching point for new unmanned drone designs. There are no plans for commercial vehicles, however, although an Australian inventor using a similar design hopes to bring the technology to the masses.

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GM Invests in NanoSteel

General Motors, via its GM Ventures arm, is investing in Providence, RI-based NanoSteel, a nano-structured steel provider that offers high-strength steels to help reduce vehicle weight.

NanoSteel offers an iron-based alloy that has been modified through nano-structuring. Sheet metals with tensile strengths of 950, 1,200 and 1,600 MPa will be available for automotive production next year. With higher-strength steel, automakers can use thinner components to reduce vehicle weight while still maintaining structural integrity.

According to NanoSteel, its material can be formed into component parts using room-temperature metal stamping processes on existing manufacturing equipment (cold forming); other types of advanced high strength steels (AHSS) require elevated temperatures for part forming.

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Researchers Light the Way to Quantum Chips

A team of researchers, led by experts at the University of Bristol's Center for Quantum Photonics, say they believe they have overcome a serious obstacle in the path of quantum computing with the development of silicon-based quantum chips.

The difference between a standard silicon chip and a quantum chip is in how data is transmitted. Instead of relaying an electrical current, the quantum chip uses photons to perform calculations.

"Using silicon to manipulate light, we have made circuits over 1,000 times smaller than current glass-based technologies," says Mark Thompson, deputy director of the Centre for Quantum Photonics. "It will be possible to mass-produce this kind of chip using standard microelectronic techniques, and the much smaller size means it can be incorporated in to technology and devices that would not previously have been compatible with glass chips."

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Better Bionic Body Parts

RSLSteeper is set to release Version 3 of its powered prosthetic hand replacement, the bebionic3. It can carry up to 99 lbs. Along with the technological improvements, the prosthetic offers customizable grip speed and patterns to match the interests of the user. A new unit will cost about $30,000.

Meanwhile, an Australian woman was the first recipient of a new bionic eye implant. Dianne Ashworth, who lost her vision because of an inherited condition called retinitis pigmentosa, has regained some limited vision thanks to a prototype system from Bionic Vision Australia.

The device is a retinal implant with 24 electrodes, and works by stimulating neurons in the retina with electrical impulses.

MORE ➜ engineeringontheedge.com/?p=2694 and engineeringontheedge.

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Paralympics Athletes Benefit from Additive Manufacturing

Additive manufacturing (AM) has had a positive impact for athletes in the Paralympics. Britain's Paralympics basketball team comes to the court in wheelchairs designed by BMW. The chairs are custom-made for each athlete.


©BMW

The athletes are 3D scanned while sitting to produce a computer image with an accuracy of within 1 mm. A CAD design is created using the scans to make a custom seat for each athlete. The CAD designs are then fed into an EOSINT P 395, which prints out the new seats.

MORE → More: rapidreadytech.com/?p=2252

Ancient Tech Might Improve 3D Printing

Around 7,000 years ago, the Egyptians figured out how to create a ceramic paste that would harden with firing into decorative designs called Egyptian faience. A team of scientists led by Professor Stephen Hoskins, director of the University of West England's (UWE) Centre for Fine Print Research, and research fellow David Huson have begun an investigation into using an Egyptian faience-like paste for the 3D printing of ceramics. The project has received funding for a three-year look into how to turn theory into a practical application.

MORE → More: rapidreadytech.com/?p=2313

MakerBot Moves into Professional 3D Printing

MakerBot has launched its newest 3D printer, the Replicator 2. The company is targeting it at engineers and industrial designers. Instead of of coming as a kit like MakerBot's previous printers, the Replicator 2 comes fully assembled and ready to use, along with a copy of MakerWare, MakerBot's 3D modeling program.

The Replicator 2 has a layer resolution of 100µ (0.0039 in). MakerBot's new machine also offers a build envelope of 11.2x6.0x6.1 in. Both layer thickness and build envelope are comparable or superior to professional desktop 3D printers. The Replicator 2 has been designed to use poly lactic acid (PLA), making it green as well.

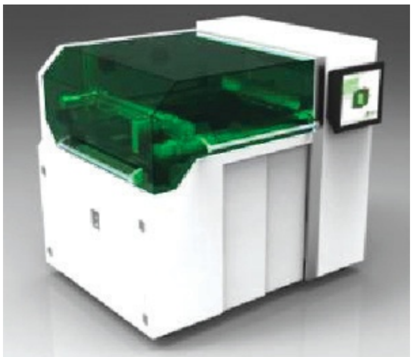
The Replicator 2 is being launched at $2,199.

MORE → More: rapidreadytech.com/?p=2401

ExOne Debuts New M-FLEX 3D Printer

ExOne has unveiled the M-FLEX. It has been designed to work primarily with metal, but it's also capable of building objects in glass, ceramics and other materials used for casting. According to the company, the M-FLEX offers seven times the volume output of other additive manufacturing (AM) systems.

The new 3D printer continues to use ExOne's "Digital Part Materialization" process (ASTM binder jetting). This process builds objects by treating a powdered material with a bonding agent from a print head. The object is then placed into a furnace for sintering, which burns out the binder and fuses the metal molecules into a solid part.



The M-FLEX has a build envelope of 15.7x9.8x9.8 in., with a build speed of 30 seconds/0.1mm layer. It offers a print resolution of 0.0635mm (X/Y), 0.1mm (Z).

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Annual International Wohlers Conference

For the last 14 years, Wohlers Associates has held an international conference to discuss additive manufacturing (AM) and rapid manufacturing. This year's conference will be held Nov. 29 at Euromold 2012. With a theme of "Advances in Metal Additive Manufacturing," the conference will focus on "high-value" metal parts built using AM.

The conference will feature nine speakers, including Dr. Eberhard Döring, CEO of DEMAT GmbH, who will open the program. **DE**

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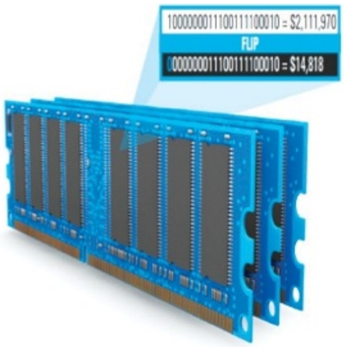


The 10 Most Common Workstation Questions

What it means to use a professional workstation.

BY PETER VARHOL

1) What is a workstation?

Workstations are optimized and tuned to help you acquire the best possible experience for a given set of professional applications. They typically include Intel Xeon processors, ECC memory, enhanced I/O, and professional graphics cards.

2) Why do I need ECC memory?

Your job depends on accurate data. You may not even realize your data has become corrupted. Error-correcting code (ECC) memory detects and corrects the more common kinds of internal data corruption.

3) How likely am I to experience a memory error?

Recent studies by Google suggest there is a 1-in-3 chance your computer will experience a memory error. AMD published a study suggesting a 4GB system can expect to encounter roughly one error per week. And lambda-diode.com suggests that a computer has a 96% chance of having a memory bit error approximately every three days.

4) Why do I need a second processor?

If you are doing any simulation, photorealistic imaging, or analysis, or you are migrating to the suites offered by Autodesk, SolidWorks, and other companies, then consider adding a second processor. It will help you realize more value from your software investments and can greatly increase your productivity.

5) Why do I need more cores?

While some applications may be single-threaded, engineering users aren't. Even the ideal CAD workstation should have four to six cores. If you are engaged in photorealistic imaging or simulation, a dual-socket Intel Xeon-based workstation would be ideal.

6) What is the impact of solid state drive (SSD) technology on my workflow?

SSDs are expensive, but the increase in productivity creates an opportunity to recover that cost in less than 60 days. An SSD can approximately double job throughput.

7) How much memory do I need on my workstation?

A rule of thumb is to look at the largest model you work with and then increase the amount of memory by at least twice. Poorly configured workstations with inadequate memory decreased workstation productivity by up to 54.7%. Do not skimp on memory; it's really not that expensive.

8) Which graphics card is best for me?

While a more powerful graphics card can increase performance, other investments in processor speeds, core counts, memory, and storage can impact a user's overall experience more. Computer Aided Technology Inc. research revealed the typical CAD user would be OK with an entry-level graphics card, while other users engaged in applications like those from Adobe would benefit from greater investments in graphics cards.

9) Which processor is the ideal workstation solution?

When it comes to delivered reliability, performance, and scalability, then the Intel Xeon processor is the obvious choice. Workstations play a key role in providing users with the best possible experience for a given set of professional applications.

If you are a CAD-only user, then a workstation based on the Intel Xeon processor E3 1200 v2 product family may meet your needs. A better choice would be an Intel Xeon processor E5-1600 product family based workstation with six cores and a discrete professional graphics card from either NVIDIA or AMD.

If you are engaged in simulation and photorealistic reviews, then a dual-processor Intel Xeon processor E5-2600 based workstation is the best choice.

10) When should I consider an accelerator?

If your work is embarrassingly parallel and you do this type of work more than 80% of the time at your workstation, then you may benefit from an accelerator. However, if you are like most users and you're doing an assortment of simulations or analysis; or you are engaged in photorealistic ray tracing applications, then the flexibility and the performance offered by a second processor may be a better investment. DE

INFO ➜ Intel Corp: intel.com/go/workstation

Cloud Computing Accelerates Design

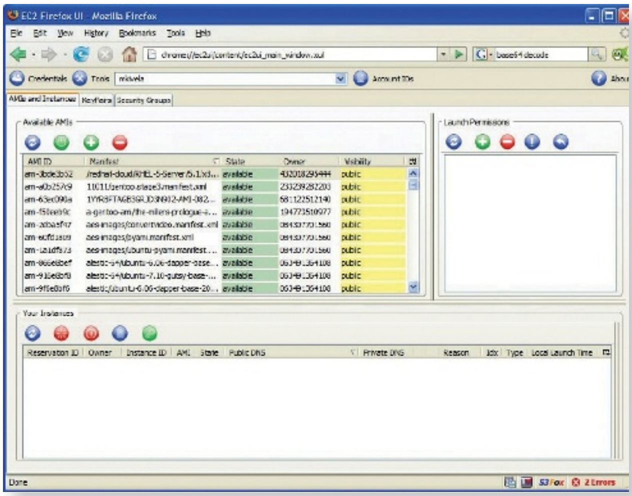
Cloud technologies offer a processing power alternative.

BY FRANK J. OHLHORST

Hype aside, the cloud has made a significant impact on business operations. Today's businesses rely on cloud services for a multitude of IT functions—ranging from storage to unified communications to hosted applications, with no end in sight.

Major cloud services vendors, such as Amazon, Google and HP, are offering advanced services that scale up to data center capabilities, with support for massive computational loads. What's more, niche vendors, such as PBS Works and PEER1 Hosting, are focusing on high-performance computing (HPC) as a service, bringing new capabilities to a market that is poised for explosive growth.

Let's take a look at some of the options available, and how those offerings can be transformed into replacements or reinforcements for onsite HPC needs.



Amazon's EC2 Cluster instances.

Amazon EC2

Amazon offers HPC on its Amazon Web Services (AWS) platform. The service is designed to support scientists and engineers who are looking to solve complex science, engineering and business problems using applications that require high-bandwidth, low-latency networking, and very high compute capabilities.

With the service, Amazon is able to eliminate the biggest problem faced by those seeking HPC resources: access. Typically, scientists and engineers must wait in long queues to access shared clusters or acquire expensive hardware systems. Amazon offers a hosted HPC environment that can grow and shrink by using Amazon EC2 Cluster instances. That allows customers to expedite their HPC workloads on elastic resources as needed—and save money by choosing from low-cost pricing models that match utilization needs. Customers can choose from Cluster Compute or Cluster GPU instances within a full-bisection high bandwidth network for tightly coupled and IO-intensive workloads, or scale out across thousands of cores for throughput-oriented applications.

Several Amazon partners have prebuilt HPC environments that offer processing power at affordable rates. For example, MapR Technologies offers an analytics platform that starts at just 6 cents an hour for access to an enterprise-level Hadoop platform, while StackIQ offers a big infrastructure management platform that supports applications that require thousands of instances for as little as $2.34 an hour. Other partners include Gambit Communications, which provides a MIMIC Virtual Lab Cloud starting at $90 for 90 days. Univa's Grid Engine provides HPC Compute Nodes for as little as 2 cents an hour.

Each offering comes with its own management interface, which is designed for quick configuration and deployment. Prices can increase quickly with scale and the loads applied, so it is best to plan out what your workload requirements are before engaging Amazon EC2 and its partners.

Google Compute Engine

Google offers a bevy of cloud services, including storage services, application engines, query services and many others. The Google Compute Engine is designed expressly for the HPC services market. In a nutshell, the Google Compute Engine is a hosted platform that is designed to run large-scale computing workloads on Linux virtual machines (VMs) across Google's infrastructure.

At press time, the Google Compute Engine is only available as a limited preview, which means the service is not fully available to all customers and is still going through testing. That said, the company has provided information on the initial use cases for the service, including batch processing, data processing and HPC.

Much like any other cloud service, Google promises elasticity, where loads can be scaled based upon need, which in turn means that you only pay for what you use. Google uses a formula to calculate charges, which is based upon the number of virtual cores, memory requirements, local disk space consumed and traffic generated.

For example, someone requiring eight virtual cores, 30GB of memory and 1,170GB disk storage would pay about $1.11 per hour, plus monthly ingress and egress fees and persistent disk storage charges. That proves to be a billing model used by many vendors in the hosted HPC space, where CPU cycles, storage amounts and processing power are bundled together into hourly charges.

Users access the service using a project methodology. In other words, users define an HPC project using a Google APIs Console and the Compute Engine Console. Here, projects are defined by selecting a collection of services and resources, and sharing those with team members. Projects do not share resources; each project is a totally compartmentalized world and can have instances, firewalls and other resources as specified.

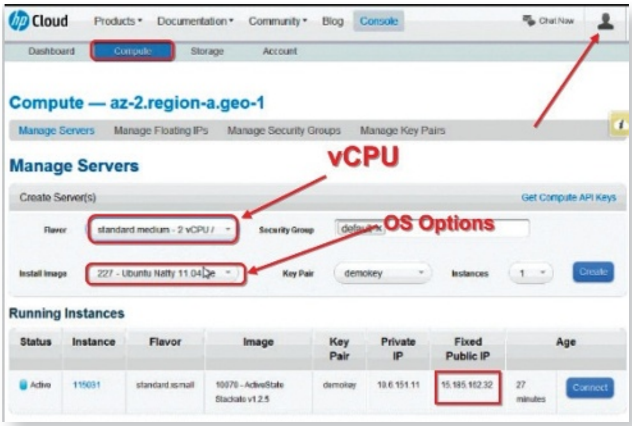
Google offers a rich set of services that can be integrated into an HPC project. Still, it takes a bit of infrastructure and HPC knowledge to effectively thread those services together to execute a project. As Google Compute Engine matures, prospective users can expect the inclusion of sample projects, templates and wizards that will make it much easier to build projects in the cloud.

HP Cloud Compute

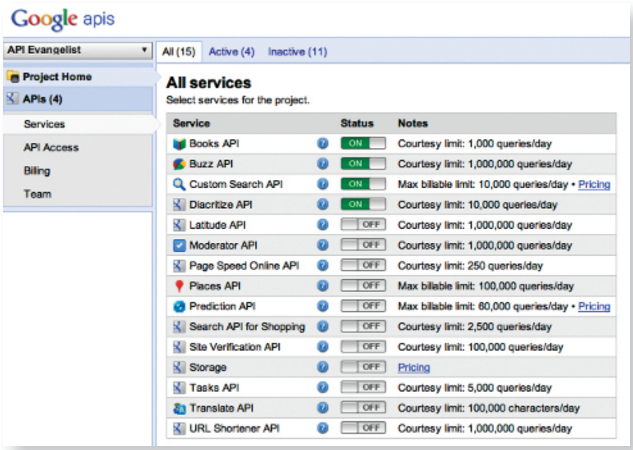
HP is another large, mainstream vendor that has entered the world of cloud-based HPC computing. With services starting at just 4 cents an hour for an entry-level virtual server with 30GB of storage and 1GB of RAM, HP Cloud Compute proves to be quite affordable. However, HPC loads require a lot more processing power than a single server instance.

Here, HP scales up to offer 32GB RAM, 8 vCPUs and 960GB of disk space for $1.28 an hour, which translates to more than $900 per month for continual usage. Of course, HP offers options above and beyond that, as well as smaller instances of hosted processing power to meet elasticity needs and provide on-demand scalability—both of which are very important for HPC processing projects. HP leverages open standards, which ensures workload portability and avoids vendor lock-in problems.

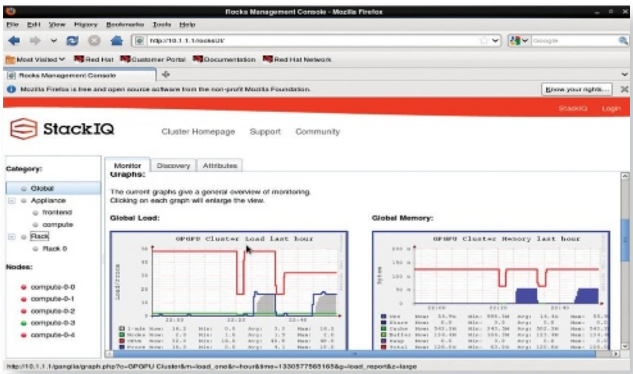
At press time, HP's cloud compute is a public beta, and it is



HP's cloud compute is a public beta.



Google Compute Engine is a hosted platform that is designed to run large-scale computing workloads on Linux virtual machines (VMs) across Google's infrastructure.



StackIQ offers an infrastructure management platform that supports applications that require thousands of instances.

still evolving. That means additional capabilities, management controls and options should become available as the services move toward the final release.

PBS Works HyperWorks On-Demand

PBS Works fits more into the engineering niche than the mainstream HPC cloud-computing vendors do. That is evidenced by the company's offering of on-demand solutions that include hosted GPU scheduling, as well as its HyperWorks On-Demand offering, which leverages Altair's patented technology to deliver a scalable HPC infrastructure on a web-based platform.

PBS Works offers several HPC capabilities that are pre-configured for use on the HyperWorks On-Demand platform, including Altair's specialized processing products, such as RADIOSS (for structure analysis), OptiStruct (structural optimization), AcuSolve (a computational fluid dynamics solver), and BatchMesher (a finite element mesher for large assemblies).

It is those specialized offerings that make PBS Works a focused engineering cloud-computing service, which is aimed at the specialized computational environments in demand by engineers and scientists. That pre-integration approach could potentially save countless hours for those looking to delve deeper into HPC environments and services. With most mainstream offerings, those specialized software and computational packages usually have to be purchased and integrated by the end customer.

PBS Works does not publish base prices; it offers customized pricing packages based upon a particular client's needs. Pricing is based upon a pay-per-usage model, however, which means that costs can be contained by only paying for what you use. The company offers a portal-based management console, and extensive support packages to speed deployment and simplify setup.

Peer1 Hosting HPC Cloud

Peer1 offers two paths to hosted HPC: a self-service HPC cloud and a Managed HPC cloud. Marketed under the Zunicore brand name, the self-service HPC cloud is designed for those looking for hosted compute cycles (based on NVIDIA Tesla GPU cards) and want to manage their own HPC environments using a private cloud model. By contrast, the Managed offering is designed for businesses with a consistently high volume of projects that require more HPC power and a custom supercomputing infrastructure, all handled by an external team of experts.

Zunicore offers a full self-serve environment that features utility billing. In other words, like many other on-demand services, you only pay for what you use. Zunicore also offers access to some hundred applications that can be automatically installed into operational VMs, saving time and money in the long run. Other interesting capabilities include physical GPU servers (not virtualized) that maximize performance, choice of operating systems (CentOS or Windows 2008 R2), and a 1Gb public and private network connectivity for seamless integration with front-end systems.

Peer1's Managed HPC Cloud offers everything Zunicore does, and then some. The key differentiator is the "managed" element, where professional management of the infrastructure is included. Here, Peer1 employees handle the provisioning and deployment of the HPC systems and related infrastructures. While that does increase the costs significantly, it also reduces the need for in-house professionals to manage the systems—perhaps significantly reducing payroll costs.

Peer1 offers a multitude of billing plans, each of which can be customized or adapted to particular clients' demands. The company has a dedicated sales team that can price out a solution based upon needs, such as CPU cycles, storage, bandwidth, support and a handful of other options.

Cloud Service Conclusions

HPC cloud services are still evolving, and many more service providers and vendors are sure to join the fray. As it stands now, the niche vendors are more in tune with the needs of the HPC market, while the larger vendors are gearing up their offerings to match. Important considerations for selecting an HPC cloud services vendor include the type of HPC infrastructure offered, available operating systems, secure connectivity options, and the level of support offered from the vendor. What's more, those pursuing HPC cloud services should look for providers that use open standards to avoid vendor lock-in. **DE**

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INFO → **Altair Engineering:** Altair.com

→ **Amazon:** AWS.Amazon.com/ec2

→ **Gambit Communications:** GambitComm.com

→ **Google:** Cloud.Google.com/compute

→ **HP:** HPCloud.com/products/cloud-compute

→ **MapR Technologies:** MapR.com

→ **NVIDIA:** NVIDIA.com

→ **PBS Works:** PBSWorks.com

→ **Peer1:** Peer1.com

→ **StackIQ:** StackIQ.com

→ **Univa:** Univa.com/products/grid-engine

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A Parallel Processing Path

Getting your programs to run in parallel may become easier with SET from Advanced Cluster Systems.

BY PETER VARHOL

Every programmer knows that writing parallel code can be difficult. You have to manually identify the parts of the code that can be parallelized, insert control code that ensures they are executed separately and independently, and bring everything together once the parallel routine is complete.

What's worse is that we don't think in parallel. The thought processes of a programmer solving a computing problem are typically sequential, or one step at a time. That mental model makes parallel computations even harder to code.

Advanced Cluster Systems is aiming to change that. With its product SET, programmers can write code sequentially, then insert SET application programming interface (API) instructions that will automatically identify opportunities for parallel execution—and take care of the low-level details that arrange the code so that it can be executed in parallel.

According to Zvi Tannenbaum, CEO of Advanced Cluster Systems, this technique enables programmers to quickly and easily bring parallel execution to existing code. Alternatively, programmers can write entirely new applications, in the sequential style they are used to, and use SET to apply parallel operations to those applications.

This means that any programmer can create an application that can execute in parallel, regardless of whether he or she has received specialized training in writing parallel code. Commercial software vendors or enterprises don't have to acquire additional skills to use SET.

Creating and Managing Messages

SET employs the message-passing interface (MPI) for parallel computations, which focuses on making sure code and data is on the processor or core required to complete a calculation. It identifies areas that can be computed in parallel, then coordinates their execution across cores in a processor, or processors in a cluster.

Even working with the source code may not be a strict requirement. Tannenbaum describes the company's initial efforts at working with Wolfram Research's Mathematica engine: "Without the source code, we were able to insert SET to automatically run copies of the Mathematica kernel on each processor, executing the same Mathematica code, and essentially enabling Mathematica to run its programs in parallel."

Advanced Cluster Systems offers a version of SET that works specifically with the Mathematica symbolic mathematics engine.

SET encourages and supports a software architecture approach known as Model-View-Controller, or MVC. View represents the user interface, while Model represents the programming logic that enables the code to carry out its function. SET takes over the Controller part of an application, and ensures that data and the code needed to operate on that data is replicated and assigned a processor or core. For applications that are already written using this architecture, understanding where to place the SET instructions is straightforward.

SET may be a godsend for commercial engineering software vendors who have not yet ported their code to multiprocessor and multicore systems. But it is also useful to larger engineering organizations that have their own code for custom analysis and simulation workloads. According to Tannenbaum, the pricing is aggressive enough to enable teams to use it with their own code.

Currently, SET is available for Linux and Mac systems. While Macs aren't used often in engineering clusters, Linux is popular, so commercial vendors and engineering organizations alike can immediately start to parallelize their Linux simulation and modeling code.

But for engineers, this could be a clear win in their ability to run applications on their desktops, then take those same applications and run them faster on clusters. If you're not taking full advantage of available processors and cores, take a look at SET as a solution to quickly and easily build parallel applications. **DE**

Contributing Editor **Peter Varhol** *covers the HPC and IT beat for* DE. *His expertise is software development, math systems, and systems management. You can reach him at DE-Editors@deskeng.com.*

INFO → Advanced Cluster Systems: AdvancedClusterSystems.com

→ Wolfram Research: Wolfram.com/mathematica

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

SC12 Promises *Super Surprises*

Conference features experts and educational opportunities.

BY FRANK J. OHLHORST

For the last 24 years, the Supercomputing Conference has been charged with bringing the best and brightest minds in supercomputing together in an event that explores advanced technology, predicts the future, and delivers an educational experience from which even the most jaded of computer enthusiasts could benefit.

Taking place Nov. 10-16 in Salt Lake City, SC12 features a keynote speech by world-renowned theoretical physicist and futurist Dr. Michio Kaku, who will offer insights on physics of the future and how the revolutionary developments in medicine, computers, quantum physics and space travel will forever change our way of life, and alter the course of civilization itself.

SC12 will also feature talks by supercomputing leaders from industry, government and academia, who will detail such critical events as the trials and tribulations of siting two new large scale systems (LLNL's Sequoia and ORNL's Titan), delve into how energy consumption is becoming the dominant issue for supercomputing systems, and detail important algorithmic advances.

Other presentations will include a thesis on how computer architecture trends will shape future simulation and large-scale data systems, and how the latest advances in compiling will benefit accelerators. Other presentations of note include talks that detail scientific advances that have been achieved through large-scale simulations.

Emphasis on Education

Of course, there is a great deal more to SC12 than talks and presentations—educational opportunities abound. The conference offers tutorials that will deliver new content and insights on a variety of engineering topics. Examples include analyzing parallel code performance, OpenMP parallel programming, using ParaView for large-scale visualization, Hands-on introduction to OpenMP, mastering Parallel IO, using OpenACC compilers, understanding InfiniBand, big data analytics, and more. The tutorial sessions are geared to be interactive—and in some cases, hands-on.

In addition to keynotes and presentations, representatives from leading technology companies will demonstrate their products on the show floor at SC12.

But Wait, There's More

The exhibit hall, which will be open Nov. 12-15, will feature dozens of vendors, universities, organizations and agencies—including NASA, HP, NVIDIA, INTEL and others. Exhibitors will be offering hands-on demonstrations, announcements of new products, tips and tricks, and other collateral that is sure to benefit the HPC community.

Attendees will also have access to panels, workshops, tutorials, invited talks and "Birds-of-a-Feather" (BOF) sessions that are among the most popular sessions of the SC Conference Series. The BOF sessions provide a non-commercial venue for conference attendees to discuss mutual interests within the HPC community, with an emphasis on audience-driven discussion, professional networking and grassroots participation. **DE**

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→ **NVIDIA:** NVIDIA.com

→ **RIKEN Advanced Institute for Computational Science:** RIKEN.jp/engn/r-world/research/lab/aics/index.html

→ **SC12:** SC12.supercomputing.org

→ **Swiss Federal Institute for Technology:** ETHZ.ch/index_EN

Scanning for CAD

There are old engineering drawings stacked, rolled and folded in shops all over the world. How can we best make use of them in the 21st century?

BY MARK CLARKSON

While there are all kinds of ways of digitizing and sharing paper drawings, the predominant technology is large-format scanning. Large-format scanners come in two primary flavors: charge-coupled devices (CCD) and contact image sensors (CIS).

CCD scanners have been around for a long time, and are still the dominant scanning technology. They provide higher resolution and better, more accurate color than CIS scanners. If you're scanning artwork, CCD still reigns supreme.

Although they can't match CCD scanning resolutions, the relatively new CIS scanners offer some advantages. Large-format CIS scanners cost about 75% as much as their CCD counterparts. They also use energy-thrifty LEDs, rather than fluorescent bulbs—cutting the scanner's energy consumption and, incidentally, eliminating fluorescents' long warm-up times. CIS scanners even have fewer moving parts.

CIS scanners are often limited to 600 dpi, or even 300 dpi resolution. That's no match for the 2,400+ dpi resolutions offered by CCD scanners, but for old documents and drawings, 300 dpi is more than adequate. Resolutions above 200 dpi bloat your file size without actually adding any useful new information. Doubling the resolution quadruples the size of the scanned image.

In the U.S., CIS scanners are your best tools for document scanning. In the United States, most companies roll their drawings or keep them stored flat, in trays. In many other countries, drawings are often folded. This arbitrary regional preference is important when scanning the documents into the computer.

CIS scanners require the scanning head to be in near contact with the media. CIS scanners have poor depth of field; they do not like media that isn't flat. If you're going to be scanning folded documents, then a traditional CCD scanner is still your best bet.

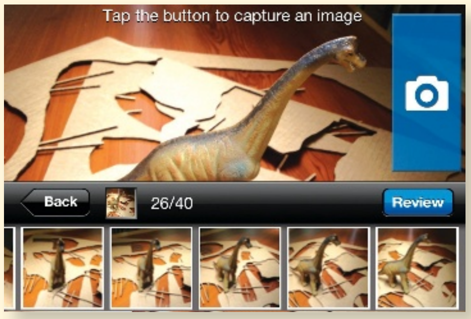
Don't Get It Too Clean

Once you've chosen the right technology, there are a couple of important tips for scanning in your old drawings. The first is: Scan in grayscale.

When scanning in a line drawing, the scanner defaults to pure, binary black and white. While this works fine with a new, clean drawing, it becomes problematic with older drawings that can be dark, faded, smudged—and worst off all, in-

Review: Easy as 1-2-3

123D Catch is an interesting tool, available for free from Autodesk for your PC or smartphone. 123D Catch is a photogrammetry application; it performs a statistical analysis on a series of photos of an object, then recreates a textured 3D model of that object—or at least, tries to. (123D Catch utilizes technology developed in Autodesk's Photofly.)



You start by taking photos of your object from as many angles as you can manage (with a limit of 40), making sure there's plenty of overlap. When you're satisfied, a tap of a button sends the photos off to the cloud, where they're processed automatically.

The application gives you back a textured, 3D mesh. Getting a good result requires a bit of practice, but it's easy to see the possibilities.

"A laser scanner is still very expensive," says Elmer Boyle, Autodesk's director of Reality Capture Technologies, "but your phone is free. So that is the ultimate form of democratization for capturing the real world."

Most design packages are start with a blank sheet of paper, but no design exists without a context. Parts go in machines. Machines go in factories.

"A simple example," says Boyle, "is changing something in a plant. Maybe you're adding a new piece of machinery, or adding pipes for cooling; that's always going to be part of an existing environment."

Photogrammetry isn't the answer to everything. It's not very accurate, for starters, and it doesn't address the conceptual design process at all. And 123D Catch itself is, Boyle admits, a bit of a toy, better suited for consumer fun than professional work. "But this is not the end game," Boyle says.

consistent. In an old drawing, what constitutes a dark line in one place may be the background color in another.

Even if you scan in grayscale, you can inadvertently cost yourself information.

"A lot of people think a crisp, white background is a perfect image," says Steve Blanken, general manager of North and South America for Contex America. "They'll spend a lot of time cleaning up the background to make the image look pretty. But if you completely wipe out the background, chances are you're going to wipe out some data. Small numbers and dimension lines get lost.

The Need for Speed and Sharing

If you have to scan a lot of documents, you want to scan the quickly. But how fast is fast enough?

"We have this argument all the time," says Blanken. "People can only go so fast when they operate a scanner. Sixty inches per second doesn't mean anything, because people can't run a scanner that fast. We prefer to measure productivity—not in mechanical speed, but in scans per hour.

Once you've got your scan into the computer, what are you going to do with it? Storing it on your hard drive is so 2008.

Consider HP's new T2300, which combines a 36-in. CIS scanner with a 44-in. dual-roll inkjet printer. What's noteworthy here is the scanner's ability to send the scanned file directly to the cloud or an FTP address, as well as print from the cloud or FTP. Combined with the machine's built-in image cleanup capabilities, the T2300 can bypass the PC altogether. Storage and sharing options surely won't stop there: What about SharePoint, Dropbox or email?

"Customers are asking to be able to scan directly to email," confirms Eric DuPaul, HP's Designjet business development manager. "They'd like to scan to PDF and directly to email, and bypass everything in-between."

Raster-to-Vector

But what happens when it's time to make changes to those plans? A scanned document is just a bitmap; you can't make design changes to it. It's got to be converted to a useable vector format. The worst possible case is just tracing over the scanned drawing in your CAD program—and there's a depressing amount of that going on.

"Even though the [changes you need to make] will only take you five minutes, you might have to spend eight hours re-drafting the original into CAD so that you can make that five-minute change," says Contex America's Western regional manager, Michael McMillen.

What you'd like is some high-tech voodoo that turns a scan into a useable vector CAD drawing. That magic is called raster-to-vector, and it's been around about as long as the desktop PC.

Seamless conversion is a sort of persistent Holy Grail in scanning; in practice, the software often doesn't gets things quite right—and sometimes gets them quite wrong. Even so, it can save you a ton of time doing things by hand.

The HP Designjet T2300 uses HP ePrint & Share technology.

There are many CAD-oriented raster-to-vector applications on the market, including Avia's Scan2CAD, CSoft's WiseImage and Autodesk Raster Designer Pro. Prices and feature sets vary, but the basic idea is the same: to turn that scanned document into editable CAD. The programs recognize features—lines, rectangles, circles, text, specific symbols, etc.—and recreate them in vector form, with greater or lesser amounts of input from you.

Basic proficiency with one of these applications might take a week of training, but it can pay off in hundreds of hours saved converting old paper documents to useable vector data.

WiseImage allows you to edit your scanned image without actually converting it to vector.

"You're editing the raster," says McMillen, "but you can also add CAD info and create a hybrid file—maybe 5% CAD and 95% raster. One hundred percent of the time I invest into this drawing is toward design."

You can also convert the file to vector interactively, by selecting features on your document—circles and closed polygons, for example. WiseImage Pro will even attempt to completely automate the conversion process.

"I can tell the software the kinds of properties I have in this raster file," says McMillen, "[such as] circles, arcs and text. Then I click a button, and it will vectorize the entire drawing in minutes.

"There's always going to be cleanup required," he admits. "But [compared to manually recreating the drawings,] there is a significant time savings." **DE**

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➜ **HP:** HP.com

Wide Formats for Small Spaces

Epson and HP both release new lines of wide-format printers targeted to small- and medium-sized firms.

BY JAMIE J. GOOCH

Epson America is the American affiliate of Seiko Epson Corp., an $11.7 billion company. By the company's own measure, it has a commanding market share when it comes to the graphics printer market. Tim Check, product manager, Professional Imaging Group at Epson America, says all of the company's senior managers have engineering backgrounds. So why hasn't the company entered the scientific/engineering market by now?

"We have had a lot of people ask us about technical printing," says Check. "When we looked at that opportunity, the technology we had at the time wasn't able to be cost-effective for the technical market."

Epson's printers were geared to the photographic, fine art and commercial graphics market. But the company's new printhead and inkset have changed all that. This month, Epson says it will begin shipping its SureColor T-Series, which is targeted to small- and mid-sized engineering firms.

The SureColor T3000, T5000 and T7000 are designed to provide fast, accurate plotting. The company says its new UltraChrome XD pigment ink offers crisp output on virtually any media type, and is archival quality, smudge-proof and waterproof. T-Series ink is available in 110-, 350- and 700-ml sizes.

"The series does not have a draft mode," Check says. "It has a speed mode, but it's still presentation quality. It can produce up to 115 A1/D-sized plots per hour."

The T3000 is a 24-in. printer with a 41.3x44.4-in. (WxD) footprint. It retails for $2,995. The 36-in., $3,995 T5000 and 44-in., $4,995 T7000 have the same features in the larger sizes. The T7000 measures 63 in. wide with the same depth as the T3000. All of the printers are designed to be pushed up against a wall to save space. Paper and ink are loaded in the front, while USB and Gigabit Ethernet ports are on the side.

Each printer delivers plots with a minimum line thickness of 0.018 mm. All three printers can print down to 8.5x11-in. sheets. They are also all equipped with LCD touch panels that include a help walkthrough. The printers can email someone when they need attention, and when a print is ready. An optional web server is also available.

HP Goes Small

Epson isn't the only company to realize space is at a premium in today's engineering firms. Technical printer leader HP says the economic downturn has led to smaller workspaces and more home offices, which led the company to develop lower cost, more compact wide-format printers.

HP's new Designjet T120 (24-in.) and T520 (24- and 36-in.) entry-level ePrinters are designed for students, home offices and small engineering firms. HP labels them "ePrinters" because they can take advantage of the second generation of HP's Designjet ePrint & Share functionality. HP Designjet ePrint & Share allows mobile access and printing via a Web browser, mobile app or email.

The $1,000 T120 provides letter to D-sized printing, Wi-Fi connectivity and single printhead.

The T520 retails at $1,800 for the 24-in model and $2,500 for the 36-in version. According to the company, the T520 offers twice the speed and resolution of its predecessor, the Designjet 510. HP says the T520 operates at up to 35 seconds per D/A1 print. It has an accuracy reaching 0.0008 in. minimum line width, and up to 2,400 dpi resolution, according to HP.

Both HP and Epson realize that small- and medium-sized engineering firms continue to bring smaller print jobs in house. Their new offerings may allow those customers to save time and money by using one on-site printer for their letter-sized and many of their wide-format printing jobs. DE

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INFO ➜ Epson America: Epson.com

➜ **HP:** HP.com

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Balancing Price and Performance

The new Lenovo ThinkStation S30 combines the latest Intel Xeon processors and NVIDIA graphics to create another excellent midrange CAD workstation.

ThinkStation S30, Lenovo's latest single-socket solution, is again a great midrange CAD workstation.

BY DAVID COHN

Lenovo recently sent us its ThinkStation S30, the latest iteration of its single-socket workstation family aimed squarely at the midrange CAD market. While we recently reviewed the company's newest entry-level E30 system (see *DE* July 2012), it's been nearly three years since we looked at the S30's predecessor, the ThinkStation S20 (see *DE* November 2009).

There have been lots of changes during those three years—even though outwardly, the ThinkStation S30 looks nearly identical to the system it replaces. Like other ThinkStation workstations, the S30 comes housed in an attractive black case, which measures 6.9x18.1x16.8 in. (WxDxH). A removable front handle adds 2 in. to the height of the case. There's also a metal lip on the rear of the case as a second lift point. Our evaluation unit weighed 29.5 lbs.

The S30's front panel also appears virtually unchanged from its predecessor. The top portion provides two 5.25-in. drive bays, one of which contained a 16X DVD+/-RW dual-layer optical drive. Below these is a 3.5-in. bay containing a 25-in-1 media card reader, as well as a panel containing the power button, a pair of USB 2.0 ports, and headphone and microphone jacks. Icons above these ports light up, making them easier to find in low-light conditions. There's a spot for a FireWire (1394) port, but this $29 option was not included in our system.

The rear panel was also largely unchanged from the earlier system, except for the inclusion of two USB 3.0 ports in addition to eight more USB 2.0 ports. There is also a 9-pin serial port, one RJ45 jack for the integrated Intel 82579 Gigabit Ethernet, and thee audio jacks (line-in, line-out and microphone) for the integrated Realtec HD audio. Lenovo also offers an optional Creative Labs Sound Blaster X-Fi sound card.

Lifting a small lever and removing the left panel of the tool-less chassis exposes a well-organized interior, and it is here that three years of progress becomes evident. At the heart of the new Lenovo ThinkStation S30 is a single CPU socket that can accommodate any of Intel's "Sandy Bridge" processors. Our evaluation unit came equipped with a 3.6GHz Intel E5-1620 CPU, the fastest available quad-core processor, but Lenovo offers other Intel CPUs ranging from a 2.8GHz quad-core E5-1603 up to the eight-core 2.90GHz E5-2690. The Intel Xeon E5-1620 has a 10MB cache and a maximum turbo speed of 3.8GHz, with four memory channels, support for PCIe 3.0, and a thermal design power (TDP) rating of 130 watts.

The CPU is virtually hidden beneath a large heat sink and dedicated cooling fan. It is flanked to either side by banks of four dual in-line memory module (DIMM) sockets, for a maximum memory capacity of 128GB (using registered RAM modules or 64GB using unfiltered RAM). Two of the eight memory sockets in our evaluation unit were filled with 4GB 1,333MHz uDIMM modules for a total of 8GB of RAM. The S30 supports memory speeds up to 1,600MHz.

The motherboard also provides a total of five expansion slots: three full-length PCIe 3.0x16 slots (one of which is only x4 electrically), a full-length 32-bit PCI 2.3 slot, and a half-length PCIe 2.0 x4 slot. One of the x16 slots in our evaluation unit was filled with an NVIDIA Quadro 4000 graphics accelerator with 2GB of discrete GDDR5 memory and 256 compute unified device architecture (CUDA) cores.

This high-end GPU provides a single dual link DVI-I connector and two DisplayPorts. Although its 142-watt

Engineering Workstations Compared

		Lenovo S30 workstation (one 3.6GHz Intel Xeon E5-1620 quad-core CPU [3.8GHz turbo], NVIDIA Quadro 4000, 8GB RAM)	HP Z1 workstation (one 3.5GHz Intel Xeon E3-1280 quad-core CPU [3.9GHz turbo], NVIDIA Quadro 4000M, 16GB RAM)	Lenovo E30 workstation (one 3.2GHz Intel Xeon E3-1230 quad-core CPU [3.6GHz turbo], NVIDIA Quadro 600, 4GB RAM)		HP Z210 workstation (one 3.36GHz Intel Xeon E3-1245 quad-core CPU [3.7GHz turbo], NVIDIA Quadro 2000, 8GB RAM)		BOXX 3DBOXX 3970 EXTREME workstation (one 3.4GHz Intel Core i7-2600K quad-core CPU over-clocked to 4.5GHz, NVIDIA Quadro 4000, 8GB RAM)	HP Z820 workstation (two 3.1GHz Intel Xeon eight-core CPU [3.8GHz turbo], NVIDIA Quadro 5000, 32GB RAM)	BOXX 3DBOXX 8550XTREME workstation (two 3.33GHz Intel Xeon X5680 six-core CPUs over-clocked to 4.2GHz, NVIDIA Quadro 5000, 24GB RAM)	
Price as tested		$2,614	$5,625	$1,099		$2,269		$4,048	$9,984	$11,396	
Date tested		8/18/12	6/29/12	4/21/12		2/12/12		10/12/11	7/16/12	3/20/11	
Operating System			Windows 7 64-bit	Windows XP	Windows 7 64-bit	Windows XP	Windows 7 64-bit	Windows 7 64-bit	Windows 7 64-bit	Windows XP	Windows 7 64-bit
SPECviewperf	higher										
3dsmax-04		80.63[1]	82.83[1]	79.01[1]	77.43[1]	80.67	79.46	99.03[1]	82.08[1]	95.97	95.44[1]
catia-02		101.18[1]	98.89[1]	77.80[1]	77.68[1]	94.20	91.47	124.75[1]	111.43[1]	120.44	121.10[1]
ensight-03		95.71[1]	90.20[1]	48.20[1]	49.27[1]	75.78	73.57	109.56[1]	124.41[1]	132.41	130.13[1]
maya-02		371.89[1]	330.32[1]	156.64[1]	157.63[1]	291.17	270.83	399.43[1]	461.72[1]	529.89	476.95[1]
proe-04		93.53[1]	97.22[1]	60.66[1]	60.79[1]	88.48	84.83	120.33[1]	114.54[1]	113.84	113.24
SW-01		179.06[1]	196.11[1]	94.38[1]	94.68[1]	168.06	161.45	231.44[1]	236.80[1]	221.31	214.06
tcvis-01		78.98[1]	62.98[1]	34.25[1]	34.22[1]	56.41	54.43	79.05[1]	94.77[1]	98.58	94.17
ugnx-01		61.83[1]	44.98[1]	29.01[1]	29.16[1]	43.41	42.49	65.91[1]	86.93[1]	89.32	86.90
SPECapc SolidWorks	lower										
Score	seconds	106.46[1,2]	110.61[1,2]	127.48[1]	n/a	110.91	n/a	n/a	126.73[1,2]	106.56[1]	n/a
Graphics	seconds	38.68[1,2]	38.31[1,2]	48.40[1]	n/a	35.71	n/a	n/a	42.43[1,2]	35.33[1]	n/a
CPU	seconds	26.88[1,2]	30.52[1,2]	27.90[1]	n/a	25.89	n/a	26.44[1]	37.53[1,2]	25.99[1]	n/a
I/O	seconds	40.90[1,2]	41.32[1,2]	55.17[1]	n/a	50.74	n/a	47.01[1]	46.77[1,2]	46.51[1]	n/a
SPECapc SolidWorks	higher										
Score	ratio	4.80[1,2]	4.46[1,2]	6.25[1]	n/a	7.92	n/a	n/a	3.84[1,2]	8.23[1]	n/a
Graphics	ratio	5.33[1,2]	5.06[1,2]	3.89[1]	n/a	5.78	n/a	n/a	4.58[1,2]	6.08[1]	n/a
CPU	ratio	4.56[1,2]	4.01[1,2]	11.57[1]	n/a	12.46	n/a	12.20[1]	3.26[1,2]	12.61[1]	n/a
I/O	ratio	3.46[1,2]	3.42[1,2]	5.74[1]	n/a	6.24	n/a	6.73[1]	3.03[1,2]	6.81[1]	n/a
Autodesk Render Test	lower										
Time	seconds	63.80[1]	87.92[1]	85.66[1]	71.75[1]	71.66[1]	62.33[1]	45.6[1]	41.0[1]	34.0[1]	19.0[1]

Numbers in blue indicate best recorded results. Numbers in red indicate worst recorded results. 1=Hyper-threading enabled. 2= SPECapcSW2007 benchmark. Results are shown separately for single- and dual-socket workstations.

power consumption requires an auxiliary power connection, it occupies just a single slot, so the other four expansion slots in the Lenovo S30 remain available for future expansion. Lenovo also offers other NVIDIA graphics boards, ranging from the entry-level NVS 310 to the ultra-high-end NVIDIA Quadro 5000.

Like its predecessor, the drive cage in the ThinkStation S30 provides three 3.5-in. internal drive bays with quick-release acoustic dampening rails. Our evaluation unit came equipped with a pair of 500GB Western Digital Caviar 7,200rpm drives configured in a redundant array of independent disks (RAID) 0; they appeared as a single 1TB drive. While that arrangement can boost performance, it's not the safest configuration because all data would be lost if either drive failed.

The system BIOS also supports RAID 1 and RAID 5, and the motherboard includes three SATA/SAS connectors for hard drives and four additional SATA connectors for optical drives and additional hard drives. There's also an eSATA connector and an internal USB port. In addition to the drives in our evaluation unit, Lenovo offers other SATA hard drives up to 2TB in capacity, a 128GB solid state drive, and 15,000rpm SAS drives of up to 300GB (with the inclusion of an optional SAS enablement module).

The 610-watt power supply remains relatively unchanged from the previous model, but should deliver ample energy to meet any of the system's expansion needs. In spite of fans on the CPU, rear panel, power supply and graphics card, the S30 is virtually silent after its initial startup.

Excellent Performance

Once again, Lenovo proves that its engineers know how to combine and configure quality components for optimum performance. The ThinkStation S30 equipped with the NVIDIA Quadro 4000 graphics board turned in some of the best SPECviewperf scores we've recorded to date on a single-socket workstation without the added boost of an over-clocked CPU.

When we turned our attention to the SPECapc SolidWorks benchmark, which is more of a real-world test (and breaks out graphics, CPU and I/O performance separately from the overall score), the S30 also did quite well. Because we previously tested systems using an older version of this benchmark under Windows XP and have since moved to a new release of the test under Windows 7, the ratio results are not directly comparable. Looking at the times, however, the S30 did extremely well—even outperforming some other systems equipped with overclocked CPUs.

On the AutoCAD rendering test, which is multithreaded and therefore clearly shows the benefits of multiple CPU cores, the Lenovo ThinkStation S30 turned in the best results of any single-socket quad-core-based system we've ever tested, taking just over one minute to complete the rendered image.

Lenovo rounded out our evaluation unit with a full-size 104-key USB keyboard and USB optical roller wheel mouse. Lenovo pre-installed 64-bit Windows 7, and customers can pay an additional $15 to receive Windows 8 when it is released. Microsoft Office, as well as other application software, is also available at the time of purchase. Lenovo backs the system with a three-year limited warranty on parts and labor, and offers onsite service and priority tech support. It also offers four- and five-year warranties for an additional cost.

A base S30 system starts at $899, but that price is based on a lesser CPU and just 2GB of memory. Yet even as equipped, our evaluation unit priced out at just $2,614, making the Lenovo ThinkStation S30 affordable.

Like its predecessor, the ThinkStation S30 is a great midrange CAD workstation, offering excellent performance at a very reasonable price. **DE**

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INFO ➜ Lenovo: Lenovo.com/thinkstation

Lenovo ThinkStation S30

- **Price:** $2,594 as tested ($899 base price)
- **Size:** 6.9x18.1x18.8-in. (WxDxH) tower
- **Weight:** 29.5 lbs.
- **CPU:** Intel Xeon (Quad Core) E5-1620 3.6GHz
- **Memory:** 8GB DDR3 ECC at 1,333MHz
- **Graphics:** NVIDIA Quadro 4000
- **Hard Disk:** two Western Digital Caviar 500GB SATA 7,200rpm drives in a RAID 0 array
- **Optical:** 16X DVD+/-RW Dual-Layer
- **Audio:** onboard HD Realtek ALC662 codec (front panel: microphone, headphone; rear panel: line-in, line-out, microphone)
- **Network:** integrated Gigabit Ethernet (Intel 82579), one RJ45 port
- **Other:** One 9-pin serial, 10 USB 2.0, two USB 3.0, 20-in-1 media card reader
- **Keyboard:** 104-key Lenovo Preferred USB keyboard
- **Pointing device:** Lenovo USB optical wheel mouse
- **Power supply:** 610 watts
- **Warranty:** 3 years parts and labor

Moving **into** the Nonlinear World with **FEA**

A primer on the main types of nonlinearity, when and how to use them.

BY TONY ABBEY

Most engineers traditionally migrated from the linear finite element analysis (FEA) world into the nonlinear world when faced with stress levels above the elastic limit—in other words, *plasticity*. These days, it is more likely that components in an assembly make contact when loaded or unloaded, and you need to model that situation. Now you are off down the nonlinear path!

I had a colleague who steadfastly declared, "The world is nonlinear." He was quite right, but we would much prefer when doing FEA to keep things as simple as possible and ignore that fact. A lot of the time we can get away with this, but sometimes we can't.

After a quick dabble in nonlinear FEA, a lot of engineers understand the reason for the coyness: Nonlinear analysis is tough to do effectively and efficiently—it is a steep learning curve.

The Nonlinear Strategy

When we carry out a nonlinear analysis, we are taking a journey into the unknown. Fig. 1 shows a typical nonlinear history. Notice how the load is now broken down into smaller steps. We can't just apply the total and hope we get a good result. We have to tiptoe up the load scale.

Here we see two load increments: up to 10% and up to 20%. In practice, these may be as low as 1% increments for a highly nonlinear problem.

At each load increment, the solver has to iterate within the solution to find a load balance. The first approximation is a linear analysis, so it will not be in balance if the response is nonlinear. The solver transforms the solution into a one-dimensional search path, looking for this balance point.

Once the first balance point is found, we have the first known point in our journey. We can then carry out another exploratory linear analysis and see where that takes us. Again, it is an approximation and we have to iterate to find the nonlinear balance point. The journey continues, finding each balance point up to the full 100% loading. We have then established the nonlinear response at each point in the structure.

The cost of doing these successive iterations can be quite significant. If it takes 10 steps, with each one needing a full stiffness matrix update and solution, that means the analysis is 10 times more expensive than an equivalent-sized static solution. There are many strategies to make this updating as parsimonious as possible, so it is not quite so savage a scaling effect on cost. But for a highly nonlinear structure, there is often no other option than to accept the cost.

The convergence to a balance at each step can be the cause of much heartache. If we use too large a step, or have highly nonlinear events such as large contact changes, big changes in the material slope or abrupt collapse due to nonlinear buckling or snap-through, the solver can have a tough time seeking a balance. We may even find that there is no physically realizable solution—as in the case with a collapse load.

This leads us to one of the most important tips: Simplify the nonlinearity

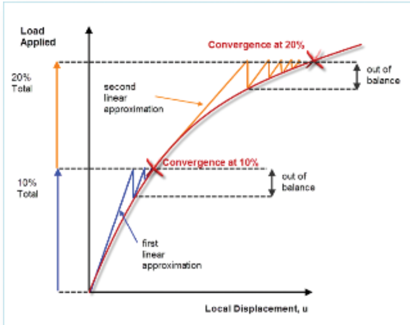

FIG. 1: Nonlinear strategy.

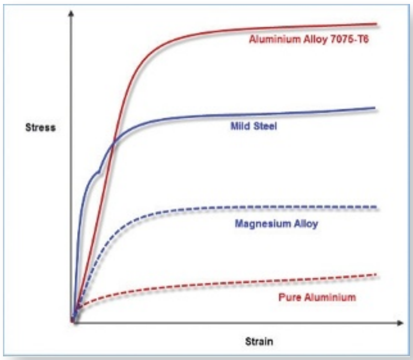

FIG. 2: Various metal stress-strain curves.

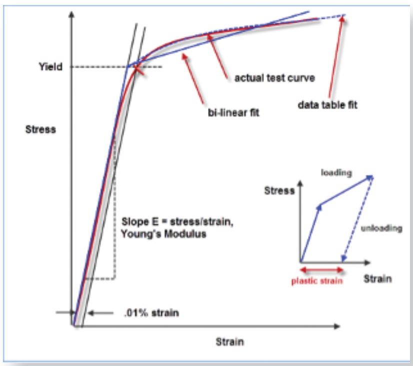

FIG. 3: FEA material fit to data.

as much as possible. If you have contact, friction, geometric nonlinearity and plasticity all going on at once, take a step backward and introduce these effects one at a time. You may "bond" the contact surfaces together for simplicity, and make the material linear. Now you can shake down the geometric nonlinearity and get that to work. Even here, you may want to start with a simpler model to establish the physics of the structural behavior and work up from there.

Material Nonlinearity

When the stress level in a component exceeds the yield point, the material in the affected zone starts to go plastic. The presence of plasticity means the material is following a nonlinear stress strain curve, typified by test results shown in Fig. 2. Some materials show a distinct transition from linear elastic to nonlinear plastic at a clearly defined yield point; others show a slow drift off the linear curve. Fig. 3 shows how to deal with the "drift"—an arbitrary line at 0.1% or 0.2% strain is drawn parallel to the initial slope, and the yield point is taken to be where this crosses the material curve.

We usually have to simplify the actual stress strain curve in an FEA material model. The input to FEA can be rationalized by an elastic linear section, whose slope matches the linear material stiffness E, and a plastic nonlinear part, which can be a constant slope (the two slopes are described as a bilinear fit), or a varying slope defined by a data table. Both types are shown in Fig. 3.

The Fig. 3 inset shows the loading and unloading along the elastic and plastic curves. The unloading occurs parallel to the elastic curve, and leaves a "locked-in" strain when fully unloaded. This is the residual plastic strain left in the structure, with associated permanent set.

If a nonlinear solution is used, all elements in the model are monitored to check for values above yield. If this occurs, the elements in the affected regions have a modified material stiffness term invoked, which uses the new slope of the elastic plastic curve.

In general, we need to tiptoe along this curve so that stiffness updates are carried out slowly, and equilibrium enforced as we go.

If we adopt this gradual-increment approach, we can capture the growth of a plastic zone. It is important to realize, however, that as the plastic zone grows, the stress flow in the component and around the plastic zone will change. Often, a plastic "lobe" type shape appears, and then grows. Fig. 4 shows a sequence yield stress front growth around a hole in a plate as load is increased. Fig. 5 shows the corresponding plastic strain growth.

We may have a situation where only

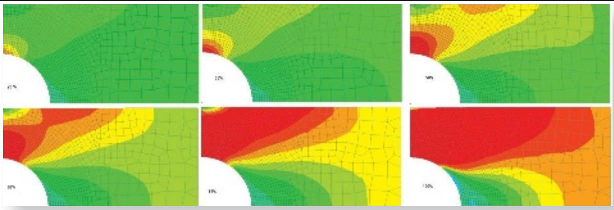

FIG. 4: Progressive axial stress distribution.

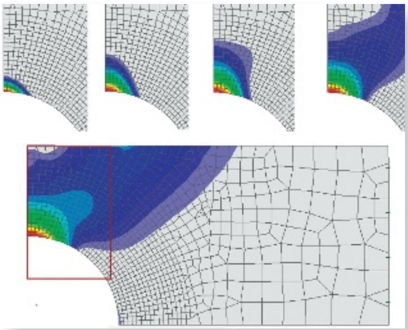

FIG. 5: Progressive plastic strains.

FIG. 6: Nonlinear deflections.

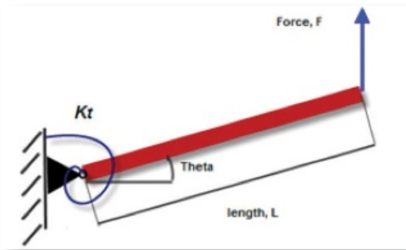

FIG. 7: Rigid rod and torsional spring.

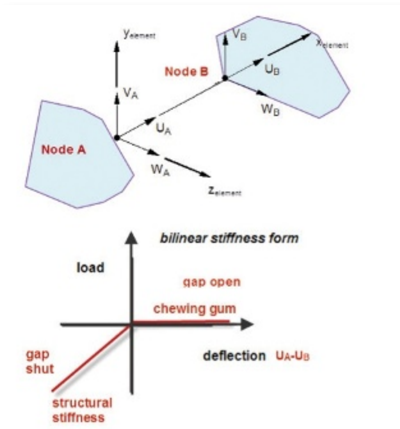

FIG. 8: Original gap element.

very local plasticity is seen, such as at a local notch or other stress raiser, or at the extreme fiber positions of a beam in bending. The analysis tends to be stable as the overall stiffness changes are small. Conversely, as the plastic zones spread, such as in the final stages of the loaded hole in Fig. 5, large sections of the model are affected and the overall stiffness changes can be significant. This makes it difficult for the nonlinear solver to handle the solution.

Geometric Nonlinearity

Looking at the tent in Fig. 6, we can see the walls have been deflected inward under the wind pressure. Internal balancing loads in the tent wall develop as it moves into this shape, and the corresponding internal stresses are dominated by membrane—or in-plane stresses. It wouldn't make sense to think of the tent in its undeformed, flat, initial state, trying to resist the wind pressure. When a structure has to deform and the loads can only be balanced in that configuration, the phenomena is called *geometric nonlinearity*. Notice there is no material nonlinearity here—it is all down to the loading and deflection.

Contrast this with a stiff bridge deck, carrying its own weight plus traffic, wind loading, etc. The loads will be "beamed" from the bridge deck to the foundation structure, with very little deformation of the bridge deck. We can ignore the influence of deformations to get a load balance; this is a *linear* solution. Many years ago, I had a client who tried to analyze a tent wall with a linear solution. It can't work because it needs to deflect to transmit the loads.

Often in practice, we get to a "middle ground" when we come to deflections of thin-walled structures, like plates. The linear theory we use in FEA assumes the deflections normal to the plate are, at most, around 25% to 50% of the plate thickness. Under that assumption, pressure load is "beamed" from the center to the edges, like the bridge. If deflection goes beyond this, the load transfer starts to pick up the tent-like membrane or in-plane loading. The stress system changes from all bending and shear to bending, shear and membrane. We need to move to a non-linear FEA to pick this up.

We can see the geometric nonlinear term coming into play in a simple example. Fig. 7 shows a rigid bar connected to a pivot at one end. A linear rotational spring resists motion at that end. We apply a small force at the free end of the bar, and it rotates slightly about the pivot. The movement applied to the bar balances the torque produced in the rotary spring. The bar movement (force times length) equals the torque reaction in the spring. We can also estimate the rotation of the bar about the pivot by knowing the torque and the spring rate.

The important point here is that we carry out the force balance in the undeformed position as a linear approximation. This is the basis of linear analysis.

As the bar rotates, the movement gets smaller, because the line of action of the force creeps closer to the pivot. If we include this effect, we are balancing the rod and spring in the deformed position. This is a *nonlinear* solution.

The linear solution ... just stays linear! It doesn't care how absurd the solution gets. Think about a force of 2E5 N applied at the tip. The rotation is "off the clock." We could extrapolate and calculate a rotation that implies the rod does four or five complete pirouettes around the pivot. It is an absurd answer, but we often see exactly that in a linear analysis that is trying to handle nonlinear geometric response. We can't map this back to a physically meaningful situation. We have overshot the limits of a linear analysis, and need to move to nonlinear analysis.

The nonlinear solution shows a divergence away from the linear at around 30° of rotation. If we apply 2E5N now, we get a rotation of around 82°—clearly balanced only in a nearly vertical deformed state.

Sometimes, analysis with geometric nonlinearity is called a "large displacement" analysis. I don't like this term because it begs the question "how large is large?" Every analysis is material-, loading- and configuration-dependent, so there is no real answer.

Geometric Nonlinear Load Types

The pressure force in a tent wall will always "follow" the tent wall deformation. An inflating toy balloon changes shape dramatically, but pressure is always normal to the surface. The rod force was applied and stayed in the vertical sense, whatever the rod rotation. This is a *non-follower* load.

It is important to establish what type of loading is present. Gravity loads will always be non-follower, but a bearing load from an adjacent structure can be either.

The setup of a follower force is straightforward if it is pressure-loading. All FEA solvers should be able to automatically adjust the normal direction under deformation.

A load applied as a point force is trickier. The vector associated with the force direction has to be updated. Typically, a set of "anchor" nodes is used. As these deform, they will update the force vector. However, if nodes are badly chosen, the force vector is slaved to these and can result in bizarre changes. It is better to convert any point forces to a pressure distributed over a small "pad" of surface area. This is good practice, even in a linear analysis, to avoid spurious localized stresses.

Contact Implementation

The early implementations of contact were nothing more than a set of nonlinear springs, as shown in Fig. 8. These were referred to as *gap elements*. They are little used these days, but illustrate some of the principles still used. When the gap is open, the spring stiffness is weak, like chewing gum. When the gap is shut, the stiffness is the same as the surrounding material.

To create a "closed gap," the nodes A and B must pass through one another. This creates a problem in that we are not now modeling the real situation, both nodes just touching and then moving together. Only by having penetration can we get a resisting force. This is basically the penalty stiffness method used in many contact algorithms.

To model reality, it is really required to make contacts be just touching, and develop the corresponding reaction forces in a more natural way. This is done by an auxiliary set of forces introduced to make the contact and form the reaction forces. This method is known as the Lagrangian method, and is a later development.

Many solvers actually use a mix of these two methods. The search for good stable methods still continues, and we can expect new solver developments over the next few years.

The technology has moved beyond simple gaps and now covers whole regions of contact mesh. Now arbitrary zones of a model can be assessed to see whether they will move into contact or separate as the loading is applied. The terminology of a "master" surface and "slave" surface is often used to differentiate the two surfaces that come into contact. A typical setup is shown in Fig. 9. In single-sided contact, the regions formed by the master elements search for slave nodes that will pass through the net and will form connections. The region can be shell elements or the faces of solid elements.

The computational cost of this search can be quite high—rather like ray tracing, so methods are used to cut down "who sees whom" in a general solution. Cost equates to solution time and memory requirements. Still, techniques are getting more efficient as technology improves, so we can expect to see the cost going down and versatility increasing. One example is that double-sided contact where slave surfaces look for master nodes is now very common.

Controlling Jaggies

Other issues include getting rid of the "jaggies." The FEA mesh is usually a discontinuous discretization, and the slave region introduces into master regions, as shown in Fig. 10. This results in a set of artificial point loads, which destroy the attempt to have continuous bearing forces, for example. This

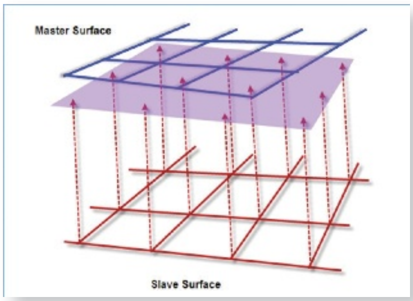

FIG. 9: General surface contact.

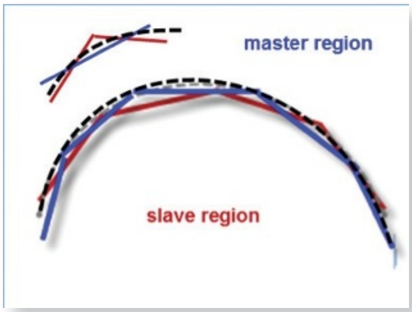

FIG. 10: Avoiding the "jaggies."

is very difficult to avoid, even by careful meshing.

Techniques are available that fit a common interpolated surface to which the nodes move, or even inherit the actual CAD geometry surface. A smooth bearing load distribution can then be achieved.

Another common issue with contacts is that of "loose" components not properly abutting each other. A typical CAD model will place components at nominal positions—for example, a pin and lug defined concentrically. In FEA, we require the pin to start off being in bearing contact with the lug to establish a load path. If we can modify the CAD model, that's a great help. However, it can be difficult to establish a stable initial load path at small initial load steps.

Other methods include putting in very weak springs to help stabilize—or in an extreme case, running a time-based analysis. The time scale does not matter, but what really helps is that each new load step convergence is not just working with an updated stiffness; we are passing forward the dynamic effects—and the key here is *inertia*.

There are many types of nonlinearity; we have looked at the main areas. It is important to assess what level of nonlinearity is needed to adequately model the problem, then take small bites of the cherry and explore the nature of the nonlinearity carefully. We want to start simply and explore—and far we need to go! **DE**

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Paper or Plastic ... *or* Metal, Wax, Bio-cells?

From what material will you 3D-print a part today?

BY PAMELA J. WATERMAN

Back in 1998, additive manufacturing (AM) industry consultant Terry Wohlers said, "New (AM) materials are being developed and commercialized regularly. Someday, they'll have as many materials as Elton John has outfits."

Wohlers' comment targeted laser-sintering (LS) powders, but with the AM/3D-printing industry now well into its third decade, material options for all processes have indeed mushroomed into the hundreds. Whether your AM parts need color, flexibility, heat resistance, end-use durability or high precision, *DE* gives you a peek at the past year's bumper crop.

Models of a laser pointer and a GPS system built with "digital materials" (multiple materials, with different properties and colors, formed during a single build) on an Objet Connex AM system. *Image courtesy Objet Geometries.*

Plastics and Wax

In the beginning, there was resin. It was clear, it was cured, and the parts produced with it on stereolithography (SLA) machines were pretty amazing—all things considered. Today, raw AM plastics and waxes come in a huge variety of liquids, powders, solids, phase-change materials and blends.

Leading the way with its "digital materials," Objet Geometries announced 39 new ink-jet-based materials this year, bringing its total inventory to 107 variations on plastics. This number is based on the Objet Connex system's ability to produce 90 composite blends on the fly by simultaneously jetting various amounts of two different primary materials. Properties offered by the 3D printing materials range from clear transparent to rigid opaque, and heat-resistant to polypropylene-like (for snap fits).

• **Resins**: Many AM customers want materials that mimic the properties of traditional production counterparts, but doing so with liquid resin systems has been a challenge. Now Envisiontec has announced two, possibly game-changing acrylonitrile butadiene (AB) resins that address that need: ABSflex and ABStuff, for use in the company's Digital Light Processing (DLP)-based 3D printers.

"Our new AB resins have the true replication DNA of production-grade ABS," says Al Siblani, Envisiontec CEO, adding that the material "offers long-term UV stability, is fully functional and does not lose any physical characteristics or incur material creep or degradation over time."

The Envisiontec resins are aimed at creating rapid prototypes with mass-production quality on an economic timeframe.

3D Systems continues to develop new resins for its family of SLA systems. In early 2012, the company introduced Accura Sapphire Plastic, a low-ash burnout material targeted to highly detailed casting and master pattern applications such as jewelry. The new formulation, which replaces Accura Amethyst, contains no heavy metal contaminants, is more durable and displays slightly flexible behavior. That last feature allows designers to actually set gemstones into a master pattern, holding them in place during melt-out, so that gems are cast into place without manual handling.

A second SLA resin, 3D Systems' CastPro, is designed for quick-cast processing where the part is dipped into a plaster then burned out, leaving a mold for casting. The material is dimensionally stable over days, making it suitable for creating multiple parts to assemble into large molds, without any swelling from moisture that previously led to tolerance issues.

The entire line of resin materials for the 3D Systems ProJet family has been upgraded and updated over the past 12 months. Buddy Byrum, 3D Systems' vice president, product and channel management, explains how three different platforms are covered by the ProJet brand.

"The 1000 and 1500 Personal Printers use film-transfer imaging—the evolution of the VFlash DLP technology—and there are some significant differences in the way the system operates and materials are presented," Byrum explains. "We developed a whole new range of liquid materials: the five color materials and the Zoom material, which was designed to build at a faster rate, building at over 0.8 in. in an hour." The resulting polypropylene-like parts can be used for snap-fit applications.

The ProJet 3500/5000 professional printers employ multijet modeling (MJM) technology to create wax, acrylate or wax-acrylate blend parts.

At the high end, the 3D Systems ProJet 6000/7000 machines operate with "cross-over" technology—a hybrid of SLA technology. These systems use a different set of VisiJet materials that are epoxy-based (laser-cured) liquids that do not undergo phase change. 3D System's acquisition of the Huntsman RenShape material line led to the development of a new VisiJet Black ABS-like material—and in June, the VisiJet Clear Plastic material was Class VI (medically) certified.

• **Powders**: Supporting the LS world, CRP Technology of Modena, Italy, opened a US office in South Carolina, the de facto home of NASCAR racing. The expansion made sense, putting this materials-development company spot-on for some of its most demanding customers of end-use parts.

3D color-printed topological map showing the rock formation (the remains of a volcano) called "Arthur's Seat" in Holyrood Park in the center of Edinburgh, Scotland. Created in full color from paper stock and proprietary inks on the new Matrix IRIS system from Mcor Technologies. *Image courtesy Mcor Technologies.*

Recently, CRP Technology updated its Windform line of high-temperature, high-strength composite plastics to include GT (slightly flexible, incorporating polyamide fiberglass), XT 2.0 (carbon microfiber), and LX 2.0 (mineral fiber). Parts made from the latter two materials were featured in the June Le Mans invitational performance of the DeltaWing racecar. Just announced is Windform SP, a black composite-polyamide, carbon-filled material with waterproof properties and increased resistance to shock, vibration and deformation.

Advanced Laser Materials (ALM) markets and formulates more than 40 custom powdered plastics for LS systems. By blending nylons with additives such as aluminum, carbon fibers, hollow glass spheres and even copper (for heat-conductive molds), the company tailors materials to exhibit specific properties. Flow rate, heat deflection and z-direction adhesion are all affected by viscosity, filler content and particle size distribution. Neil Lehman, ALM vice president, marketing and commercial development, says the company's latest materials are the glass-filled nylons PA 816-GS and PA 840-GSL.

• **Droplets/Extrusions**: For the 3D Systems ProJet 3500 and 5000 models, the wax, acrylate and wax-acrylate-blend VisiJet MJM materials are all considered "phase-change" materials—solid at room-temperature and liquid when heated for jetting. The jetted "dots" do not spread, and no UV curing is necessary, so the parts retain sharp features for modeling and casting. New plastics in the past year are VisiJet Crystal, Stoneplast, EX200 and MP200, all of which have Class VI medical certification.

In July, Solidscape, a Stratasys company, announced its 3ZMODEL organic build compound with wax-like properties and 3ZSUPPORT wax support. Both materials are

Internal cooling-channel detail on a metal part built on an EOS DMLS system. *Image courtesy Morris Technologies.*

stronger and more durable than their predecessors, and are targeted for use in the new Solidscape 3ZPRO one-touch printer (still based on the company's drop-on-demand thermoplastic ink-jetting process). Solidscape says the advanced materials, primarily for jewelry and dental applications, produce no-ash/no-shrinkage wax patterns that are easier to work with, while retaining the precision and characteristics required for investment casting. 3ZMODEL offers a 50% strength improvement over previous generations. Both non-toxic materials come in color-coded and shaped solid "crayon" sticks for easy loading into the new printer.

Of course, all systems from parent company Stratasys build fused-deposition modeling (FDM) parts from extruded ABSplus plastic, but this year's efforts have focused on offering new systems (such as the Mojo personal printer) and new partnerships. As an example of the latter activity, Stratasys is working with Oak Ridge National Laboratory to develop carbon-fiber reinforced FDM plastics to reduce commercial aircraft weight, and therefore fuel consumption; one project targets the design of an aircraft access-door.

Metals and Ceramics

The Ex One Co. is one of the early licensees of MIT's 3D printing (ink-jet) process, adapting the technology for use with powdered metals and ceramics. Historically a rather low-key player, the company says it is now aggressively introducing new materials, and working on adding additional binder resins (besides its current furan) that will work with silica sand for cores and castings, including a phenolic and an inorganic binder. A new ceramic material will also be compatible with all three, and new metal materials are coming in support of the ExOne M-Flex printer.

"Customers need to be sure that the 3DP materials will compare favorably with parts that are machined or cast," says Ex One CTO Rick Lucas. "Because of this, Ex One is establishing a new materials laboratory (Ex MaL) to be one of the premier 3D printing materials research, printing, processing and testing laboratories in the world."

For parts made on EOS metal LS systems, besides the newer use of precious metals, some of the recent activity centers on the ability to create parts with variable porosity. For a knee replacement, adding a porous, base transitional structure (a tibial tray) aids in osseointegration, or bone ingrowth. Mechanically, large pores provide stress transfer, while small pores help with initial fixation; medically, the pores provide a large surface area that can be coated with a bioabsorbable bone-growth stimulant.

Morris Technologies, the largest service bureau of EOS systems, continues its work with pure and alloy versions of such metals as titanium, aluminum, stainless steel and the alloy cobalt-chrome (Co-Cr). It is developing copper alloys per customer requests. The heat transfer properties of copper alloys make them attractive; also near-net shape parts could be electrical discharge machined (EDMed) for electronics use. Another newer offering is Hastelloy X, a trademarked, nickel-based alloy known for its high-oxidation resistance.

A recent entrant in this industry, Viridis3D (co-founded in 2010), combines the expertise of original developers of processes at ZCorp (now a 3D Systems company) and Specific Surface (another of the MIT 3D-printer licensees).

Row, Row Your AM Boat

Not all progress comes from big-name companies. In a great thinking-outside-the-box story this summer, a University of Washington student club called the Washington Open Object Fabricators (WOOF) recycled, melted and extruded milk jugs into a 7-ft.-long boat, using a university custom 3D printer. The goal was to compete in the annual Milk Carton Derby in Green Lake, Seattle. Speaking to Phys.org, faculty adviser Mark Ganter, UW professor of mechanical engineering, said that printing a boat "was a historic first."

"Frankly, milk jug material is an awful material to work with," Ganter said. "It shrinks, it curls, it doesn't want to stick to itself. Overcoming all those parts of the problem was part of the achievement."

Not knowing how to handle this unexpected take on recycled cartons, contest judges decided to list the boat as an "unofficial entry in the adult open category;" it took second place in the race.

—PJW

INFO ➜ **3D Systems:** 3DSystems.com

➜ **Advanced Laser Materials:** ALM-LLC.com

➜ **CRP Technology:** Windform.it

➜ **Envisiontec:** Envisiontec.com

➜ **EOS:** EOS.info

➜ **Ex One:** ExOne.com

➜ **Figulo:** Figulo.com

➜ **Mcor Technologies:** McorTechnologies.com

➜ **Morris Technologies:** MorrisTech.com

➜ **National Additive Manufacturing Innovation Initiative:** NAMII.org

➜ **Objet Geometries:** Objet.com

➜ **Organovo:** Organovo.com

➜ **Rapid Prototyping & Manufacturing:** RPPlusM.com

➜ **Solidscape:** Solid-scape.com

➜ **Stratasys:** Stratasys.com

➜ **Viridis3D:** Visidis3D.com

➜ **Wohlers Associates:** WohlersAssociates.com

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

Viridis3D sells materials, 3D printing machines, software, scanners and training to help customers deploy functional 3D printed solutions for metal casting, ceramic applications and composites. They currently develop and market materials for sand-casting molds and cores as well as ceramic shells, including ViriShell alumina/silica ceramic, and have already spun off a custom ceramic manufacturing company called Figulo.

Paper/Organic Materials

Full-color-printed paper now counts as an AM material, thanks to Mcor Technologies. The company continues to build on its low-cost, office-friendly systems (using ordinary copy paper and water-based adhesives) with the Mcor IRIS, a full-color 3D printing system that works on the same principle as the earlier Matrix 300. However, the IRIS system produces photorealistic parts by using specialized Mcor inks (at up to 600 dpi) to preprint the appropriate image-layer on each sheet of paper before it is fed into the build/trim chamber. At press time, Mcor Technologies expected to market the color system before the end of the year.

Touching on the realm of bio-printed materials, Envisiontec's Bioplotter can fabricate scaffolds—for example, out of jetted soft hydrogels (such as collagen and alginate) for tissue engineering and controlled-drug-release structures, while Organovo's Novogen MMX outputs patient-specific bioink spheroids onto a biopaper hydrogel to form each layer. In the latter process, when the object is complete, the biopaper slowly dissolves away and the bioink spheroids fuse together into living tissue.

Many other relevant bio-printed projects are also under way, such as the dynamic optical projection stereolithography (DOPsL) system at the University of California San Diego.

National News

The pilot institute of the National Additive Manufacturing Innovation Initiative (NAMII) in Youngstown, OH, is now official, under the direction of the National Center for Defense Manufacturing and Machining—and should really boost the development and understanding of AM materials. Members come from industry, research universities, workforce development groups, non-profits and professional associations. They will be focusing on applied research, bridging that critical gap between basic research and mature development work.

Clark Patterson is a special operations manager at service bureau Rapid Prototyping & Manufacturing, one of the industry members of the NAMII team. Regarding materials development, he says "AM metals have been done very well, but polymers are lacking in real development of commercial materials, especially where we have aerospace applications."

Patterson says per discussions with NASA and other groups,

Plastic Durability Comparison

Perhaps the top question from prospective buyers is how durable AM-built end-use parts are. To shed light on the answer, Vista Technologies, a Minnesota service bureau operating Objet and Stratasys equipment, had an independent laboratory test and rank various properties of the eight most commonly requested materials, per their 2,000+ customers: SLS Duraform, SLS Duraform GF, SLA Accura60, SLA Accura Xtreme, FDM Polycarbonate, FDM ABS, Objet Vero White Plus and Objet Krypton Green.

Results are posted online (Vistatek.com/Plastic_Prototype_Material_Test.html), and include parameters such as surface finish, soft durometer, heat deflection and tolerance.

—PJW

his company is currently working on carbon-fiber/carbon-nanotube-reinforced materials—primarily for FDM use, because that technology is suited to accommodating long-fibers. Thermoplastic polyamides and PolyEtherEtherKetones (PEEKs) are attractive materials for more development due to the "Big 3" properties of strength, heat resistance and chemical resistance, though radiation shielding is another topic of interest.

Although material standards are still in their infancy (ASTM Subcommittee 42 received approval in January for its first material standard for powder-bed fusion of Ti6Al4V), that fact certainly hasn't slowed material innovation. And, remember—this article has just touched on new developments; don't forget about such awesome "old" materials as the LS thermoplastic powder TP 210 for creating rubber-like parts.

Soon the variety of materials will have Elton John asking for samples. **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.*

SPOTLIGHT

Directing your search to the companies that have what you need.

With Liberty and Optimization for All

Altair Engineering's SolidThinking Inspire 9.0 simplifies the quest for optimal geometry.

BY KENNETH WONG

If you're involved in analysis, you're already engaged in design optimization. After all, the reason you're running stress analysis on your computer chassis is to identify the right thickness for its walls. If you overdesign it to beef up durability, you add weight to the unit, making it cumbersome to deploy and operate. If you skimp on material, the unit breaks at the first accidental collision with a hard surface. The search for the correct thickness is, in a manner of speaking, the quest for optimal design.

The current process is to build the geometry, analyze it, refine the geometry, analyze it again—and it goes on until the designers and engineers are satisfied that they've reached the best design. But a new, emerging workflow could replace the current cycle with a shorter one, by relying on the software to identify the best shape for your design. Altair Engineering's SolidThinking Inspire, a companion to SolidThinking Evolve (reviewed in *DE's* October issue), exemplifies such a workflow.

Modeling Tools

Whereas SolidThinking Evolve is a non-uniform rational basis spline (NURBS) modeler intended for building complex surfaces using splines, SolidThinking Inspire aims to help you analyze your design and identify the best possible shape, based on your design criteria. (Author's note: For this review, Inspire 9.0 Beta code was used.) That doesn't mean Inspire is completely devoid of modeling tools, however. It comes with a collection of 2D sketching and 3D modeling commands.

In 2D, the lines and arcs behave as they should in top-of-the-line parametric drafting programs. When you move your center points and connected corners in the drawing, you'll notice that nearby elements adjust themselves to preserve their parametric relationships with the changing geometry. In 3D modeling, you build geometry mostly through Boolean operations and extrusions. Though they're not as comprehensive as the modeling tools you'd find in a standard mechanical CAD modeler, Inspire's tools are sufficient for creating shapes to represent a design's geometric volume, or to prepare imported models for optimization.

To those unfamiliar with it, optimization may seem like a mystical art practiced by digital alchemists. But Inspire simplifies the process to the point where it's much easier than, say, a typical computational fluid dynamics (CFD) job. The optimization process begins just like an analysis session. You open your design, isolate the region you'd like to study, and specify the material.

The preloaded material database in Inspire 9.0 Beta is limited. Andrew Bartels, Altair's program manager for Inspire, explains: "We'll add a few more [material types] before we release 9.0, including a few plastics. If a material you'd like to use isn't listed, it is easy to add it to Inspire by selecting the My Materials tab on the Parts and Materials dialog. We only require E, Nu and Rho of the material. If your model is completely made out of plastic or steel or aluminum, it doesn't really matter what material you use for the optimization as the load paths won't change. If you have steel bosses in plastic parts, it is important to understand your materials, as the load paths will change between the two dissimilar materials."

The Draw Directions & Shape Controls

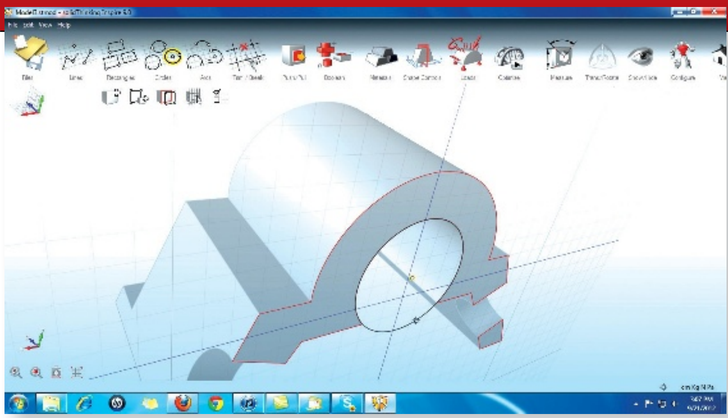
One step required for Inspire's optimization that you don't need in analysis is specifying a draw direction. Simply put, the draw direction defines the manner in which your part will be built. For example, for a part intended to be injection-molded in two halves, you'd use a split draw direction with a plane located at the center. A part to be built by stamping, on the other hand, requires a different type of draw direction. The draw direction affects how the software calculates the optimized shape, so the result displayed is different when you alter the draw direction.

If you don't specify any shape control preferences, Inspire shows results based on the exact distribution of forces. This often produces a shape that's asymmetrical. Because most manufactured designs contain symmetry (both for aesthetics as well as easy production), you may specify if you'd like Inspire to mediate the results into symmetrical features.

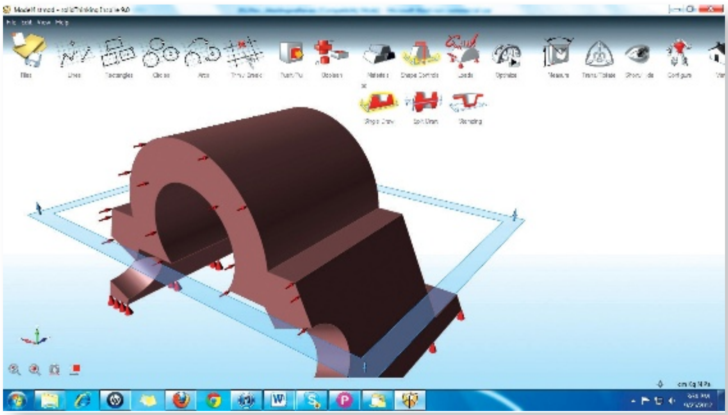
Time to Optimize

The remaining steps in optimization with Inspire are almost identical to typical steps analysis. You specify loads, pressures and torques on surfaces where you want to simulate impact or forces. Then you specify the surfaces or points where you expect the part to be fixed or mounted. Once these inputs are in order, you have all the essentials for an optimization study.

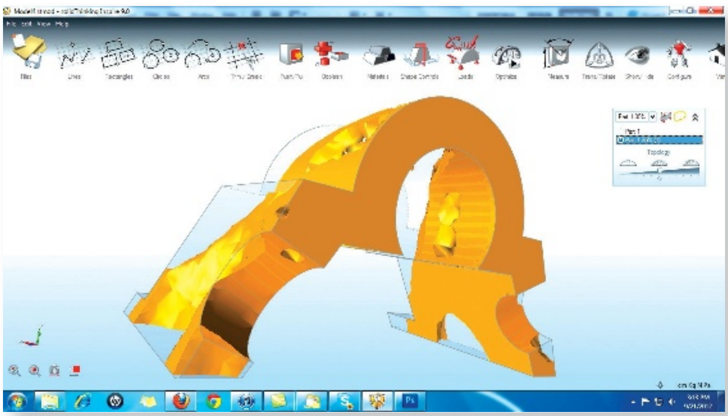
The optimization dialog box gives you a way to choose your



Altair Engineering's Inspire comes with some modeling and sketching tools, but its primary aim is design optimization.



The optimization process is similar to analysis. Required inputs include loads, pressures and fixtures. The extra step is specifying a draw direction, as shown here.



The optimization results show where you should add more material, and where you may trim to counteract the concentration of loads.

target mass reduction by percentages. This allows you to consider, for instance, how you might redesign a mounting bracket or chassis with 30% less material. In many cases, weight or mass is a critical consideration for optimization, as lowering weight can reduce cost in material acquisition, manufacturing and transportation.

Once completed, Inspire reveals where you should place a concentration of materials to counteract the loads and stresses you've specified. This optimized shape (which can resemble a mesh model of an earthquake-ravaged region) serves as guidance for you to refine your geometry.

You can view the results as a mesh model overlaid on a transparent model of your original design, which gives you clear guidance on where to trim materials and where to reinforce. The interactive display allows you to use a drag bar to see a possible material reduction strategy in increments. The results can be exported directly to Evolve for model refinement, or exported as a mesh model readable in your preferred CAD program for the same purpose.

Asking Different Questions

Software-driven optimization is certainly not a substitute for good design judgment and engineering instincts. Nevertheless, with increased computing power and sophistication in simulation algorithms, it makes sense to rely on software to do the heaviest number crunching and show you the force distribution in micro details. The software-generated results can shepherd your design toward directions you've not considered previously (because some force concentration in asymmetrical designs may not be intuitive); they may also confirm what you've always suspected.

Running a stress analysis is, in essence, asking the question "How will my part break?" in a language the computer can understand. By the same token, running optimization amounts to asking "How do I redesign the part so it won't break?"

Altair Engineering's Inspire makes it easy not only to ask such questions, but also to understand the answer produced by the computer. DE

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Weigh Approaches to Test **Instrumentation**

Designers can customize how their test systems operate by modifying embedded software or by customizing the equipment itself.

BY DEBBIE SNIDERMAN

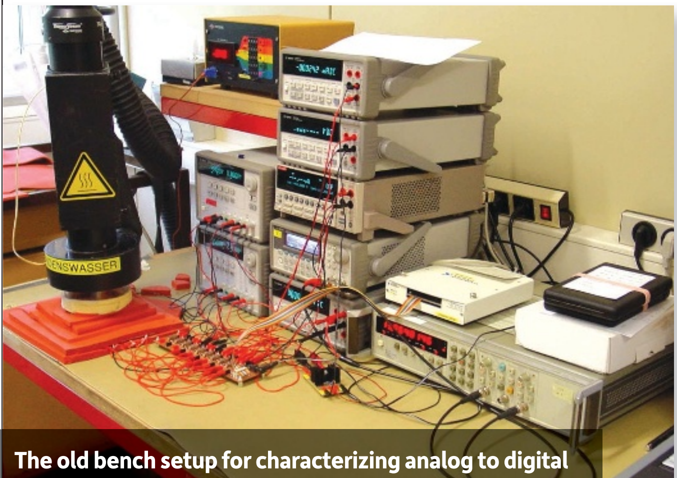
Test system architectures, independent of the instrumentations, consist of three main technologies: a piece of hardware that acquires a signal, a signal processor, and integrated circuits designed to be configured by a customer or a designer after manufacturing. The signal processor operates partly through embedded software existing within the test equipment hardware, and partly through field-programmable gate arrays (FPGAs). This approach is common across industries—all types of test equipment use the same building blocks.

Test equipment is offered in different form factors—broken down into modules, benchtop, automated and embedded—to better fit a designer's need. If a designer is debugging an electrical system and needs a quick scope measurement for rapid insight on the design, a benchtop form factor fits well. But if a designer needs to make a custom measurement with application-specific or proprietary protocols, customizable test equipment will fit better.

Degree of Customization is Important

Jean Manuel Dassonville, modular solutions outbound manager at Agilent Technologies, discusses some of the benefits and weaknesses of each approach.

"Embedded software is usually flexible, but isn't fast enough to do signal processing in real time," he explains. "Real-time processing needs an execution engine and a signal processing agent that is very fast. FPGAs can perform very high speed signal processing, but they have a limited number of agents. Processing signals with sophisticated algorithms may not fit within the constrained space of an FPGA, and you have to rely on software that has much more space to fit in.



The old bench setup for characterizing analog to digital converters, a form of integrated circuit testing.

"Instrumentation has always involved a compromise between the speed of the measurement and the depth of the insight," Dassonville continues. "You can use FPGAs for basic processing, and they're fast, but it's hard to accomplish accurate measurements or very complex processing."

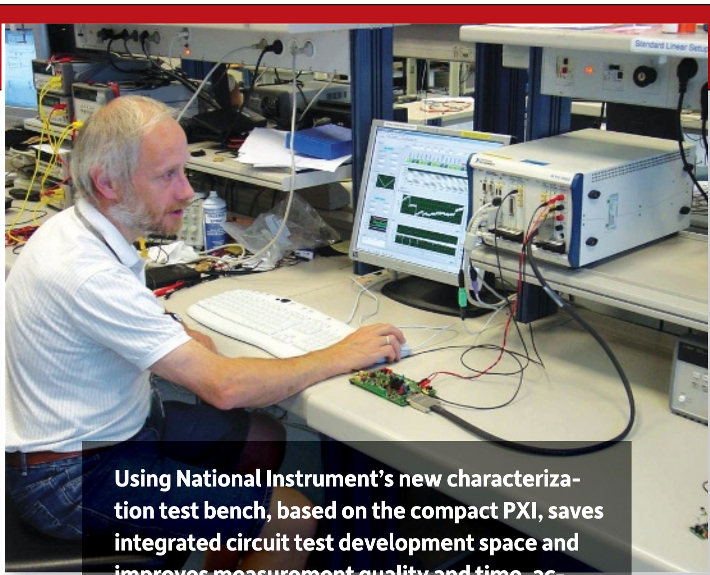
Dassonville maintains that of the three ways to make a measurement, the best quality will come from hardware that was designed to make the measurement. The only downside is that there is limited flexibility there. Using software to make the measurement gives you flexibility, but on the other hand, it can only process the signal that has been given by the hardware—"so if the signal isn't good, the measurement quality isn't either," he says. As for the third option, FPGA? "It's somewhere in-between," Dassonville says.

Dassonville says it's important to consider more than one dimension: Is the product modular? Is the software customizable? Both factors are important.

"It is possible to have a benchtop tester that is customizable, depending on the different degrees of flexibility that are enabled," he says. "While one trend in the market is moving toward modularity, it's not at the expense of benchtops. Not everyone needs customization. There are many applications that require quick measurements made ASAP. It's not one against the other. Some are customizable, and others are less customizable."

Testing equipment vendors may not know the specifications of customers who deal with proprietary information, such as communication signals in military applications or signals that are defined with confidential specifications.

"Testing tools need to provide a degree of customization so engineers will be able to build test equipment to fit their needs," Dassonville says. "Modularity brings flexibility, so you can customize equipment by putting modules to-



Using National Instrument's new characterization test bench, based on the compact PXI, saves integrated circuit test development space and improves measurement quality and time, according to the company.

gether. But software customization is a complementary way to go even further, making sure that your test equipment fits the measurements you need to perform. Customers combine both by testing with hardware bricks that are modular, then customizing the software."

The ability to customize measurements has existed for a long time. But Dassonville points out that there are more ways to customize today—with room to grow.

"We are seeing a proliferation of standards in the RF, computing and interconnect testing space, fragmenting the types of testing technologies used in the world," he says. "There is a large market force driving our need to build testing equipment."

Moving Toward Open Source

Luke Schreier, senior group manager for automated test at National Instruments, says we're moving away from the 40- to 50-year-old testing instrumentation paradigm—a vendor's view of how a problem should be solved—to a new, user-defined view. This new approach allows users to take reconfigured hardware and software packages and find the one that works best for them.

Schreier says some customers may not be ready for this new level of empowerment, and prefer the traditional vendor-defined view of the world. They know what they're going to get: the warrantied, calibrated-signal instrument to which they're accustomed. But while National provides this out-of-the-box traditional experience, Schreier says his company also allows users to "see every ounce of the software that runs on the instrument. All of the firmware is written in LabVIEW System Design Software and is open, so users can change it. Providing access to all of an instrument's inner workings allows customers who aren't doing something conventional to develop their own algorithms."

An example of a customer who embraces this testing paradigm is someone who needs a relative calibration reference instead of a calibration to a standard that doesn't mean much in real-time.

The industry is responding to both groups. Traditional-use cases can be solved in this new paradigm. And for those who think the idea is good, but the customization sounds complicated, Schreier says the LabVIEW community has a huge user base—and more than 26 years of data acquisition and complex automation design experience upon which to draw.

The industry is shifting its approach to software, making it as open for the user as possible, without needing vast domain knowledge in programming. Schreier says National takes the concept a step further, allowing users to program not only the software specific to their application on a PC connected to one of the instruments, but to write software that is on the instrument itself, reprogramming how the instrument works.

National is pushing the concept of allowing the user as much access to the software as possible, whether it resides on the host PC with which users are already comfortable, or on the instrument itself. By programming FGPAs inside, one piece of testing hardware could work in vector signal analyzer mode, in generator mode, or in a real-time streaming processing model.

This mode changes the nature of support, as well as the relationship between the customer and the vendor.

"After 36 years of supporting LabVIEW software, we have rigorous training and certification programs for customers to become well-versed in the tool," says Schreier. "Customers can consult with not only a community of peers using the tools, but also consultants with expertise when custom development is desired. Once you modify the instrument, and take more ownership of the IP, you become the expert. You can always reload the original files that shipped with the instrument, and return to the original state. But, the more customization you make, the less advice we can give about how it should work. Since it's written in LabVIEW, there are many people that can serve, support and add value to your customized code."

National's new Vector Signal Transceiver is the first combination of a calibrated instrumentation grade front end with a programmable FGPA. Schreier says there is a lot of interest from semiconductor and mobile chipset markets, among others, and customers have embraced how they are able to characterize 802.11 wireless LAN chipsets quicker and more efficiently using this open source approach.

Debbie Sniderman *is an engineer, writer and consultant in manufacturing and R&D. Contact her at VIVLLC.com.*

INFO ➜ Agilent PXI Products: http://goo.gl/OE7RB

➜ **National Instruments Video: "101 Things You Can Do With a Software-Designed Instrument":** http://goo.gl/EKLEx

➜ **National Instruments Video: "Introduction to the World's First Vector Signal Transceiver":** http://goo.gl/6MnT2

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Your CAD Software: *Coming to a Browser Near You*

Online CAD is inevitable, but many issues remain unresolved.

BY KENNETH WONG

Some think it's a premature idea, a risky experiment. Others believe it's the way of the future. I'm talking about CAD in the cloud—using a professional design program installed on a remote server through the web.

The proposition is attractive to many for one simple reason: convenience. If you can remotely run a CAD program, you're no longer confined to your desk, no longer chained to your dedicated workstation. Your iPad, your Android phone, your game console—anything can be your design device.

The widespread availability of high-bandwidth connections and the popularity of mobile devices open a door that was previously shut. Funny thing about an open door—it often admits uninvited guests. The optimism raised by cloud-hosted CAD is also shrouded in uncertainties about security, intellectual property (IP) control and licensing issues.

Cloud in the Hot Seat

At the SolidWorks World 2010 conference, SolidWorks delivered a series of teasers from the main stage, demonstrating how its technology might work in the future. Among the previews was a version of its flagship CAD software running in a browser.

The notable event catapulted cloud-hosted CAD into the blogosphere, with some users vehemently rejecting the idea. Brian Benton, CAD blogger (CAD-a-Blog.com), author and trainer, offered some clues to users' concerns.

"The biggest concern is the loss of control of the software," he remarked. "What if the software provider updates the software and it breaks? … I can't roll the update back. I can't even test it before I implement it companywide."

At the recent press event launching SolidWorks 2013, I asked SolidWorks' new R&D vice president, Gian Paolo Bassi, for his prognostics on cloud-hosted CAD.

"It's not a premature idea," he said. "A lot can be achieved in the cloud: for example, to realize the dream of predictive computing. So you can do things in the background that helps you design—analysis, rendering ... There's also the scale factor that's possible in the cloud [adding more computing cores to address a larger job]."

But Bassi held back when it came to designing from a remote client: "As for interactive modeling in the cloud, I believe it's still far away in the future," he said. "Latency is still a problem. I don't think it's possible in the next two to three years."

The Online-Offline Hybrid Mode

If having to rely solely on a workstation to run CAD is a handicap, perhaps having to rely on a live Internet connection to work with CAD models is a disadvantage as well. The remedy, some propose, is to give users the option to work both online and offline—through automatic license detecting and data caches.

Fabien Fedida, Dassault Systèmes' senior director of Global Offer Strategy, notes that with his company's CATIA V6 product, a designer working at home can access the 3D design and all product lifecycle management (PLM) data on the cloud—or in the office—with a web connection, and can directly refine the 3D design by streaming up and down only what is necessary.

"While this assumes that you still have a V6-rich client installed on the laptop, we have already removed one big barrier to the holy grail of fully web-enabled design: the very important prerequisite of moving to the cloud's powerful CAD capabilities," he adds.

Paul Brown, NX marketing director with Siemens PLM Software, notes that Siemens had customers using the private cloud—remotely hosting NX and accessing it and data over the network—since before the term "cloud" was coined.

"Siemens also supports the concepts of take-home licensing," Brown says, noting that while software is loaded locally, users "check licenses and data out of a central vault and can then disconnect from the network and work remotely. When they sign back online, those users can again check the licenses and data back into that central vault. This is especially useful when dealing with countries and regions where the network infrastructure and bandwidth is still in growth mode."

A Twitch-y Start

In September 2009, Autodesk launched a program to let people test-drive some of its software titles: AutoCAD, Autodesk Inventor, Autodesk Revit and Autodesk Maya. The company has been providing downloadable trial versions of the same titles, but the 2009 initiative, dubbed Project Twitch, was different. It allowed people to try out the software over the Internet.

To run a software title listed on Twitch, you needed to install a client app, much smaller than the full-scale trial installation. The desktop client served as the door to software installed elsewhere. In essence, Twitch participants were running Autodesk Inventor without installing the software on their desktops.

In the beginning, Autodesk limited the Twitch experience to people located within 1,000 miles of its data center, equipped with fast machines connected at 5MB per second. Even so, the initial experience was at times frustrating. The infrastructure could only support 50 simultaneous users at a time, leading to unexpected session terminations. The Twitch experiment ended in August 2011.

"We have taken what we have learned during the technology preview and applied it to running an AutoCAD LT trial remotely," wrote Autodesk. Instead of activating AutoCAD LT from the desktop using a license file, you launch the software by logging into the software with a name and a password.

"[Twitch] leverages the Amazon cloud," explains Amy Bunszel, vice president of AutoCAD products. "It scales pretty well with Amazon infrastructure."

For example, Bunszel offers, when one user is idle online, the cloud resources are redistributed to other users. Even so, users work within their own AutoCAD LT sessions, just like they do in desktop instances.

The Borderless Office

Reinventing itself as a company with lighter, nimbler design and data management apps, PTC began repackaging its flagship all-in-one product Pro/ENGINEER into a series of Creo modules in late 2010. Currently in Creo 2.0, the suite lets you choose modules that perform specific functions: Creo Direct for direct editing, Creo View for viewing and markup, or Creo Parametric for history-based editing, to name but a few.

"Engineers graduating from Stanford or MIT today, they demand to be disconnected [from the physical office]," observes Mike Campbell, PTC's divisional general manager of CAD. "They want to work wherever and whenever they want. They won't sit in a cubicle or an office."

Some PTC customers are using Creo apps hosted on private clouds using technology from Citrix , Campbell revealed. "We are working on optimizing, improving and certifying different configurations of remote-access software to work with our Creo suite," he says. "They'll be done by Creo 3.0's timeframe."

In its R&D labs, PTC is experimenting with the idea of batch computing in the cloud.

Workstation-Installed CAD vs. Cloud-Hosted CAD

Workstation-Installed CAD	Cloud-Hosted CAD
• User has full control over software.	• Software provider has more control over the software.
• Upfront cost of the hardware could be significant.	• The cost of subscription is low, but could add up over time.
• User is responsible for hardware upgrades and maintenance.	• Software vendor is responsible for hardware upgrades and maintenance.
• When running on a sufficiently powerful machine, there's no delay in the software's responses to user commands.	• Depending on the bandwidth of the client-to-server connection, there could be delay in software's responses to user commands.
• Software user is responsible for data security.	• Where cloud-hosted storage option is provided, service provider is responsible for data security.
• User has full access to the software at all times.	• User relies on software provider to keep the system up and running 24/7.
• Available computing power is limited to what's in the machine	• Computing power is scalable for larger jobs that require more cores.
• User is vulnerable to hardware crashes.	• User is vulnerable to unexpected downtimes.

"Say you're running a heavy analysis job. Can you offload that to Amazon servers?" Campbell says. "We're also looking at providing storage solutions in the cloud. All of these are areas of research and evaluation for us."

Issues to Solve

Because most portable devices available today are tablets and smartphones operated primarily by fingertips, cloud-hosted CAD confronts new input mechanisms and new display modes.

"We as vendors have to work out a couple of things," says Autodesk's Bunszel. "The other area is the graphics. We need to make sure you're seeing the same robust model [in a cloud application] as you do on your desktop. Another area we're innovating is the amount of data you pass back and forth. We have to make sure that's the smallest size possible."

Siemens' Brown points out that another issue the cloud poses is "the assumption that cloud and mobile devices are somehow locked together in their usage, and you can't have a cloud approach without a mobile device. That's just not true. While mobile devices have uses in the overall PLM environment, we are not seeing heavy demand for full access to CAx applications. View and markup use is commonplace, but developing a simulation model, complex meshing, etc., isn't realistic with the current state of mobile technology."

On desktop-installed software, the CAD application responds with virtually no delay when a user issues a command. Therefore, any noticeable lag between a user's click and the cloud-hosted application's response could mar the online experience. The trick is to keep the data packets as small as possible so they can be passed back and forth—between the user's device and the hosted app—with no discernible delay in performance.

The Security Hole

"Our customers are very sensitive to the IP captured in their CAD data," says PTC's Campbell. "Frankly, I don't think there are good [cloud security] solutions today. We've got to work on that more before CAD on cloud can go mainstream."

Krunoslav Knezic, owner and CEO of EVOLVE, a product design firm based on Croatia, believes multiplayer online games and social media may help change people's attitude toward cloud security. It changed his.

"I have been researching this option for one of my projects for a new business model," he says. "The basic idea comes from … World of Warcraft."

On security in the cloud, Knezic looks to the new generation's changing attitude as the answer, not technology.

"There are no 100%-secure networks, so if you look what Google does, Facebook does, all that information is out there and literally everyone could get to them, but no one complains," he says. "Maybe now is a good time for new thinking and to point to sharing information and knowledge—open innovation and crowdsourcing could help to make things better and faster, and without fear of stealing ideas."

Advertising Index

The Forecast

Working with remote CAD software is, PTC's Campbell observes, "a natural evolution of the way we work with CAD." The leap from private cloud to public cloud is inevitable, even if it's currently treated with some trepidation.

Autodesk's Bunszel agrees: "Today we're not seeing as much editing in 3D online, but I think it's only a matter of time."

Blogger Benton concludes that, despite his reservations about the cloud-hosted approach, "it is happening. I hope that both a cloud-based and a standalone version [of my preferred CAD software] will always be available. That way, as a user, I get to choose how I use the tools that I need." DE

Kenneth Wong *is* Desktop Engineering's *resident blogger and senior editor. He literally computes in the cloud when traveling on Wi-Fi-enabled flights. Email him at kennethwong@deskeng.com or share your thoughts on this article at deskeng.com/facebook.*

INFO ➜ Autodesk: USA.Autodesk.com

➜ **Dassault Systèmes:** 3DS.com

➜ **PTC:** PTC.com

➜ **Siemens:** PLM.automation.siemens.com/en_us

Fluid-Structure Interaction: Reducing Risk and Predicting Outcomes with Engineering Software

An interview with Gilles Eggenspiele, product manager with ANSYS Software.

BY JIM ROMEO

Fluid Dynamics is a complex discipline that crosses many disciplines—from wind and air movements around structures to blood and plasma interactions in the human body. Gilles Eggenspiele is a senior product manager for Pittsburgh-based ANSYS Inc. *DE* spoke to Eggenspiele to better understand the application of ANSYS products for fluid dynamics modeling and simulation, and how such applications may benefit design engineers in the modeling of fluid systems.

DE: Is the fluid-structure (FSI) interaction a coupling of more than one ANSYS software application?

GE: ANSYS offers fast and accurate fluid and structural simulation tools, as well as an easy-to-use environment to seamlessly connect both physics in an automated workflow.

To perform an FSI simulation with ANSYS, engineers use two physics-dedicated solutions and the ANSYS Workbench environment, which manages all required connections. This allows for all relevant information to be seamlessly passed from one solver to the other.

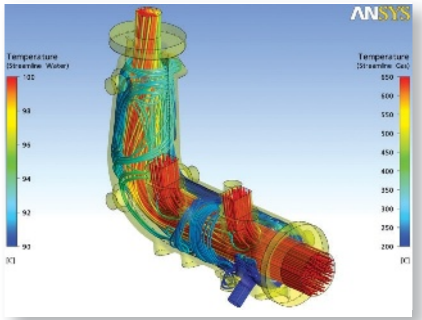
Without ANSYS' accurate and reliable solvers and FSI capabilities, performing an FSI simulation is a complex and time-consuming process. Engineers would have to manually manage different software—often from different providers—as well as the transfer of information from one solver to the other, etc.

DE: Can you offer a few examples of which fluid systems work well with ANSYS Workbench?

GE: ANSYS Workbench is the simulation environment in which engineers can set up fluid simulation using computational fluid dynamics, or CFD, software ANSYS Fluent or ANSYS CFX. Companies all around the world use ANSYS CFD software for a wide range of applications.

One example would be predicting the aerodynamics properties of a car or an aircraft: ANSYS CFD allows those companies to reduce drag—hence, reducing fuel consumption. Other companies use CFD to design high-performance internal combustion engines or to enhance the safety of nuclear reactors. Its multiphase capabilities help engineers design ships that can withstand extreme weather conditions. It is interesting to note that many clients are now also performing design exploration or optimization; they are performing hundreds of simulations automatically thanks to the ANSYS Workbench automatable workflows.

Clients are taking advantage of our CFD software to explore many design possibilities to optimize the performance and robustness of the product. For example, a client recently used data from more than 1,200 separate simulations conducted with ANSYS multiphysics software to replicate the dynamic pressures of a competitive atmosphere in a risk-free virtual environment. These simulations helped engineers address real-world design



concerns, and provided the necessary insight to identify the optimal product design—all while reducing time to market. Physically testing such a large number of design iterations would be nearly impossible.

DE: Is your software routinely used to develop interactive models to predict outcomes and identify risks?

GE: Yes, this is one of the key reasons why engineers use our software. Any time during the simulation process, the user can modify a geometry or operating condition to answer "what if" questions. For example: What if the geometry of the product is changed? What if the product is used under different conditions than anticipated? Using simulation to develop better products is not about analyzing a single design; it's about both interactively and automatically analyzing hundreds of design iterations in many different operating conditions—and ultimately, creating the one that will deliver the best performance. **DE**

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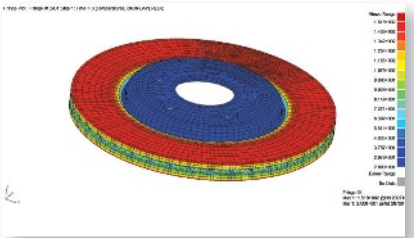
INFO ➜ ANSYS: ANSYS.com

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

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.



MSC Announces New Release of Nastran 2012

High-performance computing and nonlinear analyses focus of 2012.2 release.

MSC consolidated its MSC Nastran and MD (multidisciplinary) Nastran products into one solution. This simplifies matters for MD and MSC Nastran users. Oh, and to boot, it creates a monster-powerful suite for FEA-based analysis and optimization.

Now here comes MSC Nastran 2012.2 with even more performance enhancements reported. For HPC (high-performance computing) productivity, MSC Nastran now takes advantage of Advanced Vector Extensions (AVX) on Intel's Sandy Bridge class processors on Windows platforms. The benefit here is that the AVX instruction set helps speed up numerically intensive applications.

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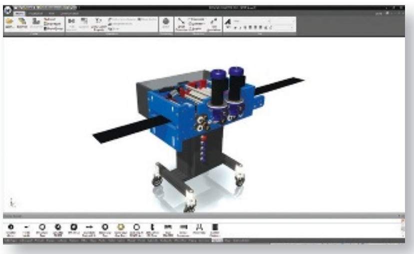

Collaboration Tool Enables Viewing and Configuration

Free enterprise-wide data sharing and data manipulation tool.

IronCAD Compose is a 3D viewer and configuration tool that lets you collaborate, share, manipulate, and configure 3D models and assemblies. Since it's stand-alone, you don't have to be an IronCAD user to leverage it. And since it leverages IronCAD's direct-modeling prowess, the learning curve should be short for everyone who has a stake in a design.

OK, so what can you do with IronCAD Compose? A lot. You can interrogate and measure solid geometry, and you can make changes to a design's structure and assembly. But there's more.

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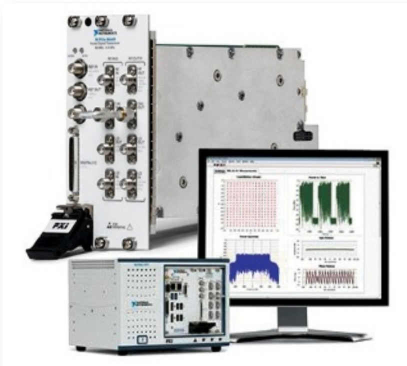

Configurable RF Vector Signal Transceiver

National Instruments unveils a new class of software-designed instrumentation.

At NI Week, National Instruments introduced an RF vector signal transceiver (VST) on a single 3-slot PXI Express modular instrument module for real-time signal processing and control. Designated the NI PXIe-5644R, this device combines a vector signal analyzer and vector signal generator with user-programmable field-programmable gate array (FPGA) architecture at its core. In other words, A) this hardware is software-centric and B) the RF design, testing, and implementation processes are integrated. The world of RF design and testing has never known such a thing.

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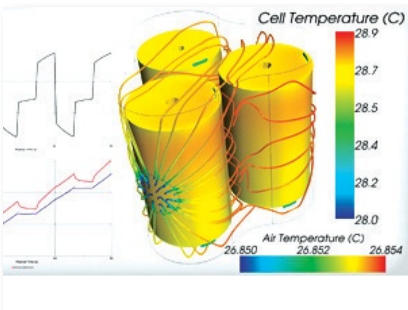

CD-adapco Unveils Lithium-Ion Battery Cell Simulation

Solution targeted at electric vehicle design.

The new STAR-CCM + Battery Simulation Module from CD-adapco is said to let you simulate spirally wound lithium-ion battery cells quickly. "Quickly" is the operative word here, since this sort of analysis has been anything but fleet.

In short, what the STAR-CCM + Battery Simulation Module does for you is bring together extensive domain expertise in an integrated multi-physics environment. That means you can simulate the flow, thermal, and electrochemical phenomena that made previous analyses of spirally wound lithium-ion cells aggressively difficult to perform.

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