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Degrees of Freedom

by Steve Robbins

Infinite computing sums up future technologies

Cloud computing, grid computing, CPUs, GPUs, gigaflops, teraflops, petaflops, exaflops, multicore, parallel computing … and on and on. I attended the SC10 event recently in New Orleans, then home for Thanksgiving, and right back to Las Vegas the following Monday to attend Autodesk University. It was a whirlwind of acronyms and amazing technologies.

Infinite computing for engineers will change the way we think and work.

The supercomputing show was great, but mind-boggling. Workstations are becoming supercomputers. The Top 500 world's fastest computers were announced to coincide with the show. The Chinese Tianhe-1A system at the National Supercomputer Center in Tianjin is numero uno, achieving a performance level of 2.57 petaflop/s (quadrillions of calculations per second). It seems only yesterday that everyone was so excited by achieving teraflop status. There was a lot of great hardware there, and some of it will be arriving on engineers' desks this coming year. Local clusters are a reality. I saw an unmanaged, 8-port, InfinaBand switch that is just made for workstation clusters. And for really screaming performance, rip out the hard drive and add a new solid-state drive.

Supercomputing Advantages

There are real advantages to local supercomputing within your workgroup: no scheduling time on the data center, no hassles with the network administrator, and no special power or cooling requirements. All you need to do is get the OK for the equipment, which you have most of anyway, and off you go. Of course, getting all of your applications to work together in a multicore environment can be a pain, but setting up these clusters is getting easier. We'll be reporting more on cluster setups in the near future.

But the really big subject on everyone's agenda was cloud computing. If you go to Wikipedia, the definition for cloud computing is, "Internet-based computing, whereby shared servers provide resources, software, and data to computers and other devices on demand, as with the electricity grid." That sounds so '80s, like we are going back to the client-server days. And, in many of our discussions with vendors at SC10, the definition of cloud computing was very cloudy indeed. One vendor was demonstrating the compute power of a data center in two racks, including storage. But no doubt about it, cloud computing is the biggest news happening this year, and it's changing the world as we know it.

Computing Gets Infinite

Let's move on to Autodesk University. During AU, the trade press had an opportunity to meet with Carl Bass, Autodesk's CEO. It was a question-and-answer format. Of course, one of the first questions was about how Autodesk will be using "the cloud." This is when it all came together. Carl started to explain how compute resources becoming available to engineers has become infinite. He used the term "infinite computing." Wow. This makes so much more sense than "the cloud." This means an engineer can scale a visualization or simulation to the outcome desired, not by what resources are available. And the cost? $0.037 per core per hour.

Bass used a great example: An engineer doing a structural analysis of a part or assembly could schedule 15 different scenarios from their workstation to cores on Amazon.com or Verizon, then go to lunch. Upon their return, the results will be waiting and the application software will have tagged the three that are the best outcomes. The engineer can decide which action to take for the design.

Infinite computing for engineers will change the way we think and work. Infinite computing is local and remote. At the same time, engineering software is catching up with the power of computers. Together they will change our world. **DE**

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

DE January 2011 VOLUME 16/ISSUE 5

SPECIAL FOCUS

Engineering for the Environment

ON THE COVER: Engineers use technology to create the products that drive sustainability.
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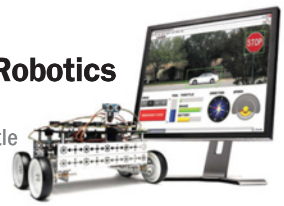

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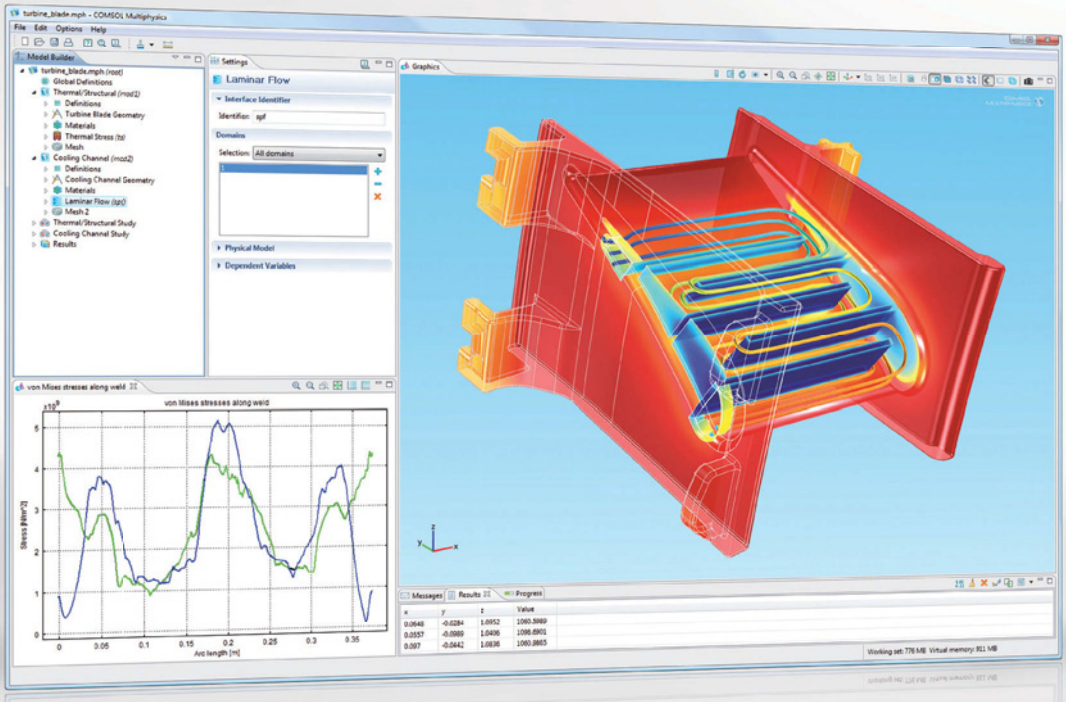

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Answers for industry.

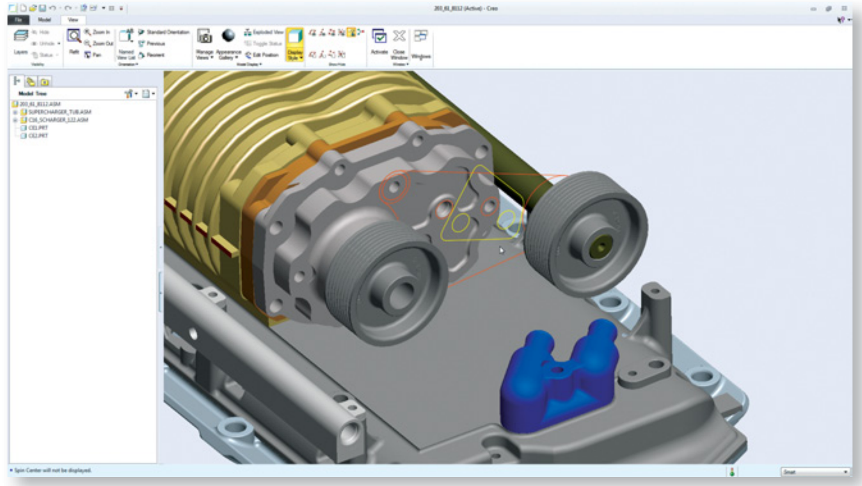
SIEMENS

by Kenneth Wong

PTC Unveiled its 20-Year Vision: PTC Creo

Since mid-2010, PTC had been in a stealth mode, giving away teasers about its Project Lightning but keeping its details under wrap. Last October, Lightning struck, bringing in a season of change with a significant reshuffling of the company's major brands. On the way out are three household names: Pro/ENGINEER, CoCreate, and ProductView. They're to be replaced by Creo Elements/Pro, Creo Elements/Direct, and Creo Elements/View.

Creo represents "PTC's vision for the next 20 years of mechanical design," said Brian Shepherd, PTC's executive vice president of product development. Instead of a single software platform, Creo is "a suite of interoperable, role-specific applications designed from the ground up to be an open system," he added.



PTC Creo, the product family that'll become the company's new vision, comprises of a series of AnyRole Apps, applications tailored for specific tasks.

PTC Creo, Marked for Mid-2011

The first phase of PTC Lightning is a simple renaming of its products, effective immediately. This is to be followed by the release of Creo 1.0, scheduled for the middle of 2011, followed by Creo 2.0. Creo is not an all-encompassing "big, gigantic, monolithic product," Shepherd said. It's to serve as a platform, upon which user can add on AnyRole apps (apps suitable for individual roles).

Creo will use a new data model as its native format, allowing parametric and direct geometry to be exchanged. Creo will allow what PTC calls Any-Mode modeling, to accommodate both parametric and direct modeling methods. Creo is expected to support both Pro/E and CoCreate models as customers gradually migrate to the new apps.

The interface for Creo will look like neither Pro/E nor CoCreate, explained Shepherd. In fact, Creo's interface may look different from user to user, based on the role he or she has chosen. Accordingly, available Creo apps will vary in price, ranging from premium pricing to free, based on its complexity or simplicity. Available apps will include dedicated 2D modeling, subdivision modeling, rendering, numeric controlled machining, simulation, visualization and markup, among others.

One area that PTC felt has always been neglected is assembly management, or (to be more precise) configuration management. With Creo, you'll be able to record, chart out, and manage different product configurations in a flowchart-like interface. PTC also plans to let Creo users interact with different geometry created in other programs by converting them to a Creo-adoptable format.

App Developers Wanted

To foster a large Creo ecosystem, PTC plans to offer its development partners access to Creo's common data model and app templates, allowing them to develop and offer Creo-like apps targeted at specific industries and markets beyond PTC's core expertise. It's not yet clear how PTC plans to distribute these applications or how much they'll be licensed for.

PTC's Creo product suite is a major shakeup for the company itself. For the past two decades, PTC has been a fervent champion of parametric modeling, or history-based modeling. The company is, in fact, credited with being a parametric pioneer. But its acquisition of CoCreate, a direct modeling CAD software, opened its eyes to new possibilities, admitted Heppelmann.

As newcomers like SpaceClaim grabs market share, as established vendors like Autodesk and Siemens PLM begin nurturing their own direct modeling products, traditional history-based modelers like Pro/E face immense pressure to evolve. For PTC, a company deeply rooted in parametric modeling with 25,000 customers, shifting gear is no easy task. So there's a lot riding on Creo. But there's also a lot to gain, since Creo could put PTC on the radar of many small and mid-size businesses that view Pro/E as an overly complex solution to relatively straightforward design problems. DE

INFO → PTC: creo/ptc.com

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

The Era of Infinite Computing

It wasn't that long ago that we were confined to 12, 24, or 36 exposures with film. With a finite number of shots in each, we constantly monitored the remaining number and used them frugally. We had to make every shot count. Today, with digital cameras providing seemingly infinite capacity, we take photos with a different attitude. We say, "Shoot now, choose later." We shoot on a whim. Even if we're unskilled, we can be confident that one out of every ten will turn out well. The numbers are in our favor.

What if you can treat computing power much in the same way you now treat digital photography? What if high-performance computing is always within reach and you can deploy it on a whim? The Era of Infinite Computing, as Autodesk CEO Carl Bass calls it, is on the way. But many of us don't yet possess the right mindset to take full advantage of it.

A Change in Mindset

In his opening keynote at Autodesk University conference (Nov. 28-Dec. 2, 2010), Autodesk CTO Jeff Kowalski invoked the spirit of Albert Einstein with a quote: "You cannot solve a problem with the same mindset that created it."

Up to now, we have been using computing power sparingly, for good reason. We're confined to what we own. Short of buying another machine, we can't get more horsepower than the maximum output of the processor in our desktop or laptop. But what if near-infinite computing power is available upon request? Kowalski pointed out, "We don't have to own all the computing power ourselves; we just have to [be able to] get to it."

A good place to take a peek at how Autodesk plans to integrate infinite computing is Autodesk Labs, a public site where the company previews many of its R&D projects and let early adopters try them out. For example, Project Photofly and its accompanying application Photo Scene Editor let you upload a series of digital photos (roughly 36) of an object taken at slightly different angles to automatically extrapolate and construct a 3D scene from the source images. You run Photo Scene Editor (downloadable from Autodesk Labs) from your desktop or laptop, but the heaviest of computing — algorithmically analyzing similar shapes and geometry in your uploaded photos and translating them into points in 3D space — takes place on a remote server.

Autodesk's Carl Bass makes a presentation at Autodesk University.

Not About Bigger, Faster Design

It would not be the wisest use of infinite computing if we simply think of it as a means to increase our design in scale: Design bigger, render larger, and so on. That would be the equivalent of the way early moviemakers used — or misused — the additional possibilities offered by the invention of the movie camera.

"What they did," says Kowalski, "was simply planting a camera in front of a stage and recording plays that were already successful. Even the name they chose, Photoplay, shows how they perpetuated the old mindset using the new tool set. The real breakthrough only came when we began to look at the [movie] camera as a way to do something new, not as a new way to do something old."

Remote access to infinite computing and storage means you can now use relatively lightweight devices, such as an iPhone or iPad, to interact with complex design files. It also bypasses the need for software-and-OS compatibility. Case in point: AutoCAD WS, now available at Apple app store, lets you use a mobile device like iPad or iPod to open, view, and revise DWG files.

Later, in the Technology Main Stage panel discussion, Kowalski offered some of his own ideas about how infinite computing, coupled with omnipresent broadband connectivity, might enable us to live and work. "I want data to follow me; I want content to follow," he said. "And I want the spaces around us to react to our presence."

The switch "from scarcity and conservation to abundance [of computing power]," as Bass put it, is bound to give many engineers and designs a chance to try out computational experiments previously impossible to undertake. Here's hoping we will learn to wield it responsibly. **DE**

INFO → Autodesk: autodesk.com

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

by Kenneth Wong

Data Deluge in the City of Jazz

Two months ago, a superfast network went online in New Orleans, the birthplace of Jazz. With the capacity to transfer over 260 gigabits per second, this network could, in theory, let you download the entire content of the Library of Congress in under 30 seconds. Alas, it wasn't a permanent installation. Called SCinet, the superhighway was a temporary setup, put together to celebrate the techophiles' Mardi Gras, otherwise known as Supercomputing 2010 (SC10).

SCinet was available for seven days only, just enough to get you drunk on the horsepower boost. But similar networks may pop up sooner than you think. The show's leading sponsors are technology powerhouses with a vested interest in the proliferation of supercomputers, hosted online or installed on premise.

Clouds Bursting at the Seams

Just as SC10 was under way, Platform Computing, which specializes in cluster, grid, and cloud management, issued a white paper titled "High Performance Computing in the Cloud" (November 2010). Fusing premonition and admonition, the paper's tag line warns that we must "[Prepare] for the inevitable."

Cloud-hosted HPC is inevitable for one simple fact: cost effectiveness. "When IT departments buy, build, and maintain clusters to handle peak loads it can be expensive, time consuming, and wasteful. Compute environments designed for peak loads often see utilization rates drop with idle compute resources when the project that created the spike is complete," the paper points out.

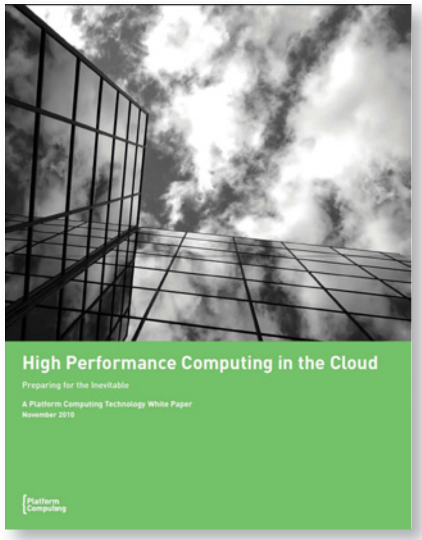
"High-performance computing (HPC) has a long tradition of using dedicated, homogeneous, and fast resources connected via an extremely high speed network. Therefore, many HPC users don't believe that cloud computing can be used as an HPC resource," the paper observes. "Why? Because implementations of cloud computing are generally a loose set of commodity servers in an infrastructure that is not designed for speed ..."

The authors go on to explain that "the low application performance in virtualized environments created a huge barrier for cloud adoption in HPC." But the barriers are about to come down. "Virtualization technology has advanced in recent years and performance is becoming less of an issue. Processor support for virtualization as well as para-virtualized operating system device drivers have improved …"

The Battleground at a Glance

Big names generally associated with desktop workstations and home computing are carving their own corners in the cloud. Microsoft told SC10 attendees that Windows HPC Server users will soon be able to run HPC workloads on Windows Azure. HP alerted HPC seekers that it was responsible for the TSUBAME 2.0, the first Peta-scale system designed to support applications in climate and weather forecasting, tsunami simulations, and computational fluid dynamics. It comprises 1,357 HP ProLiant SL390s G7 servers, each with three NVIDIA Tesla M2050 GPUs, touting a sustained performance of 1.192 Petaflops. The computer maker also supplied two other systems inducted into this year's TOP500 (that's the HPC-equivalent of Fortune 500): one at Georgia Tech, another at MD Anderson Cancer Center.

HP's workstation rival Dell declared its HPC program for CERN's ATLAS experiment is expanding to all Large Hadron Collider research experiments, powered by Dell PowerEdge HPC technologies. GPU maker NVIDIA continues to encroach on the HPC and technical computing market, evident in the recent Amazon announcement that its Web Services division now offers Cluster GPU Instances, designed to deliver GPU-driven processing in the cloud.



The cover for Platform Computing's whitepaper, "High Performance Computing in the Cloud: Preparing for the Invitable."

SC10's seven-day HPC bonanza, SCinet, was delivered through an InfiniBand network, consisting of Quad Data Rate (QDR) 40-, 80-, and 120-gigabit per second (Gbps) circuits. That's far superior to the kind of wired or wireless connection you might get in an office or at home. Whereas Fat Tuesday marks the peak of Mardi Gras festivities, fat data pipelines may determine the future of on-demand HPC via cloud. **DE**

Kenneth Wong *writes about technology, its innovative use, and its implications. One of* DE's *MCAD/PLM experts, he has written for numerous technology magazines and writes* DE's *Virtual Desktop blog at deskeng.com/virtual_desktop/. You can follow him on Twitter at KennethwongSF, or send e-mail to de-editors@deskeng.com.*

INFO → SC10: sc10.supercomputing.org/

→ Platform Computing: platform.com

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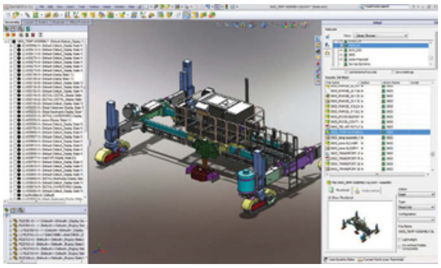
Under Construction

Adept Engineering's document management helps construction equipment manufacturer Guntert & Zimmerman compete for big projects and enter new markets.



Ripon, CA-based Guntert & Zimmerman (G&Z) is a small company that competes and thrives in the highly competitive construction equipment market. It has built a core business on solid principles—and has leveraged technology that lets it bring products to market faster.

"We were using Windows Explorer to archive and track our files with AutoCAD," explains Dahlinger. "When we started using SolidWorks, we thought we could continue to use Windows Explorer, but our productivity went down and we were nearing a crisis. It turned out we couldn't effectively use SolidWorks without a data management system that supported its interdependent file structure."

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An Ounce of Prevention ...

Laser Design's scanner showed the fallacy of a hypothesis—and saved a corporation from making a costly mistake.

Embossing serves several purposes on the surface and within absorbent pads of disposable hygiene products. On the surface, it can introduce an aesthetically pleasing pattern onto the pad, which can also affect fit and comfort attributes. It also has a functional purpose of controlling and directing surface flows. The embossing process is evaluated by the resulting embossing quality, which may be a composite measure of embossing depth, breadth and shape.

As with all commercial machines, there is a continual push to increase the machine line speed at Kimberly-Clark. Based on previous research and the theoretical balance of extrusion rates and shear deformation, it was believed that embossing quality is a function of both embossing gap (pressure) and machine speed.

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Managing Large Engineering Files with TIBCO

DE interviewed Rick Llewellyn, director of systems, vice president and senior professional associate of HDR, Omaha, NE, to see how his company shares large engineering files using products from TIBCO (formerly Proginet).

Q. Tell us a little about HDR.

A. HDR is one of the largest architectural and engineering firms in the world, with 7,800 professionals in more than 185 offices worldwide. We exchange design files with other firms and contractors, as well as clients.

Q. Can you describe how you shared large files before starting to use TIBCO in July 2010?

A. Even relatively simple two-dimensional design documents were often too large to send via e-mail. In addition, our designers were using more 3D modeling designs to increase accuracy, save time and reduce costs. However, the files became so enormous that it was difficult to share the information with others.

The types of files we share are everything from Word documents and PDFs to 2D and 3D CAD design documents, including .DGN and .DWG, and .RVT BIM files.

Q. How was your previous system?

A. We had maintained a number of FTP servers to provide the file transfer functionality, but the system was confusing and often led to problems being reported to the help desk. Many of our employees expressed dissatisfaction, because the old system had limited functionality and was difficult to use, service and manage.

In an average month, we were receiving approximately 140 incidents being reported to the support group related to the sharing of design files, both internally and with outside partners. We were also receiving negative feedback from clients who had to use FTP to come and access their design files.

Q. What made you decide to look into changing the system?

A. We were losing productivity as a company—spending hours and days trying to sort through the file transfer mess. In fact, the help desk at our Minneapolis office had three to eight incidents per month at one to 20 hours in length, possibly resulting in 1,800 hours lost companywide.

In addition, clients were complaining, and a significant number of employees were using outside services to help them overcome their file-sharing challenges. We had no control or visibility into the data that was leaving HDR, and confidential information was being stored using systems that were not reviewed or authorized by our IT and security staff.

Q. What TIBCO products do you use?

A. We were able to deploy different components of TIBCO's CyberFusion Integration Suite (CFI) to address specific business issues.

TIBCO's Slingshot simplifies the process of accessing files for both employees and clients. TIBCO's Platform Server allows a person to drop files in a folder on one file server, and have those files automatically transferred to file servers located at other offices around the world. TIBCO Internet Server allows us to standardize on CFI, yet still maintain the existing FTP sites we had in place for many of our long-term projects.

By using the Internet Server, we were able to gain greater visibility over what information was exchanged and when.

Q. What is the file-sharing process like?

A. The process is so streamlined. HDR employees are able to send files of any size as easily as they send e-mails today. Internal users access the files the same way they would access e-mail attachments, so there is no user experience change. For outside recipients, such as clients or contractors, a link within an e-mail brings them directly to the files using any standard browser.

The entire process is simple and secure—giving us the control and visibility we needed.

Q. Were there challenges in making the switch?

A. The "file transfer" use case was easily transitioned to using Slingshot. However, our biggest challenge is in our "file sharing" business use case. Our business users have been using an FTP site where they have complex folder structures, and they keep files in that location for the life of the project. They feel they need to continue with that, but maybe as we see more adoption of Slingshot, this will lessen.

Q. What benefits have you seen?

A. Moving files within and outside of an organization is a bigger challenge than most realize, especially in the engineering industry. The greatest benefit has been having a solution to address our needs.

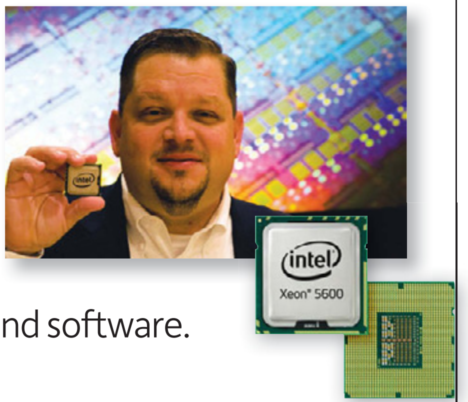
There has been a significant improvement in productivity, as TIBCO is so easy to use and maintain. We've retired two systems, but have also been able to leverage existing investments—for example, our anti-virus infrastructure.

Reducing user frustration was critical, and TIBCO does that. In addition to the improved user experience, TIBCO provides increased reliability and ensures that all file transfers meet federal security requirements. Project managers now know when partners or clients download the files.

Time is money. The amount of time and frustration TIBCO is saving, for both our engineers and our clients, is immeasurable. Help desk calls are down more than 90%.

We like to call it our "easy button," and anything that makes the file transfer process so easy is worth the upfront investment—especially given the extra layers of data security we now have in place. DE

A Revolution in Product Design



CAD engineers to benefit from innovations in processors and software.

BY PETER VARHOL

Engineers engaged in computer-aided design (CAD) can be excused for thinking that workstation performance hasn't adequately kept up with their needs. Because CAD computations don't easily lend themselves to parallel computations, the trend over the last decade toward multiple processors and multiple cores per processor doesn't provide a significant boost to executing CAD applications.

There is a strong connection between the clock speed of the processor and the performance of CAD software. However, the design and manufacturing technologies that enabled rapid increases in clock speed during the 1990s began reaching their theoretical limits, and Intel has turned to processor performance improvements using alternative technologies.

But users of CAD software from the likes of Autodesk, Siemens PLM, SolidWorks, PTC, and Bentley still have a few secret weapons in the performance race. Intel has provided some innovative processor technologies that can speed up serial applications such as CAD, and a few software partners have taken advantage of these technologies to deliver real solutions to CAD engineers.

Autodesk Inventor product suite offers a set of software for 3D mechanical design, product simulation, tooling creation, and design communication. Inventor, as well as SolidWorks, PTC and Siemens PLM all offer integrated tool suites that are intended to help engineers validate their ideas earlier in the design process.

Hardware Provides the Performance Foundation

While processor clock speed increases have given way to multiple cores, Intel has built a few tricks into its current high-performance processors such as the Intel® Xeon® processor family. One example is Turbo Boost, which provides the ability to dynamically increase the processor performance for periods of time in response to a high demand for performance. Turbo Boost activates when the operating system requests the highest performance state of the processor, delivering a substantially higher clock speed for a serial application than the rated speed of the processor.

Another innovation is hyperthreading. A hyperthreaded core has multiple parts of the pipeline—typically control registers or general-purpose registers, allowing the operating system to schedule two threads or processes simultaneously. The result is the processor can hold multiple thread states at once. Hyperthreading makes the context switches that processors normally engage in occur much faster.

Intel has also focused on better hardware support for virtualization. Intel Virtualization Technology for Directed I/O enables users to create virtual partitions and concurrently run interactive and batch applications with assured levels of performance. It includes several important capabilities, such as I/O device assignment, DMA remapping, interrupt remapping, and reliability features that prevent memory or virtual machine (VM) corruption.

Software Delivers Virtualization Flexibility

Software providers Microsoft and Parallels have taken advantage of Intel hardware virtualization technologies to bring better performance using virtual machines. Microsoft Windows HPC Server R2 provides engineering groups with access to affordable and powerful supercomputing resources in the familiar Windows environment. Effectively, it enables clusters of workstations to act as a single HPC cluster, enabling all engineers to share computing resources. Parallels PWE delivers the a high-performance virtualization platform for workstations that gives end users dedicated HPC, graphic and networking resources for both host and guest workstation environments.

You may not be able to take good advantage of multiple processor cores to accelerate parallel execution, but today's workstations and software provide ways to improve engineering processes. Using virtualization,you can test out multiple designs on separate VMs, with each performing at close to the full speed of the CPU. With Microsoft's HPC Server, you can do so at cluster speeds, without taking a backseat to analysis and simulation jobs.

While processor innovations continue to occur, the notion of faster processor clock speeds in the foreseeable future is unlikely. However, companies can rethink the engineering process and leverage the software advancements being made by CAD vendors. These companies are exploring the value of simulation-based design and how these solutions allow companies to employ all the available technology to increase innovation.

The question as we start 2011 for the rest of us is—are we going to see how we can change the way we work in order to make the best use of new innovations? DE

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

➜ intel.com/go/hpc

➜ intel.com/go/cluster

Bragging Rights

This tweaked-out system from BOXX Technologies delivers incredible performance.

BY DAVID COHN

BOXX Technologies, based in Austin, TX, has been building high-performance computer systems since 1996. While most of its workstations are targeted toward digital content creation and visual effects—customers include TV networks and major film and VFX studios—its 3DBOXX line has also found a home among CAD and engineering users. Since it's been quite a while since we last looked at one of these powerful workstations, we were quite pleased when BOXX offered to send us one of its latest systems.

There are currently three different series within the 3DBOXX lineup, including single- and dual-CPU models based on both Intel and AMD processors. For this review, the company sent us one of its 3DBOXX 4800 Series systems, a 4860 Extreme, based on a "performance enhanced" six-core Intel i7 processor.

All of the company's 3DBOXX workstations come housed in a custom-designed aluminum chassis that's a far cry from your everyday, run-of-the-mill boxes. The front is a beautiful brushed aluminum panel with a BOXX logo in the middle. Above this panel are two drive bays and a panel containing four USB 2.0 ports and one IEEE 1394a (FireWire) port, as well as headphone and microphone jacks. This panel also houses a round power button, a bright-white LED power indicator, a blue hard drive light, and a small reset button (which proved far too easy to accidently press, immediately rebooting the system). The topmost bay housed a 20X dual layer DVD +/- RW drive. The sides of the 7.0x19.5x17.5-in. (WxDxH) tower case have removable black aluminum panels, while the top is brushed gray.

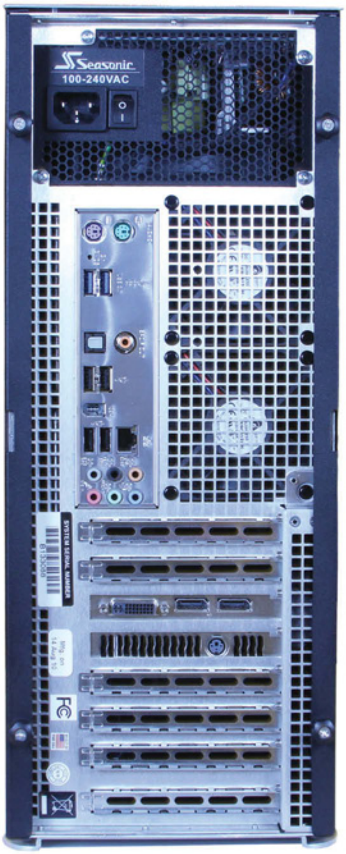
The rear panel provides four more USB 2.0 ports, as well as a pair of USB 3.0 ports. There's also another IEEE 1394a port, six audio connectors (separate microphone and line-in jacks, as well as jacks for front, side, rear and base output channels), both S/PDIF and optical S/PDIF ports, and PS/2 connectors for a keyboard and mouse.

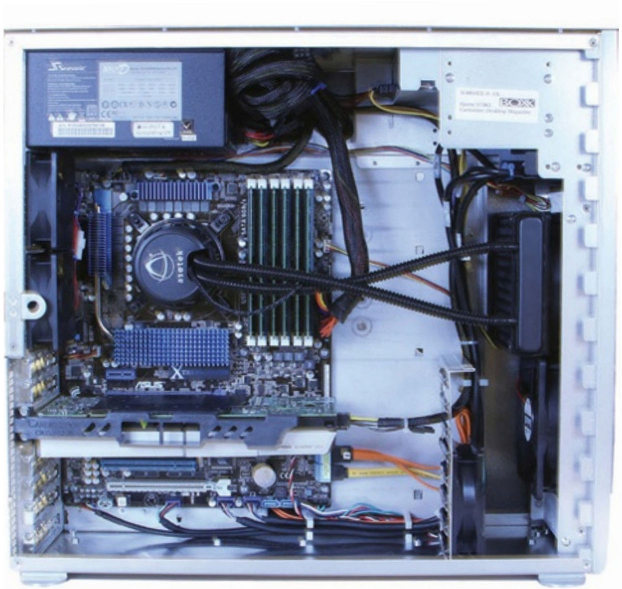
The 3DBOXX 4860 Extreme workstation from BOXX Technologies uses an over-clocked Intel i7 six-core CPU and top-of-the-line components to deliver one of the fastest workstations available. ***Images courtesy of David Cohn***

Where's the Hard Drive?

The side panels are held in place with captive thumbscrews. Once we loosened these and removed the side panel, we were immediately struck by the extremely clean interior. The ASUS P6X58D-E motherboard, based on an Intel X58 chipset, takes up just a bit more than half the case. Above this we noted a compact, 850-watt Seasonic power supply. Also quite prominent was the Asetek liquid cooling module mounted over the CPU. But where were the hard drives?

The specifications for the 3DBOXX 4860 listed a drive





The 3DBOXX has plenty of ports, room for up to 24GB of DDR3 SDRAM, liquid cooling and six separate drives. It still manages to keep a tidy interior, in part by separating the drive bays from the rest of the components.

cage supporting up to six separate drives. Because our evaluation unit obviously booted up, and a quick check showed two separate hard drives, we were quite puzzled—that is, until we removed the panel on the other side of the system, the side behind the motherboard.

Sure enough, there we found a pair of 7,200rpm Western Digital SATA hard drives—a 250GB primary drive and a 500GB secondary drive—as well as space for up to four more. The drives mount flat against a metal plate separating the space from the back of the motherboard. To install drives, you must first remove a pair of phillips head screws to release an individual cage, then mount the drive using four additional screws, route some cables, and then reattach the cage. It's a clever system, but we'd be a bit concerned about heat buildup. While it's a novel spot to hide the drives, they're likely to get just a fraction of the air flowing through the case, particularly if the space is filled with hard drives. The company says it has tested the system with a full complement of six drives, and that airflow is not an issue. BOXX offers hard drives of up to 2TB capacity, as well as a redundant array of independent disks (RAID).

Tweaking Six Cores

The 3DBOXX 4860 Extreme is the first system we've received based on the new Intel i7 X980 processor, one of the company's new six-core CPUs, codenamed "Gulftown." The X980, based on a 32-nanometer process, comes with 12MB of shared L3 cache and has a clock speed of 3.33GHz. But as soon as we began our testing, it was pretty obvious that the 3DBOXX was running faster than that.

Sure enough, there's good reason for the BOXX team to put liquid cooling on the CPU: They over-clocked the processor 125% to a claimed 4.15GHz. At that speed, the CPU is going to consume more power and generate more heat.

The Gulftown CPU has an incredible 1.17 billion transistors, and supports both hyper-threading and turbo boost. With hyper-threading enabled, the processor appears to the operating system as having 12 cores; turbo boost means that the

FEATURES

- BOXX 3DBOXX 4860 Extreme
- Price: $6,325 as tested ($3,899 base price)
- Size: 7.00x19.50 x17.50 in. (WxDxH, w/handle) tower
- Weight: 31 lbs.
- CPU: one Intel Core i7 X980 (six-core) 3.33GHz (over-clocked to 4.15GHz)
- Memory: 12GB DDR3 SDRAM at 1333MHz (up to 24GB supported)
- Graphics: NVIDIA Quadro 5000
- Hard disk: Western Digital 250GB SATA 7,200 rpm drive, Western Digital 500GB SATA 7,200rpm drive
- Optical: 20X DVD+/-RW Dual-Layer
- Audio: onboard integrated high-definition audio (microphone, line-in, front, side, rear and bass)
- Network: integrated 10/100/1000 LAN
- Other: Eight USB 2.0, two USB 3.0, two 1394a (FireWire), S/PDIF, optical S/PDIF,
- PS/2 mouse, PS/2 keyboard
- Keyboard: 104-key Logitech K120 USB keyboard
- Pointing device: Logitech LX3 Optical Mouse

Design Engineering Workstations Compared

		BOXX 3DBOXX 4860 Extreme workstation (one 3.33GHz Intel i7-X980 six-core CPU (over-clocked to 4.15GHz), NVIDIA Quadro 5000, 12GB RAM)		**Lenov E20** workstation (one 3.19GHz Intel i5-650 dual core CPUs, NVIDIA Quadro FX 580, 4GB RAM)		**HP Z200** workstation (one 3.47GHz Intel i5-670 dual core CPUs, NVIDIA Quadro FX 1800, 4GB RAM)		**Lenovo D20** workstation (two 2.66GHz Intel Xeon X5550 quad core CPUs, NVIDIA Quadro FX 4800, 8GB RAM)		**Dell Precision T3500** workstation (one 2.27GHz Intel Xeon E5520 quad core CPU, NVIDIA Quadro FX 3800, 4GB RAM)		**Lenovo S20** workstation (one 2.27GHz Intel Xeon E5520 quad core CPU, NVIDIA Quadro FX 3800, 4GB RAM)		**HP Z800** workstation (two 3.2GHz Intel Xeon X5580 quad core CPUs, NVIDIA Quadro FX 4800, 12GB RAM)	
Price as tested		$6,325		$1,224		$2,089		$5,943		$2,544		$3,885		$10,604	
Date tested		11/14/10		9/15/10		8/7/10		1/11/10		7/30/09		7/29/09		4/24/09	
Operating System		Windows XP	Windows 7 64-bit	Windows XP	Windows 7	Windows XP	Windows 7	Windows XP	Windows Vista	Windows XP	Windows Vista	Windows XP	Windows Vista	Windows XP	
SPECviewperf	higher														
3dsmax-04		n/a	**90.25**	66.73	64.98	60.87	60.65	50.38	51.21	**39.91**	42.75	48.43	52.59	50.55	51.51
catia-02		n/a	**115.36**	68.28	63.79	68.13	66.87	61.79	62.01	**51.85**	53.33	60.40	60.61	62.10	61.66
ensight-03		n/a	**120.41**	45.79	**43.40**	53.85	53.06	55.26	53.51	47.26	47.84	51.74	**55.33**	53.99	53.62
maya-02		n/a	**458.21**	185.81	**157.57**	238.59	208.40	**250.41**	223.73	220.79	199.04	232.92	207.87	231.80	209.74
proe-04		n/a	**114.34**	64.08	59.17	**68.03**	65.74	64.83	63.66	55.67	**55.54**	61.56	64.49	63.59	61.48
SW-01		n/a	**223.03**	97.07	**89.67**	138.22	137.48	144.17	**145.19**	123.28	120.57	136.81	139.54	135.24	128.08
tcvis-01		n/a	**95.26**	23.66	**23.00**	35.60	34.81	**40.55**	39.51	28.71	28.07	29.17	38.76	28.93	28.29
ugnx-01		n/a	**88.75**	23.15	**16.93**	30.91	31.23	**34.93**	34.52	33.40	32.27	33.41	33.19	33.34	32.38
SPECapc SolidWorks	lower														
Score	seconds	n/a	n/a	**153.29**	n/a	148.72	n/a	141.59	n/a	178.39	n/a	**140.42**[1]	n/a	145.17[1]	n/a
Graphics	seconds	n/a	n/a	**58.71**	n/a	56.83	n/a	41.48	n/a	62.99	n/a	47.33[1]	n/a	**41.31**[1]	n/a
CPU	seconds	n/a	31.63	**33.67**	n/a	32.81	n/a	33.00	n/a	36.38	n/a	**31.01**[1]	n/a	32.68[1]	n/a
I/O	seconds	n/a	**54.68**	65.44	n/a	63.10	n/a	67.73	n/a	**83.35**	n/a	65.86	n/a	71.94[1]	n/a
SPECapc SolidWorks	higher														
Score	ratio	n/a	n/a	5.21	n/a	5.27	n/a	6.28	n/a	**4.66**	n/a	5.91[1]	n/a	**6.38**[1]	n/a
Graphics	ratio	n/a	n/a	3.25	n/a	3.23	n/a	4.68	n/a	**2.92**	n/a	3.92[1]	n/a	**4.85**[1]	n/a
CPU	ratio	n/a	10.20	9.58	n/a	9.83	n/a	9.78	n/a	**8.80**	n/a	**10.41**[1]	n/a	9.87[1]	n/a
I/O	ratio	n/a	**5.79**	4.84	n/a	5.02	n/a	4.67	n/a	**3.80**	n/a	4.81[1]	n/a	4.40[1]	n/a

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

CPU can actually run even faster at times (our tests showed it accelerating to nearly 4.26GHz).

In addition to speeding up the CPU, BOXX provided us with a full load of system memory—a total of 12GB of RAM installed as six 2GB DDR3 1333MHz dual in-line memory modules (DIMMs), filling all of the available memory sockets. The system can accommodate up to 24GB using 4GB memory modules. The ASUS motherboard also provides six expansion slots: one PCIe x1 slot, two PCI slots, and three PCIe x16 slots each capable of a PCI Express graphics card. Our evaluation unit came equipped with an NVIDIA Quadro 5000 graphics board with 2.5GB of GDDR5 video memory. Built on NVIDIA's Fermi architecture, the Quadro 5000 is one of NVIDIA's latest high-end graphics accelerators, with 352 compute unified device architecture (CUDA) cores.

The extra thickness of the NVIDIA board meant that the adjacent PCI slot was unusable. Installing a second similar graphics board could also cover the other PCI slot, depending on which PCIe x16 slot you used. BOXX does offer other NVIDIA boards, ranging from a Quadro FX 580 up to the ultra-high-end Quadro 6000.

Blowing the Doors Off

With all of the power packed into this 3DBOXX, we had high hopes for our benchmarks—and the 4860 Extreme certainly delivered. On the SPECviewperf test, which focuses solely on graphics performance, the results were nothing short of incredible. The 3DBOXX 4860 Extreme, equipped with the NVIDIA Quadro 5000, not only beat every system we've ever tested, it demolished them, with some results more than two times faster than those previously recorded.

Unfortunately, since the system came with only Windows 7 installed, we were not able to obtain a complete set of meaningful results from our SPECapc SolidWorks benchmark, since this benchmark only runs effectively under Windows XP. That said, the CPU and I/O performance scores were excellent, and we'd expect actual performance when running SolidWorks or any other CAD application to be quite fast.

On our own AutoCAD rendering test, however, which clearly shows the advantages of hyper-threading, the 3DBOXX 4860 Extreme became just the second system we've ever tested to complete the renderings in less than a minute. But again, it not only beat the previous record, it was 1.3 times faster—and it managed this feat with the equivalent of 12 CPU cores, compared to 16 cores in the next fastest machine. The results of all our tests appear in the accompanying table.

A system as fast as the 3DBOXX 4860 Extreme needs lots of cooling, and BOXX certainly didn't skimp. We counted a total of seven fans: two behind the front panel (including one dedicated to the Asetek liquid cooling unit), another mounted near the front, two more on the rear panel, one on the NVIDIA graphics board, and one more inside the power supply. With all these spinning and lots of air moving through the case, the 3DBOXX was certainly not silent, although the fan noise was not obtrusive and would likely vanish into the background in a busy office. But on our test bench, we knew when this system was running.

BOXX rounded out the system with a Logitech K120 104-key keyboard and a Logitech LX3 optical mouse. Windows 7 Professional 64-bit came pre-installed, although we had to complete the final installation steps and locate the 25-character product key on a small label located behind the removable front grill. BOXX Technologies backs its systems with a three-year limited warranty, including return shipment costs in the first year, with phone and email tech support Monday through Friday from 7 a.m. to 6 p.m. Central Standard Time.

While we were quite astounded by the performance of the 3DBOXX 4860 Extreme, it certainly won't appeal to everyone. First, the system is currently only certified for SolidWorks and DCC products from Autodesk and a few others. Second, the incredible performance comes with a price to match. The 3DBOXX 4860 Extreme has a base price of $3,899, and the configuration of our evaluation unit would set you back $6,325. But for the price, you get bragging rights to one of the fastest systems currently built—and for some applications, the cost of the 3DBOXX 4860 Extreme is money well spent. DE

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

INFO → **BOXX Technologies, Inc.:** BoxxTech.com

→ **Asetek:** Asetek.com

→ **ASUS:** ASUS.com

→ **Autodesk:** USA.Autodesk.com

→ **Dassault Systèmes:** SolidWorks.com

→ **Intel Corp.:** Intel.com

→ **Logitech:** Logitech.com

→ **NVIDIA:** NVIDIA.com

→ **Seasonic:** SeasonicUSA.com

→ **Western Digital:** WDC.com

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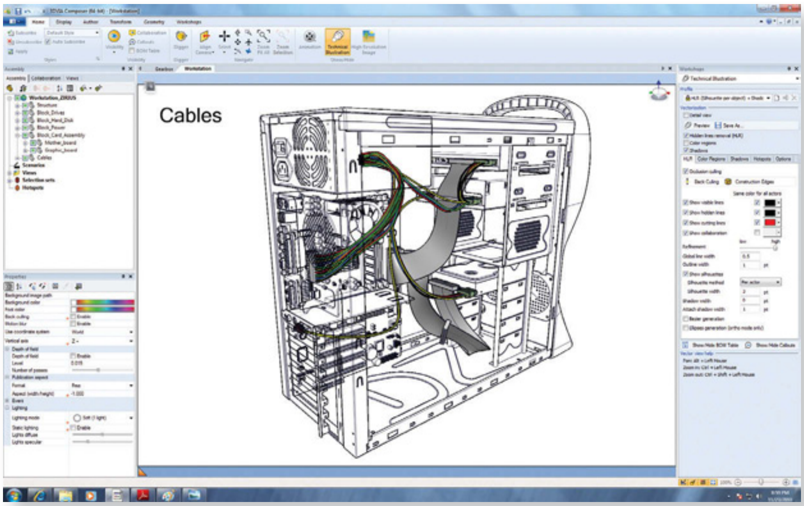
Documentation by Design

3DVIA Composer 2011x allows visuals to be integrated engineers' workflows.

BY JOSH MINGS

It happens to many of us: We're done with a project, moving onto the next, but the request for models, exploded views and other sorts of data distractions pummel the efficiency we so deeply enjoy. You might shrug it off because "that's all just part of the engineering process."

Somehow, shifting our focus away from the designing and the engineering has become the norm. Because we're engineers, have access to the model and know how to work with it, it makes a little bit of sense that we would be the ones to provide that perfectly oriented perspective view, a data dump via FTP or the .zip file of 500 screenshots.



The new vector settings for Technical Illustrations allow you to set priorities for (layer) the actors (parts) and groups of actors.

But on the other hand, we're over it. There has to be better ways to take care of all the supplemental data requests and still stay focused on our engineering.

That's exactly where 3DVIA Composer comes in.

Over the last several years, 3DVIA has developed products such as Studio, Scenes, Virtools, Shape, Player and Composer. Each of these programs could be seen as having applications in 3D content development across different industries, but the one thing they all have in common is bringing the ease of creating that 3D content to everyone. You could do it by creating graphically stunning virtual environments, as in the case of Studio, Scenes and Virtools. You could communicate your ideas and show how they function with Shape, Player or Composer. But of all of these, 3DVIA Composer takes direct aim at the time-consuming aspects of documenting 3D data.

Many may know of Composer as a way to create interactive assembly instructions or wildly descriptive technical illustrations. Well, what if it could be more? What if it could actually supplement, or even replace time-consuming chores of your current workflow? It can.

New Features

This year's release of 2011 and 2011x is establishing 3DVIA as *the* purveyor of fine-tech pub development. But more than that, the company has been adding features that cause it to trim the time involved in engineering documentation—with the potential to eliminate even more.

Visual representation of models created with Composer now become even more useful. Because Composer has the ability to create vector graphics (images that can be scaled without loss of quality), vector output functionality has received a lot of focus in this release. Imagine being able to layer drawing views in your 3D CAD drawing, see the internals and make them stand out beyond the rest. 2011x brings in this ability.

You also have more control over the line thickness of edges. Called Silhouette Generation, working in Hidden Lines Removed (HLR) mode allows you to thicken the edge of the entire model or the single parts. Raster output also gets a big addition: You now have the ability to flip the alpha channel switch to create rasterized images with transparency, a feature commonly needed when putting product images on top of various backgrounds.

Three additions are introduced to the Viewport options in this version, to bring a more authentic look to your Composer workspace and the model inhabiting it. You have rendering options to cast deeper shadow with Ambient Occlusion, define view focus with a camera-like Depth of Field (DOF), and refine the highlights on a model with Per-Pixel Lighting (PPL).

While the visuals get a nice boost, more has also been done to make documenting more streamlined. Among the new features are better note and bubble functionality. While 2011 allowed you to create magnetic guides to line up notes, views or bubbles, 2011x adds an option to make bubbles a uniform size—and adds multiple properties to collaborative text attributes. Lining up alongside these are new customizable hotspots that can be created to highlight objects or group of objects, applying yet another level of interactivity to the vector graphic output.

Within all of this functionality, 3DVIA Composer and its related applications move to Unicode character encoding. While this allows you to use more languages in your visuals, 2011x files do lose compatibility with previous versions.

Revamping the Design Process

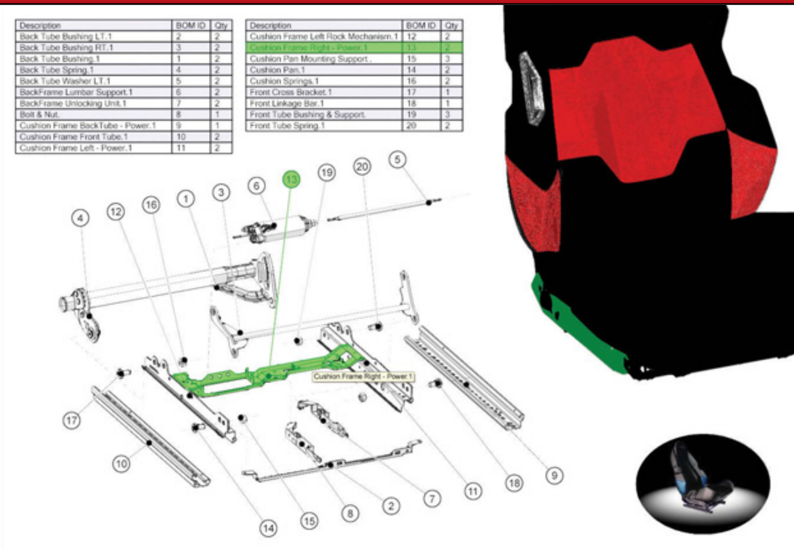
There are a few scenarios where 3DVIA Composer provides the typical type of hum-drum benefit: The engineer could use Composer to make some "quick" visuals for marketing, create assembly instructions for manufacturing, or lay out exploded views for a technical publisher. The engineer could also provide 3DVIA composer files to a publisher, whereby limiting the amount of proprietary data that leaves engineering. The engineer could even send models directly to marketing, manufacturing or a publisher to completely eliminate the amount of additional documentation with which he is involved. Any or all could be valid ways of using 3DVIA Composer to bring more efficiency to your workflow.

However, there's one way that could encapsulate all of these, plus eliminate the additional process or creating 2D drawings. For a minute, think of all the types of views that can be created with 3DVIA Composer. Then, think of the interactive bills of materials (BOMs) that can be embedded—or how fast it is to work with assemblies.

You're creating these views of your model, adding information and saving it out just as you would a 2D drawing. What if you eliminated creating those 2D drawings with the CAD program, and instead used 3DVIA Composer to create the drawings? For one, Composer has the ability to provide the same type of information as drawings, with the addition of being able to use the same information for all the other requests that come up through the engineering process. In a very real sense, Composer could be overkill for the typical engineering drawing that is produced, but if the shop gets a quick animated assembly instruction, which in turn can be used to market the product, what could be so bad?

There are disadvantages, of course, like losing the geometry link between your modeling package and Composer, but in a way there's a benefit to that in defining where the documentation happened.

As you may now be thinking, there's much more to 3DVIA Composer than simply being able to clean up documentation with slick visuals. The increased options for view styles, plus how you're able to communicate the design, the process and the entire scope of how a product is developed, manufactured and marketed is overtaking the monochromatic edges of traditional 2D drawings. Composer 2011x introduces more rendering options and useful documenting tools to get you there. **DE**



3DVIA Composer 2011x now provide the ability to create custom hotspots highlighting bill of material and parts on output of the vector graphic.

CONCEPTS WITH 3DVIA SHAPE

3DVIA Shape isn't a 3DVIA Composer plugin or additional software to document your models. Shape is a free program to create your models. It provides a simple way to create 3D concepts and share them online. Seen as a competitor in many regards to the Google's 3D modeler, SketchUp, it allows you to quickly create and manipulate geometry with simple push and pull commands, then publish them to the 3DVIA community at 3DVIA.com.

While the focus of the program is for architectural models, there are certainly enough features to create concepts and explore any idea. It doesn't work directly with Composer. However, if you create a model in 3DVIA Shape and upload it to 3DVIA.com, you can then export it as a .3DXML file. This file can then be brought into 3DVIA Composer.

Josh Mings *is an engineer with Cabin Innovations, and specializes in 3D modeling and visualization for aircraft interiors. He is editor at SolidSmack.com, covering 3D design, product development and related technology. Contact him at DE-editors@deskeng.com.*

INFO → 3DVIA: 3DVIA.com/Composer

3DVIA Composer 2011x

Price: $7,995

Minumum requirements: 3GB free space, 512MB RAM, FPU with 3D OpenGL Acceleration

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

3D Scanning Options

How to choose digitizing technologies.

BY DEBBIE SNIDERMAN

The 3D Imaging and Modeling Metrology Group of the National Research Council of Canada and InnovMetric Software, Inc., maker of PolyWorks software, studied 3D measurement hardware technologies and external frame of reference (EFR) monitoring techniques as a basis for research into developing 3D measurement standards. DE looks at some of their findings.

With multiple digitizing technologies available, it is often not obvious which might best serve your needs. This study looked at principles, characteristics and key advantages and disadvantages of both low- and high-density scanning techniques.

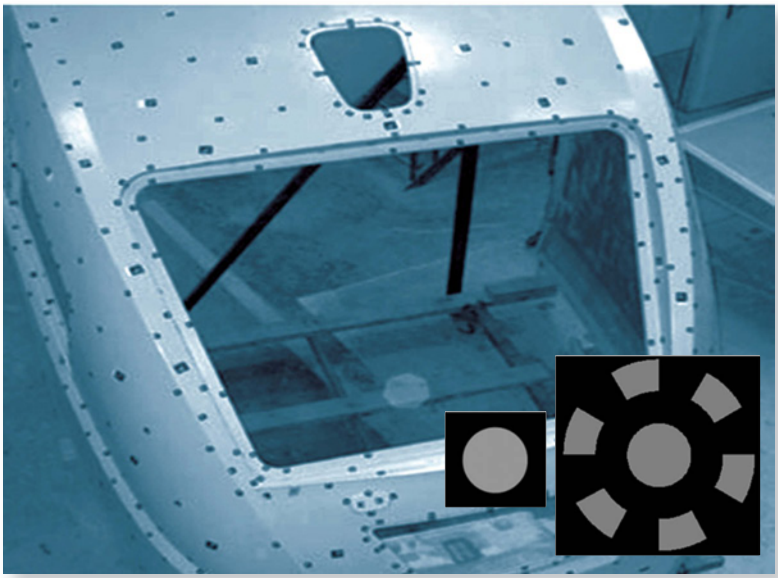


FIGURE 1: This physical object is covered with targets, ready for photographing. Photogrammetry software extracts geometric information of the reflective targets' centers.

FIGURE 2 (INSET): Simple and coded reflective targets.

Low-density, Single-point Techniques

Single-point measurement tools target and measure one or more specific points at a time by mechanical contact or optical non-contact methods. There are five key reasons that both mechanical contact and optical non-contact, low-density methods are still relevant and important (see Table 1):

1. When combined with mechanical EFR tracking and controlling software, they can produce automated, rapid, repeated 3D surface measurements.
2. They are suitable for measuring parts with highly reflective or transparent surfaces.
3. Difficult-to-reach areas such as deep holes or underbodies may be easier to measure.
4. They can rapidly measure small objects or those with a small number of features.
5. In general, they provide very accurate measurements.

Mechanical measuring methods involve moving a spherical stylus or probe tip to contact an object's surface and measuring the (x,y,z) position of the tip's center.

Optical measuring methods project light generated from a lamp, bulb or laser, onto a surface, a reflective marker affixed to a surface, or other reflectors such as spherically mounted retro-reflectors (SMRs). The absolute or relative distance between the scanner and the object is calculated based on the speed of light and the travel time to and from the object (see Figures 1 and 2).

Mechanical tracking for single point measuring techniques retains the same coordinate system as the scanned object. Fixed or portable CMMs' base or zero does not change as measurements are made.

Optical tracking for single-point measuring techniques involves either a laser tracker following the center of a reflective probe, or light-emitting or passive targets affixed to a touch probe mount. Again, these tracking technologies remain in the same coordinate system as the object.

Conceptually, this is similar to a camera pivoting on a tripod mount to take multiple photos of an object, but the tripod is not moved to a different vantage point.

External Frame of Reference

EFR hardware or software monitors the digitizer's position in real time as it moves around an object, and aligns its many images into a common coordinate system to fully capture and assemble the object's 3D geometry. EFR is used for precise measurements of large (>1 meter) or complex objects, and can be combined with either low- or high-density digitizing technologies. EFR is required whenever digitizing hardware is moved out of the coordinate system of the object—conceptually equivalent to moving a tripod-mounted camera to another vantage point.

High-density, Non-contact Digitizing

High density, non-contact digitizing methods provide a much faster option for measuring large numbers of points without requiring targets. Since the 1980s, non-contact methods have been preferred for large or free-form surfaces, objects with many features, flexible objects, or fragile objects, because surfaces are not touched by a probe.

Active High-density Scanning

High-density digitizing can be active or passive, but active scanning is the more commonly used method. Conceptually, energy is projected onto a physical part, reflected, and viewed or sensed by an electronic detection device (typically a camera or sensor). Analyzing the position of the reflected energy's image determines (x,y,z) coordinates of the object (see Figure 3).

Surface 3D digitizers capture an object's external visible surfaces. Volumetric 3D digitizers capture both exterior visible surfaces and hidden interior geometries.

Identify Your Needs

To help you evaluate 3D scanning technologies appropriate for your needs, visit deskeng.com/articles/aaazje.htm for graphics that present performance ranges and technology definitions.

External frame of reference (EFR) techniques have their own performance specifications that are indicated separately. According to Marc Soucy, president of InnovMetric, EFR techniques can influence overall measurement results, and their performances should be taken into consideration.

Other important factors to consider include:

- number of operators required
- fixture requirements, system footprint and power
- setup, data collection and data processing time
- calibration procedures
- formats of output files and results
- availability of options such as continuous or energy-saving modes, wireless data transfer, remote controls and the dynamic compensation for thermal expansion, temperature, vibration or other environmental conditions.

Destructive Volumetric 3D techniques slowly grind away a small layer of material, digitize what is seen, and repeat until the entire part has been fully digitized and destroyed.

Table 1: Low-density/Single-point Measurement Technologies

Name of Method	Contact/ Non-contact Method	Incremental or Absolute Distance Measurement (ADM)	Detection Method	What is Measured or Algorithmically Extracted	Type of Tracking Along Surface	Portability
Traditional Fixed CMM	Contact	Absolute	Center of Spherical Tip Contacts Surface	Probe tip's center (x,y,z) position is recorded, true surface calculated based on a compensation vector, displacement in time	Fixed multi-axis coordinate measurement machine (CMM)	Immobile technique requiring part be brought to the measurement tool
Portable CMM: Articulated Arm	Contact	Absolute	Center of Spherical Tip Contacts Surface	Probe tip's center position is recorded, true surface calculated based on a compensation vector, displacement in time	Six-axis or a seven-axis articulated (jointed) arm	Arm with many flexible joints, brought near the part to be measured
Portable CMM: Laser Tracker	Contact	Either or both, Interferometer based or ADM	Center of a spherically mounted retro reflector (SMR) contacts surface	Laser beam is locked on center of SMR; azimuth and elevation angles of laser beam are measured, distance between laser tracker origin and SMR is measured	Laser beam tracks the 3D coordinates of SMR's center	Portable; tracker is brought near the part to measure
Portable CMM: Optical Tracker	Contact	Absolute	Center of a spherical tip mounted with light-emitting or passive targets contacts surface	Center of all visible light-emitting or passive targets affixed on contact probe	Tracks reflective or emitting targets	Portable; tracker is brought near the part to measure
Photogrammetry	Non-contact (but targets do contact object)	Absolute	Optical: Digital camera photographs targets on a surface	Center of light-emitting or passive targets affixed or mounted on object's surface	Tracks targets whose position are determined by photogrammetry	Portable; cameras are brought to the part to be photographed

Destructive methods are typically used for smaller, low cost, mass-produced parts for which internal structure is crucial.

Most digitizers used in industrial applications use non-destructive techniques. About 90% of close-range, high-density digitizers belong in the triangulation category enclosed in red.

Table 2 summarizes principles and characteristics of high-density measuring technologies and associated EFR methods.

Triangulation-based Laser Techniques

Laser triangulation digitizers project a line or a single spot (projected as a line using mirrors) onto an object, which reflects and is imaged by a camera. Knowing projection and collection angles relative to a baseline determines a triangle's dimensions and the coordinates of a point on the surface.

These close-range laser techniques offer excellent depth resolution on large parts, and can measure small detail such as bor-

Table 2: High-density Non-contact Measurement Technologies

Technology Name(s)	Category	Active or Passive	Surface or Volumeric	Type of Radiant Energy	Detection Method	Principle	Typical Beneficial EFR Technologies
Laser Flying Spot Triangulation	Triangulation	Active	Surface	Laser	Optical detection of a single laser spot by camera sensors or CCDs	Reflected light is focused onto a camera. Known projection and collection angles relative to a baseline determines the dimensions of a triangle and coordinates of surface point.	Custom encoder-based translation or rotation systems, laser trackers, optical trackers, photogrammetry, articulated arm portable CMM, robots
Laser Line Scanning	Triangulation	Active	Surface	Laser	Optical detection of projected laser line by camera sensors or CCDs	Reflected light is focused onto a camera. Known projection and collection angles relative to a baseline determine the dimensions of a triangle and coordinates of surface point.	Custom encoder-based translation or rotation systems, laser trackers, optical trackers, photogrammetry, articulated arm portable CMM, robots
Fringe-based Projection Digitizing	Triangulation	Active	Surface	White light from halogen or other lamp source	Optical detection of projected light fringe patterns on camera sensors or CCDs	Fringe patterns of light of various resolutions are used to uniquely determine projection directions over object's surface. Reflections are collected in one or more cameras and analyzed.	For areas <1m x 1m: photogrammetry, turntable and gantry, or best-fit alignment using overlapping areas. For large areas >1m x 1m: photogrammetry, optical tracker, mechanical tracker or robot
Conoscopic Holography	Triangulation	Active	Surface	Laser	Optical detection of polarized light interference patterns on CCDs	Reflected light is diffused through a crystal and projected onto a CCD. Frequency analyses of the resulting diffraction patterns determines distance to the object, producing 3D holograms.	Fixed CMM or 3-axis mechanical tracking system
Industrial Computer Tomography (CT)	Computer Tomography	Active	Volumetric	X-ray	X-ray detection	Attenuated x-ray energy passes through a rotating object. Stacking 2D cross sectional images builds 3D image.	No external EFR, included in turnkey system
Time of Flight (TOF), Pulse-based Laser Digitzing, Laser Tracking	Time of Flight	Active	Surface	Laser	Optical detection of laser beam pulses	Pulsed laser light is sent to the object, and a portion of that pulse is reflected. Absolute distance to target is calculated based on the time for the pulse to return to the detector.	Center of reflective probe is tracked by laser. EFR using optical targets in the scene and post-processing software
TOF Phase Shift Laser Digitizing	Time of Flight	Active	Surface	Laser	Optical detection of laser light's phase shift	Varying wavelength laser light is sent to object; phase shift of reflected wave is measured to determine object's position and intensity.	Center of reflective probe is tracked by laser. EFR using optical targets in the scene and post-processing software
Dense Stereo Vision Digitizing	Non-destructive	Passive	Surface	None-ambient white light	Optical detection of white light using high-resolution or stereo cameras	A point on the surface is located by analyzing the difference of multiple images of the surface taken by high-speed, high-resolution or stereo cameras placed around a part.	Post-processing software

Benchmark Before You Buy

Benchmarking involves evaluating sample scans and comparing results to known nominal values. It can highlight unpredictable or non-obvious issues, and can help the user gain confidence in a technique and its results. It can also help determine whether additional external reference hardware or software is needed for your specific application.

Marc Soucy, president of InnovMetric, stresses that benchmarking allows a wide variety of software options, plug-ins and add-ons to be demonstrated, that can control digitizing hardware or reduce sample or evaluation time. He suggests that benchmarking should include repeated measurements of a known part before making a system purchase, and recommends benchmarking the digitizing and external frame of reference (EFR) technologies under consideration together.

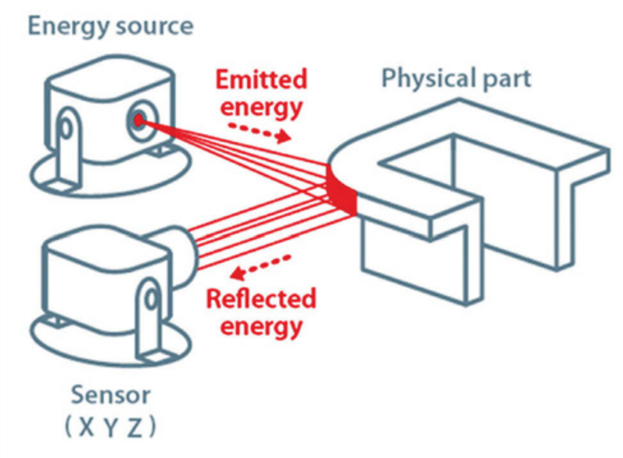


FIGURE 3: The basic concept of high-density, non-contact digitizing.

ders, edges and cracks. They are more robust to ambient light sources, and less subject to noise from object color or luster.

There is a performance trade-off, however, for technologies with a baseline, such as triangulation. Larger baselines are more accurate, whereas smaller baselines exhibit fewer occlusion effects. The laser speckle effect also limits this technique's accuracy on optically rough surfaces.

Fringe-based Projection Techniques

Successive images of fringe patterns are projected onto an object, and one or two high-density cameras capture surface images. Enough fringe patterns are projected until a grid of object coordinates can be formed from intersecting reflections on individual camera pixels (see Figures 13 and 14).

Detailed measurements can be made by taking a series of photos with different stripe pattern widths (phase-shifting). This technique is known as white light time-multiplexed pattern projection.

These close-range measurement techniques offer good accuracy and lateral resolution along two axes, and are fast to measure objects with low-curvature surfaces. Important limitations of fringe techniques, however, are that they lack the dynamic range needed to scan shiny finishes, are slow to measure objects with intricate details, and suffer from occlusion effects, requiring additional shots depending on the size of the object.

Industrial Computer Tomography (CT) Techniques

These close-range, turnkey techniques produce a complete volumetric point cloud of an object, and in some cases, allow porosity and internal defects to be seen. They are very accurate techniques. Unfortunately, CT can be quite expensive, and calibrating and measuring parts made with different materials is a challenge.

Time-of-flight (TOF)-based Laser Techniques

Pulse-based and phase-shift TOF techniques are co-axial technologies with no baseline and therefore no occlusion effects. They are compatible with conventional surveying tools such as GPS, GIS and LIDAR. Their acquisition speeds are suitable for measuring objects such as cars, planes, trains or buildings. One disadvantage of TOF laser techniques, however, is that they are less accurate than close-range techniques.

Passive High-density Scanning

Also known as dense stereo vision (DSV) digitizing, passive scanners capture high-resolution photographs of surfaces lit with high-lumen external or ambient light, instead of radiating light. DSV techniques use multiple cameras and processing software, and are useful for mid-range scanning. They are simple to set up, have rapid measurement times, and some commercial versions provide automated surface matching. Drawbacks include being less accurate than close-range techniques due to occlusion effects, and only working on parts with texture. DE

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INFO → InnovMetric Software, Inc.: Innovmetric.com/polyworks/3D-scanners/home.aspx?lang=en

→ National Research Council Canada: NRC-CNRC.GC.ca/eng/projects/iit/3d-metrology.html

For more information, visit deskeng.com/articles/aaazje.htm.

Bunkspeed SHOT Aims for Simplicity

Software makes photorealistic still images easy to render.

BY MARK CLARKSON

Bunkspeed SHOT is focused on one thing: It produces photorealistic still images of models created in other applications, and it produces them in a minimum of time with a minimum of fuss. In fact, it produces them almost instantly.

The SHOT renderer progressively refines the image.

Super Simple

Good news for those new to 3D rendering, or those sick of learning the ins and outs of new applications: Bunkspeed SHOT is designed to be as super-simple as possible.

For example, when you open a file, SHOT automatically begins rendering it. You don't even have to press a button, just open the file and wait a bit. Another example: There are no quality settings. There's no mucking about with ray bounce settings, photon emission or shadow quality. Everything is turned on and set to its highest quality at all times. The final quality of the render depends on how long you feel like letting it run.

SHOT iteratively refines the render. With every pass—SHOT calls them frames—each pixel gets closer and closer to its theoretical "perfect" value. It's a bit like watching a progressive download JPG from the olden days of dial-up connections. You can save the onscreen render at any time. SHOT keeps refining until you stop it, giving you a running total of frames rendered along with the current frames per second.

It's done when it looks done.

Change the camera's depth of field, add an object, move an object, or adjust a texture and SHOT starts the render over again. Fortunately, those renders are stunningly quick.

GPU Adds Speed

SHOT employs mental images' iray technology for interactive photorealistic rendering. One often hears the phrase "real time" bandied about, but it's not real time. It is ferociously fast, much, much faster than my normal rendering applications.

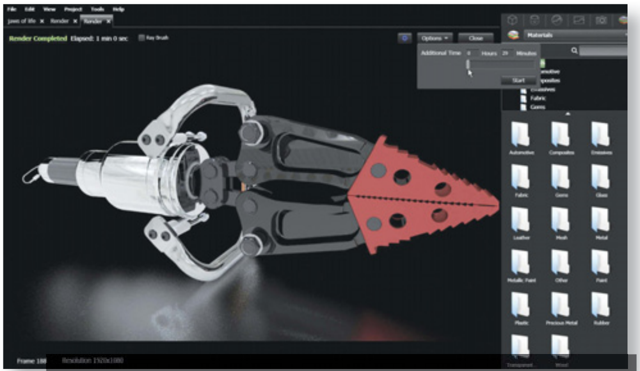
SHOT—and iray—pull this off by leveraging all the processor cores in my graphics card, as well as those in the CPU. iray runs on NVIDIA's CUDA parallel computing architecture. CUDA-capable NVIDIA cards contribute their GPU processors to the computing task at hand.

I ran SHOT on a dated Dell XPS workstation with a dual-core CPU and NVIDIA Quadro card. I then started testing with a Quadro FX 4800 with 192 64-bit GPUs. Performance didn't increase by a factor of 100, but it did jump by a factor of six or so, increasing from 0.6 frames per second to 3.6 frames per second in my 3.77 million-polygon test scene.

I then swapped the FX 4800 for a Quadro 5000 with 352 GPUs. This pushed performance up to 5.2 frames per second—roughly an order of magnitude faster than the CPU alone.

SHOT doesn't actually require a CUDA-capable card to run. You can render using just the CPU, just the GPUs, or both. (Even in GPU-only mode, SHOT kept one of my cores pumping at 100%.) SHOT's pretty fast running on just the CPU, but to see it really do its stuff you'll need a lot of CUDA cores.

In GPU or GPU+CPU mode, SHOT visibly sucked the performance out of my system. My mouse moved in little jumps and



If the finished render hasn't achieved the quality you want, you can add more render time.

Materials for the current scene are accessible via the explorer pane.

hops across the screen. When you want to start moving objects around on the screen, it's time to switch ray tracing off. In raster mode, response actually is in real time. Raster mode looks pretty good, with reflections and highlights.

Minimal User Interface

SHOT's interface has been pared down to a bare minimum. There's only one window. There are no orthographic views (top, front, etc.). Everything is done looking through the camera, although you can have multiple cameras so that you can observe your scene from different positions.

A tool bar at the top gives access to cameras, the selection tool, move and rotate tools, and a render button. Here you can turn ray tracing on and off and enable the Ray Brush. If this still takes too much real estate, you can "un-pin" the toolbar to automatically hide it.

The right side of the screen is an explorer window that lets you browse through materials, models, parts, environments and so forth. The model tree shows small 3D snapshots of the parts, which pop up to a larger size when you mouse over them.

SHOT provides you with genuinely useful tooltips. Hover your mouse over the Roughness slider on a plastic material, for example, and you'll get the tip: "Roughness decreases reflectivity" rather that the usual (and useless) "Drag to increase/decrease roughness." Kudos, Bunkspeed!

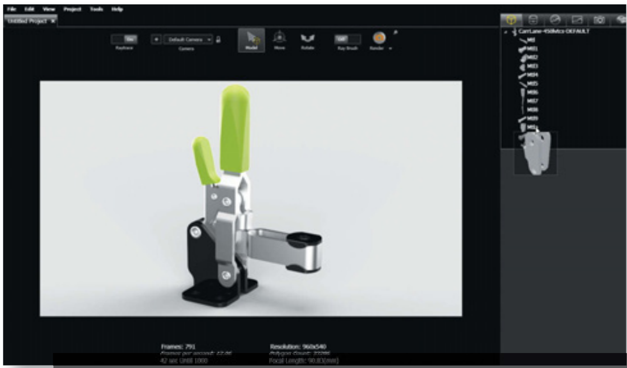
SHOT's version of a render region is an interactive tool called the Ray Brush. When the Ray Brush is active, you get a resizable circular region on the screen, similar in appearance to a Photoshop brush. As you move the Ray Brush around the screen, all of SHOT's rendering power is applied within that circular region. If the car body looks fine but the chrome wheels are a bit spotty, use the ray brush to focus SHOT's renderer on them. The Ray Brush provides optional magnification of the highlighted area as well.

Working with Models

You can't model in SHOT. Alright, you can. A little bit. Unlike its predecessor, Hypershot, SHOT allows you to create and manipulate an assortment of basic primitives—cones, spheres, tori, tubes, arrows, walls, planes, boxes and so forth. These are useful for creating floors, walls and tables to hold your models, and also for creating lights through the use of emissive materials.

Aside from these primitives, though, all of your models will come from outside applications such as SolidWorks or

You can duplicate, move, rotate and scale objects to place them where you want them in the scene.



Browsing through the parts of an imported SolidWorks assembly.

3ds Max. Bunkspeed offers free plug-ins for Creo Elements/Pro, SolidWorks and Rhino that launch SHOT from within those applications.

SHOT also supports the import of a goodly number of file formats including 3ds, STL, FBX, Collada and SolidWorks parts and assemblies. It can auto-size imported objects and snap them to the ground plane. You can select by model, part or material and perform the usual movement, rotation and scaling transformations. If you have an array of objects, SHOT will arrange them for you in lines or circles.

Retexturing Materials

Materials on imported models range from not-quite-right to not-there-at-all, so you'll need to retexture them before rendering. Fortunately, SHOT's material editor is basic and easy to use.

Choose a material from the basic types—glass, metal, paint, matte, etc.—and adjust its relatively few settings. Materials only have controls pertinent to that particular type. Painted materials have clear coat settings. Metal materials have roughness. Emissive materials have intensity. You can add textures maps to control color, bump, specular and anisotropics.

You cannot build the kinds of infinitely complex materials here that you can in, say 3ds Max. SHOT's materials are limited but adequate and, moreover, pretty easy for non-technical types to understand and manipulate. If you want shiny red metal, you select the metal material type, make it red and turn the roughness down.

Environments and lighting

Basic lighting in SHOT is provided by high dynamic range (HDR) environments. In essence, SHOT uses the light from a photograph to light the scene. Drag in an outdoor, environment and your model gets outdoor lighting complete with reflections of clouds, sky and mountains. Or, drag in a photo studio, or a kitchen. Light, shadows and reflections are automatic and accurate—no lights required. You can adjust the brightness of the environment, spin it around, and make the ground reflective. You can also make the environment invisible. It still provides the scene lighting, but doesn't show up in the final render.

SHOT also lets you construct lights of a sort by creating simple primitives and assigning them emissive materials. There are no IES standard lights—no real-world light settings at all. It's more of a by-guess-and-by-gosh process of sliding the material's intensity slider around. But, again, it's easy and interactive.

Rendering

What about when the time comes to, you know, really render? SHOT's interactive, on-screen render is actually good enough for lots of uses, but when screen resolution isn't adequate, push the Render button and create whatever size and quality you need.

Remember that there are no quality settings, per se. To tell SHOT when to stop, you set a time limit, or limit the number of frames to be rendered. Don't let the reference to "frames" deceive you. SHOT has no animation capabilities. I'm sure Bunkspeed will be addressing that shortly.

Even the final render is fairly interactive. You can use the Ray Brush here to focus the renderer on areas needing extra work. You can watch the render as it refines and save it when it looks good enough. Conversely, if, at the end of your allotted render time, the image isn't up to snuff, you can add more render time.

SHOT's focus on ease of use may alienate some advanced users who want to create 20-layer material trees or emulate a Canon F/1.4 50 mm lens. SHOT is a one-button mouse in a world of programmable 3D peripherals. But it's fast, it's easy and it makes beautiful pictures. Did I mention it's fast? I like it a lot.

Download a 30-day trial version at bunkspeed.com/shot. **DE**

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5 Tips for Prototyping Robotics

Keep complexity in check with early-phase prototypes.

BY JAMIE BRETTLE

FIGURE 1: **Engineers from Virginia Tech University developed an autonomous robotic system to assist vision-impaired drivers.**

Robotics present an opportunity to introduce a disruptive technology force that can serve to improve everyday lives in a multitude of ways—from robots that perform surgeries to autonomous vehicles. In order for robots to perform complex tasks they require an ever increasing number of sensors and actuators to interpret the world and more powerful complex algorithms running on the newest embedded processors.

However, as engineers and scientists are able to create more capable robots, managing system complexity becomes a risky proposition. As a result, developers are forced to discover new methodologies to help mitigate the risk associated with complex and novel designs. One such methodology is to develop early phase prototypes that can help reduce the risk associated with developing robotic applications. Prototyping offers benefits to engineers by providing early feedback into the design process while engaging potential clients, customers and investors.

Here are five tips that will help you prototype your next robotic system:

1 Ideas are Cheap

With the advent of the Internet, ideas are being shared faster and more cheaply than at any time in history. Technologies like YouTube and Twitter drive cost and time involved with sharing an idea to virtually nothing. The most costly part of creating a new robotic system is not in coming up with the idea, but rather in determining whether the idea holds any economic value.

By creating a robotic prototype, you can show potential customers and investors an idea in a concrete form. This provides a platform for you to solicit feedback and test whether the idea has value in the marketplace; something that is challenging to do when an idea only exists on a whiteboard or technical specification document. For example, engineers from Virginia Tech University were able to develop a semi-autonomous vehicle that allows a blind driver to successfully navigate, control speed, and avoid collision through a secure driving course (See Figure 1). By developing the robotic system, they were able to successfully test their ideas out in the real world.

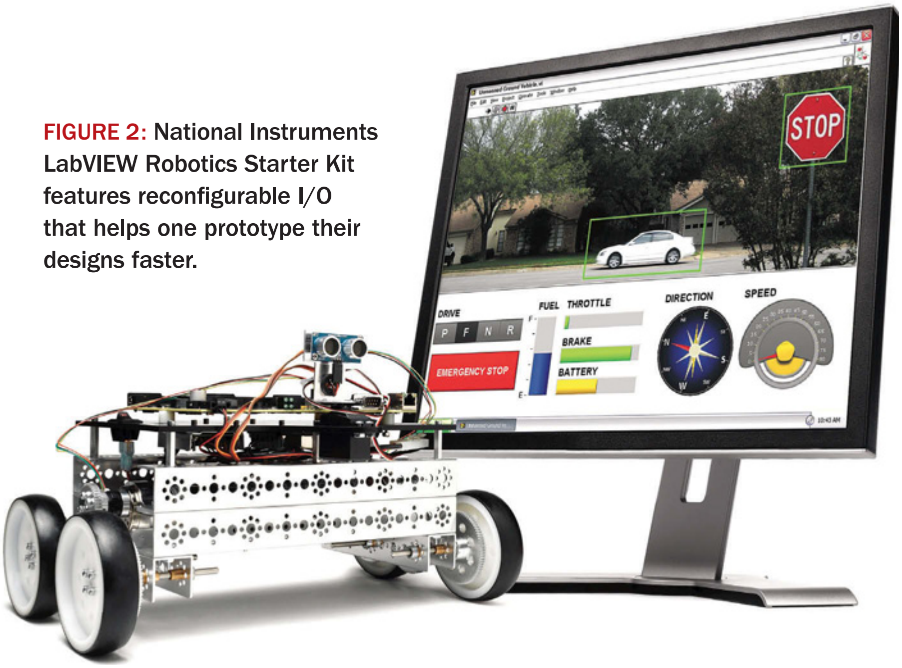

FIGURE 2: National Instruments LabVIEW Robotics Starter Kit features reconfigurable I/O that helps one prototype their designs faster.

2 Don't Optimize for Cost

As engineers, we're tempted to always aim for the best and most elegant solution. When creating the final customer-facing robot, this is an admirable and necessary trait. However, when designing a prototype system, this is not always desirable. A potential pitfall when creating the electromechanical system is getting caught in endless cost optimization while selecting processors, memory, sensors and motors, trying to squeeze as much performance out of

Why Build a Prototype

With any engineering endeavor where innovation is taking place at unprecedented levels, such as robotics, prototyping is an absolute must. Prototyping offers engineering teams the ability to test and understand if a project is feasible both technically and economically, while mitigating the risk associated with building a ready-to-deploy system. Prototypes help one to iterate on a design, using the parts that work while refining those that fall short of applications. Ultimately, the prototype allows you to put your best foot forward when presenting to customers and investors who help determine the level of success at your company.

each of these subsystems. The same can hold true for the software engineers on staff, constantly refining and optimizing code, resulting in slipping deadlines. This process of optimization can often become a giant time sink at the beginning of the project, a time when it is most important to validate whether the project is possible and economically viable. Many projects run out of money and time before anyone ever sees what the engineers have been working on.

While cost is an important factor, the goal of the prototype is to create a platform that is within a striking distance of profitability. The robotic team should focus on building a system that clearly demonstrates the value the robot offers. Setting this as your bar of success will help your team showcase your technology to the public before running out of capital. Once customers and investors are interested and supportive, your team can then focus on optimizing the design down to an efficient and profitable system.

3 Reconfigurable I/O

Sensors and actuators are what allow a robot to experience and manipulate the world. Unfortunately, at the beginning of the design process, it's almost impossible to know all the details about the inputs and outputs of the system, including what voltage levels are required, sampling rates, number of channels of input and number of digital lines just to name a few. That being said, incorporating I/O in your prototype is essential in creating a truly functional system. By adding sensory input and control output, engineers prove their design can be implemented in the real world. Creating a paper design, implementing that design in software and even simulating the design in a virtual environment are still largely conceptual exercises. To prove the value of your design to skeptical investors, the prototype needs to receive data and respond accordingly. Additionally, data from prototyping operations helps you refine functional requirements with clients and the rest of the design team based on actual performance.

Choosing a prototyping platform that allows engineers to quickly swap out I/O and try new combinations allows your robot to be dynamic and change as the engineers learn more about the problem they're trying to solve. The robot in Figure 2 is a National Instruments based platform that enables engineers to mix and match I/O depending on the needs of the system. This allows you to quickly prompt a robot to interact with the real world, while still permitting the flexibility to change when necessary.

4 Design for Reuse

One aim of the prototype is to be able to move to a subsequent design, either one more optimized and closer to the end product or one that incorporates customer feedback. In either case, the engineering team must decide which components can be used in the next iteration of the design. Extra focus must be given to these components—whether a communication protocol or software algorithm—to ensure that their interfaces and implementations make them as portable as possible in the next phase of development. This involves making sure you have consistent interfaces, decoupling components and maintain a modular design.

When choosing tools to prototype your system, it is important to consider whether these tools offer a platform that can enable engineers and scientists to develop the system at the volume required and at a price point that is profitable

5 Demonstrate Your Prototype

It should be easy to demonstrate your robotic prototype. This prototype will become your calling card–the first thing that customers, venture capitalists, and potential employees notice. A prototype that is easy to set up and quickly illustrates what differentiates your product is the best way to generate positive buzz around the company and robot. When pitching your idea, show the demo as quickly as possible. An impressive demo can do so much more for your company and product than simple slides on a projector. DE

Jamie Brettle *is product manager for LabVIEW Embedded Software at National Instruments. Comment on this article via de-editors@deskeng.com.*

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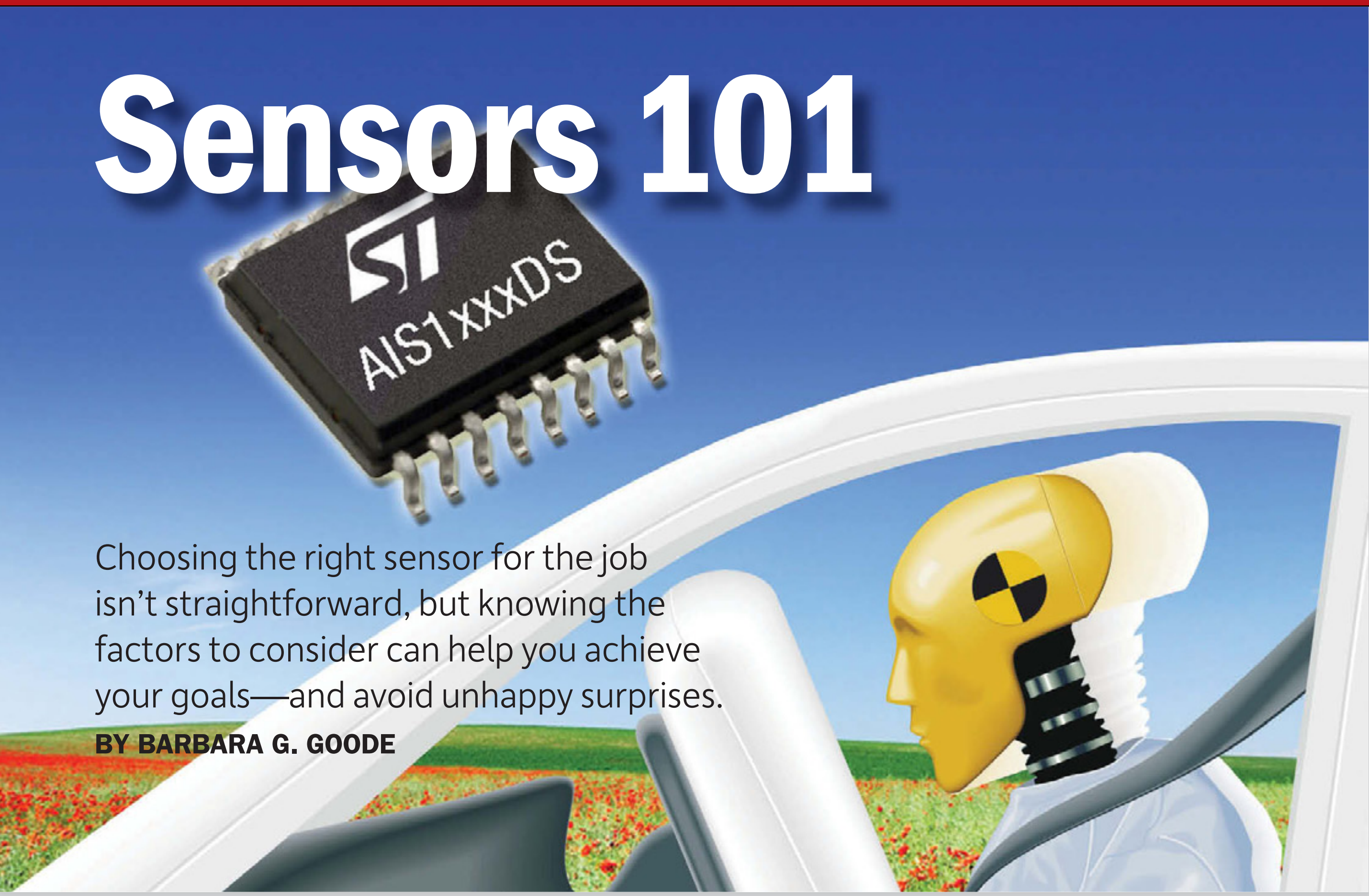
Sensors 101



Choosing the right sensor for the job isn't straightforward, but knowing the factors to consider can help you achieve your goals—and avoid unhappy surprises.

BY BARBARA G. GOODE

An airbag sensor is an example of a device whose application requires fast response time.
Image courtesy STMicroelectronics.

Life is good for engineers looking to add functionality to their designs and enable product differentiation. Why? Because such functionality depends upon sensors, and now more than ever, sensors are available to detect every type of physical phenomenon conceivable. What's more, sensors are more reliable and capable, smaller and much more affordable than ever before.

How Sensors Work

The function that a sensor performs is to detect a physical parameter and transduce its energy to a signal that can be understood. Thus, many people use the words "sensor," "detector" and "transducer" interchangeably—and sometimes the word "monitor." Implied in the act of detection or sensing is measurement of the strength of the phenomenon, and so the terms "sensing" and "measurement" can likewise mean the same thing.

Analog sensor signals are processed—digitized and often amplified—before the data is transmitted either to a controller, which evaluates it and may perform some responsive action, or to a data storage unit for the purpose of subsequent analysis.

Sensors can measure physical phenomena either directly, or indirectly, by inference. Tire Rack, Inc., for example, does a good job of explaining the difference using the example of tire pressure monitoring: "Direct systems attach a pressure sensor/transmitter to the vehicle's wheels. An in-vehicle receiver warns the driver if the pressure in any tire falls below a predetermined level." On the other hand, "indirect systems use the vehicle's antilock braking system's wheel speed sensors to compare the rotational speed of one tire versus the others. If a tire is low on pressure, it will roll at a different number of revolutions per mile than the other three and alert the vehicle's onboard computer."

Although many parameters can be measured directly or indirectly, some, like velocity, can be measured only indirectly. Similarly, phenomena can be measured either through contact with a sensor (that is, by a contact sensor) or without (that is, by a non-contact sensor). Contact sensors tend to be more reliable, but are not always practical or preferable because physical contact can have an effect on the measured parameter. Beyond that, the two approaches have distinct capabilities.

For instance, contact temperature sensors have a more sluggish response rate (seconds) than do non-contact (milliseconds). Watlow, a supplier of temperature sensors, outlines the pros and cons of contact and non-contact temperature sensing online at Din-a-Mite.com. Among the characteristics of each are:

Contact temperature sensor

- relatively rugged and accurate;
- economical;
- wide application range;
- simple to apply
- can cause wear on components; and
- acts as a heatsink, alters readings on small objects

Non-contact temperature sensor

- relatively rugged;
- can sense temperature of irregularly shaped objects, and objects in motion
- cannot sense temperature of gases;
- will not deface, mar, contaminate or interfere with the process;
- will not act as a heatsink;
- field-of-view (spot size) restrictions;
- ambient temperature restrictions; and
- indicated temperature affected by environmental conditions (dust, smoke, etc.)

Critical Concepts

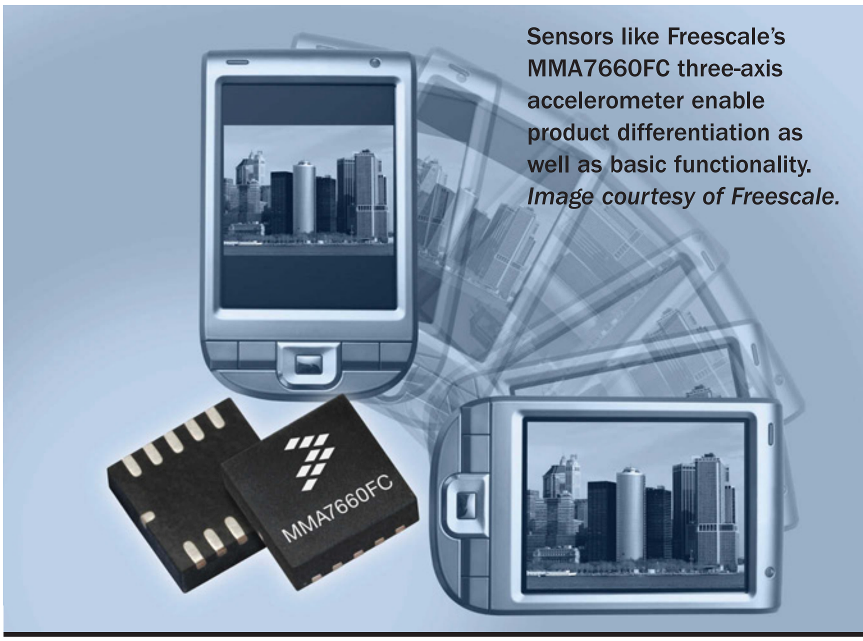
Important concepts in sensing include **sensitivity**, which is the smallest amount of change in the measured phenomenon able to generate a detectable change in output. Similarly, **resolution** is the smallest unit of change evident in the signal generated.

The **range** of a sensor refers to the span within which it can deliver accurate measurements. For instance, a pressure sensor may have a range of 0 to 25 psi. Exposing it to conditions beyond this range can result in bad data or destruction of the sensor.

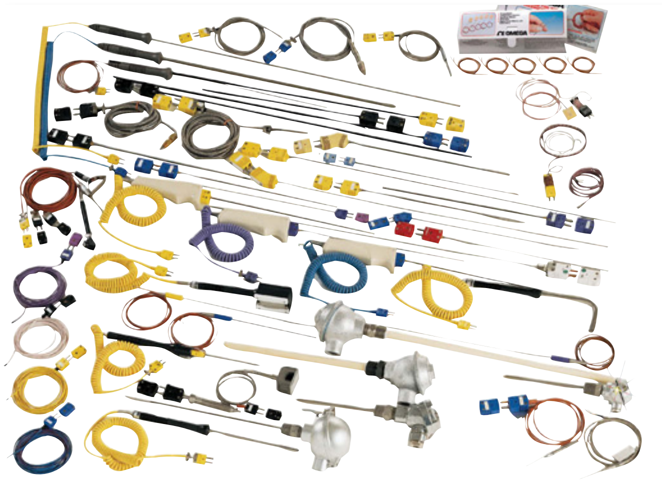
Precision and accuracy are often confused: **Precision** indicates a sensor's ability to repeatedly produce the same output when measuring a phenomenon that remains stable. By contrast, the **accuracy** of a sensor is the maximum difference between the actual value of the measured phenomenon (for instance, temperature as measured by a calibration standard) and the value that the sensor outputs.

Along the same lines, **offset** is the reading that a sensor will produce compared with what it ought to produce—either when the output should be zero, or when it should correspond to a particular reading under a certain set of conditions (realistically, a sensor's output will be ideal only at one point).

Response time is the increment of time that it takes a sensor to produce a settled output within an acceptable range of tolerance once it is exposed to the measurand (the quantity being determined by measurement), while **linearity** is the ability of the sensor to produce an output signal proportional to changes in the measured property over the working range of the device.



Sensors like Freescale's MMA7660FC three-axis accelerometer enable product differentiation as well as basic functionality. *Image courtesy of Freescale.*



Temperature is the physical phenomenon most often measured. The most commonly used sensors for measuring temperature include both resistance temperature detectors (RTDs) and thermistors (left), and thermocouples (right). ***Images courtesy Omega Engineering, Inc.***

By contrast, **dynamic linearity** measures a sensor's ability to represent changes in the property being measured. And **hysteresis** represents the ability of a sensor to respond to changes in the measured property, both up and down within the range.

When looking at sensor options, you must understand your needs in these various areas. For instance, an accelerometer in an automobile that deploys an airbag in response to a crash must have quick response time, but a temperature sensor that monitors liquid in a large tank need not.

What will you sense, and how?

Ideally, a sensor measures the property of interest—and is influenced by nothing else. For each property you may want to measure, there are multiple technologies available to accomplish the task. But not all of the sensor types may be suited to your application.

SENSOR RESOURCES

A number of vendors and independent media outlets provide helpful basic information on specific types of sensing, as well as general sensor topics. These are a few examples:

Temperature sensing

- Picotech.com/applications/temperature.html
- CP.literature.agilent.com/litweb/pdf/5965-7822E.pdf
- temperatures.com

Pressure sensing

- CTSensors.com/basic_of_pressure_measurements.pdf

General sensing

- Zone.ni.com/devzone/cda/tut/p/id/4045

For instance, options for sensing temperature include resistance temperature detectors (RTDs), thermocouples and thermistors (thermal resistors)—each of which has different capabilities. **Thermocouples** are inexpensive and rugged, and have a wide range, but they are not known for accuracy. **Thermistors** are relatively cost-efficient, but have a narrow temperature range—though within that range they tend to be accurate. Likewise, **RTDs** are accurate within narrow temperature ranges, but costly. On the other hand, they offer repeatability and long-term stability, among other benefits.

And so it is with every measurand. Engineers can use sensors to measure many dozens of distinct phenomena, including acceleration, chemical composition and gas, displacement, flow, force, motion, pressure, proximity, position and presence; strain, torque, velocity, vibration, and viscosity. Multiple options exist for detection of each phenomenon, and every type of sensor has a specific range of capabilities.

Thus, it's important to understand the particular demands of your application, in addition to the strengths, limitations and common sources of error inherent in each technology. **DE**

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INFO ➜ Freescale: Freescale.com

➜ **Omega Engineering:** Omega.com

➜ **STMicrosystems:** ST.com

➜ **Tire Rack, Inc.:** TireRack.com/tires/tiretech/techpage.jsp?techid=44

➜ **Watlow:** Watlow.com

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

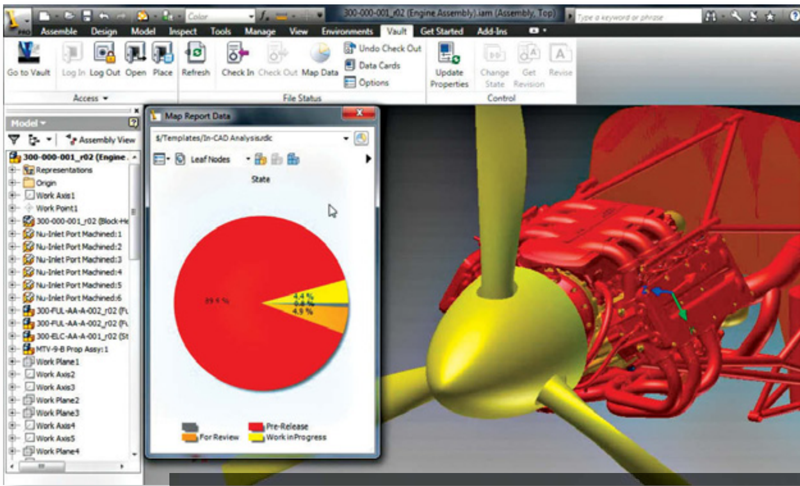
Take 5 Steps to Protect Your 'Legacy'

Autodesk Vault can help organize and manage all of your historical engineering data so that it's there when you need it.

BY DARREN HARTENSTINE

Old data: Everyone who uses a computer has it. In my consulting visits with manufacturers, I have seen many attempts at securing and managing their legacy of information, which typically consists of paper drawings, electronic drawings, 3D models, MS Word and Excel documents, and more.

As a consultant for an Autodesk reseller, we implement the Autodesk Vault products. When we implement our data management solution, we recommend importing all our clients' engineering data—some of which was created decades ago. To successfully import this data, it must go though several steps to guarantee the information is up-to-date and accessible:



Autodesk Vault's visual data-management environment, with red highlights to display subassembly components in pre-release phase. *Image courtesy of Autodesk*

1 Evaluate the Data

Understanding what, where and how much data exists will provide the current state of the information and help plan for the next steps. There are many tools available to scan and document legacy information before it can be imported into the Autodesk Vault.

We use a tool called Autodesk Autoloader during the various phases of an implementation. In the initial phase, it provides us with a list of the CAD data and any issues that may exist.

To set it up properly, we add the various root folders that contain the customer's engineering data. Autoloader will scan each of the folders, determine whether the data is older than a particular product release, and validate the location of the external references (XREFs) for AutoCAD files and the parent-child relationships for Autodesk Inventor files. Any issues will be documented and outputted into various file formats for review.

These file relationship issues can be caused by users renaming, deleting or moving files without updating the parent file with the changes. The files that are marked as problems must be fixed before the data is imported into Autodesk Vault. This is my primary rule for implementing Autodesk Vault—or the results will be detrimental to the success of the implementation. As the old saying goes, "garbage in, garbage out."

Autoloader will also search the selected folders for duplicate files. Although the output of duplicate files is important, they can still be imported into Autodesk Vault. We typically recommend importing the duplicate files into Autodesk Vault and using the various tools within Vault to rectify the duplicate file issues.

2 Clean up the Data

From the previous step, we have a list of "bad" files that must be repaired before they can be imported successfully to Autodesk Vault. The log file from Autoloader will list the location of the parent files, as well as each of the issues with the children files.

Repairing the files in this stage is typically the responsibility of the customer, because of the liability of the process. The customer knows its data and can make the determination of which files are used to repair the issues.

3 Migrate the Data

Depending on the amount of CAD data and the various CAD applications used, this step could potentially take some time to complete. We typically work with AutoCAD and Autodesk Inventor data and use two separate programs to perform the migration.

For AutoCAD data, we will run an automated tool that will recover corrupted files, purge unused entities, migrate it to the latest version and configure page setups for each file.

Usually with Inventor data, we only need to migrate to the latest version using Autodesk Task Scheduler, which is available with any version of Autodesk Inventor.

Each of these tools can be distributed among several computers to process the data in parallel. This provides faster processing of all of the AutoCAD and Inventor data.

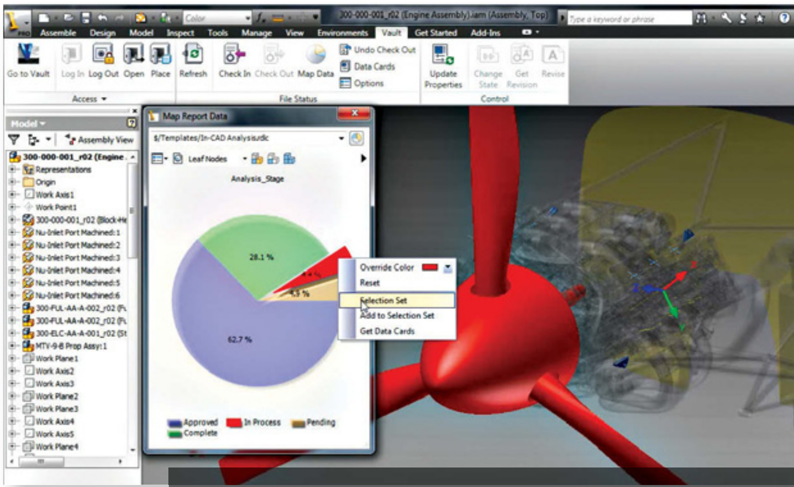
4 Import the Data

Using Autodesk Autoloader, the engineering data is scanned a final time. This will tell us whether all of the data has been repaired or migrated to the latest release.

When all is successful, the importation process can begin. This process is automated and can take some time, depending on the number of files. Autoloader can be run on several computers during this phase to optimize performance.

5 Make the Data 'Intelligent'

Once the files are imported into Autodesk Vault, additional intelligence can be added. Some of this may have been automatic by using the block attribute names or iProperties that exist within AutoCAD and Inventor files and indexing the values. Examples include the description, part number, created by, etc., which are usually located in the title block of the drawing. With non-Autodesk files, the Vault can index standard file properties like Title, Subject, Keywords, Category, Comments, Author, etc.



Project data is housed in Autodesk Vault, but can be displayed inside an Autodesk Inventor assembly file with in-process components isolated in red. ***Image courtesy of Autodesk***

If these properties contain data, Autodesk Vault will automatically populate the equivalent property in the database for Vault. This makes it easier to search and organize data within the Vault. If the properties are blank, the Vault will allow for easy editing and the data can be synchronized back to the original file.

With all implementations, the process of analyzing, preparing, importing and maintaining the legacy data is similar. What tasks are performed and what data is imported may differ based on the needs and requirements of a client's design processes.

The bottom line, however, is that there are many benefits that result from this effort—including easy access, searching, editing and design reuse. **DE**

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INFO → Autodesk: USA.Autodesk.com.

→ MasterGraphics: mastergraphics.com.

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

What to Do with Paper Drawings

In some cases, there are a lot of paper drawings that were created many years ago. To import this data into the Vault, it must be scanned and converted to a file format. With Autodesk Vault, this data can be outputted to PDF or Autodesk's DWF technology. We recommend using DWF, because the output size is generally smaller than a PDF, but either will work fine. With the 2011 release of Autodesk Vault, viewing of PDF files can be done within Vault Explorer.

Additional information like Description, Part Number, Material, etc., can be added once the data has been imported to Autodesk Vault.

Toward the Windy City

Dr. Majid Rashidi has designed an economical way to squeeze more power out of less wind by windspeed amplification.

By Mike Hudspeth, IDSA

Dr. Rashidi's turbines can be retrofitted to such structures as water towers and grain silos. He believes there are plenty of round structures that would be ideal places to generate electricity.

Just about everything we use, enjoy or depend upon is electric—a situation that continues to grow more problematic. From rolling brownouts in California to complete blackouts in the northeast, we are continually seeing that we need to find new ways of meeting our electrical needs.

Today, we generate power in many ways. We burn coal, but clean it all you want—it still pollutes (and is dangerous to dig). We build hydroelectric dams that use the potential energy of water concentrated by gravity to turn turbines downstream, but they submerge and destroy a lot of natural habitat. We split the atom in nuclear power plants, but few people want one in their back yards.

In the alternative energy corner, we have solar power. Solar cells are cleaner and are getting more efficient all the time, but still lag far behind most traditional forms of energy generation. We are building giant wind farms, but many people think they are eyesores, loud and dangerous for wildlife. We are even starting to use waves and the tides to generate energy.

We are trying, but how are we going to get the job done?

Enter Dr. Majid Rashidi. He has designed a new kind of wind tower that could help make a difference between convenience and doing without.

DFM Basics

Design for manufacturing (DFM) is a discipline that pays careful attention, from the earliest stages of a project, to how something is made. It looks to simplify the process and make it easier. There are lots of examples of how this is done: snaps instead of screws and labor (automated or human) to screw them in, assembly part reduction, materials specification, etc. It all adds up.

How It Works

A wind tower introduces a propeller into an air flow. The wind pushes against the propeller's surfaces, causing it to turn, which rotates a turbine (essentially a motor) that generates electricity by passing magnets near conductive coils, thus inducing electron flow, or current.

There are usually two problems at this point:

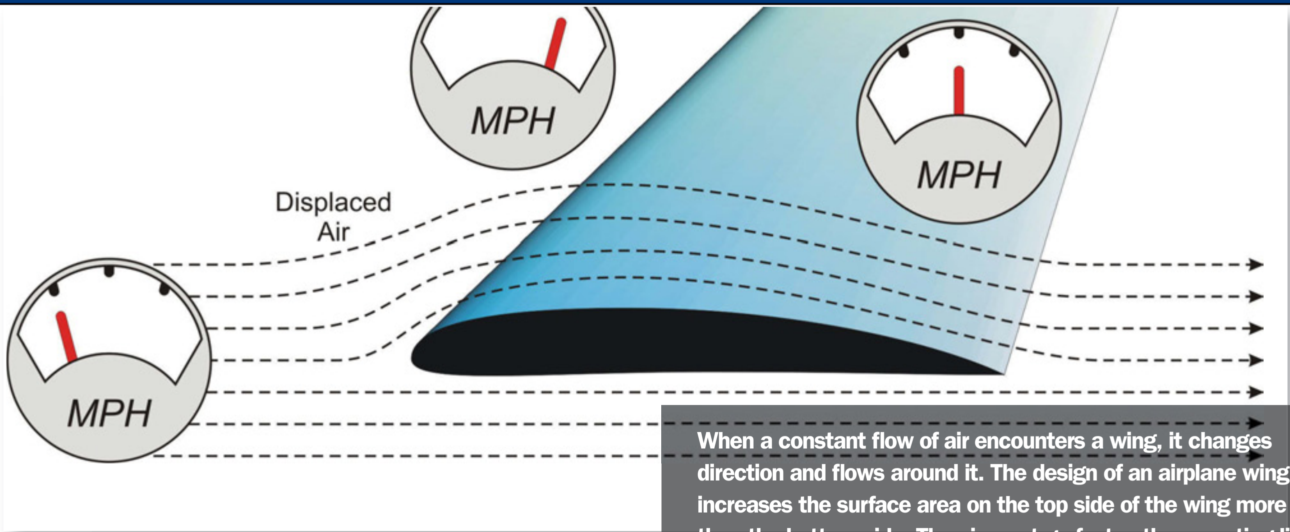
1. Rotational motion is transmitted through a gearbox to the turbine, an inherently inefficient process.

2. It takes a lot of wind to rotate the propellers. Even the best turbines don't operate near their theoretical limits.

Friction is the enemy of efficiency. Bearings aren't perfect. They drag on the turbine, slowing it down. Even the magnetic field inside the turbine does all it can to stop the rotation. Air is a relatively low-density energy source, and even when propellers get going there is what is called a "cut-in speed"—the speed the propellers have to rotate before they can even begin to generate usable electricity.

Rashidi developed a wind tower that can operate in much lighter winds. Not only that, but it is considered to be much safer than existing wind towers. It doesn't use huge propellers, instead employing multiple smaller ones.

Rashidi is a professor at the Fenn College of Engineering at Cleveland State University in Ohio. His expertise is in machine system design, machine component design, design for manufacturing (DFM), dynamics/vibrations of machinery, fluid-solid interactions in machinery, and bearing design.



When a constant flow of air encounters a wing, it changes direction and flows around it. The design of an airplane wing increases the surface area on the top side of the wing more than the bottom side. The air must go faster, thus creating lift.

Air is basically a fluid. It ebbs and flows, following the path of least resistance. When forced against an obstacle, it will displace or flow around the object. Any time there is a change in direction, relative velocity increases. This is how a wing generates lift. The ambient air velocity increases as the air goes over the wing, but must equalize by the time it flows off the back of the wing.

Rashidi capitalizes on this principle by mounting a column of turbines on a rotating base on each side of a cylindrical structure. When the wind encounters the cylinder, it flows around it, picking up speed. The turbines are located to either side, right in the path of the flowing air where it's going its fastest. Testing has indicated that efficiencies of up to 60% are possible—much higher than most wind tower designs. And because of the rotating base, the wind can come from any direction.

Developmental Details

Rashidi fleshed out designs he hopes will spread across the globe.

"It's not the initial idea that I patented," he says; rather, it's the result of tinkering and shaping the model into a feasible product. Using DFM principles, Rashidi modified and streamlined the wind tower, making it more cost-effective.

"I used SolidWorks' design software for generating the engineering drawings of the project," Rashidi explains. "I also used Fluent software for computational fluid dynamics (CFD) analysis to simulate the air flow patterns for my system."

Rashidi is quick to note that although that was the software he used, equivalent results would have been realized with other products. "The above tools made it possible for us to optimally design the system and minimized the fabrication trial-and-error that we would have otherwise encountered," he says.

Rashidi used a Z Corp. rapid prototyping machine to develop tabletop, scaled-down selective laser sintering (SLS) models of the system, and tested the main design concept in small scale.

Plan of Action

Rashidi's prototype wind tower graces the roof at Cleveland State University, and he says there are places in the heart of just about every city where the wind tower could be installed. Because the propellers are much smaller than traditional wind towers, it will fit on existing structures like water towers.

By using energy that is available at night, when demand is lightest, water can be pumped up into towers. Later, that water can be released and the flow used to turn turbines. Thus, a water tower becomes a sort of "hydro-gravitic battery," capturing and using the potential energy of the elevated water. Rashidi also notes that the wind tower can even be placed on a grain silo to help power a farm. **DE**

Mike Hudspeth, *IDSA, is an industrial designer, illustrator, and author who has been using CAD and design products for more than 20 years. He is* DE*'s expert in ID, design, rapid prototyping, and surfacing and solid modeling. Contact him via de-editors@deskeng.com.*

Wind Tower Costs

The short answer is that it depends on how it's put together. When piecing together the prototype for Cleveland State University's roof, Dr. Majid Rashidi was constrained to go through certain channels to acquire parts. The turbines for his system came in at about $10,000 apiece. Obviously, though, these units can be had much cheaper. In fact, he notes that any secondhand electric motor or junkyard automotive alternator could be made to do the same thing. Using materials of this kind, then, would enable anyone's budget to build one of Rashidi's wind towers.

INFO ➜ ANSYS: Fluent.com

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

➜ **Z Corp.:** Zcorp.com

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

Going Green with Rapid Tech

Reducing both materials and the weight of transported components are key benefits of additive manufacturing processes.

By Susan Smith

Many years ago, Kermit the Frog made a profound statement: "It's not easy being green." Little did he know that being green would become a catchphrase in the 20th and 21st centuries, a goal for every business wanting to demonstrate its commitment to saving the ailing planet.

Traditional manufacturing processes have come under scrutiny by green watchers because of the large carbon footprint they leave when moving large manufactured parts, such as those belonging to aircraft or automobiles. In addition to the manufacturing impact, they incur greater fuel consumption and add time to the design-to-manufacture process. They also can produce a great deal of waste products.

On the other hand, additive manufacturing (AM) processes and material types are thought to generate less waste and less weight, in general, which reduces the amount of material that goes into the finished product. They also have been known to reduce the time it takes to design and manufacture products.

Issues to consider when comparing AM to traditional manufacturing processes include:

- Recycling materials, waste products and disposal.
- Weight of materials and finished products, leading to fuel consumption in transport.
- Reducing design and manufacture time.

The V-flash cartridge is completely self-contained and is recyclable via 3D Systems' recycling center. Image courtesy of 3D Systems.

According to Drs. Christopher Tuck and Richard Hague of the Additive Manufacturing Research Group, Loughborough University, UK, AM can reduce the carbon footprint in some ways, even while they add to it in other ways. The real environmental benefits of AM come from reducing material and reducing the weight of components that are transported.

Tuck and Hague spearhead the Atkins Project, a $4.6 million collaborative research and development project funded by the UK government and a consortium of leading industrial partners. The aim of Atkins is to migrate the design, manufacturing and distribution of products and parts away from the high energy-intensive processes used in many organizations to a more sustainable method of production, service and distribution to the consumer.

Because there are several different AM systems, it is hard to quantify the amount of waste for AM in general. Tuck says that some of the systems produce considerable waste products, noting that "where the design uses a similar amount of material or doesn't improve on the performance of the product, the use of AM may actually increase the carbon footprint.

"For polymers, laser sintering is only around 20% material efficient at best, with only a certain portion of the remaining material able to be recycled," he adds. "Again, for complex or lightweight products, this may be better than for competing manufacturing technologies, but it is not correct to say there are little waste materials. For other polymer systems, there are support structures that are either land-filled or dissolved into waste water again."

Depending on the product in question, this can be a large amount of material. For metal products, the waste streams are significantly less, where unused powder can be almost 100% recycled (agglomerates require re-

Stratasys' WaveWash cleaning system dissolves the brittle plastic support material from models made with Dimension 3D printers. Image courtesy of Dimension 3D.

moval) in powder bed systems (i.e. service lifecycle management [SLM] or e-beam). In each of these aforementioned systems, however, support structures must be removed and recycled. "In addition, there are filter systems within these metal machines that require disposal," Hague says.

Most of the results from Atkins stem from energy monitoring and component redesign. "We are typically seeing 50% weight reductions on our 'optimized' components; however, we still need to validate these designs and the production methods," says Tuck. "We also have a beta-test version of carbon footprint mapping software that is capable of letting manufacturers know what inherent carbon content is within their products, made anywhere in the world with both traditional and AM systems."

Materials Management and Handling

Tuck says a portion of polymer laser sintering powder (PA12) can be recycled, but it needs continual mixing with fresh powder (roughly a 60:40 ratio). This inevitably leads to a large amount of waste. By comparison, support structures in other polymer systems are generally landfilled or dissolved using water.

Some vendors have found a way around that process, however. 3D Systems' ProJet is an inkjet 3D printer that uses photocurable resins to produce parts.

"We have formulated support materials out of paraffin wax, which is an inert, friendly substance," says Buddy Byrum, senior director of management product marketing for 3D Systems. "When our parts are built, the materials are in fully closed cartridges. They don't require any exposure of the operator to any non-friendly materials, and the process in the machine fully cures the plastics. So when you take a part out, you've got a plastic part that you can handle, and the support material simply melts away into an inert wax that doesn't have disposal hazards."

3D Systems' VFlash has a thin, small and non-dense support structure, enabling it to break off easily, and generates no in-process waste in the machine. Byrum says 3D printers have traditionally had a significant amount of in-process waste. "VFlash uses up all the material that is put into it," he says.

ZP 150 is a material used for all ZCorp 3D printers except its ZBuilder, which uses polymers. The ZP 150 material is not harmful to the environment and does not involve photopolymer-based materials, according to the company.

"The ZPrinter 150 and 250 are intended for small group use and being right next to the desk, so you don't want to be ingesting chemicals," says Joe Titlow, vice president, product management. "The user of the machine is going to be a person without training in how to deal with chemicals. You don't get any training for how to deal with the ink cartridges you put in your printer, and that's the same model we try to follow."

ZCorp subscribes to a powder-based process, which diminishes the amount of waste that would be the byproduct of some supports. The powder used for a temporary support in the build process needs to be 100% recyclable and reusable in the machine in real time, which is a feature of the most recent 150 and 250. The ZPrinter is run under negative pressure to contain the small particles of powder.

"They get put through a filtering and vacuum system that filters them out of the air and actually deposits them right

RESEARCH NOTES

The following are the Atkins Project areas of investigation.

- Waste minimization during production. Ensuring optimized and repeatable AM production systems can substantially reduce or eliminate waste materials.
- Process efficiency gains. Use AM processes to replace inefficient and wasteful conventional manufacturing processes.
- Reducing transportation. Using digital supply chains and AM technologies to significantly reduce logistical requirements by shortening the supply chain and minimizing the need for waste material disposal or recycling.
- Product design for whole lifecycle impact. Exploiting AM design freedoms to minimize weight for significant reductions in greenhouse gas emissions over the whole product lifecycle.
- Product design for optimized performance. Manufacturing truly optimized products that are more efficient in their application compared to traditional parts constrained by design for manufacture.

back into the powdered stream, so that none of it's wasted during the build," says Titlow. "It keeps the air and the surfaces around the machine much cleaner."

The RapMan Kit from Technology Education Concepts (TEC) runs with two key materials: acrylonitrile butadiene styrene (ABS) and polylactic acid (PLA). Both of these materials are supplied to the machine on spools, and 100% of the material from the spool can be used. The only waste that occurs during part build comes from the support structure.

ABS is a common plastic material that can be shredded and then recycled (yet still maintains its plastic properties); PLA is a biopolymer, and therefore biodegradable and environmentally friendly. It is capable of building large parts, but with the crucial benefit that the lifecycle of the part itself has zero carbon impact on the environment.

Solido's 3D desktop prototype printer, the SD300 Pro 3D printer, enables users to use CAD specifications to cut, glue and layer engineered plastic sheets from a spool, a process known as laminated object manufacturing (LOM).

As the process allows nested multiple parts to be run simultaneously, there is less leftover waste product. The other green plus of this printer is that the consumable material is non-toxic and can be peeled away with forceps supplied with the machine.

The ZPrinter is run under negative pressure to contain the small particles of powder in its powder-based process. ***Image courtesy of Z Corp.***

Dimension 3D Printing, a brand of Stratasys Inc., launched its WaveWash cleaning system that dissolves the brittle plastic support material from models made with Dimension 3D printers. This cleaning system requires no gloves, goggles or other protective wear. The pH level of the cleaning solution generally meets drain water requirements worldwide.

According to Public Relations Manager Joe Hiemenz, the model is submerged in the tanks, and the system automatically fills with water and drains at the end of the cycle. There is a powder in a dissolvable packet inside another packet that never is released into the air, as it goes directly into the water and does not become loose until it is in the water. WaveWash weighs 36 lbs. and is 18.24x17 in. With an 8x8x6-in. part capacity, it has a 2- or 4-gal. water level and selectable cycle lengths.

Another effort from Stratasys is the part support style called SMART Supports, which generates supports that use less material during the part building process. SMART Supports is said to reduce build time up to 14%, and lowers material cost by reducing consumption up to 40%. SMART Supports are a user-selection option for Fortus 3D Production Systems and Dimension 3D printers.

EOS also addresses the disposal of powder materials. It has adopted integrated process chain management (IPCM) now also for EOSINT M systems, a process that allows for the reuse of powder materials. Powder is sieved quickly under defined conditions before its reuse. The powder is prepared outside the machine via powder homogenization, to help ensure high quality and flexibility. The IPCM-product range includes multi-purpose lifting trolleys for transporting powder containers, building platforms and clamping systems, as well as for other uses.

Recycling Programs

Manufacturers are also sensitive to recycling issues. Most note when their materials are recyclable—and some even offer their own programs.

3D Systems offers a V-Flash recycling program for the material cartridges as well for the post-processing materials that are used to wash and clean the parts. Recycling centers located in the U.S. and Europe allow customers to return them.

3D Systems also offers trade-up programs for ProJet customers to take in existing machines and re-manufacture and recycle components for use in new machines, avoiding scrapping parts from old machines, thereby reducing the energy and material consumption of building new parts.

All packaging for Stratasys 3D printers, including the spools of material and the cartridges they go into, are recyclable. The fused deposition modeling (FDM) process, used by all Stratasys machines, uses only material necessary to build a part without incurring waste.

ABS plastic models are fully recyclable through any

company's regular industrial materials recycling program, and most AM vendors will have a way to return cartridges and materials. For example, Solido has a recycling program where every SD300 Pro 3D printer shipped will include a pre-paid pouch for sending back excess material and consumables containers for recycling. Customers will receive "green points" to use toward credit on their next order of consumable products.

Objet Geometries' material can be recycled with any plastic recycling program once cured and printed by an Objet 3D printer. In addition, Objet announced a program for its customers to send back all used plastic resin cartridges to Objet U.S. headquarters, and another program to dispose of unused waste resin from its printers.

Energy Efficiency

Tuck says that in terms of machinery, AM uses very little energy during processing compared to traditional manufacturing on a per-hour basis.

"However, the amount of material processed (i.e. sintered or deposited) per hour is much lower than that processed with traditional manufacturing systems," he says. "So the overall energy consumption for a part may be higher for an identical same part conventionally produced. The benefit for AM comes when the design cannot be manufactured by other means, and/or uses less virgin material and offers a performance advantage over a traditionally designed product."

Manufacturers can limit the environmental impact of AM processes by producing products faster.

"Speed is the key to both economics and to the environmental footprint of the machinery. If more material can be consolidated with a similar energy input, all the better," says Tuck.

The volume of waste from support materials can be minimized by a well-designed part and part orientation on the machine.

ZCorp's efforts to make machines more energy-efficient have resulted in an optimized process that eliminates the need for a heater in the machine. In addition, the company has changed motors.

"There's a big blower motor inside that creates the vacuum that we've used," says Titlow. "We downsized it through one engineering effort. The new one draws significantly less electricity. We've got an optimized sleep mode for the machine, so if you're not using the machine for a certain amount of time, it shuts itself down and goes to sleep."

Faster, more efficient production runs, the nesting of multiple parts to be run simultaneously, the increase of non-toxic substances for both supports and cleaning solutions, recycling, re-engineering, re-design and research all contribute to the greater good in terms of going green with additive manufacturing. But how will Atkins' findings influence the additive manufacturing of the future?

"I think that Atkins could have serious implications for future manufacturing," says Tuck. "Being able to use less material is of significant importance in a world where there are fewer readily available resources. Coupling this with more effective designs that are 'optimized' for performance and weight saving shows benefits not just for the environment, but also for business, making products more efficient—and thereby more saleable." **DE**

Contributing Editor **Susan Smith** *is* DE's *expert in rapid technologies and has been immersed in the tech industry for more than 17 years. Send e-mail about this article to de-editors@deskeng.com.*

INFO ➜ 3D Systems: 3Dsystems.com

Additive Manufacturing Research Group: lboro.ac.uk/research/amrg/research/current/Atkins.html

Atkins Project: Atkins-Project.com

Dimension Printing: Uprint.DimensionPrinting.com

EOS: EOS.info

Objet Geometries, Ltd.: Objet.com

RapManUSA: RapManUSA.com

Solido: Solido3D.com

Stratasys: Stratasys.com

Technology Education Concepts: TECedu.com

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

Fuel for Thought

Tecplot 360's CFD visualization solutions aids alternative fuel research and engine design technologies.

By Mike Peery

The interdependent advancement of alternative fuels and engine technologies is a key component of what is becoming a significant and global effort to reduce our reliance on petroleum-based fuels and the pollution they create. With automobile and truck transportation accounting for two-thirds of domestic oil use, identifying and exploiting new fuel sources is becoming particularly critical in the U.S. It also requires new combustion engines designed to perform at optimal efficiency for each new fuel.

Discovering, studying and analyzing these fuel compounds present a variety of fresh challenges for researchers, but new high-tech research tools are emerging to help in the efforts. Researchers such as Jacqueline Chen and Joseph Oefelein at the Combustion Research Facility of Sandia National Laboratories in Livermore, CA, working in conjunction with the U.S. Department of Energy (DOE), have undertaken what may prove to be significant research to help unravel the complexities of these alternate fuels and create a body of work that will help inform the design of future combustion engines.

Both experts in computational combustion science, Chen and Oefelein found it critical to develop high-fidelity simulation approaches to their research that take full advantage of some of the world's fastest supercomputers operated by DOE's Office of Science. To quickly interpret their computationally intensive data, Oefelein and Chen rely on Tecplot 360, an advanced computational fluid dynamics (CFD) visualization and analysis software that combines engineering plotting and data visualization into one tool.

Chen and Oefelein are using these tools to harness the massive amounts of data they need to better study the burning processes of a variety of fuels, which will ultimately help engineers to design internal combustion engines that burn alternative fuels in a way that maximizes performance and minimizes emissions.

Petroleum-based fuels have enjoyed a certain ubiquity since the mid-1850s. Such longevity has allowed industry experts to develop a pretty thorough understanding of how internal combustion engines function on gasoline and diesel. This research cannot be extended to alternative fuels, however, because each fuel responds dramatically differently to diverse temperatures and pressures. Gathering data and building new alternative-fuel models requires extremely reliable, complicated, and nuanced computational models to generate new, appropriate data.

In specific terms, the Sandia National Laboratories researchers are performing high-fidelity simulations to understand the complex thermo-chemical interactions in internal combustion engines using carbon-neutral fuels such as biofuels, and alcohols like ethanol and dimethyl ether. A primary goal is to maximize the way alternative fuels are used by the next generation of internal combustion engines.

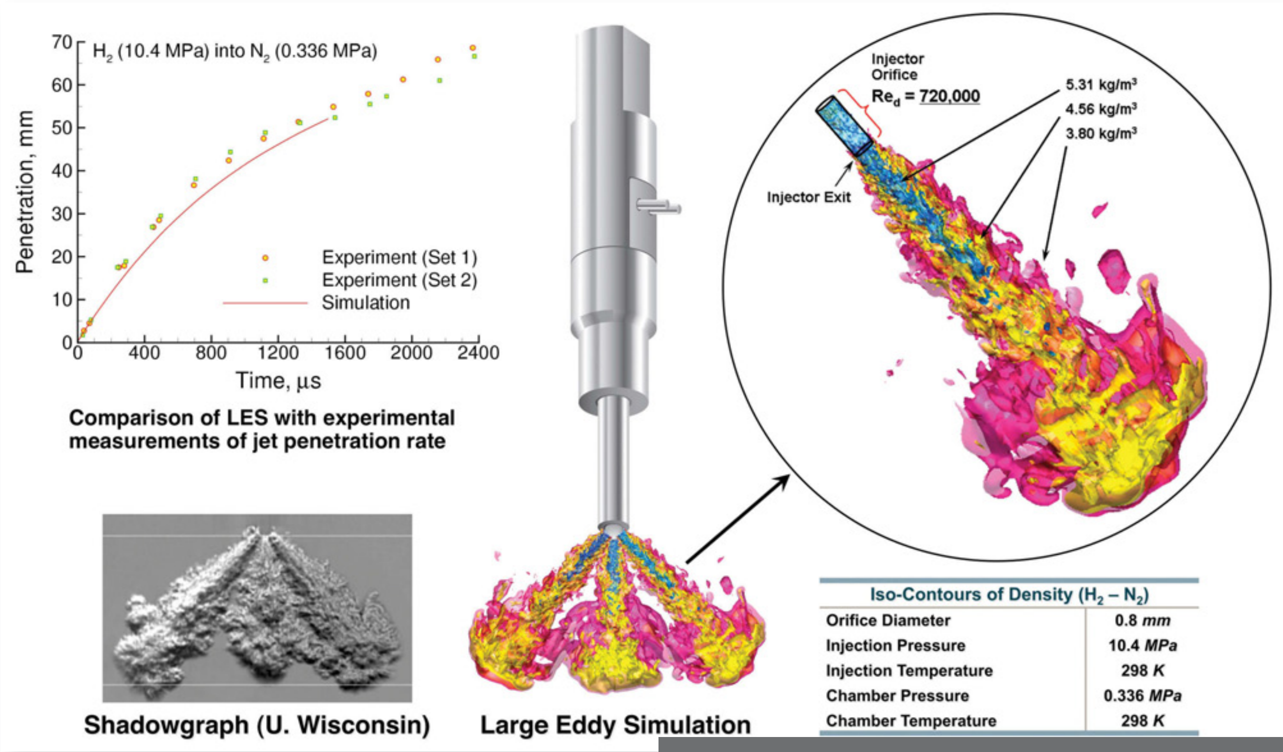
"You always want a clean-burning, highly efficient system," says Oefelein. "And you want it to be a stable system, meaning that there are no combustion instabilities or transient types of processes that will damage the engine."

To develop predictive models that will help design clean and fuel-efficient engines, Oefelein and Chen are using two computational methodologies:

1. Large eddy simulation is a numerical technique used to solve the partial differential equations governing turbulent fluid flow. With this approach, the energy containing eddying motions that are dependent upon the geometry of the combustor are resolved numerically, and the dissipative small-scale turbulence and combustion scales require closure models.

2. Direct numerical simulation investigates the entire range of spatial and temporal scales of turbulence and flames, and therefore is restricted to a limited dynamic range of scales. Often, this approach is well-suited for studying the micro-scales of turbulence chemistry interactions—where turbulent mixing scales interact with the reactive flame and ignition scales.

These two approaches complement each other, with large eddy simulation characterizing the large-scale entrainment and mixing processes, and direct numerical simulation providing sub-grid information regarding micromixing and reaction.



Visualizing data helps researchers at the Sandia National Laboratories understand alternative fuels, which could help design better combustion engines.

Both techniques are computationally intensive, generating petabytes of data in many cases—with each petabyte representing more than six times the amount of data found in the U.S. Library of Congress archive.

"Ten years ago, this research was at the terascale level in terms of computational speed. Now it's at petascale," says Chen. "In a few years, we'll be at exascale."

As computing power continues to increase, Chen and Oefelein will be able to simulate a wider dynamic range of scales. Because the scaling of turbulence with Reynolds number (the ratio of inertial to viscous forces) is so challenging, researchers can only simulate a 10-fold increase in dynamic range of turbulence scales for every 1,000-fold increase in computing power. As a result, no one method can resolve the entire range of scales relevant to practical combustors in the foreseeable future. Instead, a multi-scale approach is required in which different, well-suited methods, like those that Chen and Oefelein are using, are necessary to bridge the gaps between the differing ranges of scales.

Plotting the Data

Oefelein and Chen discovered Tecplot 360 as a way to interpret and visualize the massive amounts of data their research required. Because they routinely perform calculations on supercomputers located offsite, using a computer dashboard with a user interface and intuitive drop-down menus, they send Tecplot images such as isocontour plots, 2D and 3D plots, and animations back to their home facility, which helps them hone in on key statistics and identify critical trends.

"It's a lot easier to examine visual images than it is to wade through numbers or statistics," says Chen. "By looking at isocontour plots or volume renderings, we can see what's going on at a broad perspective, and then zoom in and gather statistics at a finer level."

Analyzing the data visually also helps provide a more easily understood diagnostic view.

"If there's a problem with the way the code or numerical parameters were set up, it's much faster to spot these anomalies visually than by printing out rows and rows of numbers," says Chen.

Visualization is the key that helps the duo present their results in a way that's easy for others to grasp.

"Visualization software guides both our research and our presentation of results," says Oefelein. "When we're done and we're ready to publish a paper, it helps us to tell our story and summarize what we saw in a concise way." **DE**

Mike Perry *is president of Tecplot, Inc. Contact him via de-editors@deskeng.com.*

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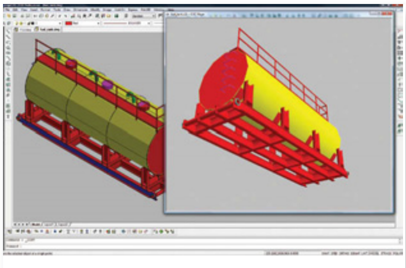
For more information on this topic, visit deskeng.com.

by Anthony J. Lockwood

Editor's Picks

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.



Low-Cost CAD System Improved

Release of progeCAD 2010 Professional offers fixes and improvements.

rogeCAD Professional 2010 from progeCAD USA is a low-cost, general-purpose 2D and 3D design CAD system appropriate for all the neat stuff you have to do from concept sketches to MCAD layout. It's an AutoCAD-like application, meaning that it can handle DWG files easily and that it offers commands, interfaces, "feel," and functionality that should make it readily accessible to seasoned AutoCAD users. The company just came out with a step upgrade that, in and off itself, is mostly a collection of bug fixes and miscellaneous updates, but it gives me an excuse to recommend that you give progeCAD Professional a whirl.

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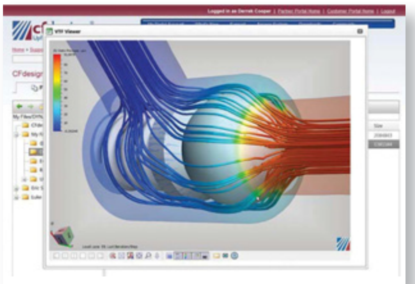

Design Study Automation Embedded in the CAD

Blue Ridge Numerics releases CFdesign 2011.

Awhile back, I had a webcast demo of CFdesign version 2011. As part of the intro, they mentioned that the company is the fast-growing CFD outfit around. I haven't verified that, but I do know that CFdesign is high-powered CFD for designers not analyst druids. Version 2011 has just been announced, and any designer who must deal with fluid and thermal issues should make it a point to give CFdesign a serious look.

The CFdesign modus operandi is simple: Give designers and engineers an easy-to-use system to leverage CFD power early and often in their design cycle.

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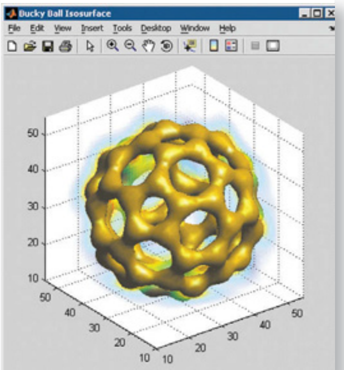

MathWorks Announces Release 2010b of MATLAB and Simulink Products

MathWorks has released the 2010b version of its MATLAB and Simulink product families. So, what's new with them and why might you want to learn more? The second part of that question really goes without saying. In certain quarters, MATLAB, Simulink, or both are ubiquitous tools upon which many a company's fortunes rests. Now let's look at the first half.

Updates to MATLAB include new commands and graphical tools. It now offers support for advanced programming such as custom enumerated data types and 64-bit integer arithmetic.

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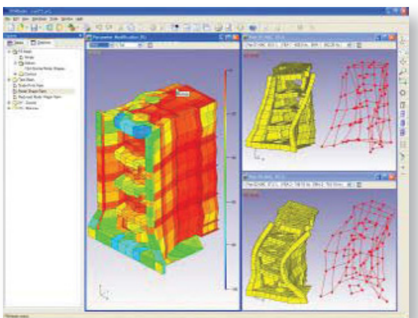

Analysis and Scripting Solution Upgraded

FEMtools 3.5 now also available for the Mac OS 64-bit platform.

Probably the most understated press release I've come across in years arrived in the DE editor's mailbox a few days ago. It was from Dynamic Design Solutions, a Belgian outfit that has been quietly going about its business for more than 15 years. Realizing that my memory of this company and its wares was no substitute for checking out some facts, I went to see what I could learn about their flagship product, FEMtools. I'll get back to why this release was so understated in a few lines. FEMtools are for validating your simulation models, optimizing engineering designs, and integrating as well as automating simulation processes.

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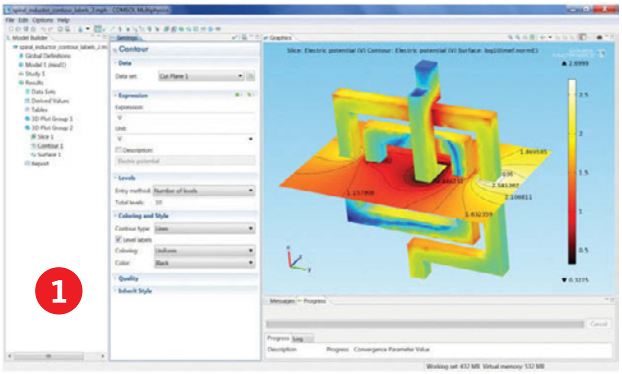

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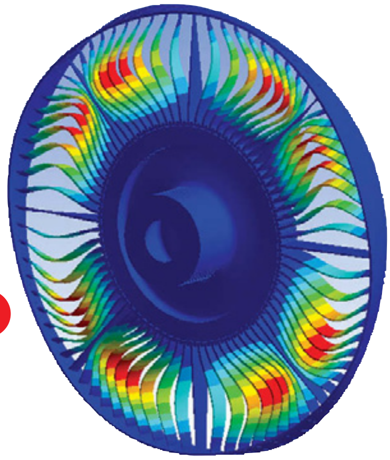

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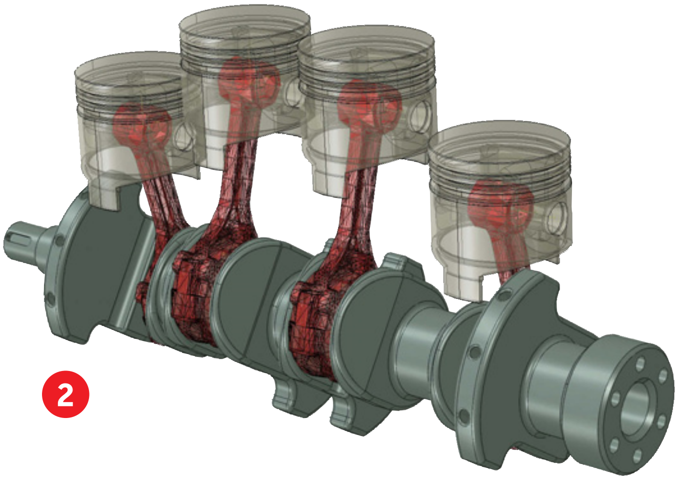

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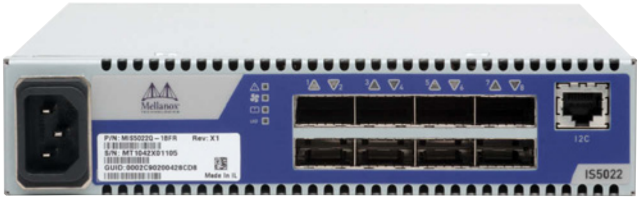
1 COMSOL Multiphysics version 4.1 builds on the usability introduced enhancements in the version 4 architecture and offers dozens of features designed to make the modeling and simulation process more productive. Version 4.1 highlights include: copy/paste and duplication of selected nodes in the model tree, undo/redo of operations in the model builder and the settings window, automatic save and recovery of models during solver operations, up-front display of equations in physics interfaces, and parametric curves in 2D and 3D. In addition, the AC/DC Module now offers electric currents in porous media, the Batteries and Fuel Cells Module has a new physics interface for lead acid battery modeling, and the CFD Module now comes with a new Spalart-Allmaras turbulence model.
Comsol.com

2 Dassault Systèmes has announced the availability of Abaqus 6.10 Extended Functionality (6.10-EF), a unified finite element analysis (FEA) and multiphysics product suite from SIMULIA. Among the modeling and visualization enhancements in 6.10-EF is improved support for substructure modeling capabilities. Abaqus users can now more easily create a substructure of a distinct region in their product, import it into an assembly, recover the results during an analysis, and reuse the substructures in future models.
3ds.com

3 ANSYS, Inc. has launched ANSYS 13.0, the newest release of its engineering simulation technology suite. The company says ANSYS 13.0 has been enhanced with hundreds of new features that deliver new benefits in three major areas — greater fidelity via new solver methods, higher productivity built on an adaptive architecture, and performance enhancements via software and computational power. Multiphysics integration features in ANSYS 13.0 include fluid and structural simulation tools for turbomachinery design and analysis, such as cyclic symmetry and multiple moving reference frames; new models for internal combustion engine applications; as well as new process and energy industry solutions such as multiphase, real gas, nucleate boiling, and chemical reaction tools. Meshing, element modeling, more-tightly coupled fluid-structure interaction (FSI), and nonlinear functionality are some of the additional improvements.
ansys.com

4 EOS has introduced the EOSINT M 280 laser sintering system. It is available with either the same 200-watt fiber laser used in the EOSINT M 270, or a 400-watt fiber laser option. The higher-power laser can



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melt more metal powder per second. Another improvement of the EOSINT M 280 compared to its predecessor is the increase of the maximum building height up to 325 mm. This enables taller parts to be placed in the process chamber, again expanding the application areas. eos.info

5 Mellanox Technologies, Ltd. has announced its new low-port count and power-efficient unmanaged switches in the IS5000 switch system family: the 8-port IS5022 and 18-port IS5023. These switches can be combined with Mellanox's portfolio of 40Gb/s switch systems to enable cluster build-outs of any size. The high bandwidth and low-latency connectivity options are suited to a variety of embedded and small cluster applications, such as storage, database and GPGPU clusters. mellanox.com

6 NEC Display Solutions of America's MultiSync PA231W is a 23-in. professional graphics monitor designed for users working in color-critical applications. The MultiSync PA231W offers users DisplayPort, two DVI-D inputs, VGA and a USB hub. Its color performance brings 71.6% coverage of the NTSC color space, full HD resolution (1920 x 1080) and a contrast ratio of 1000:1, according to NEC. It has a 14-bit 3D lookup table (LUT) for precise color calibrations. Additionally, by using DisplaySync ProT technology, users can control two computers connected to the MultiSync PA231W with only one keyboard and mouse, each with its own color space. necdisplay.com

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Commentary  by Jeff Ray

Open to New Software Models

Only a fraction of established software companies have bought into the new computing models that have challenged the tech world in the last few years: open source and social. We've all heard of Linux, Red Hat, MySQL, Firefox, and other open source software products that have achieved great success. We all know Facebook is the shining example of the power of a vibrant social network.

Clearly not every software company should be literally open source—i.e., with all code owned, managed, and continually modified by the user community. But every software company should at least consider adopting some of the characteristics of open source software that can make life better for the consumer. These include:

- no-charge software product,
- widely accessible product that enables viral distribution,
- grassroots product specification,
- constant upgrades, and
- optional paid support.

Transparency is a key part of both the open source and social models. Users increasingly expect to ask questions of vendors publicly, and get those questions answered just as publicly. Users expect to propose improvements to the software and have these suggestions duly considered, maybe even voted on by colleagues, and implemented. And even if the software is free, users expect the maker to ensure its quality. Some daring new-generation vendors even publish user satisfaction ratings on their websites.

It boils down to a shift in the software's center of gravity from the vendor to the user community.

Paradigm shift

All this boils down to a shift in the software's "center of gravity" from the vendor to the user community. The user community's voice is amplified, and the community decides what's going to be in the software. That's the model that's emerged from the evolution of software over the past two decades, and it appears this is the way software will continue to go. Although many traditional software companies haven't yet embraced these new principles, we've applied the "open source" style of doing business to DraftSight, our new free software for reading, writing, and sharing DWG files. We couldn't be happier with the results: rapid uptake, high satisfaction, and dramatic expansion of our customer base.

We have also created an online community to support it. DraftSight's social network community is a Facebook-like system for users to share ideas, support each other, and tell us what belongs in the next version of DraftSight software. We have done everything we can to make DraftSight software and the draftsight.com community experience compelling, attractive, and worthy of a recommendation. This is critical because our marketing budget is zero. It's all word of mouth. Our mantra is, "let's make people smile and tell a friend."

You might be asking why we don't go all the way and release the code as true open source software. Well, we've given it some thought. CAD software is mission critical: the brakes engineers are designing are trusted to actually stop cars, and wings are expected to keep planes aloft. Therefore, most users want the code to stay with a trusted vendor.

Long-term Profits

You might also be asking what's in it for a vendor who creates free software, empowers a user community, and makes everything transparent? Well, there's a lot. Free software gives prospective users a low-risk way to become part of your family. Users get comfortable with you and consider buying other products and offerings. You can generate revenue, e.g., through a fee for premium support, though users will expect it to be a low one.

Then there's valuable market research to be gained. You can learn a lot more from a public launch of free software than you can by distributing it the old way. For example, we were surprised to see how many Mac users wanted our software, and how many users came from industries beyond our usual target market.

Of course, there's a catch. Trying these new open and social strategies takes courage. You are essentially putting your brand on the line. When you release free software to the world and invite everyone into a public beta, that software needs to work well. If nine features work spectacularly but the tenth one freezes, you can expect to be taken to task.

And you need to follow through. If you invite the community to suggest software upgrades, you must follow up and deliver on a timely, rolling schedule. No more yearly releases.

By doing all this right, you can dramatically expand your customer base. By failing, you can alienate your existing customer base. The risk here entails a potential reward, yet there's also a risk in doing nothing. Either way, it's time for vendors to take a close look at their product development and distribution strategy. **DE**

Jeff Ray *is the CEO of Dassault Systèmes SolidWorks Corporation. Send comments about this commentary to de-editors@deskeng.com.*

Digital Light Processor

1 The all-in-one ZBuilder builds parts additively using a high-resolution Digital Light Processor (DLP) projector to solidify a liquid photopolymer, resulting in plastic parts the company says mimics injection molding for accuracy, material properties, detail, and surface finish. It builds at a rate of 0.3 to 0.4 in. per hour.

Touchscreen

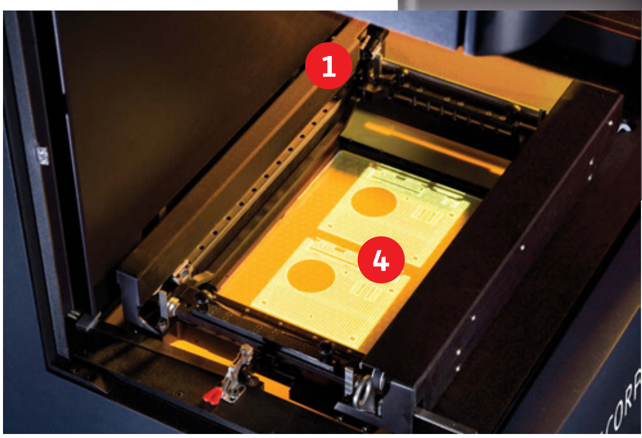
2 The ZBuilder is controlled via a Windows-based touchscreen computer mounted in the rapid prototyping system.

Touchscreen

3 The ZBuilder Ultra has a build size of 10.2x6.3x7.5 in. It has a minimum feature size of 0.005 in., so is well suited for monochrome, thin-walled parts.

Material Properties

4 Z Corp. says the ZBuilder Ultra can produce durable plastic parts that rival injection molding's accuracy, material properties, detail, and surface finish, at one-third of the price of machines with comparable performance. Parts can flex like plastic.



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TECH SPECS

- Dimensions: 28 x 30.5 x 71 inches (71.1 x 77.5 x 180.3 cm), with optional stand
- Input File Formats: stl, 3ds, dxf, obj, wrl, zpr
- Weight: 360 lbs. (163 kg)
- Power Requirement: 115V, 10A; 230V, 6A
- Regulatory Compliance: CE, CSA
- X/Y Resolution: 0.005 in. (138 microns)
- Z Resolution: 50 – 100 microns (adjustable)
- Minimum feature size: 0.005 in. (138 microns)
- Accuracy: +/- 0.008 inches, typically (+/- 0.2 mm)
- Vertical Build speed: up to 0.5 in./hour (12.7 mm/hour)
- Build Size: 10.2 x 6.3 x 7.5 in. (260 x 160 x 190 mm)
- Cost of operation: $8 to $10 per cubic inch in terms of materials.
- Manufacturer's suggested retail price: $34,900

For more information, visit zcorp.com