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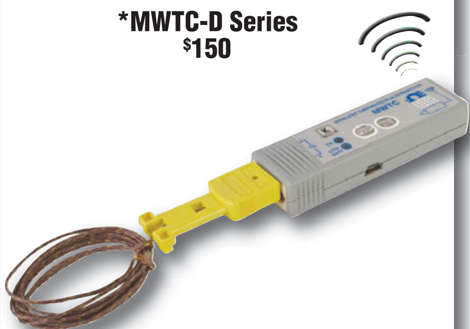

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by Steve Robbins

Uncompromising Composites

I have owned the same fiberglass sailboat, a Southern Cross 31, for more than 25 years. It was built in 1983 out of glass fiber and polyester resin with an Airex foam core. The challenge of building with composites, even 30 years ago, was to build the boat to be as light as possible without comprising its structural integrity. Without the simulation and mechanical testing tools we have today, my sailboat, designed to be used for offshore cruising, was overbuilt for toughness and stability. It weighs a lot.

You really don't want your sailboat hull oil canning 300 miles offshore in the middle of the Atlantic Ocean in 12-ft. seas. But weight doesn't matter in a boat like it does in an aircraft or even a car. Whether in an automobile, spacecraft, or the cellphone in your pocket, composite materials need to perform to the specified requirements of particular products. Fatigue, puncture, delamination, and tensile strength are key factors in using the right composite.

Composites will continue to make their mark in designs that will change the way we live.

A Lighter, Stronger Future

Today, there are many tools to help design composite parts and structures. They fall into two areas: simulation tools used during the design phase and mechanical testing tools that are used during the prototyping phase. Composite simulation has become a hot topic in the design engineering world as more engineers are using it to great advantage. Composite materials are a great, lightweight way to improve stiffness and strength.

In recent issues of *DE*, we have covered applications where lightweight structures are very important. In aerospace and automotive, for instance, fuel efficiencies improve greatly as weight is jettisoned. As materials and manufacturing processes continue to improve, composites will continue to make their mark in designs that will change the way we live. In the future, one of the greatest advantages to using composites, aside from its inherent strength and reduced weight, is the ability to easily manufacture them into complex shapes. This ability has been used in military aircraft to build stealth contour surfaces and in consumer aircraft to add strength. The new Boeing 787, for example, is made of approximately 60% composite materials.

The uses of these materials in current designs has been facilitated by the increased availability of the right materials for the right jobs, and a decreased overall cost of the materials. But the key factor to using composites is being able to test the designs in a cost effective and accurate manner.

Simulate and Test

Being able to simulate the lifecycle of a design using composite material will save companies time and money, and they will be able to build better products. Although simulation is getting a lot of attention, mechanical testing will not diminish in this area. Have you noticed how composite test equipment looks a lot like torture machines from the Inquisition? That's because they are designed to torture composite materials until they break!

Composite simulation and mechanical testing has come a long way from the day my sailboat was launched. In 1983, boat builders didn't know the durability and strength of the materials they were using. Polyester resin was relatively new and vacuum bagging the laminate was almost unheard of, so they just added a few more inches of material to stress areas, like compression posts and hull-to-deck joints. The foam core in my boat added tremendous strength. It was cutting edge. Most builders were using solid fiberglass layups.

But today, using the appropriate software and test equipment, designers can build aerodynamic, lightweight vessels, vehicles and aircraft — from composite tractor-trailer trucks that will double their mileage to larger planes that use less fuel. I haven't flown in a 787 yet, but when I do, I will look out the window at the composite wing and remember the night I spent offshore sailing from Bimini to Lake Worth, FL, in 25-knot winds from the northeast, directly opposite the direction of the Gulf Stream. Crashing into 12-ft. waves, I was comforted by the strength of Ananda's hull, and I will marvel at the engineering accomplishments made possible with the composites we now experience in our lives. 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.*


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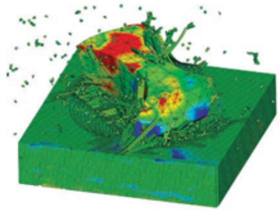
DE May 2012 VOLUME 17/ISSUE 9

COVER STORY

Composites Blast Off

ON THE COVER: SpaceX's Dragon spacecraft launches atop a Falcon 9 rocket. *Image courtesy of Space Exploration Technologies Corp./Chris Thompson.*

SIMULATE



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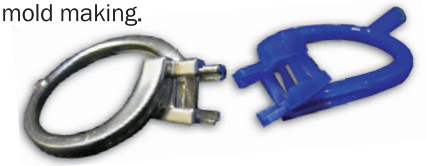

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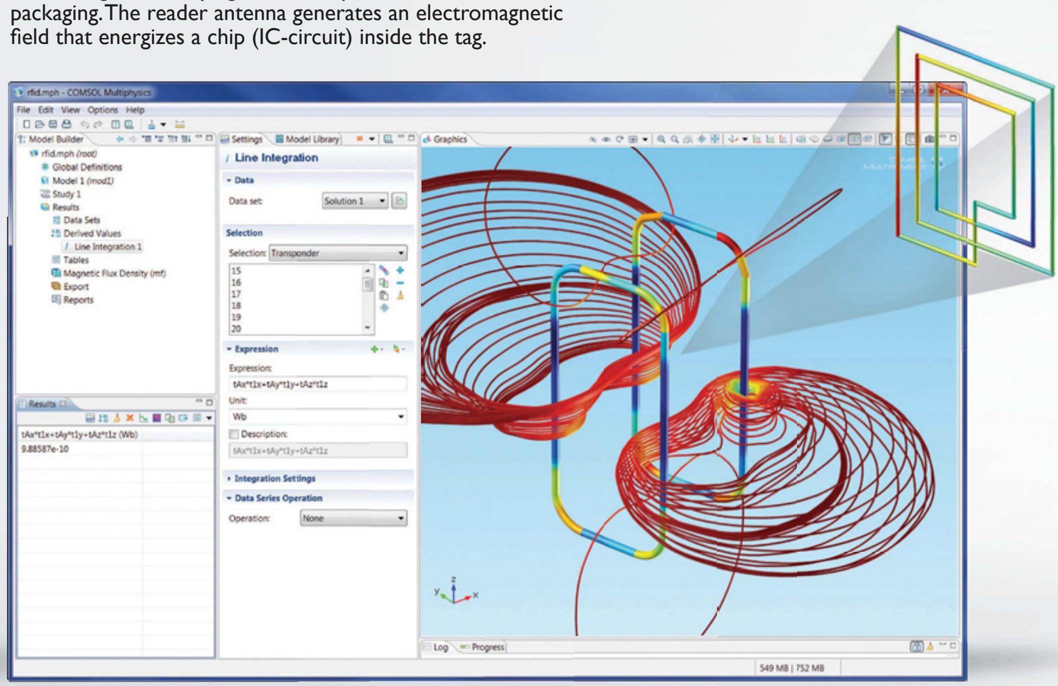

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A LEVEL 5 COMMUNICATIONS PUBLICATION
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ADVERTISING, BUSINESS, & EDITORIAL OFFICES
***Desktop Engineering*® magazine**
Level 5 Communications, Inc.
1283D Main St., PO Box 1039 • Dublin, NH 03444
603-563-1631 • Fax 603-563-8192
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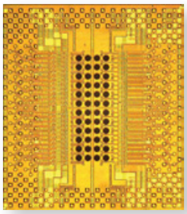
***Desktop Engineering*®** (ISSN 1085-0422) is published monthly by Level 5 Communications, Inc., 1283D Main Street, P.O. Box 1039, Dublin, NH 03444, 603-563-1631. Periodicals postage paid at Dublin, NH, and at additional mailing offices. Desktop Engineering® is distributed free to qualified U.S. subscribers.

SUBSCRIPTION RATES: for non-qualified; U.S. $108 one year; Canada and Mexico $126 one year; all other countries $195 one year.

LIST RENTALS: For information on list rentals, contact Statlistics, Danbury, CT: 203-778-8700.

POSTMASTER: Send all address changes to ***Desktop Engineering***, P.O. Box 677, Northbrook, IL 60065-0677.



IBM's Holey Optochip Breaks the Terabit Barrier

IBM Labs' Holey Optochip is a parallel optical transceiver that has managed to break 1 terabit (1 trillion bits) per second. For some perspective, that would allow users to download 500 HD movies in a second, or the entirety of the Library of Congress in about an hour.

Scientists have been working on a way to create photonic chipsets that allow for low-cost, mass production. IBM researchers created the Holey Optochip by manufacturing a silicon CMOS chip with 48 holes in it, to allow light to reach the back of the chip. The result allows 24 receiver and 24 transmitter channels to operate on a compact frame.

The prototype proves that a shift in high-speed communications is possible in the near future. Photonic chips could allow companies to leverage the power of cloud computing at speeds fast enough to make working with remote collaborators as easy as sending an e-mail.

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Intel Invests in 'Connected Cars'

The world's largest chipmaker wants to help bring the Internet to your car. Intel is investing $100 million into connected car technology via its new Intel Capital Connected Car Investment Fund, which will help bankroll development of technologies like in-vehicle infotainment systems, mobile connectivity systems and advanced driver assistance systems.

Intel also announced it would create a new Automotive Innovation and Product Development Center, expand the Intel Labs Interaction and Experience Research (IXR) division's focus on automotive, and create an academic outreach program.

The product development center in Karlsruhe, Germany, will concentrate on creating products and technologies for infotainment and telematics. The facility includes a secured car park, wireless and GPS development and testing facilities, and what the company describes as a "world-class engineering computer infrastructure."

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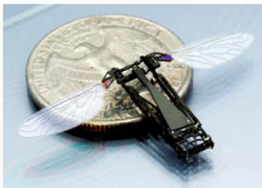
Making Pop-up Robotic Bees



The Harvard Microrobotics Lab has come up with a manufacturing process that uses CAD models and laser milling to economically produce small-scale flying robots, and that could enable industrial-scale microbot production.

Sheets of carbon fiber, titanium, plastic and other materials are laser-cut and sandwiched together to create tiny robots. The robots are then pressed into a 3D shape using pop-up folding and locking in a process the researchers have compared to origami or a pop-up book.

The initial microbot created via the process is called the Monolithic Bee (Mobee), and includes a carbon-fiber airframe and titanium wings. Designers had to hand-draw CAD files for each of the 18 layers cut during laser milling.

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Carbon Nanotubes Could Make Space Elevator

Potential space tourists may be able to ditch their tickets for one of the various spacecraft now under development, and instead simply queue up for a ride on a space elevator. Tokyo-based engineering firm Obayashi Corp. has proposed building just such a massive elevator for space travel, with a potential launch date of 2050.

A 60,000-mile-long cable would be anchored to the ground here on Earth; the other end would be a counterweight. The elevator (capable of carrying 30 passengers) would ascend at 125 mph, taking about a week to reach the terminal station approximately 22,400 miles up in geosynchronous orbit.

Key to the project would be carbon nanotubes—stronger and lighter than steel—that could be used to build the cabling.

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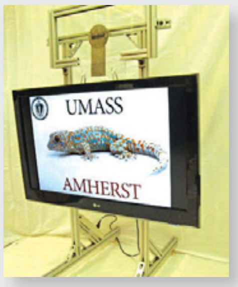
Gecko Feet Inspire Superadhesive



Geckos are good at two things: selling insurance, and using their tiny feet to apply enough adhesive force to carry nearly 18 times their own body weight up a wall. What could design engineers do with a dry adhesive device that could hold that much weight, and be easily removed without leaving any residue? Some polymer scientists and biologists at the University of Massachusetts Amherst wanted to know, and have come up with their own adhesive, called Geckskin, that mimics the lizard's fancy footwork.

The UMass Amherst group created an adhesive with a soft pad woven into a stiff fabric. Geckskin, which comes in an index-card-sized sheet, can hold up to 700 lbs. on a smooth wall (like the TV in the picture above). Using the same types of high-capacity reversibility and dry adhesion as gecko feet, it can easily attach and detach heavy objects on flat or slanted surfaces—even glass. The Geckskin can be released with little effort and re-used, and leaves no residue.

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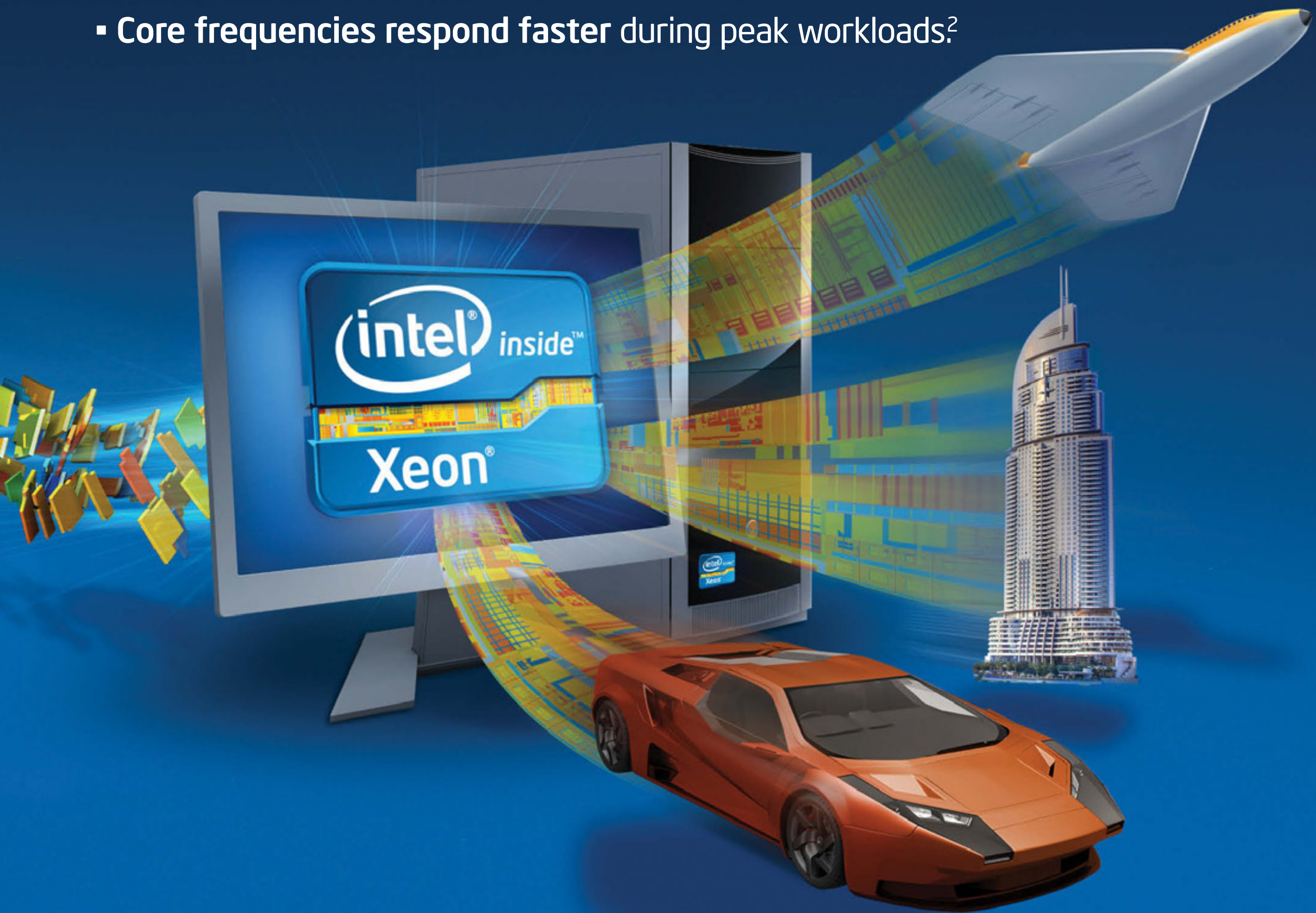

[1]Intel measurements of average time for an I/O device read to local system memory under idle conditions. Improvement compares Intel® Xeon® processor E5-2600 product family (230 ns) vs. Intel® Xeon® processor 5500 series (340 ns). Baseline Configuration: Green City system with two Intel® Xeon processor E5520 (2.26GHz, 4C), 12GB memory @ 1333, C-States Disabled, Turbo Disabled, SMT Disabled, Rubicon* PCIe* 2.0 x8. New Configuration: Meridian system with two Intel Xeon processor E5-2665 (C0 stepping, 2.4GHz, 8C), 32GB memory @1600 MHz, C-States Enabled, Turbo Enabled. The measurements were taken with a LeCroy* PCIe* protocol analyzer using Intel internal Rubicon (PCIe* 2.0) and Florin (PCIe* 3.0) test cards running under Windows* 2008 R2 w/SP1.

[2]Requires a system with Intel® Turbo Boost Technology capability. Intel Turbo Boost Technology 2.0 is the next generation of Turbo Boost Technology and is only available on select Intel® processors. Consult your PC manufacturer. Performance varies depending on hardware, software, and system configuration. For more information, visit http://www.intel.com/go/turbo.

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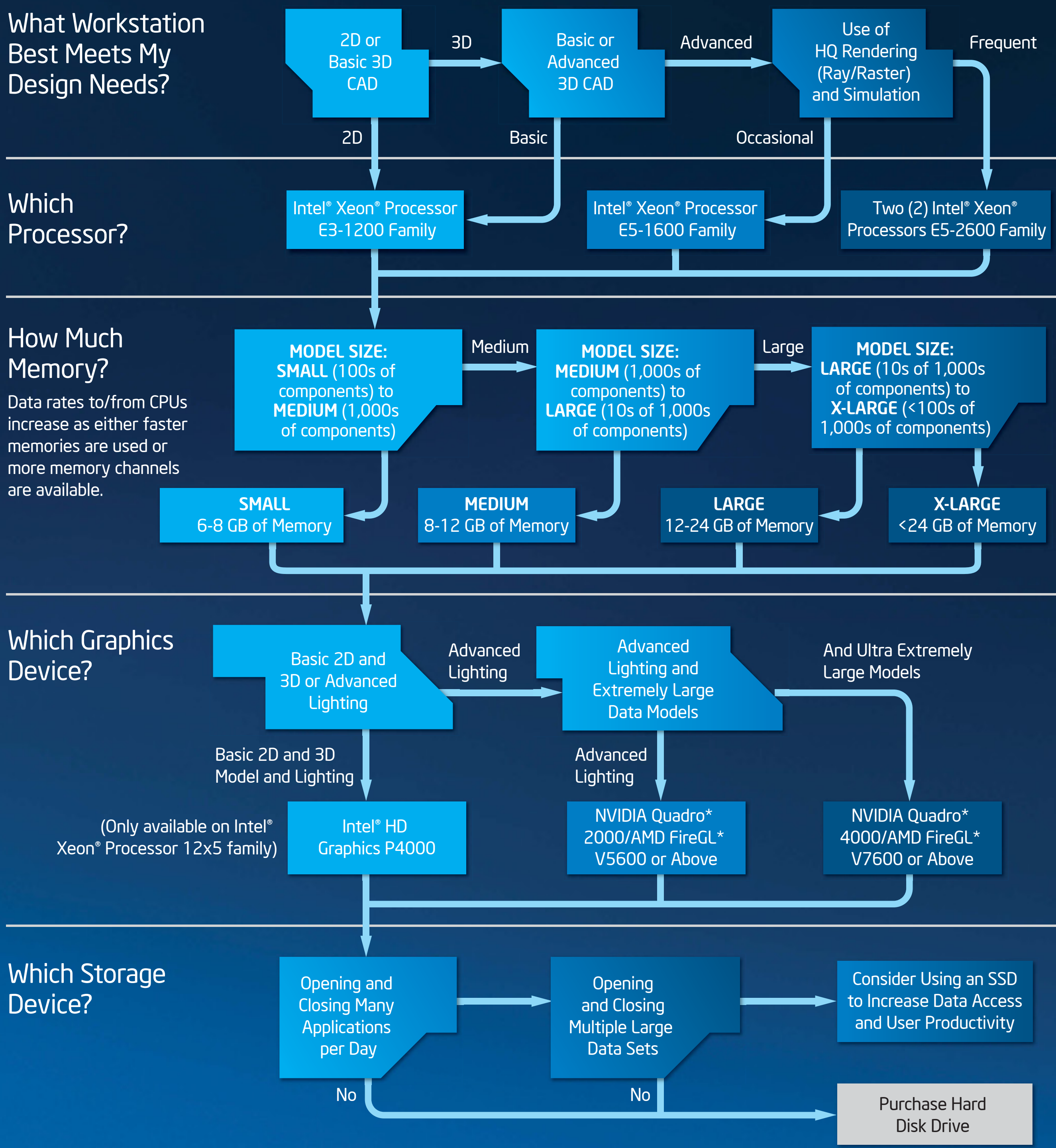

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by Kenneth Wong

Autodesk PLM 360 Goes Live

AutodeskPLM360.com is live The site is not a just a product homepage to tell you how to get the compamy's new product lifecycle management (PLM) software; the site is the software.

Coming to the market nearly a decade behind, Autodesk is undeniably a Johnny-come-lately. But its offering, delivered in the software-as-a-service (SaaS) style, has one serious advantage over those from its rivals: For the first three users, Autodesk PLM 360 is completely free. You may add additional users at $25 to $75 per user per month, through annual subscription agreements. This is PLM at Walmart pricing—something few others would or could attempt.

Introducing the product in a webcast, Brenda Discher, Autodesk's vice president of marketing, emphasized that Autodesk PLM 360 is "insanely configurable." She added, "We think our pricing underscores our belief that customers and companies of all sizes should have access to PLM."

"The only technical skill you need is to use a browser," quipped Buzz Kross, Autodesk's senior vice president of manufacturing. Autodesk PLM 360's interface allows you to map out business processes using drag-and-drop schematics, and customize the type of reports to view. However, those with a knack for programming may incorporate Java scripts.

Subscriptions are offered at two levels: Participant ($25 per month) and Professional ($75 per month). Participants have only limited workflow access and communication functions. Professional subscription gives you full access.

At launch time, subscribers can access about 140 apps to accomplish different tasks. The initial lineup includes apps for:

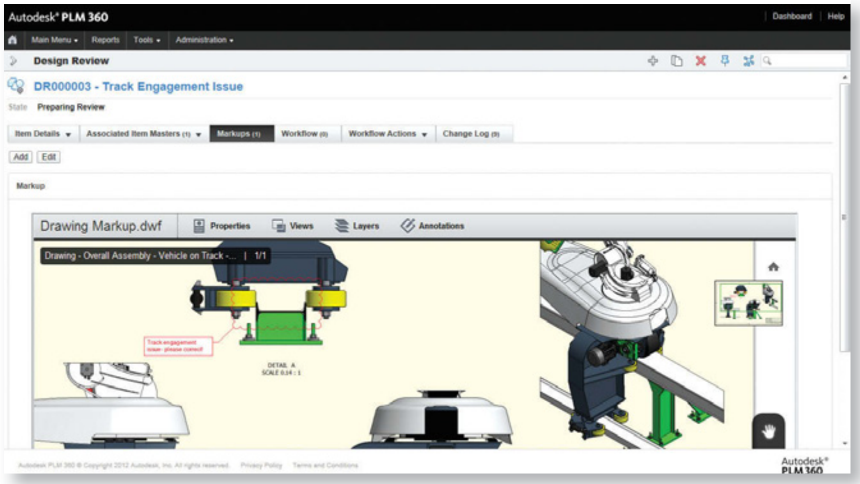
- program and project management;
- requirements management;
- task management;
- costing;
- change order;
- design review;
- bill of materials; and more.

As with other SaaS solutions, Autodesk PLM 360 is expected to be always on, accessible from "anywhere, from any device," according to Steve Bodnar, Autodesk's vice president of PLM and product data management (PDM). At press time, the Apple App Store offers a slew of Autodesk apps, but no app specific to Autodesk PLM 360 is listed yet.

Autodesk continues to offer Autodesk Vault as a PDM solution, to be installed and maintained on-premise at client sites, behind firewalls. By contrast, Autodesk PLM 360 is aimed at small, medium and large enterprises looking for a PLM system with low overhead and low cost.

"Customers do not need Vault to work with PLM 360," clarified Bodnar. "More than half of our beta customers do not use Vault."

According to Kross, some of the beta testers are small firms with employee numbers in single digits.



Autodesk PLM 360 launched with more than 140 apps, each designed to address a business operation. Where appropriate, the web-based interface offers viewing and markup (based on Autodesk Design Review) tools.

Market Impact

Cloud-hosted PLM is also available from several vendors, including Arena Solutions, Oracle and PTC. But the variety and comprehensiveness of apps available through Autodesk makes Autodesk PLM 360 a serious contender in the SaaS PLM segment. Other PLM vendors like Dassault Systèmes and Siemens PLM Software offer some cloud-hosted data-management functions and mobile apps, but their reliance on the cloud is only partial. Autodesk PLM 360 requires full commitment to the cloud, which comes with benefits as well as risks.

Autodesk PLM 360's aggressive pricing poses a threat to smaller vendors with similar web-hosted functions. With its cloud-hosted DWG display technology AutoCAD WS in the background, Autodesk PLM 360 offers browser-based viewing and markup that few others can rival.

"Autodesk PLM 360 is 1/20th of the costs of the traditional PLM systems. The cost benefits users get is pretty phenomenal," hailed Kross at a recent media summit in San Francisco.

Autodesk CEO Carl Bass once mocked PLM as "a solution in search of a problem." Now, Autodesk has officially unleashed a PLM solution that could become a problem for many of its competitors.

Altair Gets Ready for HTC 2012

An astronaut, a designer and an analyst walk into a hotel ...

It's not a joke. It's a scenario that will come to pass in the Marriott at the Renaissance Center in Detroit. That's the site of Altair Engineering's HyperWorks Technology Conference (HTC) 2012, scheduled for May 15-17. The astronaut is T.K. Mattingly, the retired astronaut who once flew on the Apollo 16, STS-4 and STS-51-C missions. The designer is Luca Pignacca, chief designer at Dallara Automobili. The analyst is Marc Halpern, vice president of research, Gartner. They're all keynote speakers who have signed on to appear at HTC 2012. They will join Altair's Chairman and CEO Jim Scapa on stage.

Hosted by the HyperWorks division of Altair, HTC is a series of events that focuses on using high-performance computing (HPC) to solve engineering and simulation problems. Since its launch five years ago, the conference has grown to include events in Japan, India, China and Europe, among other locations. Most of them are free to attend (attendees have to cover their travel and accommodation expenses).

Altair landed an astronaut as a speaker this year because of the work the company has been doing with NASA to develop a crew-landing module, explains Altair's chief marketing officer, Jeff Brennan. (*Editor's note: For more on aerospace design and simulation, see this month's cover story on page 26.*)

"The computer-aided engineering industry is very dynamic," says Brennan, taking note of the focus of Altair and HTC. "There's a lot of players, a lot of change as well. Technology is changing rapidly. People are taking up the technology … Last year, we showed our conceptual design product [Solidthinking] on stage, and how it integrates with simulation tools."

The conference is expected to deliver sessions on computational fluid dynamics, scripting, optimization, crash-worthiness analysis, advanced mid-surface processing, noise, vibration and harshness, vehicle durability testing, and composites materials. Hands-on training will be punctuated with networking events. To register, visit AltairHTC.com/na/HTC12RegistrationForm.aspx.

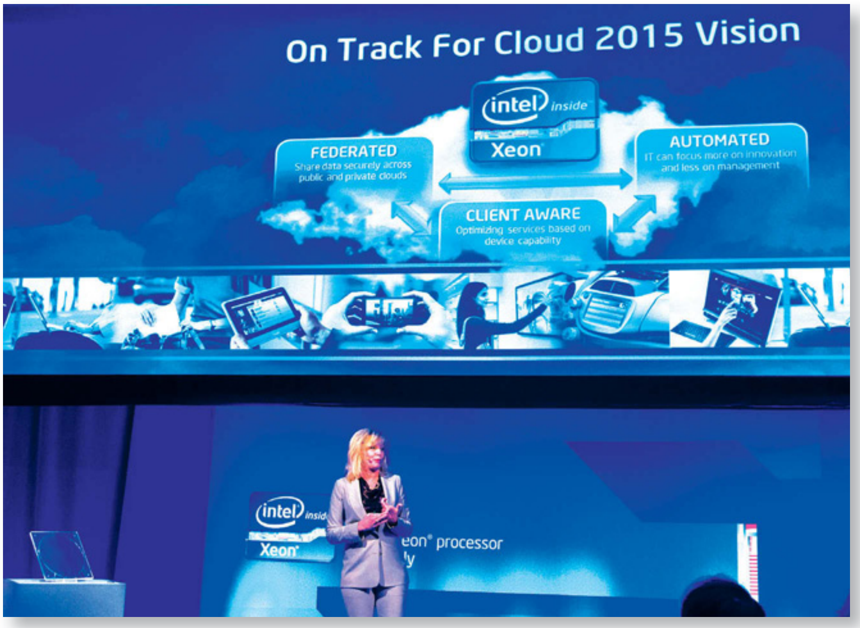
by Kenneth Wong

Intel Xeon E5-2600, a Better Traffic Cop for the Cloud

In early March, as commuters in the West Coast begrudgingly joined the morning's rush hour traffic, Intel unveiled what could be the solution to heavy traffic in the cloud. Diane Bryant, the newly appointed vice president and general manager of Intel's Datacenter and Connected Systems Group, took the stage at San Francisco's Contemporary Jewish Museum to launch the Intel Xeon E5-2600 family, described by Intel as "the heart of a flexible, efficient data center."

"The growth in cloud computing and connected devices is transforming the way businesses benefit from IT products and services," said Bryant. "For businesses to capitalize on these innovations, the industry must address unprecedented demand for efficient, secure and high-performing data center infrastructure. The Intel Xeon processor E5-2600 product family is designed to address these challenges by offering unparalleled, balanced performance across compute, storage and network, while reducing operating costs."

One of the biggest changes that comes with the new processors is its input/output (I/O) delivery. Xeon E5-2600 uses Intel Ethernet controllers and adapters to route I/O traffic directly to the processor cache. This, the company claims, results in "reducing trips to system memory [and] reducing power consumption and I/O latency." Xeon E5-2600 will support PCI-Express 3.0, which promises to "triple the movement of data into and out of the processor," according to Intel.



Diane Bryant, vice president and general manager of Intel's Datacenter and Connected Systems Group, ushered in the Xeon E5-2600 family, which is designed to tackle cloud traffic.

The new processors are expected to increase performance "by up to 80% compared to the previous-generation Intel Xeon processor 5600 series," according to Intel. The new processors come with Advanced Vector Extension (AVX) instruction set.

"These instructions double the number of floating point operations per clock," said Bryant.

The increased I/O throughput and processing power, Intel theorizes, will make E5 processors ideal for those seeking to deploy cloud computing and virtualization solutions.

10 Gigabit Going Mainstream

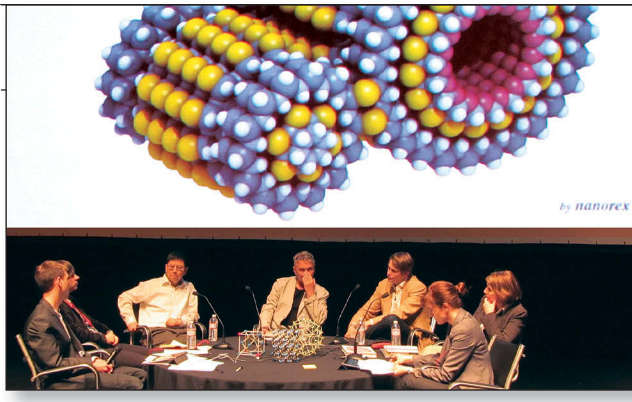
"Increasing bandwidth demands driven by server virtualization and data and storage network consolidation have led to strong growth in 10 Gigabit Ethernet deployments, with adapter port shipments exceeding 1 million units in each quarter of 2011," Intel reports.

The integrated controllers in Xeon E5 family, according to the company, represent Intel's "commitment to driving 10 Gigabit Ethernet to the mainstream by reducing implementation costs."

Intel plans to offer the E5-2600 with 17 different parts, which range in price from $198 to $2,050 in quantities of 1,000.

Additionally, three single-socket Intel Xeon processor E5-1600 parts will be offered for workstations that range in price from $284 to $1,080.

Bentley Wraps Up sg2012



SmartGeometry 2012 (sg2012), the annual conference hosted by Bentley Systems, came to a close on March 24, following a series of workshops and a public symposium in Troy, NY, home of the Rensselaer Polytechnic Institute (RPI).

Between March 19 and 23, several working groups—known as "clusters" in sg lingo—set up temporary headquarters inside the RPI's Experimental Media and Performing Arts Center. With a blend of academic researchers and professionals in each cluster, they set out to explore the year's theme of "Material Intensities: Simulation, Energy and Environment" by combining theory, practice and prototypes. The clusters investigated, among other things, bio-responsive building envelopes, acoustic environments and fiber-enforced polymer behaviors.

The clusters' workflow and progress are guided by leaders. But, as sg veteran Shane Burger (Grimshaw Architects, NY) pointed out, "It's not a student-teacher relationship; it's a champion who came up with the idea, and collaborators who made it happen."

Often, sg participants use a mix of programming, electrical components, parametric modeling software (such as Bentley Systems' GenerativeComponents and Rhino plug-in Grasshopper), handmade prototypes and 3D-printed prototypes to test their ideas. On the last day of the event, participants present their experience to a wider audience at a symposium.

Annual sg conferences are sponsored and supported by Bentley Systems, 3D Systems and other technology suppliers. The event usually takes place on the premises of an academic institution.

The strength of sg conferences comes from the participants' commitment to produce, usually in time for the Symposium, a scale model or a physical prototype representing the solution they are proposing. This tradition forces clusters to collaboratively troubleshoot, use creative methods, and work in a multi-disciplinary environment. **DE**

Kenneth Wong *is DE's Senior Editor. Read his Virtual Desktop blog at deskeng.com/virtual_desktop.*

3D Printing Brings Style to Prosthetics

Bespoke Innovations has taken aesthetic philosophy to heart with the creation of what it calls prosthetic fairings. In this case, a fairing is a covering for a prosthetic leg that is designed to emulate the shape of the human body.

Bespoke uses a 3D scanner to capture the shape of a client's leg. The company then uses CAD software to adjust and reverse the image, creating a duplicate virtual leg. For bilateral amputees, Bespoke looks for volunteers with similar features as the customer and creates a scan to be "donated" to the cause.

Scan complete, the client chooses the materials used to construct the fairing. Available materials include leather, ballistic nylon fabric and chrome plating. The company also allows for designs to be included on the fairing, creating patterns or approximating tattoos. All the available options allow a customer to create something that goes beyond functional—instead, becoming a personal statement.

Once the design has been finalized, Bespoke sends the file to 3D Systems to be printed. The result is a fairing that weighs an average of 6.6 oz. (depending on materials used) and costs between $4,000 and $6,000. Bespoke hopes to work with prosthetists and insurance companies to help defray the cost. It is also developing whole leg replacements that integrate the art of fairings with a prosthetic limb into a single whole.

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GE Garages Offer Hands-on 3D Printing

As part of its GE Works campaign, GE has rolled out a program it calls GE Garages. Begun in March in Austin, TX, at South by Southwest (SXSW), the program allows the public a chance to interact with MakerBot's Replicator 3D printer, a CNC mill, laser cutter, MIG welder, injection molder, cold saw and an ironworker (all under expert supervision, naturally).

GE hopes to drum up interest in manufacturing by exposing the public to a number of different high-tech procedures. The GE Garage was designed by Sub Rosa, and is part of a collaborative effort that involves the community-teaching marketplace Skillshare, manufacturing developers TechShop, Quirky, Inventables and Make. A number of the companies involved will also have staff on hand to discuss manufacturing.

The GE Garage moved from Austin to Houston and San Francisco. Later this summer or early fall, the it will take up permanent residency in Houston and Cincinnati.

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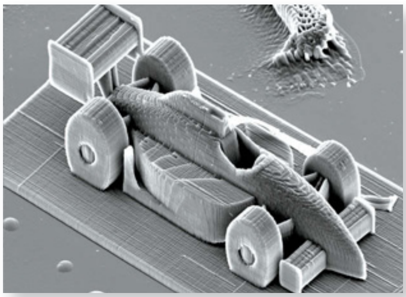
University Develops Two-Photon Lithography

Vienna University has created a 3D printer using what it calls "two-photon lithography." The process is able to build objects with nanometer-thick layers, using mirrors to produce a narrow-focus laser that builds layers of liquid resin.

Researchers gave the process its name because the resin must be able to absorb a minimum of two photons in order to set. This particular process also allows layers to be built without having to cure to topmost layer, which speeds up the build.

Researchers are working on developing biocompatible resins for medical applications. Potential applications include using the process to create scaffolds for living cells to latch onto.

MORE → RapidReadyTech.com/?p=811



Mcor to Showcase Matrix 300 at RAPID 2012

Mcor Technologies is a 3D printer manufacturer that uses standard paper as its material of choice.

The machine designed by Mcor lays down paper one sheet at a time, where it's cut before being attached to the next sheet by a water-based adhesive. The end result of the process is an object built by layers the same way as other 3D printers.

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Expanding Operations

Shapeways, a Dutch 3D printing services marketplace, has recently expanded operations to Queens, NY. The company intends to use the new facilities to reduce costs and shipping times for customers. Among the tech to be deployed at the production facility is a ZPrinter 650 full-color 3D printer.

Belgium-based Materialise is opening a new additive manufacturing (AM) Automation and Control System center to help better manage its flow of products. The center will have an interactive focus and complete integration with the company's Magics AM software.

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Improve Efficiency and Reduce Costs with Process Simulation

BY JIM ROMEO

Engineering design is ordinarily an effort that depends on a larger system or process. That system or process may be a manufacturing line, supply chain or some flow where variables are many and undetermined—and the engineered design of a product, equipment or complex process depends on what those variables are.

This is where simulation software comes in. When simulation and modeling are applied to a process or system, risk and probability of failure can be known and controlled, and a design engineer or other process owner can be more expedient in his or her design.

Based in Glasgow, Scotland, SIMUL8 Corp. offers simulation solutions for many different applications and settings, from the shop floor of an auto manufacturing facility to a major healthcare facility. *Desktop Engineering* recently spoke with Frances Sneddon, chief technology officer of the firm, which was founded in 1994:

DE: ***Can you tell us a little bit more about SIMUL8 and the applications it offers?***

FS: SIMUL8 is business process simulation software. With SIMUL8, you can create a visual representation of your business to allow you to experiment with new ideas to improve efficiency and reduce costs—all in a risk-free environment. Think of it like a bird's eye view of your business or process.

Take, for example, the new $1 million oven the guys on the shop floor say you'll need to meet demand next year. With SIMUL8, you can see whether the investment is justified, or if there are ways you can do things a little differently with your current setup to meet the demand.

General Motors increased throughput on one of its assembly lines by 5%, by experimenting with some clever maintenance rules using SIMUL8. This is something they wouldn't have otherwise been able to do without stopping the line, changing the entire layout of the factory, and testing out new schedules over a few months. SIMUL8 gave them the freedom to experiment with new layouts, the ability to see the impact in years to come, and the confidence that they would see results in a matter of hours.

DE: ***Does SIMUL8 develop its products with a niche industry in mind, or are products developed to serve a functional requirement across multiple industries?***

FS: SIMUL8 can be applied to any industry; however, custom-built products have been created using SIMUL8 as a base to address a specific need within that industry.

The design of airport security can be pretty crucial to the smooth running of any airport, and we're currently working with the team at London's Gatwick Airport—the busiest single-runway airport in the world—to improve the passenger experience there.

By using SIMUL8 to create a visual representation of the security process, the team can experiment with key factors like new layouts for waiting lines, number of X-ray machines, and makeup of staff at peak times to see what setup will reduce bottlenecks for passengers.

This ability to quickly experiment with ideas has led to exciting new initiatives like "family-friendly" lanes that separate business travelers from those heading on vacation—and that keeps everybody happy!

DE: ***In developing new products and revising existing products, how does SIMUL8 incorporate user feedback?***

FS: We have a pretty aggressive development schedule, which means we release a new version of our main product, SIMUL8, each year. This allows us to incorporate user feedback over the year to improve existing features and introduce exciting new ideas from our team. The people who use the product are those who are closest to it, so input from users and our in-house consultants—who deliver various external projects—is key to enhancing the user experience. We also ask our users to nominate features they'd like to see included in the next release, and this has resulted in some great features over the years.

DE: ***How much training is required for users to be able to use your products to build simulation models and bring about results?***

FS: Our aim is for the user to start using the product straight away, and to start seeing results as quickly as possible—so, within the first few hours! Of course, simulations can be as complex as you need them to be, but we believe that the best simulations are built quickly, produce results and develop over time. We have numerous support resources to help users get started on our website at SIMUL8.com. **DE**

Jim Romeo *is based in Chesapeake, VA. Contact him via de-editors@deskeng.com.*

INFO → SIMUL8: SIMUL8.com

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

Developing a Powertrain Test Bench

Dynacar combines digital and physical simulation to model powertrains for hybrid electric vehicles.

BY ADRIAN MARTÍN

Nearly 2 million hybrid electric vehicles (HEVs) have been sold in the U.S. since 1999, according to the U.S. Department of Energy. And with soaring gasoline prices and stringent governmental regulations mandating better vehicle fuel efficiency and reduced vehicle emissions, interest in HEVs grows daily. Many characteristics of HEVs—energy efficiency, vehicle performance, distance traveled and total cost, for example—depend on the vehicle's powertrain system design and its control strategy.

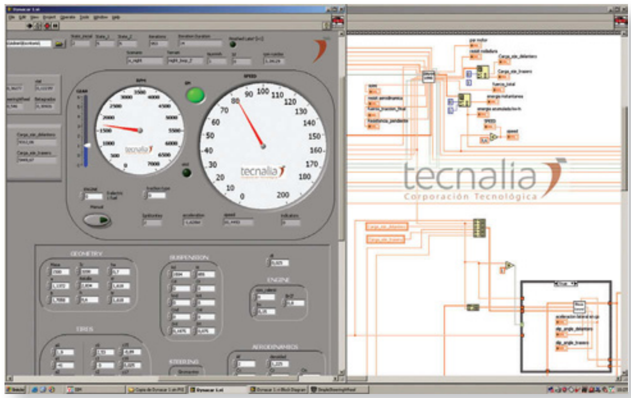
A team of engineers at Robotiker-Tecnalia in Spain, one of the largest research institutes in Europe, developed Dynacar, a parametrized model that can simulate HEV powertrains, as well as powertrains for electric and conventional fossil-fuel vehicles. Dynacar simulates longitudinal and lateral vehicle dynamics—as well as the powertrain system components in real time, for testing in model-in-the-loop (MIL), hardware-in-the-loop (HIL) and dynamometer test applications.

One key component of the model is that it integrates digital simulations with physical simulations of powertrain components. This combination enables HuIL (human-in-the-loop) testing, which provides an advanced virtual driving simulator for complete vehicle simulation over a test bench. By using HuIL simulation, the team was able to develop analyses of driver requirements and the dynamic response of an entire HEV.

The Robotiker-Tecnalia team used NI LabVIEW as the development environment for the vehicle model. They used NI VeriStand real-time testing software for model integration, stimulus generation, and data logging, and the INERTIA add-on for NI VeriStand, created by Wineman Technology, to implement multi-mode control of a dynamometer-based test cell. Additionally, the team used NI's PXI hardware, and a range of vehicle bus communication cards, and data acquisition (DA) interfaces.

HEV Full Dynamic Model

HEVs have electrical components—such as energy storage systems (batteries or supercapacitors), electric machines, power inverters and control systems—that are key factors in the electrical powertrain design phase. Because these components can be complex, the team used high-fidelity tools for modeling and simulation in the conceptual and preliminary design stages of its HEV to analyze the behavior of all components integrated in the powertrain.

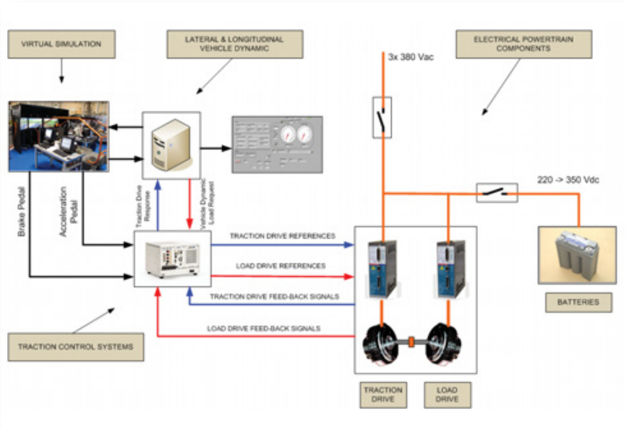


Here, a model front panel features code programmed in LabVIEW software. Users can configure the model according to the needs of the test carried out.

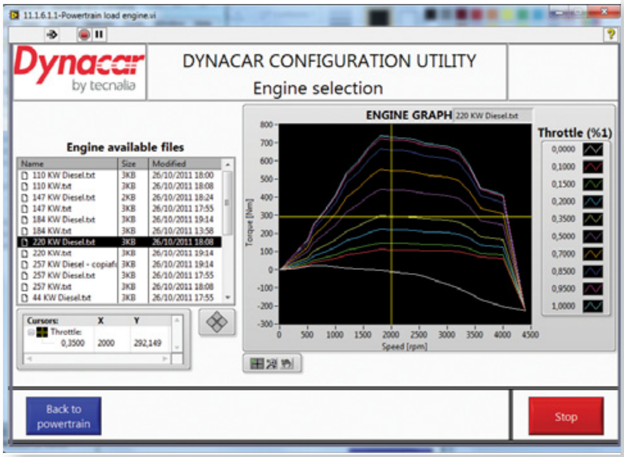
After defining the general powertrain architecture, Robotiker-Tecnalia conducted model-based studies to implement control and optimization strategies to manage the different energy sources. They also considered the differences in the dynamic responses of the components in an electrical powertrain from those in conventional powertrains. Because the electrical powertrain provides greater motor speed, they developed a new drive control strategy to give HEV motorists equal or increased vehicle drivability, comfort and safety.

They considered both longitudinal and lateral vehicle dynamic responses with the powertrain components and dynamic effects, as well as tire data and the modeling approach of road-to-tire contact. The model target was to calculate the vehicle speed and position, in addition to such dynamic variables as force, torque, slip angle, lateral acceleration and vertical axis load.

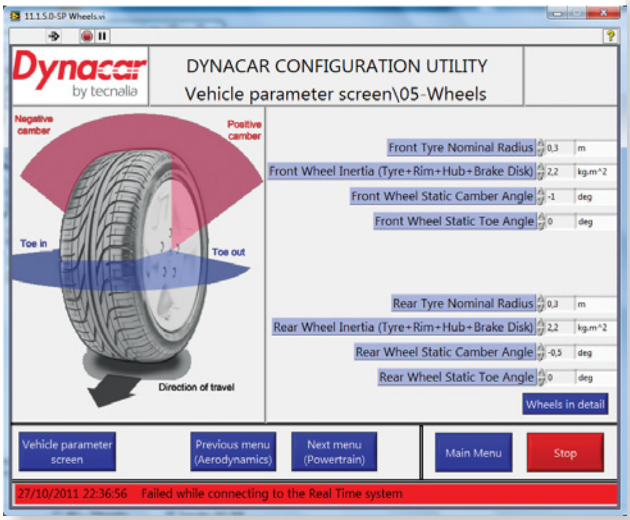
These variables are part of the differential equations that define the vehicle dynamic response, such as roll stiffness, weight transfer and vehicle model, according to such inputs as acceleration and brake pedal position, steering and wheel position, as well as tire,



This HEV test bench architecture layout shows virtual models of the Dynacar dynamic model and real hardware.



The Dynacar engine selection configuration utility.



The Dynacar wheel selection configuration utility.

geometry, roll center, inertia, weight and powertrain parameters. To solve the differential equations, the team used an integration solver based on the Runge-Kutta method in NI LabVIEW.

Architecture of the Integrated HEV Test Bench

The team replaced the powertrain electric component dynamic submodels with a PXI platform populated with real electronic components. They ran two motors with a physical coupling: one working as a load and the other as a traction drive. The load drive and traction drive torque reference commands were calculated using the Dynacar vehicle dynamic model. Drive response feedback signals were sent back to the Dynacar model through the NI PXI platform. This data was used in the vehicle dynamic response calculation.

The PXI platform integrates multiple I/O options. These include data acquisition with the NI PXI-6229 module, as well as communication and data interfaces required by a variety of applications with the NI PXI-8464 two-port, transceiver-selectable CAN interface. The team also developed additional communication and DA interfaces using the NI PXI-7833R multifunction intelligent DA module and the LabVIEW FPGA module.

SCANeR II, a driving simulation software system from OKTAL, completed the test bench architecture. SCANeR conducts driving cycle simulations using a human driver over virtual scenarios with a HuIL approach. To connect SCANeR with the Dynacar dynamic model, the team leveraged an application programming interface (API) for LabVIEW, based in .NET provided by OKTAL. They implemented the connection with the SCANeR II modules through an Ethernet cable.

This approach allowed the developers to play with different parameters while a human drove the components under interest. Similar to a sound jury with noise, vibration and harshness (NVH) research, the driver can identify the user features that please or repel—and the developers can make better decisions that balance safety and efficiency with human subjectivity.

The Robotiker-Tecnalia engineers will continue to use an integrated test bench architecture with real components. The researchers hope that detailed analysis of powertrain configurations will further improve the implementation of advanced control and optimization strategies for energy and power management, as well as electric traction advanced control solutions. DE

Adrian Martín *and his teammates, Iñaki Iglesias, Angel Goti, Jose Luis Calvo and Juanjo Valera, work for Robotiker-Tecnalia.*

INFO → Inertia: WinemanTech.com

→ **National Instruments:** NI.com

→ **OKTAL:** SCANeRsimulation.com

→ **Robotiker-Tecnalia:** Tecnalia.com/en

→ **Real-time Test and Hybrid Car Demo:** NI.com/niweek/keynote_videos.htm

Moving into "Intelligent Engineering"

The Center for Advanced Engineering Environments assists researchers, industry and government partners with product creation and testing.

BY DEBBIE SNIDERMAN

The Center for Advanced Engineering Environments (CAEE) at Old Dominion University in Hampton, VA, serves as a pathfinder and a focal point for research activities pertaining to advanced learning environments—and collaborative, distributed knowledge discovery and exploitation. It identifies the direction of aeronautical and space research, and demonstrates and transfers results to engineers and researchers.

CAEE's advanced visualization equipment ranges from autostereoscopic displays that allow users to view 3D images without headgear or glasses, to an EON TouchLight display that uses gestures and multimodal interactions. It also includes an EON IPresence tele-immersion facility, EON Icatcher 3D stereo projector, and a multi-user, touch- and gesture-activated tabletop display that is debris-tolerant.

Technologies that link virtual and physical worlds are used to create immersive, interactive 3D virtual worlds with augmented reality to get the most out of visual simulations. When used effectively, says Ahmed Noor, Ph.D., the center's director and professor of Modeling, Simulation and Visualization Engineering at Old Dominion University, they can automate several activities and significantly enhance an engineer's or user's productivity, creativity and innovation. They also allow collaboration with a wide range of people.

Virtual reality tools and new methods of interfacing enable groups of people to interact with a model simultaneously in an immersive classroom setting.

"As the trends of distributed collaboration, large-scale integration of computing resources, enterprise tools, facilities and processes continue, a fundamental paradigm shift will occur in the virtual product creation," he adds. "Future high-tech systems will be complex systems-of-systems, developed through just-in-time collaborations of globally distributed teams, linked seamlessly by an infrastructure of networked devices, tools, facilities and processes."

With this as motivation, Noor says researchers at the center are trying to build an intelligent, adaptive, cyber-physical ecosystem that has intelligent knowledge discovery so product planners and developers can visualize, assemble, test and optimize products and production processes very quickly.

Assisting NASA

Virtual structural test facilities and wind tunnels are just two examples of the type of virtual facilities the center uses for elaborate structural, material and aerodynamic testing. Simulations of NASA Langley's Subsonic and Full-scale Wind Tunnels were built to help NASA understand how simulations could help quickly converge on optimal component and system designs. They wanted to validate the simu-

Avatars are available to answer a wide variety of questions about the model, the simulation, or procedures, to help users complete virtual testing.

lations and understand what they could obtain from physical tests that could not easily be obtained from the simulations.

By using simulations of these wind tunnels and major structural test facilities in the virtual world, users can obtain procedural and operational training—and complete intelligent design of experiments to run in the facilities. The simulations also help them understand response quantities that can be measured during testing, the types of materials and sensors required, and their placement on test articles before arriving at the facility. After completing pre-test work, virtual tests can be run as often as required to understand the response before going to the physical test facility, where testing time is expensive.

CAEE also completed a simulation of a large structural test facility for NASA: the Combined Loads Testing System (COLTS). The COLTS simulation allowed a user to run a virtual test, then adjust the experiment, the boundary conditions, or change the test article material itself and re-run the test. Virtual testing with facility simulations is less expensive than performing multiple iterations of physical experiments, according to Noor. Once the simulation system is built, virtual tests are available at the relatively low cost of labor.

The Role of Immersive Displays

NASA found that traditional training methods—using courses, lectures and slides—were not exciting for younger audiences, and some older audiences felt intimidated when new technologies were introduced. To solve this problem, CAEE proposed using the most advanced technologies available that will engage the younger audiences, along with very simple interfaces for the older audiences, and demonstrated the concept using a number of simulations and design systems.

The interface of the center's TouchLight display was designed to be very simple to interact with, using hand gestures, voice commands or a smart mobile device. There is no user manual to read. Standing in front of the display containing simulation models, the system will list possible interactions. Users can ask "what are the models you have now in the system" to display a list of models. Commands such as "show me this model" or "what commands can I use with this model" are understood, and users can change command words to those they are more comfortable with, including foreign words.

The center has also developed technology that adds intelligence to simulation and design systems, providing intelligent virtual assistants as advisers. Not only can these intelligent agents perform mundane tasks such as auto-

The center has developed tools such as this TouchLight Display for interacting with models and simulations, using brain and gestural commands.

mating model generation, they can also lead a user through solving a problem, or help a technician running the test facility during a physical test.

Eventually, facility technicians or users will be able to use handheld devices to ask a virtual agent for assistance during any point of the testing, such as retrieving a specification or querying a manual for operational instructions. Prototypes were developed more than five years ago, long before the invention of Siri used with the iPhone 4S.

The CAEE has developed intelligent avatars—"cognitive" agents that use novel interaction technologies. Brain-based interfaces that combine brain signals to register thoughts, multimodal interfaces that include gestures, and facial expression recognition are used to facilitate the natural interaction of the user with the simulation system. One prototype notices when users look puzzled, and offers assistance. Noor says the avatar "feels" when the user needs help. He says he believes that more simulation systems should include these types of avatars: "They can significantly enhance productivity and engage the user."

Digital Simulation Complements Physical Testing

Digital and visual simulation tools are being used to accelerate the development of powerful systems, far beyond automatic model generation and self-designing components.

"We are moving from what we call the Information Age to another era, the Intelligence Era, which is essentially the result of advances in artificial intelligence going way beyond expert systems of the past, to artificial general intelligence trying to mimic cognitive characteristics of humans in our systems," Noor says. "In the Intelligence Era, the convergence of facilities, technologies and devices will have an impact on every engineering field and activity."

He points out that it is important to have a virtual representation of the entire value chain—the ability to go through the entire process, from concept and product development through operation during the expected lifetime of a product.

"The simulation should also include upgrade or disposal in a way that will not adversely affect the environment," Noor continues. "We should capture and reuse the multi-disciplinary knowledge of the organization that is developing the system, and consider how to effectively apply this knowledge to other products."

Digital factories of the future will be able to create much bigger components than the 3D printers of today, he adds: "We will add intelligence to those systems, so they can automatically select the production process and test it in a virtual world, like Second Life."

But Noor stresses that this doesn't replace physical testing.

"Physical testing will be reduced, and it will be done in much more intelligent ways than are done today," he concludes. "Simulations will be used to intelligently design the experiments, and we should think about the simulation and physical testing as two components of an integrated system that looks for 'predictive engineering' to obtain more knowledge than we are today, by thinking more intelligently about the role that each could play." DE

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

INFO ➜ CAEE: aee.odu.edu

➜ Visualization Technologies at CAEE: aee.odu.edu/facilities_visualization.php

➜ "Emerging CAE technologies and their role in Future Ambient Intelligence Environments": SpringerLink.com/content/b03n746w81521654

➜ EON Reality Inc.: EONreality.com

1 NI Releases Two New Mobile Apps

National Instruments (ni.com) has announced NI LabVIEW software- and NI hardware-compatible mobile apps for iPhone, iPad and Android devices. Data Dashboard for LabVIEW and Data Dashboard Mobile for LabVIEW allow users to remotely view PC or embedded measurements from LabVIEW on mobile devices using a combination of charts, gauges, text indicators and LEDs. The NI cDAQ-9191 Data Display directly connects wireless NI CompactDAQ hardware to iOS and Android devices using new technology featured on NI Labs. Users can configure, visualize and save measurements without a PC or tethered display.

Free Data Logging Software Available

MicroDAQ.com, an online provider of data loggers and data acquisition products, has announced the newest version of the Lascar data logging software, EL-WIN-USB. It is compatible with all Lascar loggers purchased in the last five years and will work on PCs running Windows 7, XP, and Vista.

2 Data Logger Has Built in GPS

Kistler (kistler.com) has released the Corrsys-Datron model CDS-GPS, a high-performance data logger with a built-in global positioning system (GPS) for longitudinal vehicle dynamics testing applications. Offering compatibility with other sensors within Kistler's Corrsys-Datron product range, model CDS-GPS has an update rate of 100 Hz with GPS signal output via CANBus. With quick vehicle mounting capabilities, the device provides high-accuracy measurements of absolute speed, traveled distance, latitudinal and longitudinal position, height, time and date, and system status information, such as the number of satellites, signal quality, and other factors.

Log Event Data

Omega (omega.com) has released a series of event data loggers. The OM-CP-EVENT101A interfaces to other devices with TTL pulse or contact closure output. They feature a 10-year battery, 4Hz reading rate, a multiple start/stop function, and an ultra-high-speed download capability, according to Omega. Options include memory wrap and password protection.

3 LOG Storm Has 8MB Memory Buffer

Saelig (saelig.com) has introduced Byte Paradigm's LOG Storm, a high-speed digital data logger for troubleshooting digital system buses. It is a hardware/software combination that can collect high-speed digital bus activity for periods of hours or even days, and extract specific functional events of interest. LOG Storm contains an 8MB sample memory buffer, enabling large bursts of data up to 20bits at 100MHz to be sampled, according to the company. A USB 2.0 connection is used to stream collected data to the PC, enabling more data storage. It features a data filtering capability, storing only relevant data.

Model 2701 DMM, Data Acquisition, Datalogging System

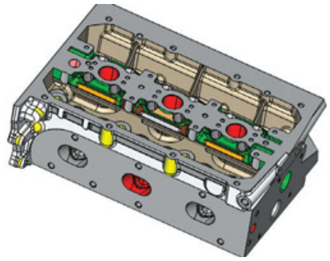
Keithley Instruments' (keithley.com) Integra Series systems (2700, 2701, 2750) combine measurement, switching, and control in a single, integrated enclosure for either rack-mounted or benchtop applications. These test platforms offer alternatives to separate DMMs and switch systems, dataloggers/recorders, plug-in card data acquisition equipment, and VXI/PXI systems. System builders can create test solutions with a combination of channel count, cost per channel, and system performance. The input modules provide the flexibility to vary the channel count from 20 to 200 (2-pole), apply a stimulus to the device under test, route signals, control system components, and make precision measurements with up to 14 functions. Digital I/O capabilities can be used for triggering, handshaking with other automation equipment, and alarm limit outputs. Scan rates of up to 500 channels/second (up to 3500 readings/second on a single channel) will increase test productivity. DE

The 3D Collaboration & Interoperability Congress (CIC), May 21-23 in Denver, is dedicated to fostering and improving collaboration and interoperability in product design, development and manufacturing. The ninth annual Congress is the only vendor- and product-neutral event in the world addressing collaboration and interoperability in manufacturing and business communications. The international event has grown into an essential forum to network, learn and strategize with thought leaders from automotive, aerospace and many other manufacturing industries, as well as with representatives from government and defense.

The 2012 CIC program features these informative presentations, and many more (visit www.3dcic.com for the full agenda):

- **Lessons Learned in over 40 years in Aerospace and Defense**, Rockwell Collins; Director, Advanced Manufacturing Technology (Retired)
- **Leveraging Virtual Engineering Environments to Drive Margin Improvement AND Product Development Flexibility**, Tom Curtis, VP of United Rotocraft, A Division of Air Methods
- **Aerospace and Defense: Global Interoperability Across the Supply Network for Life**, Howard Mason, Corporate Information Standards Manager, BAE Systems
- **Democratizing 3D: Leveraging Product Data Assets Beyond Design Engineering**, Lars Peder Hansen, Senior Systems Consultant - CAD/PLM, Grundfos Group, Denmark
- **3D based Process Plans on 787, Leveraging Model Based Definition for Manufacturing**, Max Jensen, Senior Developer, ME Systems Development, Boeing
- **Driving High Volume and High Quality in a Huge, Globally Inter-Connected Automotive Supply Chain**, Rahim Alsaffar, Lead Engineering Specialist, Johnson Controls Automotive Group
- **How PMI and Data Modeling Standards Affect Successful Implementation of 3D MBD and MBE**, Bryan Fischer, President, Advanced Dimensional Management
- **Manufacturing & PLM in 2020**, Stephen Bodnar, VP Manufacturing Solutions, Autodesk, Inc.
- **How 3D is Helping with the Recovery at Fukushima**, Sakiko Seki, Business Development Manager, Smartscape, Inc., Japan
- **Leveraging the Rise of the Social Consumer for New Product Innovation**, Rob Fisher, Director of Marketing, Madison Electric Products
- **Incorporating Equipment Information into New Facility Construction and Retrofits**, Jason Hosch, Senior Industrial Engineer, Intel
- **Data Distribution on the 787, Bringing Model Based Definition to the World**, David Briggs, Associate Technical Fellow -787 Engineering Information Delivery, The Boeing Company
- **Design, Development, and Testing of an Open Standards-Based Simulation Data Management and Archival System**, Keith Hunten, Senior Staff Aerospace Engineer, Lockheed Martin Aeronautics Company

Automated Geometry Simplification in a Multi-CAD PLM Environment



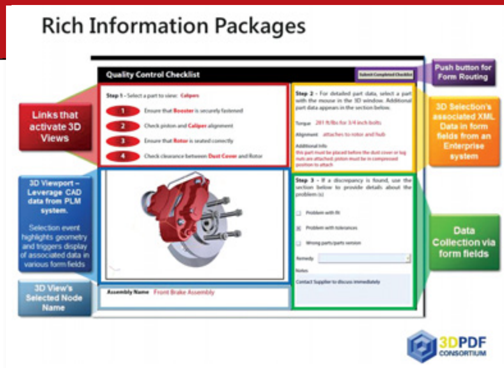
A large general machinery company wanted to develop an automated process to generate simplified 3D CAD models from existing master models and manage the results in their PLM application. The current manual process was time consuming with inconsistent results. It was difficult to keep in sync the master models with the simplified models due to concurrent modifications. In addition, the company wanted to protect their Intellectual Property (IP) by removing the internal components, thus creating the envelop and reducing the size of the model by 65%.

To gain a competitive advantage in a global environment, companies must be able to safeguard IP contained in their 3D CAD models, while retaining the ability to share data through process automation. A persistent challenge in sharing data is reducing the size of a model. Another major challenge is to create simplified representations without compromising the information business partners need to accomplish their tasks. CT Core Technologies is introducing Automated Geometry Simplification using 3D Evolution for Multi-CAD PLM applications. The module is based on the 3D_Evolution software. With the press of a button the Geometry Simplification (GS) module enables the automatic simplification of 3D models, creating a bounding geometry while reducing model size and complexity.

3D models reveal details and design features about a new product before it reaches production. This sensitive data is exposed in the model history and assembly. Because the data is sent to many different end-users for layout, mock-up, and engineering, it is difficult to control who eventually access the data. The only effective solution is geometry that does not contain confidential details. The automatic process produces models which lack internal data sets. In detailed models, such as engines, gearboxes or powertrains, a massive reduction of the file size will be achieved through 3D Evolution scripts.

Simplifying assemblies involves filling holes before GS with the removal of internal and external objects. Simplifying the bodies can be automated by keeping removed details in 'no-show.' Setup configuration allows making the choice to remove holes or bosses, saving time to remove the smallest of detailst. Automatic simplification creates an outer shape bounding geometry, which exceeds even the most stringent quality standards.

The 3D PDF Consortium

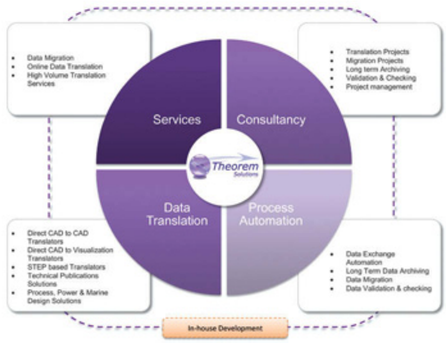


Across many industries, 3D data is becoming a key part of the data assets on which an organization operates. In discrete manufacturing, process manufacturing, geospatial applications, and health care, more and more 3D data is generated each day, and increasingly organizations need to find ways to leverage that data to improve their business processes and financial performance. One of the most significant barriers in developing tools and processes which can provide the benefits being sought, is how to standardize on the representation of that information, and the other forms of data that so often must accompany the 3D asset, in a form that is easily consumed and fits with the procedures and processes that the organization depends on.

With the addition of the ability to represent 3D data within PDF files, and the accompanying support of that representation as an ISO standard, companies now have available to them a platform on which they can innovate their processes and develop highly effective, impactful ways to represent 3D information. For instance, in discrete manufacturing, you can now include a full fidelity 3D representation of a manufactured part or assembly, along with the metadata accessible in a PLM or ERP system. Using capabilities such as templates and forms within a PDF file, you can create documents that support extremely accurate and complete representations that allow you to automate processes such as request for quote (RFQ) and request for proposal (RFP), or create dynamic documents which are deliverable as shop floor work instructions, assembly instructions, training manuals, or maintenance and repair procedures. In almost any industry, what is needed to make this effective are two key elements: a way to combine in a relational fashion 3D data with structured and unstructured text such as attributes, product manufacturing information, and instructions; and the ability to allow anyone, anywhere to consume that information in their day-to-day duties.

The 3D PDF Consortium is a new community of software developers, system integrators and end user companies that focus on driving adoption of 3D PDF-based tools and solutions through demonstration, information, and evangelism, on the premise that a dynamic community ensures world class tools and solutions continue to remain available in the marketplace. We have elected to sponsor the 3D Collaboration and Interoperability Congress as our premier event in 2012, given the relevance of the conference focus to our mission.

Theorem Solutions



Our products and solutions are all driven by market demand so listening to the needs and views of users and experts in the fields of collaboration and interoperability is one of the main objectives for Theorem as a silver sponsor at the 2012 3D CIC event.

We have always found the event very useful as it allows us to meet users and decision makers in a relaxed business environment. The event's presentations and workshops enable us to hear views and identify trends, as well as to meet with technical specialists from a broad spectrum of industries and design disciplines.

3D CIC provides us with the opportunity to refine current products to meet users' short-term needs, but also to plan for the next generation of requirements.

Over the past 20+ years we have been very successful in the CAD data translation marketplace with our CADverter products and continue to be so; however, today this only forms a part of our business.

As technology and data exchange needs have advanced, and the complexity of data has increased, we have developed and built upon our core skills and expertise based on the needs and feedback of our users. This enables us to provide solutions that reduce costs for engineering and manufacturing departments when collaborating with business partners.

Our large-scale automated solutions for CAD and PLM data migration and long-term data archiving projects save time and money by streamlining and eliminating the labour intensive tasks involved in migrating large volumes of data.

The advanced technical solutions and in-depth expertise that we bring to every project enables companies to seamlessly carry forward CAD and PLM data into the latest generation systems.

Our solutions and services for: CAD to CAD, CAD to Visualization, CAD to PLM and PLM to PLM can be tailored to meet any requirement. Resulting formats are not an issue as we partner with all major vendors. We concentrate on the "Process." Automation, data validation & checking, with detailed audit trails can all be included in one efficient process underpinned by the Theorem Process Management suite of technologies, which can also be used to manage non-Theorem products.

Providing effective engineering services is about implementing the right mix of people, technology, data, processes and infrastructure.

We welcome the views and opinions of users and look forward to meeting you at the event.

Composites Blast Off

Everywhere you look in aerospace, you'll find composites.

BY MARK CLARKSON

ATK Aerospace Systems builds composite space structures, including solid rocket boosters for the shuttle, rocket motor cases and nozzles. Its commercial launch vehicle, Liberty, is expected to launch next year.

When it comes to building for space, designs are cut to the bone, asserts Nathan Christensen, ATK's senior manager, engineering tools and analysis.

"In space vehicles," he says, "you have very low margins of safety. They're designed right down to the gnat's eyeball. An unmanned vehicle might have a safety margin of 1.2. A manned vehicle might still only have a 1.5 margin, whereas with an aircraft you're looking at margins of 4 or 5."

On top of that, Christensen says, the space industry is a lot more risk-averse than it used to be: "A lot of that has to do with our ability to do simulation. Using tools that we didn't have 20 or 30 years ago, we're able to test dozens of different designs [in the computer] before any of them take physical form."

Although those designs seem relatively straightforward—cylinders, cones, etc.—there's a bit more to them than that. Consider the nozzle of a solid rocket motor, for example.

"The throat is composite," says Christensen. "It's designed to erode while the rocket fires. The thrust changes with the throat diameter."

You can't "de-couple" the fluid and finite element (FE) simulations; each affects the other. Modeling this interaction takes sophisticated tools, which companies like ATK used to develop in-house. "But now," says Christensen, "you're seeing commercial tools—like ANSYS multiphysics and Nastran multiphysics—that do that kind of coupled analysis, coupling structure, thermal and fluid flow. It's cost-effective to use commercial software when we can. We don't have to invest the resources in software development that we once did."

The commercial availability of these tools is key to the proliferation of composites in aerospace, because composites are hard to understand.

The Many Modes of Failure

"Composites are unique," says Stanford Professor Emeritus Stephen Tsai, "in that you have structural behaviors that have no counterpart in homogeneous material."

It's much easier to characterize a flaw in a homogenous material, according to Tsai. "For composites, you not only have in-plane failures—matrix failure, fiber failure, interfacial failure—but also out-of-plane failures that involve delamination. The traditional fracture mechanics become much more complicated: You don't have one crack, you have thousands of cracks, micro-cracks, separation voids and so forth. These require very sophisticated simulations. You can't do [the math] on the back of an envelope."

Fabricators at ATK in Iuka, MS, laying up plies of composite material to create the inner honeycomb sandwich skin of the NASA crew module. The plies are being laid up with the assistance of a laser projection system, which is driven by VISTAGY's FiberSIM software.

The Parable of the Ironbridge

How did engineers build composite structures without these simulations? Jerad Stack, CEO of Firehole Composites, Laramie, WY, shares an illuminating story: "There's a place in England called Ironbridge, where humankind built the first iron bridge. We didn't really know what we were doing. All we knew then was wood, so we used wood engineering."

The cast iron bridge was built using a modified form of carpentry. It worked. The bridge is still standing 230 years later. But what's significant is that the bridge was over-designed, using perhaps twice the necessary iron.

"When composites were new, we were taking tools that we'd been using for decades with metals, and trying to use them for composites, Stack says. "But composite materials are different," he continues. "They're not metals. The mechanics behind them are different than aluminum or steel. The fundamental difference is that there are two materials there. Our belief is you have to treat it like two materials, so we have composite-specific tools like our Helius:MCT."

Embracing Anisotropy

Carbon fiber composites, for example, comprise the carbon fibers themselves and the resin, or matrix, that glues them together. The fibers are usually parallel and unidirectional. As a result, these composites are anisotropic (or orthotropic) materials; they exhibit very different material properties in different directions. They are, generally speaking, strong in the direction of the fibers, and weak in the directions perpendicular to the fibers.

To those used to working with isotropic materials such as metal, the logical response was to stack the composite in layers, or plies, with fibers oriented in different directions. The resulting laminate is reasonably strong in every direction, but it somewhat misses composites' potential.

"Many people feel more comfortable and confident with a more uniform composite," says Dr. Kim Parnell, principal and founder of Parnell Engineering & Consulting, Sunnyvale, CA. Still, he points out, its effective modulus (a measure of stiffness) is "much less than the strong modulus in the fiber direction. Its effective strength is much less."

By controlling fiber orientation, you can direct a structure's strength where it's needed. You're not just designing a part with the desired properties; you're designing a material with those properties. You're exploiting, rather than fighting, the anisotropy.

Composite material properties are also highly dependent on the manufacturing and layup processes. Different manufacturers using the same "recipe" can produce significantly different materials. But there's opportunity hidden here as well. Composites are customizable. You can create different, finely tuned materials. All of those options can be hard to sort through, but automation can help.

"The real differentiator for us is in the optimization," says Bob Yancey, executive director, global aerospace, for Altair. "If you know the general shape of the structure, and the loading and boundary conditions, you can set up an optimization problem [in Altair's OptiStruct]. How should those ply angles be distributed in the laminate? How many do I need of each ply angle? Where should my laminate be thicker? Where can it be thinner?

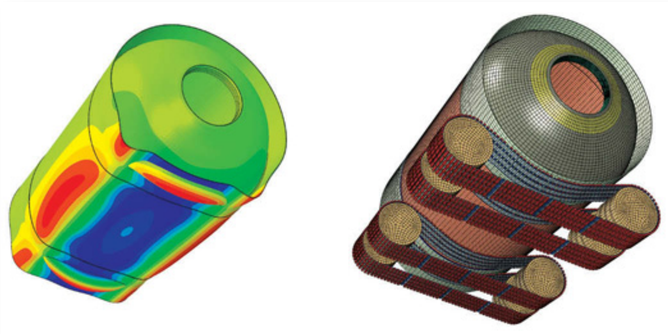
"It'll come back with a proposed design, which is a great conversation piece to get manufacturing, design, stresses and operations all in the same room, talking," he adds.

Progressive Failure

Unlike metals, composites fail progressively. Cracks or delaminations in one area redistribute stresses to adjoining areas, which fail in turn.

"I see progressive failure analysis as the next level of composite analysis," says NEi Application Engineer Allan Hsu. "It's a type of lifecycle analysis where you're concerned about not just how damage happens, but also how much damage the structure can sustain and how it changes over time. Once something starts to fail, how much load can it still sustain?

"NASTRAN and a few other [applications] do this, but I see it becoming pretty big in the next few years," he continues.



LEFT: Buckling analysis results and magnified deformation of a filament-wound composite solid rocket motor case sitting in the rotator chock system. RIGHT: 3D FEA model of graphite epoxy filament-wound composite rocket motor case sitting on rotator chock belt system. The rotator chock belt system uses a chain and rubber pads (discretely modeled) for ground-handling operations to prevent composite fiber damage. *Image Courtesy of ATK Aerospace Systems; Engineer: M. Gonzalez; Software: NX, Abaqus.*

When You Assume ...

Not every component needs to be analyzed down to the individual fibers. Your analysis can assume a homogenous material and still produce useful results.

"The more assumptions you make, the easier it is to do the analysis," says Kyle Indermuehle, director, aerospace and defense industry, for SIMULIA at Dassault Systèmes. "What assumptions do you think you can get away with?"

Take a spacecraft designed to re-enter the atmosphere, he offers as an example. The thermal loads will be tremendous.

"If you're designing an aircraft," says Indermuehle, "you could decouple the problem. The thermal loads won't affect the structure much. For spacecraft, the interaction between thermal and structure are coupled very, very tightly. If you try to decouple them, you're going to get the wrong answer."

INFO → **ANSYS:** ANSYS.com

→ **Altair Engineering:** Altair.com

→ **ATK Aerospace Systems:** ATK.com

→ **Firehole Composites:** Firehole.com

→ **MSC Software Corp.:** MSCsoftware.com

→ **Parnell Consulting & Engineering:** Parnell-Eng.com

→ **SIMULIA:** SIMULIA.com

→ **VISTAGY:** VISTAGY.com

...Continued from page 27

That answer may only be off by about 15%, but if you're running on the razor-thin safety margins of the space industry, can you afford it?

The fewer assumptions you make, the more difficult it is to set up and interpret a simulation. You have to define different layers, materials and fiber orientation angles. On the back end, you'll be studying many more contour plots.

Indermuehle estimates that about 70% of an engineer's time would be spent building the model; about 20% is spent running the model; and about 10% is spent understanding the results.

"Philosophically, we'd much rather the engineer spend 70% of the time absorbing the results and about 10% of the time developing the model," he adds. "The technology to solve the problem is there today—the usability is still a challenge, and one we take very seriously."

Simulation is Now King

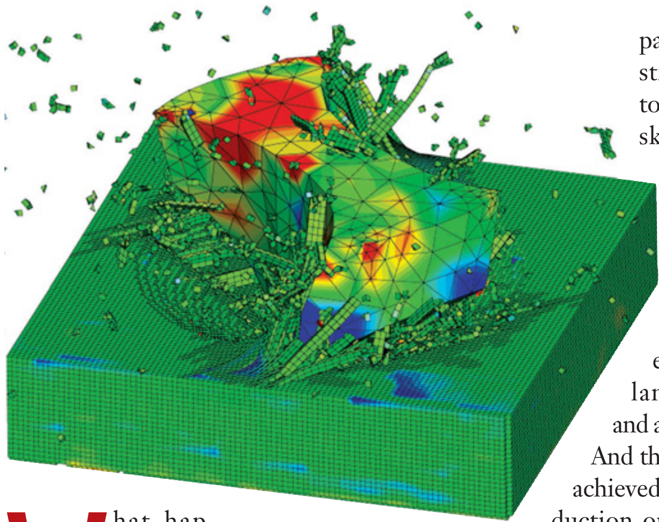
Understanding composites' many failure modes requires modern, accurate analytical tools. Previously, manufacturers' only option was to invest in expensive physical testing and testing was king.

"But that's not the case anymore," says ATK's Christensen, "Now, your test is just a confirmation of your simulation, and the test had better confirm what your simulations showed or you've got a lot of explaining to do. Our customers—the U.S. Department of Defense, the Air Force, the Navy, NASA—are very demanding that way." DE

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

Simulating Composites

BY PAMELA J. WATERMAN



What happens when you drill a hole in a multi-layer composite? Is there damage that will cause trouble when that structure is in use? And how precisely can you layer it in the first place? These are just some of the issues addressed at the 2012 SME Composites Manufacturing conference that took place in Mesa, AZ, in March.

Attendees heard about the increasingly important role that composites play in the design and manufacture of manned vehicles, wind-turbine blades and a host of applications in-between, plus new ways of dealing with them—many involving simulation for design and manufacturing.

For example, the new Boeing AH-64D Apache Block III combat helicopter uses an increased horsepower engine whose successful operation depends on redesigning a number of subsystems, with improvements that incorporate composites.

First, the new composite horizontal stabilizer saves 15.8 lbs. over the same design in metal, and also reduces the part count by 93. It still has a metallic torque box, but the skins and bars are composites. Second, the 256-in.-long main rotor blade will now be all composite, with a glass/epoxy hybrid spar laminate structure and a Nomex fiber core. And third, designers have achieved a 4-lb. weight reduction on the aft avionics pass-through doors, whose concurrent part-count reduction also makes them easier to manufacture.

Software Solutions

With so many operational benefits dictating the expanded use of composites, it was not surprising that several presentations addressed relevant software simulation tools for both design and production.

Bill Hasenjaeger is the product marketing manager for CGtech, developers of VERICUT software that simulates computer numerically controlled (CNC) machining to detect errors, potential collisions or areas of inefficiency. His company has used this experience to create VERICUT Composite Simulation (VCS), a package that reads CAD models and NC programs, and simulates the sequence of NC programs on a virtual machine.

Hasenjaeger talked about the need for process simulation software to verify the accuracy of automated fiber-placement (AFP) programs. In the real world of manufacturing, one or more bands of material are laid at the rate of 2,000 in. per minute. He emphasized, "On curved surfaces, you will have gaps and overlaps," as the tape unrolls and is laid in position over a tool's surface. Therefore, verifying the layout process and performing a design-for-manufacturing analysis are both critical tasks addressed by VCS software.

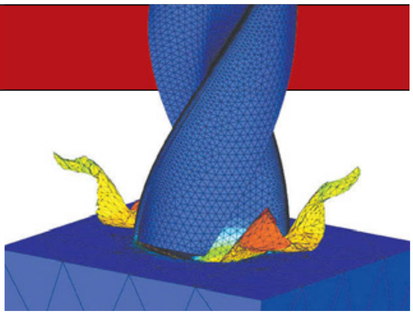
Dr. Shuji Usui, lead developer and computational mechanics engineer at Third Wave Systems, tackled another very relevant question: What happens to the microstructure of a composite material when holes are drilled into it?

Third Wave Systems markets predictive, physics-based material modeling software used by companies to improve machining processes and is currently involved in early-stage R&D efforts related to composites modeling. The company's AdvantEdge FEM software is a CAE solution traditionally targeted to the optimization of metal cutting, enabling users to analyze machining processes in 2D and 3D environments. Users are typically looking to improve part quality, increase material removal rates, and extend tool life.

Usui has now applied finite element (FE) modeling to predict the damage caused when twist-drilling holes into composites. He modeled a Constant Virtual Drill Bit with CATIA and NX software, then ran the model through AdvantEdge FEM on both composite and aluminum materials for comparison.

Cutting energy for metal includes plastic work (heat) plus friction, while cutting energy for composites must account for surface energy (transverse cracks) plus friction. Usui employed an unstructured mesh to solve the isotropic (metal) problem, and a structured mesh to handle the brittle behavior of the orthotropic (composite) problem, modeling each ply individually. AdvantEdge FEM was able to simulate a punch-shear test similar to the entry of a twist drill-bit, generating detailed animation graphics of layer delamination and fiber-shard splitting as the drill advanced.

Current Third Wave Systems work involves simulating various lay-up designs where layers are 90° to each other, 45°,



FE Modeling and analysis of twist drilling forces using Third Wave Systems AdvantEdge FEM software. The simulation shows microstructure damage when drilling a hole through (previous page) aluminum and a multi-layer composite (above). The composite delaminates and shreds. ***Images courtesy Third Wave Systems.***

-45°, etc. So far, the -45° orientation seems to result in the most internal damage. Usui is comparing the simulated results with laboratory experiments on an aluminum block and a graphite/epoxy composite. Future simulations will include the effects of the drill wearing down and cutting at an oblique angle.

John Schibler, chief engineer and IPT lead, Attack Helicopter Programs, for The Boeing Co., gave the keynote presentation about the Apache Helicopter program and its use of composites. He wrapped up his talk by noting a major wish-list item: room-temperature-curing composites. It would reduce the costs associated with autoclave curing, and allow the use of embedded-electronics sensors (which currently can't handle autoclave heat).

For more conference information, see SME.org/composites and consider joining the SME Plastics, Composites and Coatings (PCC) technical community (SME.org/pcc). **DE**

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INFO → **Dassault Systèmes:** 3ds.com

→ **CGTech:** CGtech.com

→ **Siemens PLM Software:** plm.automation.siemens.com

→ **Third Wave Systems:** ThirdWaveSys.com

Quantum Leap

FIGURE 1: This model uses the new charged particle tracing user interface to compute the trajectories of electrons in a spatially varying magnetic field.

COMSOL Version 4.2a expands its multiphysics offering.

BY VINCE ADAMS

"It is our mission to stay ahead of the curve," says Bjorn Sjodin, vice president of product management for COMSOL Inc., Burlington, MA. Its multiphysics application, COMSOL, reflects this mission—and the functionality provided with Version 4.2a is no exception.

COMSOL Version 4.2a was released in October 2011. Two highlights of this release, the Particle Tracing Module and the LiveLink for CREO Parametric, the new modeling environment from Waltham, MA-based PTC, expand the impact of multiphysics simulation and its accessibility. Features like Image Import and Digital Elevation Map import are also enhancements, while many user interface improvements show COMSOL is listening and responding to customer needs. *(See Figure 1.)*

Particle Tracing Module

While particle tracing and streamline mapping have been available as computational-fluid dynamics (CFD) post-processing tools in COMSOL, the developers have expanded its reach by introducing new solver and visualization methods with the new Particle Tracing Module. As implemented, this is a secondary or bi-directional calculation on top of field and vector data that can compute particle position in a fluid mixing scenario or ion trajectories in an electromagnetic field.

Per Sjodin, the most important aspect of this module is flexibility. Essentially, COMSOL can plot the path of particles, either with mass or massless, under the influence of any number of forces and effects. Fluid forces and electromagnetic forces are the most common applications. However, the potential is theoretically limitless. (*See Figure 2.*)

COMSOL LiveLink Upgrades

LiveLink, the bi-directional CAD interface provided by COMSOL, supported SolidWorks, AutoCAD, Autodesk Inventor, Pro/ENGINEER and SpaceClaim in the previous release. This has been extended to support the newest modeling environment from PTC, Creo Parametric.

Another upgrade for LiveLink customers is the inclusion of a Parasolids-based geometry engine at no extra cost. Because the purpose of LiveLink is to provide native CAD support with persistent boundary conditions and properties, one might ask what value there is in a COMSOL-specific solid modeling tool. Sjodin says many geometric features or updates are solely to facilitate simulation.

"Consider a box that defines the flow or field domain around a part of interest. This box has no value in the design world, but is critical to the flow or electromagnetic solution," he says.

The integrated Parasolids engine allows users to maintain the integrity of the native CAD part while leveraging geometry-based meshing and model setup. (*See Figure 3.*)

Image-to-Material Conversion

Isotropic. Homogenous. Uniform. All are common assumptions used to simplify the definition of a material for simulation. COMSOL customers have clearly communicated to the developers that each of these assumptions must be questioned if they are to expand the boundaries of

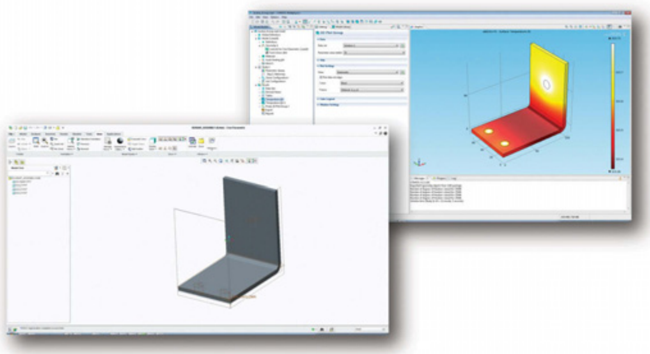


FIGURE 2: The new LiveLink for Creo Parametric.

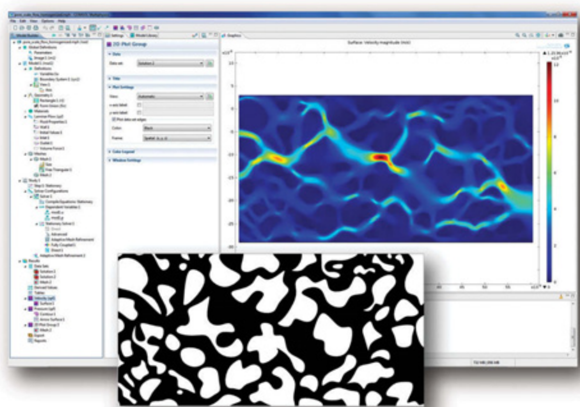


FIGURE 3: A flow simulation using image-to-material conversion, where the equivalent flow resistance is computed for a porous structure.

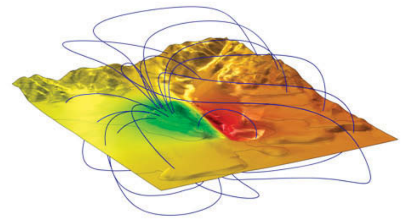


FIGURE 4: An imported DEM was used to represent the underlying geometry for magnetic prospecting.

advanced material engineering. Non-homogenous or porous material is particularly problematic when local effects must be considered.

Historically, an engineer would use CAD to manually trace around particles or voids in an image to create a finite element mesh (FEM) that was representative of local discontinuities. When you consider the porous media illustrated in Figure 3, where the black areas are open to flow and the wide regions represent obstructions, repetitive tracing—even with edge detection tools available in image-editing software—would still make creating a mesh tedious.

COMSOL Version 4.2a now offers a much more efficient means where a mesh is created over the image itself, using the pixel content to determine mesh density and property distribution. The user has additional mesh control tools if needed. COMSOL can utilize binary (black-and-white), grayscale and color images. Users can define thresholds based on the image color so clean edges aren't required.

In addition to non-homogeneous materials, many electronics manufacturers requested and are using this tool for structural, thermal and electromagnetic analysis of printed circuit boards (PCB). With trace density increasing yearly, this image processing-based mesher has reduced simulation setup time significantly. (*See Figure 4.*)

A fourth notable enhancement to COMSOL Version 4.2a is the ability to import and mesh digital elevation maps (DEMs). These standard 3D data formats were developed to represent geographic or terrain features in the mining, oil and gas, and other civil engineering-related fields. COMSOL has been adapted to these applications, which fall outside the domain of traditional FE solvers.

User Experience Improvements

In post-processing, COMSOL has added dynamic section and iso-surface control at the request of customers. This is a commonly used visualization tool in FE analysis, and a long-awaited addition.

COMSOL supports cluster computing with a simple licensing structure, which allows multi-node computing with a floating license and multi-core computing with a node-locked license. Large parametric sweep studies are ideally suited to leverage cluster computing but can create enormous amounts of data that must eventually be mined for trend plots. In Version 4.2a, COMSOL allows users to run these resource intensive studies but then save only the user-defined output required to generate these plots.

Joined datasets have been added to COMSOL Version 4.2a to allow cross-study data comparison. Users are now allowed to compare results across similar datasets at different points in the time history—and even with dissimilar meshes. Output variations from boundary condition, flow media properties and even mesh density can be readily evaluated for greater insight to the problem at hand.

Looking ahead, COMSOL Version 4.3 is set for release this month. Users can look forward to enhancements to the nonlinear structural solver, which will provide more material models. Version 4.3 will also feature two new modules for corrosion and pipe flow. **DE**

Vince Adams, *an account manager for LMS, is a simulation educator, consultant and speaker. He has authored three books on finite element analysis and many magazine articles. Contact him via de-editors@deskeng.com.*

INFO → COMSOL Inc.: COMSOL.com

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

Part 2

Direct Modelers as FEA Pre-Processors

Direct modeling and CAD-integrated FEA propels design optimization.

BY KENNETH WONG

In the past, over-engineering was an accepted way to cope with uncertainty. Today, design optimization has replaced over-engineering as the recommended approach to dealing with uncertainty. Two recent trends—the integration of direct editing into history-based CAD modelers, and the marriage of sophisticated finite element analysis (FEA) software and design software—are poised to drive design optimization even further upstream. Parametric, or history-based modeling, is favored by those trained in classic CAD programs. Direct modeling is favored by FEA experts who must adjust and refine the design, but don't necessarily have the expertise required to dissect and understand the feature history of a design.

CAD-integrated simulation tools have also become more sophisticated. In higher-end design programs like NX and CATIA, users have the option to invoke analysis tools for heat transfer, fluid flow, air flow and other scenarios beyond simple stress and load analysis. The couplings in both fronts—the merger of history-based modeling and direct modeling, and the merger of CAD and FEA—are opening new possibilities in design optimization.

A Overlooked, Familiar Name

It's quite possible that someone shopping for a direct modeler might inadvertently overlook IronCAD, simply because the company hasn't made a great effort to pitch the software as such. But for the push-pull operations possible in IronCAD, and for the software's accommodation of both history-based modeling and history-free methods, it belongs in the hybrid modeler family.

In a memo to the IronCAD user community, IronCAD Vice President of Product Marketing Cary O'Connor wrote, "Going back to the inception of IronCAD, the goal was to make both modeling paradigms available to the user without the overhead of trying to figure out which is right for a particular task and what portions of the feature are what."

Many direct modeling operations rely on the CAD software's underlying kernel to resolve geometry conflicts when you push and pull on faces, or create complex fillets and shells. IronCAD relies on two kernels—ACIS and Parasolid—to perform conflict resolution in its geometry.

The software accommodates working in traditional history-based methods, but it also offers what it describes as direct face modification (DFM) to let you move faces by dragging and dropping. DFM operations let you break history dependency, effectively throwing you in the direct-modeling environment.

IronCAD uses a TriBall with dynamic handles to let you push, pull and reposition geometry (and handle other aspects such as images and animations). The handle may also be used to easily create duplicate copies of solid geometry and position them in 3D space.

With the dynamic handle, you don't need to insert a construction plane to place the new geometry, or refer to other geometry for positioning. IronCAD also allows the copies to be independently edited and moved. The software's SmartSnap function identifies snap-worthy locations—such as midpoints of edges and center points of radiuses—to let you place and refer to features with precision when dragging and dropping.

Nastran for IronCAD

Recently, IronCAD struck a partnership with CAE vendor NEi. The outcome is NEi Nastran for IronCAD, a FEA program that runs inside IronCAD software. The free version of Nastran for IronCAD limits your models to 10,000 nodes. To analyze mesh models with a greater number of nodes, you'll need to purchase a license.

From within IronCAD's modeling window, you'll be able to mesh your model, add constraints, add loads, define materials, and solve the analysis scenario. The results can be displayed as contour maps, displacement maps and animation files. Integration with IronCAD's modeling tools allows you to edit the model in the same environment where you ran your analysis, with the mesh on or off. A modified version of your design can be resubmitted to Nastran for updated results.

LiveShape Reshaped CATIA

Dassault Systèmes' direct modeling technology, dubbed Live Shape, made its debut in CATIA V6. Customers got their first glimpse of it during Dassault Systèmes' European Customer Conference 2008 in Paris. Its Group Creation function lets you select a feature and a series of related surfaces (perhaps nearby blends and extrusions) to create a group, then move the grouped faces and features to a new location by dragging and dropping.

CATIA's Live Shape also lets you add relationships between groups (for example, a coincidence constraint between two geometry groups). With such a constraint, when you move one group of geometry, the related group follows to retain the constraint specified.

CATIA Live Shape, according to Dassault, is a direct-editing modeler which enables hybrid modeling such as solid, surface or wireframe modeling. Jacque Leveille, Dassault's vice president of product marketing for the CATIA product line, said direct modeling is expected to offer greater flexibility in "3D conceptual design phase, 3D collaboration, downstream use, especially analysis, and [editing] imported geometry."

SIMULIA, Dassault Systèmes' portfolio of simulation solutions, can be integrated with CATIA V5 and works on the same platform than CATIA in V6. These integrated solutions, according to the company, "eliminate the transfer and translation of geometry and allow users to perform analysis directly on their reference model in CATIA."

Tim Webb, SIMULIA's director of marketing communications and programs, notes that the integrated simulation solutions that work with CATIA LiveShape also include ExSight for simulation specialists and DesignSight for those without extensive FEA experience. They "leverage the full feature-based and direct modeling capabilities of CATIA, while eliminating the transfer of geometry between CAD and FEA packages."

Design and Analysis in Synchronicity

In earlier incarnations of Siemens PLM Software's Synchronous Technology (ST), the difference between NX with ST, the company's high-end CAD/CAE/CAM solution, and Solid Edge with ST, the company's midrange CAD software, is much more apparent.

Earlier versions of Solid Edge with ST required users to fully commit to a history-free mode. By contrast, NX with ST gave users the option to work in a hybrid environment. The difference, however, may be getting slimmer as SE with ST begins to incorporate the hybrid modeling mode, beginning in SE with ST3. For those who rely heavily on simulation and analysis, NX CAE—a version of NX delivered with integrated simulation tools—is available.

"NX is one of the leading applications that integrate high-end simulation with direct geometry modeling," says Ravi Shankar, Siemens PLM Software's director of simulation product marketing. "When ST was first introduced [about five years ago], people thought this would be great for design. I think people didn't realize the potential for CAE engineers."

With NX CAE, the design model and the simulation remain associative; any changes made to the design model will automatically prompt an update to the CAE model and results.

"NX CAE users can import geometry from another CAD system, modify it using Synchronous Technology, capture the changes as parameters, and use that information to drive design optimization—all this without leaving the NX environment," says Shankar.

iPhone Convergence Lessons

A little more than a decade ago, cameras, BlackBerries and cell phones were distinctly different devices. Each performed a specialized communication function.

The genius of the iPhone was the elegance with which it consolidated these operations into a single device.

Similarly, when several subsets of design engineering are consolidated, we benefit from the ability to take our digital assets from conceptual phase to analysis, then back to CAD without shuttling the data back and forth among several different software programs, without the risk of data loss and corruption.

It's only a matter of time before direct editing becomes a standard toolset of mechanical modelers. Five years from now, few CAD users will be asking whether a software program is a direct modeler or a parametric modeler, just as nobody today asks whether your cell phone can also send and receive texts or take photos. And it's only a matter of time before design optimization becomes part of every phase of design, not just the quality control phase or the post-production certification phase. Nobody will ask whether your design has been optimized, because, with the toolsets you have at your disposal, everyone will expect it to be. **DE**

Kenneth Wong *is* Desktop Engineering's *resident blogger and senior editor. Email him at kennethwong@deskeng.com or visit deskeng.com/facebook.*

This article has been edited due to space constraints. Access the full version, and all of *DE's* recent direct modeling series, at deskeng.com/direct.

Comparing Additive and Subtractive Processes

Cost, volume, geometry and tolerancing are differentiators in what technology to choose for mold making.

BY SUSAN SMITH

Since additive manufacturing (AM) has been on the scene, the technology has grown in its capabilities—including expanding into the realm of mold making. The AM market itself is growing by leaps and bounds, according to the *Wohlers Report 2011*. Wohlers Associates predicts that by 2016, the sale of AM products and services will reach $3.1 billion worldwide. The industry is expected to hit $5.2 billion by 2020.

AM offers some advantages to subtractive, computer numerically controlled (CNC) and injection molding.

Case in Point

As a service bureau, VistaTek's customers range across a number of industries. It has six 3D printers, five of which are Objet machines. Based in Vadnais Heights, MN, its customers include many medical, consumer electronics and consumer goods firms. It also has a number of hobbyists who create their own designs on Google SketchUp or lower-end CAD systems.

Because VistaTek offers both subtractive and additive manufacturing, it can compare the two processes. Allen Mischek, director of AM for VistaTek, says the tolerancing "isn't there yet for AM."

However, the ability to make lower-volume prototypes is one reason that AM is growing so fast, according to Mischek: "We use additive manufacturing for patterns for room-temperature vulcanization (RTV) or cast urethane.

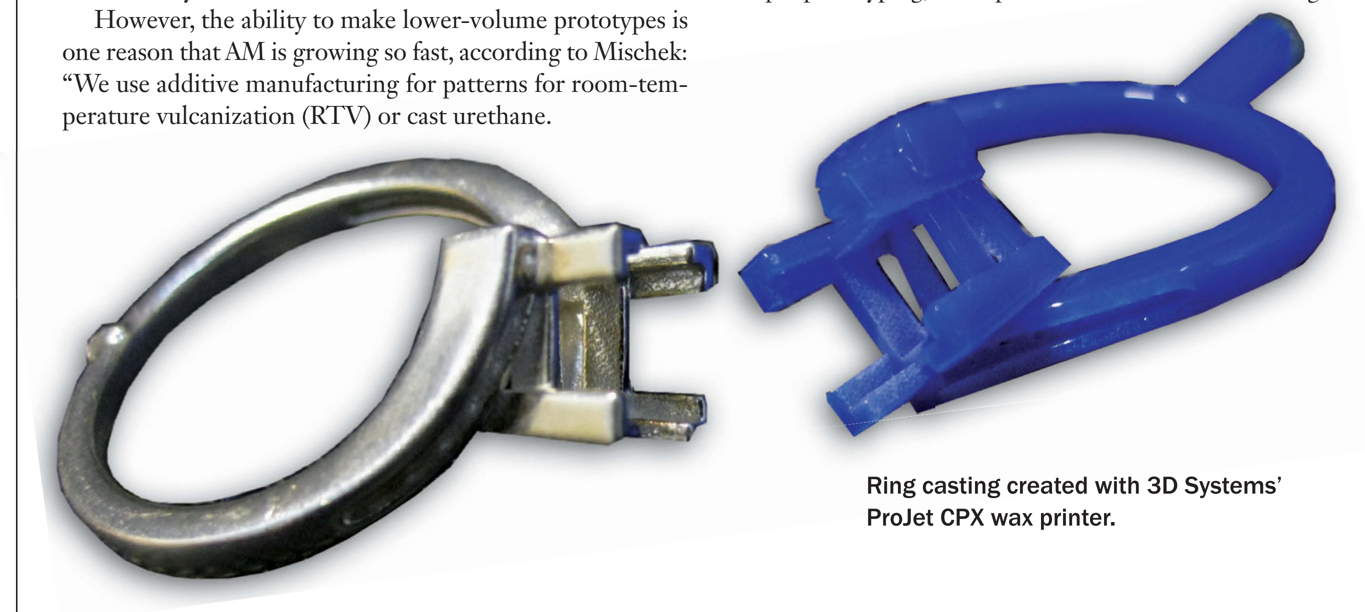
"We actually make molds via CNC injection molding in-house, and we usually use our additive manufacturing for one-off prototypes to get the form working, and then we'll make a mold for our customers," he continues. "But we do use additive manufacturing in production for fixturing. So in production, we use 3D printing or additive manufacturing for post-processing and fixtures."

For VistaTek, AM is used as a preliminary process before going to CNC. Some customers use it to build 100 small parts before needing injection-molded parts that have to be built somewhere else. For this, they may use PolyJet processes or Stratasys Fused Deposition Modeling (FDM).

For 3D printing, VistaTek uses Objet's Kryptogreen, a newer material that is a blend of two materials. It is strong and durable, with good resolution. Objet RG5160 is popular for the soft-touch overmolding abilities. Overmolding is the use of two separate materials for a single cohesive component, a technology for which Objet Geometries is well known.

AM technologies really address complex geometries, Mischek points out.

"If people need parts quick, CNC is not typically done as fast as rapid prototyping," he explains. "You can do overmolding in



Ring casting created with 3D Systems' ProJet CPX wax printer.

Objet where you can't do overmolding in a CNC machine."

With CNC, however, you can use real plastics and metals.

"With 3D printing, you have a wide variety of technologies and different metals and plastics, and powders. We have done studies of direct digital manufacturing vs. additive manufacturing and CNC machining and injection molding, and where it makes sense to use each technology. There's always that break even usage related to material specifics and quantities," says Mischek. "Those are the main factors as to when you'd use rapid prototyping vs. CNC machining or injection molding."

Material Durability

Ido Eylan from Objet Geometries in Israel says the company's ABS-like material that is being printed on Connex platforms allows users to print the same molds and geometries with their previous materials. ABS-like demonstrates a longer life length of the printed tools.

"If I print a certain mold with VeroGray and use it, it will probably last for less shots than the ABS-like material," says Eylan. "That's why we feel this application is going quite well together with ABS-like material."

The two ABS-like materials Objet manufactures are not as good as metal tools, according to Eylan. Metal tools last longer; they can also have better accuracy and edges.

"On the other hand, it takes weeks to produce them—and with us, it's only a matter of hours," says Eylan. "Also, cost is an issue, that depends on where you are. In the Far East, CNC is much cheaper than in Europe and the U.S."

The prototypes printable on Objet printers can be first-run or short-run for the injection molder to test parts. If customers have to test a design over certain parts, they can print a prototype, but if they want a prototype to be actually tested, the functional testing has to go hand-in-hand with the end material.

"In this case, there is no prototyping platform that can actually do this," says Eylan. "What we can do now is print the first tool very quickly and very cheaply, inject the real material and then you get the first rough prototype with the end material. This may require more than one tool, depending on complexity, and tool lifespan."

3D Systems, a company that has acquired a number of companies over the past year in order to offer a broad range of services, helps people get parts printed or developed through a variety of molds and/or patterns—either for multiple prints or even a one-to-one print using some of its technology. 3D Systems currently offers three different categories of devices:

- Personal devices, such as ProJet 1000 for BitsforBytes products.
- Professional products for office environments.
- Industrial professional products.

The latter two categories would use stereolithography (SLA), selective laser sintering (SLS) or Multijet modeling printhead technology (MJM).

Scott Turner, a 3D Systems researcher, says the company started direct metal printing with its technology several years ago.

3D Systems' iProTM 9000 SLA Production Center "prints" QuickCast Patterns that reduce the time and cost of producing turbines used in customized hydro-electric power plants.

"It was a two-step process, using SLS as the baseline and infiltration to get you to a near-metal part, but since then we've moved forward with other technologies—and even at that same time, we were doing molds and patterns," he says. "People can get the outputs they want without having to wait for the miracle of direct metal, which is turning out to be very expensive and time-consuming, and also not necessarily perfect for any parts that are over a certain size."

The quick turnaround, geometry, affordability, automation and lack of waste are key criteria to why people choose an AM process over CNC for making prototypes and molds.

"For a shape that is complex, organic, that has to have fine-featured detail that's super smooth, it really is better served by using something like additive manufacturing," Turner concludes. DE

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INFO → **3D Systems:** 3DSystems.com

→ **Matsuura:** Matsuura.co.jp

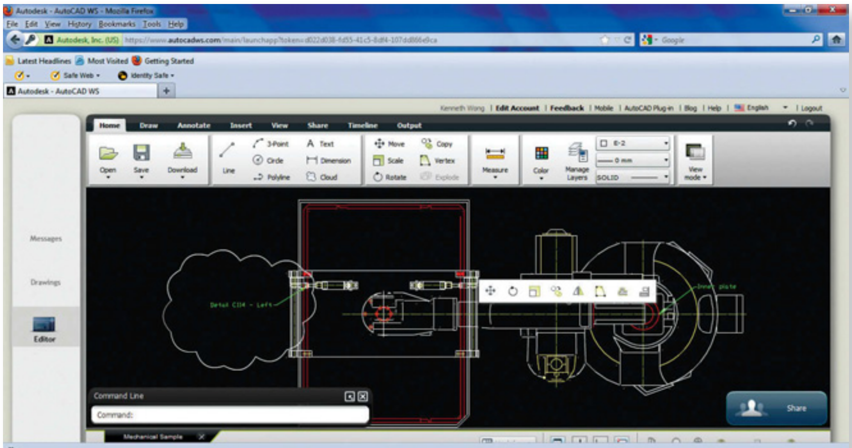
→ **Objet Geometries:** Objet.com

→ **VistaTek:** VistaTek.com

Designs Live On and On

From collaboration and rendering to technical manuals, your design can live on through neutral file formats.

BY KENNETH WONG



AutoCAD WS, available for free from Autodesk, lets you view, edit and annotate DWG files from a browser, effectively eliminating the need to install a professional software title (such as AutoCAD) to interact with the popular 2D format.

Your job as a design engineer may end with the delivery of your 3D CAD files to the manufacturer, but not so for your CAD files. They continue to serve as the basis for photorealistic renderings in a glossy product catalog, illustrations in an instruction booklet, or web-hosted movies showing how to remove the internal components of your assembly. Sometimes, even before you have finalized your design, you may need to share it with others so they can produce certain assets that are ready when the product ships.

Those who are expected to work with your design may have little or no CAD exposure. For effective reuse of your design, you need to provide it to them in an appropriate format, with enough information for them to do what they need to do. Here are a few basic rules to guide you through the neutral-file jungle.

DWG Rules

Many engineers and designers have migrated from their 2D drafting systems to 3D mechanical CAD programs. But for legal contracts and paper archives, 2D is still preferred. The dominant format is DWG, the standard output of Autodesk's AutoCAD. It's also possible to use IntelliCAD Technology Consortium's and Open Design Alliance's technologies to produce DWG files.

The format is widely supported by 3D CAD programs, both for import and export, because CAD users must still deal with design documents saved as 2D drawings over the years.

In the last five years or so, several drafting programs that cost less than AutoCAD have emerged—giving you a way to read, edit and even create from scratch DWG files. The list includes IMSI/Design's DoubleCAD XT (free, with the option to upgrade to a professional version); Dassault Systèmes' DraftSight (free, runs on Windows, Mac, and Linux); and Gräbert's ARES ($795, runs on Windows, Mac, and Linux). SolidWorks offers the free desktop DWG viewer, eDrawings; Autodesk's AutoCAD WS, available for free, gives you the ability to view, edit, and share DWG files from a browser window; and IMSI/Design's TurboViewer, also free, brings viewing functions to mobile devices. Bentley Systems and Autodesk software can read and write each other's formats. Bentley's free Bentley View software, for instance, lets you read not just Bentley's DGN format, but also Autodesk's DWG files.

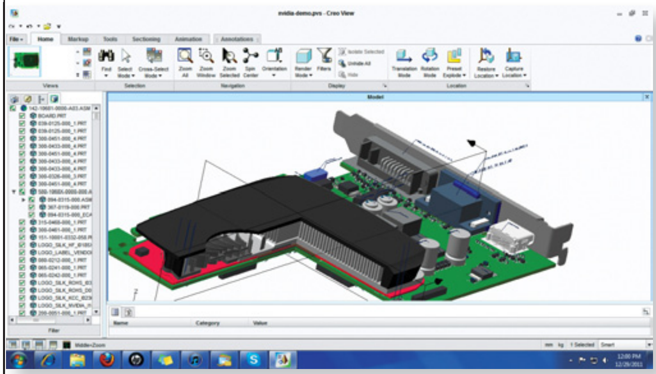
3D Exchange of Competing CAD

Say what you will of the CAD vendors and their fierce rivalry, but you must give them credit for doing a fairly good job at enabling interoperability. Many programs can now, in fact, read parts and assemblies from competing vendors' programs.

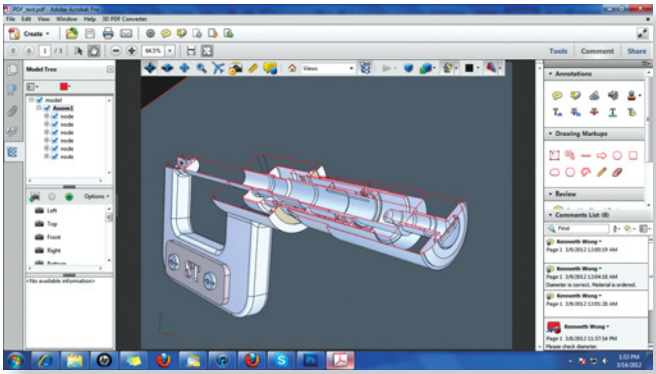
For instance, you may open an Autodesk Inventor file in SolidWorks, and you may also open a SolidWorks file in Inventor. But because of the different geometry kernels they license and employ, and variations in the way they process and translate 3D data, you may need to apply fixes and healing operations to complex surfaces post-import.

Almost universally, major 3D CAD packages support neutral formats, such as IGES, STEP, JT, STL, ACIS and Parasolid. They serve as an intermediary step when sending the original CAD file is not possible (the recipient doesn't have a way to open it) or advisable (you have concerns that your design could be reverse-engineered). They offer the recipient the meat of your design—its geometric shape, mass, volume and a limited understanding of its substructure—but not the recipe to your design, so to speak.

Among these formats, STL has emerged as the standard for 3D printing. With this format, you may send your design to a service bureau or use a 3D printer (from Objet, 3D Systems or Stratasys, for example) to literally turn your digital design into solid shape. Being a collection of meshes, STL is also widely used for simulation and analysis.



PTC Creo MCAD View, an independent app, lets you view PTC Creo CAD formats, neutral 3D formats and native CAD file formats from other vendors.



With the formation of the 3D PDF Consortium, Adobe's 3D PDF is poised to become a popular format for transmitting interactive 3D documents. Shown here is Acrobat X Professional with Tetra 4D's plug-in, allowing you to create 3D PDF documents.

Finite element analysis (FEA) experts who study and analyze 3D digital design files for stress resistance, load capacity, thermal performance and other simulated tests are not necessarily CAD software experts. Furthermore, a CAD file often contains far more information (feature history, manufacturing information, etc.) than FEA experts need. They need, most of all, the basic geometry of the design, preferably with insignificant details stripped out. For these reasons, STL—or another neutral format—is usually requested for analysts.

Initially developed by Siemens Product Lifecycle Management (PLM) Software, JT has been accepted by the International Organization for Standardization (ISO).

"Any company working with 3D digital product data in a heterogeneous environment requiring interoperability between internal departments or with external suppliers and partners can benefit from the use of JT," notes Bruce Feldt, vice president of Open Tools, Siemens PLM Software. "And now that its documentation has become an official ISO publication, JT is reinforced as the benchmark for openness in the PLM domain—paving the way for virtually any manufacturer to adopt JT as their common enterprise format for 3D workflows and long-term data retention."

Rendering for Engineers

Photorealistic rendering or ray-traced rendering is often the domain of film, game, digital content creation and media industries, but the rise of a new crop of rendering programs targeting casual users has made it possible for engineers untrained in high-end rendering and animation software (such as Autodesk 3ds Max, Maya or Alias) to easily churn out renderings from CAD files.

Such CAD-friendly rendering packages—Luxology's modo 601 with CAD loaders, Luxion's KeyShot, Bunkspeed's SHOT, and Dassault Systèmes' 3D VIA Composer, to name but a few—can accept and work with native CAD formats, such as Autodesk Inventor, SolidWorks and Solid Edge files. However, users may find that, because of size and complexity, working with native CAD files may make the software less responsive.

By contrast, loading the design as a neutral file format (IGES, STEP) may make the software far more responsive. Because of the nature of rendering operations, formats that display the design as polygons, meshes and surfaces work best. Leading rendering packages support COLLADA, FBX, OBJ and other formats better suited for rendering.

Though not a professional design tool, Google SketchUp's file format has also found a place in many rendering program's import menu. The abundance of free 3D models available in the SketchUp format at the Google 3D Warehouse makes the file type attractive to beginners, casual users and those in the do-it-yourself maker community.

Tech Pub, Markup and Mobile

Using a lightweight 3D file format for collaboration—usually the domain of viewing and markup applications—is a long-established market, but CAD software developers' attempt to conquer the technical publication market, along with the rise of mobile devices, adds new twists to the old usage.

By and large, general 3D design file viewers (like Oracle AutoVue, PTC Creo View MCAD, Dassault Systèmes' 3D VIA Composer Player, and Lattice Technology's XVL Player) support neutral formats commonly exported from CAD programs and some native CAD formats. Recently, common preference seems to have shifted from desktop and laptop machines to mobile devices in performing collaborative tasks (annotating design proposals and approving design changes, for example) and data-management operations (verifying project status, recording change history, and managing read-write privileges). The wide range of mobile apps that have recently sprung up indicates the move to lighter, portable, touch-enabled devices. It's the Wild West of expansion in downstream 3D data use.

Most major CAD vendors, including Siemens PLM Software and Dassault Systèmes, provide mobile apps that can open and view file formats associated with their primary 3D platforms. Siemens PLM Software's Teamcenter Mobility, for instance, opens and reads JT, the preferred lightweight format exportable from the company's Solid Edge and NX CAD programs. Similarly, Dassault Systèmes' 3DVIA Mobile and 3DVIA Mobile HD lets you access and view 3D files that are uploaded and stored in a secure cloud on 3DVIA.com. Supported formats include SolidWorks, CATIA, 3DVIA Shape, 3DXML, 3DVIA Composer and a host of other 3D formats. PTC's newly released Windchill Mobile lets you view and interrogate Creo View MCAD models, a lightweight format used by the company's Creo product line.

Third-party tools, like CadFaster's QuickStep, by contrast, gives you a way to view more neutral formats (IGES, STEP, DWG, DXF and HSF). Another alternative is Titansan Engineering's VueCAD app for iPad. It supports a number of neutral files, including IGES, STL, JT, 3ds Max and Collada. With an upgrade, the app lets you view some native formats, including SolidWorks, Solid Edge, CATIA, Pro/ENGINEER, and Autodesk Inventor.

For mobile apps addressing enterprise data management (EDM) and PLM, geometry alone may not be sufficient. The neutral format must also be able to retain and display tolerances, material specifications, supplier information, part numbers and other relevant metadata. For such applications, 3D XML, JT, and other metadata-rich formats are more suitable than strict geometric formats like IGES, STEP or STL.

With the formation of the 3D PDF Consortium, 3D PDF is also poised to become a commonly used format to deliver and communicate design changes, technical instructions and design review notes. As a format, PDF is already widely accepted, thanks to the free PDF viewer's dominance outside engineering.

A plug-in from Tetra 4D enables Adobe Acrobat Professional users to produce 3D PDF documents with embedded annotations, animations and cross-sections, viewable by anyone with a free PDF viewer. SHARE3D, a solution from QuadriSpace, lets you create 3D PDF documents using a template-driven approach.

Courting those who may want to repurpose 3D CAD data for technical manuals, many CAD software makers are releasing their own easy-to-use technical manual publishing software titles. The lineup includes Autodesk Inventor Publisher, Dassault Systèmes' 3D VIA Composer and PTC's Creo Illustrate. With an eye toward the same market, third-party software maker Lattice Technology also offers XVL Studio. Nearly all these programs offer an option to export the results as PDF. Because technical instructions are better delivered as animation files, these programs also offer ways to export common movie file formats.

The differences among these CAD-based tech publishing software titles may be twofold:

1. the comprehensiveness of neutral and native file formats supported; and

2. the learning curve involved in mastering the tools for producing interactive documents.

Lightweight Benefits

3D CAD files with detailed feature histories are the lifeblood of manufacturing, but they also prove too unwieldy for collaborators and subcontractors who need only a fraction of the information (usually just its basic geometry, surfaces or meshes). The primary advantage of using a neutral format is its compactness, portability (via mobile apps), and metadata-housing capacity (its ability to retain and display material info, part numbers and other attributes).

But the formats themselves, like any computer file format, are just a series of binary codes. They're useless if they do not enjoy the support of a wide range of independent viewers and mobile apps. **DE**

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For links to all the companies mentioned in this article, see the online version of the article on deskeng.com.

Print & Scan via the Cloud

Manufacturers respond to an increasingly mobile engineering workforce.

BY JAMIE J. GOOCH

The "paperless office" has gone from a seemingly reasonable prediction popularized in a 1975 *Business Week* article, to a myth as paper consumption doubled between 1980 and 2000, to a somewhat plausible scenario while U.S. office paper declined 40% from its peak in 2000.

But engineering schematics are still easier to read on 44-in.-wide sheets of paper than 10-in. tablet screens. Large-format printer and scanner manufacturers haven't sat on the sidelines as design engineers have become increasingly mobile though.

HP Shares

"We've seen people becoming more mobile and the wanting the ability to access content remotely, but there wasn't really a clean way to handle secure access, revision control, and printing," says Todd Hatfield, HP's Designjet large format category manager for the Americas.

HP needed ways to make printers and scanners available in an always-connected world. The company's answer was to web-enable its printers via a set of features it dubs ePrint & Share, which allows engineers to directly scan project files to the cloud, print and access plans from the road, share designs with remote project teams and collaborate with design partners around the world.

In addition to printing to registered printers via the ePrint & Share desktop or iOS apps, Eric DuPaul, Designjet business development manager for HP, says users of AutoCAD 2009 and later can print via a plug-in that allows them to create a PDF while printing a file, including all the print settings, and save it in the cloud. Users can also access the ePrint & Share application from the front panel of certain printers, including the HP Designjet T790 and T1300, and the HP Designjet T2300 eMultifunction printer.

HP's recent announcement of its plans to merge its printer and PC/workstation business could lead to further integration of web technologies into its printers, but it's not the only manufacturer looking for expansion via the cloud.

Océ Launches New Large-Format Systems

Océ recently announced three new large-format printing systems. The Océ PlotWave 350 monochrome printer, the Océ ColorWave 650 printing system that can print in color or black and white, and the Océ PlotWave 900 monochrome printing system, which is designed for high-volume production printing.

Océ says the WebTools-enabled **PlotWave 350** can print up to six D-size plots in one minute, with virtually no warm-up time. It uses the company's new 2.0 print driver for Microsoft Windows, which includes a "What You See is What You Print" preview. It is designed to print, copy and scan low volumes of technical documents.

The **Océ ColorWave 650** printing system uses the company's CrystalPoint solid toner technology to print in black and white and color at up to 210 D-size prints per hour. The system can hold up to six media rolls and prints come out dry, cut to size and ready to use. It also features copy and scan templates that can be customized to simplify routine tasks.

The **Océ PlotWave 900** printing system is designed for high production users. It prints up to 10 E-size prints per minute, even when printing mixed sets, according to the company. Users can print on different sizes of media from six media rolls, at consistent speeds, with automatic switching for uninterrupted printing. It delivers 600 dpi print quality.

Océ PlotWave 350 printer

Océ PlotWave 900 printing system

Océ ColorWave 650 printing system

Océ Goes Mobile

Océ, which joined the Canon Group of companies in 2010, has introduced two cloud products: Océ Mobile Tools and Océ Mobile Plot.

With Océ Mobile WebTools software, users who have access to a Wi-Fi router on their network can retrieve technical files from the cloud using their mobile device and send a print request to their Océ PlotWave 350 printing system. Users can also print from, and scan documents to, a USB flash drive or to their mobile devices using Océ Mobile WebTools software to capture changes and documents on the go, or print via Océ Publisher Select software to produce documents for complex projects.

"That's accessing the device via a browser from any mobile device," says Andrew Vecci, director of Marketing at Océ North America, Inc. "Users are able to submit prints to the printer and pull scans from it to view on their devices."

Océ Mobile Plot is an iPad app that, after a one-time setup, allows users to print files they can access on their iPads via email or other apps, including cloud-based apps such as Dropbox, and print to up to five Océ TDS, TCS, PlotWave and ColorWave plotters, old or new.

"As long as you can access the file on your iPad, you can send it to the printer," says Vecci.

He notes that, while mobile printing and scanning is still in its infancy in the technical document market, many of Océ's customers are interested in adding cloud services to their workflow. Large enterprises often have their own cloud networks, allowing engineers to access their files from multiple office locations, for instance. But smaller firms often don't have that luxury. That's where cloud printing services can really shine.

Both Océ's Vecci and HP's managers say they are still discovering how engineers want to make use of being able to print and scan via the cloud.

"We want to present more options," says Vecci. "As we see more customers moving from print shops to internal, decentralized printing environments, we're trying to develop tools to accommodate any workflow out there."

"As more and more people use the cloud, they're finding it's able to accelerate turnaround time for changes," says HP's DuPaul. "It helps facilitate a faster workflow. The use of tablets and smart phones is going to drive demand for print mobility much more significantly in the future." DE

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INFO → HP: hp.com

→ **Océ:** oce.com

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

HP's Large-Format Offerings

HP's portfolio of web-connected, large-format Designjet ePrinters includes the HP Designjet T1300 for large work groups, the HP Designjet T790 for small, mobile technical design teams, and the HP Designjet T2300 eMFP that has print, scan and copy functionality.

The **HP Designjet T790** is designed to enable small teams to produce computer-aided design drawings while collaborating with colleagues in a connected work environment. It is available in 24- and 44-in. models, which feature a top-loading roll and 8GB of memory.

The **HP Designjet T1300** has two media rolls and smart switching technology, as well as the ability to print up to two A1-sized prints per minute. It can print on paper up to 44-in. in size.

The **HP Designjet T2300 eMFP** was designed for medium and large architecture, engineering and construction firms and enterprise businesses. It has two online media rolls and simultaneous copy and scan functions, a color touchscreen interface, and driverless printing for direct printing from a notebook PC or USB drive.

HP Designjet T790

HP Designjet T1300

HP Designjet T2300 eMultifuntion printer series

Part 1

Opting for Optimization

Find out how this powerful concept can rev up your analysis tools.

BY PAMELA J. WATERMAN

Good. Better. Best. You often see these terms on product families ranging from carpeting to computers. The choices span options including price, performance, durability and visual appeal. But in many ways, this phraseology also captures the vision of a typical engineering design sequence—except that the process generally stops at "better."

Product R&D schedules leave little time for finding the design that goes beyond "better" to "best." Robert Ryan, president and CEO at Red Cedar Technology (developers of HEEDS MDO optimization software), says that typically, "with CAE models, once you prove they're pretty good, you tweak the design within the design space near what you've already done, and do a little better. Rarely have designers gone for dramatic improvement."

To do so requires a methodical optimization process that searches among alternative designs, but a manual approach is time consuming and even an automated design-of-experiment (DOE) approach may miss an opportunity in the big picture.

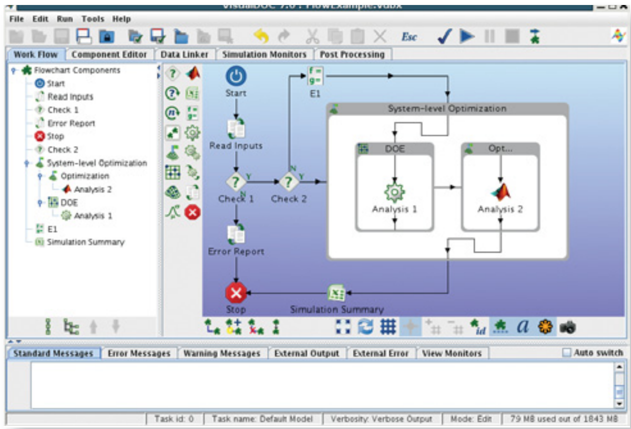
Garret Vanderplaats, founder and CEO of Vanderplaats Research & Development (VR&D), an optimization software company, says that DOE tends to focus on individual parameters—yet valid design explorations require a systematic search process that emphasizes promising regions in the design space.

Designers often strive to tweak a design to give the best performance for a few critical conditions, ignoring the issues of real-world manufacturing variation (such as geometric variation) and operational variation (such as temperature variation).

"Today, the challenge is not so much finding the global optimum, but the robust global optimum," notes Alex Van der Velden, director of Design Automation Products at SIMULIA. "Many optimization methods push the design against the failure limits, so even small operational variations would lead to failure. If a product design is based on a robust global optimum, such a product is insensitive to variations. This is the definition of product quality."

Optimizing, say, just for structure gives different answers than optimizing a part for cost. Tackling this multi-faceted problem demands software for multidisciplinary optimization (MDO), whose beauty comes from the ability to automatically evaluate hundreds—or thousands—of design combinations.

Many finite element analysis (FEA) and computational fluid dynamics (CFD) analysis packages offer some type of optimization tool, such as in MSC.Software's MSC Nastran; the Design Study Environment in Autodesk Simulation CFD (formerly known as CFdesign); and the NISAOPT module for NISA Mechanical design/analysis software. However, the past several decades have also witnessed the development of generalized, standalone optimization packages.



Workflow example for VisualDOC multidisciplinary optimization software, showing graphical user interface to set up, execute and automate a design optimization process. ***Image courtesy of Vanderplaats Research & Development.***

These tools apply optimization to the design parameters and functional results of pretty much any analysis software—whether structural, fluid dynamics, chemical or financial—as well as to any task, from minimizing weight to maximizing cooling, to predicting the probability of part failure. Much of the power of these standalone solutions lies in their ability to link together multiple analysis tools for a single product design, and optimize the product across broad performance characteristics.

Power Players

Part of the reason optimization is not done more often is that few people teach it in the first place. Even so, according to Vanderplaats, it tends to be taught as applied math, not engineering design, and then only at the graduate level.

Vanderplaats certainly knows his field: In the early 1970s, he developed an optimization code, CONMIN, that is still widely used. In the late 1980s, his company developed the optimization capability for MSC Nastran. And in the early 1990s, VR&D wrote its own GENESIS software that was "a little FEA and lots of optimization," but today is quite a bit of both. Along the way, he created a general-purpose, multidisciplinary optimization product, COPES, which is now a VR&D package called VisualDOC.

VisualDOC's capabilities include optimization, DOE, response surface approximations and probabilistic (robust and reliability-based) optimization. It can be used to add these capabilities to almost any analysis program. Its optimizers are also used by GENESIS, and can handle more than 2 million variables. GENESIS includes second-generation, physics-based approximations that are more accurate than gradient linearization—and generate an optimum structural design for the cost of about 20 FEAs.

SIMULIA, the Dassault Systèmes brand for realistic simulation products, markets both Abaqus nonlinear analysis software and Isight design optimization and process automation software. Since its acquisition in 2008 from Engineous, Isight has been continually enhanced (now at version 5.6), and offers direct interfaces that support more than 30 FEA and CFD applications, along with Excel and ASCII files. Much of the user interface is visual drag-and-drop, and results can be viewed in real time.

Van der Velden says that Isight gets designers out of their "thought-ruts. It doesn't 'know' you're designing an airfoil or a beam," he says. "It just takes the inputs it's given, and drives a solution toward the objectives of the design challenge. Because an optimization algorithm has no preconceptions about results, it may very well give you answers—like an unexpected shape or thickness—that are completely different from what you envision. And they just may be better answers."

Van der Velden recommends using Isight to automate DOE

Safety-design optimization of roof crush and side impact for an automotive passenger compartment, performed with HEEDS MDO software. This problem had 120 design variables and constraints on intrusion during side impact, minimum roof crush force, natural frequencies and bending/torsional stiffness. The HEEDS optimized design met all constraints—while reducing the mass of the safety cage by 23%. *Image courtesy of Red Cedar Technology.*

first because it's a simple way to get a handle on understanding what's important in the problem. To find the best dimensions for a part, for instance, Isight can combine and extrapolate results from 50 Abaqus runs to create a curve between the points, filling in expected response values for additional input values. Users can employ graphic "sliders" to see, in real time, the effects of changing up to eight dimensions at once. Isight will then perform a Six Sigma optimization to predict the probability of meeting a certain value (stress, for example), given variations in another factor (material thickness, for example).

Red Cedar Technology's HEEDS MDO software also performs process automation, design optimization, DOE and robustness/reliability calculations. Ryan notes that optimization tools have traditionally asked users to choose one of a dozen optimization algorithms, plus dozens of tuning parameters—tasks that generally required a doctorate to successfully complete.

HEEDS MDO eliminates this complexity by providing a default search method called SHERPA. This hybrid process uses multiple search strategies simultaneously, and dynamically adapts to the problem as it learns about the design space. Users define the objective of the study, then just specify the parameters to be varied, the fixed constraints and the number of desired iterations. HEEDS does the rest.

Because automation can have its dark side, Red Cedar Technology has made sure that its optimization process is not a "black box." Users are encouraged to view a run's progress and results, and change the direction in real time if the engineer's intuition prompts a move in a different direction as results unfold. The software offers direct input/output portals for Abaqus, Adams, ANSYS Workbench, Nastran, LS-DYNA, Moldflow, SolidWorks, Excel and NX (input only). Generic interface links also connect to any ASCII format file.

Collier Research HyperSizer software applies optimization techniques to metal and composite structures for weight, strength and durability, with strong support for certification procedures. The software targets designs for aerospace, wind blades, commercial and military aircraft, high-speed rail and ship-building, and creates what company president Craig Collier calls "a level playing field for all the possible design candidates."

HyperSizer Pro imports FE models as well as FEA-computed loads. Using non-FEA failure methods, the software analyzes and quantifies safety factors, and eliminates negative margins of safety for thousands of mechanical and thermal load sets. It then optimizes to determine the lightest weight combination of material systems, cross-sectional dimensions, and ply layups for all panels and beams in the structure, and automatically iterates with FEA for load convergence.

"What industry wants," says Collier, "is not necessarily to let (the optimizer) run overnight, and come back in the morning. The software needs to expose what's going on and be interactive."

He says a critical aspect for today's large designs is that teams work independently, but must be able to bring all the subsystem designs together and have them be manageable for evaluating throughout the design process.

Next month, in part two of *DE's* design optimization coverage, we'll explore other contributors to this field, including Sigma Technology, ESTECO Phoenix Integration, Optimal Solutions Software and Openeering. **DE**

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

Design Optimization 101

Designers can apply optimization techniques to a single discipline (structures or aerodynamics, for example) or a multidisciplinary problem (structures plus aerodynamics plus propulsion plus control-theory plus economics, for example). A good introduction to the subject can be found in a presentation by Il Yong Kim of the Department of Mechanical and Materials Engineering, Queen's University, Ontario, Canada, at qcse.queensu.ca/conferences/documents/IlYongKim.pdf.

The process requires formulating the problem, then choosing and implementing a computational solution. Here are some of the general components involved:

Simulation process flow: User-defined workflow of simulations and analyses to be performed, including task order, software tool selection and data transfer.

Models: Each analysis in the process flow requires a specific analytical or empirical model and representation. These models connect inputs, such as design variables and parameters, with output variables representing some measure of system performance.

Random variables: Parameters that are subject to variations due to chance, including manufacturing variation, material variation and operational variations such as the ambient temperature of an electrical circuit or the wind loads on a vehicle.

Design variables: Specifications the designer can control, including physical dimensions, material choice, and parameters such as the number of blades in a turbine.

Design objectives: User-defined performance characteristics to be maximized or minimized, such as fuel efficiency or mass.

Constraints: Typically, these are performance characteristic levels that need not be maximized or minimized, but must be kept above or below a certain level.

Solutions: Optimization algorithms combine the design variables, constraints, objectives and models to find possible sets of values that satisfy the defined problem. The software automatically feeds these values back to the appropriate analysis software packages for a new round of evaluation. Users choose the number of iterations to try, and specify what conditions define convergence.

The different optimization solutions fall into several categories (listed with a sample type): gradient-based (feasible directions), gradient-free (Hooke-Jeeves pattern search), population-based (genetic) and various others (simulated annealing and indirect optimization based on self-organization, or IOSO). Some work better than others on certain applications, and different packages may use different subsets. Improvements in HPC resources have definitely helped speed up calculations—and opened the door to parallelized functions. — PJW

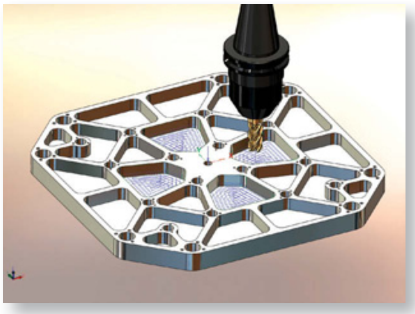
SPOTLIGHT

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

Editor's Picks

by Anthony J. Lockwood

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



Geometric Launches CAMWorksXpress

New 2.5D CAM solution runs inside SolidWorks; designed to be easy to use.

CAMWorksXpress is the smaller sibling to CAMWorks, Geometric's full-featured CAM system. Smaller, however, does not mean weakling. It means right-sized for many, many shops. Like its big brother, CAMWorksXpress works inside of SolidWorks and has things like a CNC tool database, simulation step-throughs, and functions for operations like roughing, contour and face milling, holes, and what have you. It has interactive feature recognition, and it automatically recognizes holes. Changes made to a SolidWorks design propagate to the toolpaths automatically. As of this writing, it's priced at $595.

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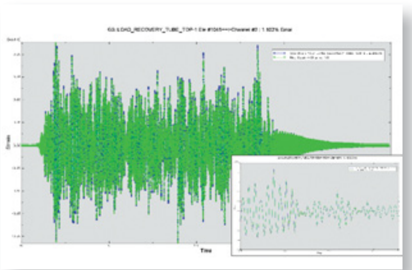

Correlate FEA and Strain Data for Load Measurements

Software predicts fatigue life and manages components subject to loads.

If your job requires predicting fatigue life and managing components in applications where your components undergo environmental loading — say, chassis, bridges, suspensions, landing gears, piping, or parts used in wind power generation — then this pick should interest you. It could mean getting a load of time back.

Safe Technology recently released an extension toolset for fe-safe, its flagship system for the fatigue analysis of finite element (FE) models. The new product, fe-safe/True-Load, helps you predict and manage the fatigue life of structures with complex loadings over an entire loading event.

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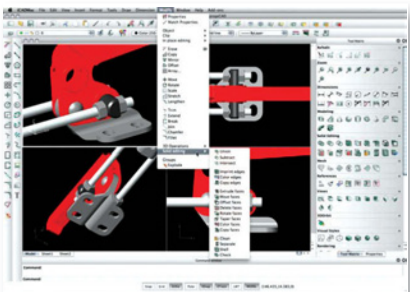

Tools for Fatigue Analysis Enhanced

HBM's nCode DesignLife 8 offers new fatigue analysis technologies.

Version 8 of HBM's nCode DesignLife toolbox of fatigue analysis applications has been upgraded with all sorts of new and expanded analysis methodologies deserving your attention. One toolset in particular caught my eye: You can analyze the durability of adhesive bonds in lightweight vehicle structures.

Adhesive bonding joins steels, aluminum alloys, and even different materials, and it affords good durability against fatigue even when compared to traditional methods such as spot welding and seam welding. Of course, nCode DesignLife has robust toolsets for spot welding and seam welding as well.

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System Supports Mobile Printing Via WiFi

New Océ PlotWave 350 said to incorporate 50 enhancements.

The Océ PlotWave 350 builds off its predecessor, the Océ PlotWave 300, and starts with a print speed that's 50% faster. To be precise, 6 D-sized pages a minute. But what makes the speed even faster is that it has instant-on technology, which, according to the literature, means less than 1 second warm-up time and, depending upon the mode, 31 to 40 seconds until first print (A1 / D-size paper). Now that's all good stuff, but that's not why you should consider looking into this printer.

See, the real wait you get rid of with the Océ PlotWave 350 is the "you'll have to wait until I get back to my desk" wait because it supports printing via the web.

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Running by the Numbers

Lotus F1 Team designers rely on Elysium CADdoctor for data transfer, software interoperability, reverse engineering and, of course, speed.

Did you know that Formula One (F1) racing can garner speeds of up to 220 miles an hour on the straightaway, and G forces can top five in the most extreme corners? It's easy to see why this sport pushes both car and driver to the edge of what's mechanically and humanly possible.

A cross between driving and flying, F1—with its maze-like circuits—requires constant acceleration, braking and cornering that put tremendous stresses on the vehicle and demands on the car's "pilot." Drivers are literally form-fitted to their seats, wearing the car like a second skin. Reflexes need to be on instinct. Vehicles must be precision-tuned. Speed is king. As a result, there is no room for error with even the smallest detail.

At a minimum weight of 1,410 lbs. (less than one-third the average passenger car in the U.S.), today's F1 racing machine—including nose, cockpit, wings and diffuser—embodies the almost-perfect aerodynamic balance of maximum down force (to keep the car in contact with the road) and minimum drag (to make sure it goes fast). New car design for the Lotus F1 Team starts with a concept.

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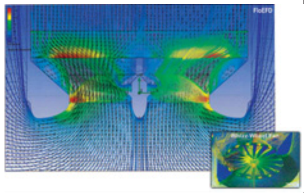
Energy Efficiency



CFD guides breakthroughs in powerful cooling fan systems.

BY GUUS BERTELS

Extracting energy—either petroleum or natural gas—is a complex process that itself consumes voluminous amounts of energy. Much of this goes toward fuelling on-site generators that power the cooling systems needed to chill the gas or oil as it emerges from the well heads.

Inside a gas- or oil-field cooling system, fans up to 33 ft. in diameter move air across cooling coils ("bundles") that carry the product. Dozens, or even hundreds of fan systems may be required, along with megawatts of electrical power to run them. Often, noise issues are as important as cost challenges. These large industrial plants are subject to stringent noise regulations.

The fans used in such applications historically have delivered a maximum efficiency of about 50%. What would happen if that efficiency could be increased to 80% or more? What would be the effect on noise output if the fans could run at a lower rpm, and still do the job? Fewer fans could do the same work with less energy, less noise and lower operational costs.

The design engineering team at Bronswerk Heat Transfer BV (Nijkerk, The Netherlands) set out to create a new air-cooled cooling system that would solve the age-old problems.

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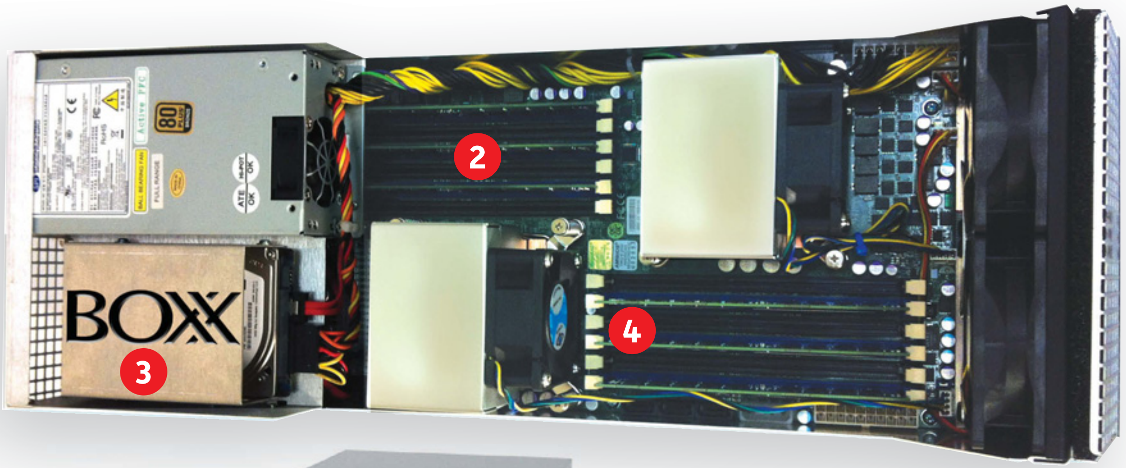
BOXX Technologies' renderPRO



Pint-Sized Power

1 BOXX Technologies' renderPRO is a render farm that sits on your desk, or even atop your workstation tower. It measures 6.75 in. wide x 3.8 in. high x 20 in. deep. It can be used to boost the rendering of intensive 3D graphics, animation, visualizations and simulations.

Customizable Specs

2 The renderPRO can be equipped with an Intel Xeon 5600 Series processor that has up to 12 cores. It's also expandable with up to 192GB of RAM.

Driving Up Speeds

3 The renderPRO is available with up to two SATA 2.5-in. drives, or optional solid state drives (SSDs) for even faster performance. It can be equipped with 160-750GB 7200 RPM drives or 80-600GB SSDs.

Data Transfer

4 With two USB 2.0 ports and two Intel Gigabit Ethernet ports, the renderPRO can transfer data to and from workstations quickly. It also includes a VGA port, a COM port and an RJ45 IPMI.

→ **DO YOU HAVE A COOL TOOL?** *Desktop Engineering* editors are always on the hunt for great tools to share with our readers. Send us your ideas at de-editors@deskeng.com.

TECH SPECS

- Processors: Intel Xeon 5600 Series Processor; Intel 5500 Chipset with QPI up to 6.4GT/S and the ICH10R.
- Memory: 12 DIMM Slots, supporting up to 192GB of 1333/1066/800MHz ECC Registered DDR3 in 1GB, 2GB, 4GB, 8GB and 16GB DIMM Sizes
- Bays: Two Internal 2.5-in. drive bays.
- Hard Drives: Up to two SATA 2.5-in. 160GB to 750GB 7200 RPM drives; 80GB to 600GB for SSD (solid state drives)
- Expansion Slots: One low Profile PCI Express Gen 2 x16
- System Management: One Intelligent Platform Management Interface (IPMI) Version 2.0 with KVM Over IP
- Power Supply: 300 Watts
- Removable Storage: External USB Floppy Drive or Dual Layer DVD+/-RW+DL Burner Drive (Optional)
- Graphics: Integrated Matrox G200eW Graphics
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