DE

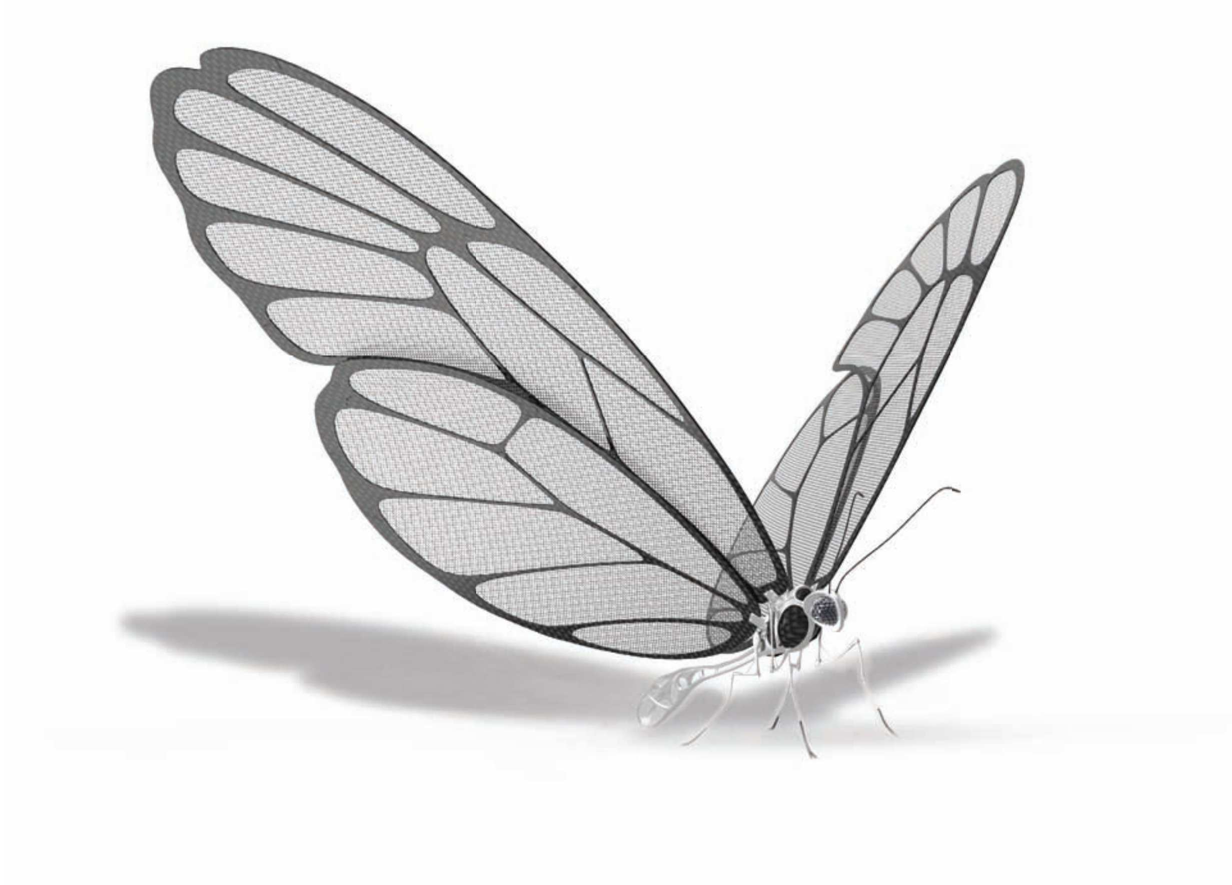
Desktop Engineering®

TECHNOLOGY FOR DESIGN ENGINEERING

August 2013 / deskeng.com

COMPOSITE COMPLEXITY

Software helps engineers peel away the layers of composite complications to produce accurate simulations. P. 22



by Jamie J. Gooch

Simplification vs. Certification

I started computing in the age of DOS, which (for any of you not old enough to remember and for those old enough to forget) required you to type in a command whenever you wanted the operating system to perform its duties. I had the most common commands memorized. Say I wanted to copy a file from my cutting-edge 10MB hard drive to my 5.25" floppy disk, I would type "copy c:filename.ext a:" at the command prompt.

With the right commands, I could make that big, ugly beige box do some pretty amazing things. Not everyone could do those things when faced with only a monochrome C> prompt and a blinking cursor. It was specialized knowledge.

Then the graphical user interface and mouse took over, and all my DOS knowledge didn't seem so special. Now everyone can copy a file with a drag and drop. But that's how initially complicated technologies proliferate quickly: they get easier to use.

How can we tell who the real simulation experts are?

Expertise Still Needed

As we show in our two-part series on simulation software for small- and medium-sized businesses that continues in this issue, software vendors would like to make their software as ubiquitous as the personal computer has become. It's hard to argue that they shouldn't, given all the benefits of simulation-led design. To do so, they need to make the software so easy to use that it doesn't require such a high level of specialized expertise. That's where the danger comes in.

If a design engineer runs a simulation by clicking a few icons, but doesn't understand what's happening behind the scenes, it could be disastrous on many different levels. Does simplifying simulation mean dumbing down the simulation so much that it's not useful, or does it mean making complicated simulations easy to perform and understand? That's the kernel of the debate being moderated by *DE's* Senior Editor Kenneth Wong on our Virtual Desktop blog, where he hosted a panel to discuss the pros and cons of simplified simulation. You can read about and listen to a podcast of the discussion, and add to it with your own comments, here: deskeng.com/virtual_desktop/?p=7293.

As Bernt Isaksen of dyNOVA Engineering Simulation noted in his comments on the debate, "When the solution approaches final design, the simplified simulations will not be sufficient anymore, and a more detailed and thorough simulation is needed. This should be handled by the simulation expert with a tool that can include all the important details."

But that begs the question: If and when all design engineers are capable of running simulations, how can we tell who the real simulation experts are?

NAFEMS, an association dedicated to the application of simulation, has an answer for that question. As we reported (deskeng.com/articles/aabkjs.htm), the association introduced the Professional Simulation Engineer (PSE) designation at NAFEMS World Congress 2013 in June.

Getting Certified

The PSE program consists of two parts: the PSE Competency Tracker and PSE Certification. The Competency Tracker is an online tool that lists competencies and educational resources, and provides a means for engineers and/or their employers to track their achievements. PSE Certification is designed to accommodate both simulation experts and newcomers, according to the association. Engineers who are already in the field need to apply and prove their competencies via their academic background and prior work, while newcomers follow a path to certification that includes Entry, Standard and Advanced levels.

For experienced simulation users who apply to be certified, two independent PSE Certification Assessors — people deemed to be experts in simulation analysis — will schedule an interview with the applicants. After the interview, in which evidence supporting the applicant's experience is discussed, the assessors can recommend certification, defer the submission with guidance, not recommend certification, or request more information.

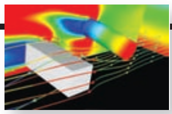
Entry-level PSEs are required to find and work with a mentor, who will monitor their workplace experience and competency levels, which the applicant has to track in a logbook. Once the entry-level applicant is ready to be certified, the mentor must approve the logbook, which is turned over to a NAFEMS assessment panel along with an assessment fee.

From the information available at nafems.org/pse, it certainly doesn't seem like certification will be a "rubber stamp" process. That's a good thing, as a certification is only meaningful if it is a true measure of an applicant's ability and knowledge. However, a process that is too burdensome could dissuade some prospective applicants from seeking certification. Time will tell whether the balance is right. If it is, the PSE Certification program could boost best practices in engineering analysis while providing engineers with a means to separate themselves from people who can run simulations, but aren't simulation experts.

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

DE August 2013 VOLUME 18/ISSUE 12

Design Software for Composites

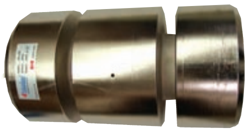


SIMULATE

PROTOTYPE

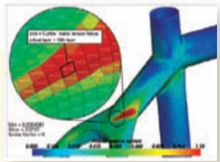
ON THE COVER: Composite technology races ahead. *Dodge Viper image courtesy of Plasan Carbon Composites, modified background image of composite jet engine blade courtesy of Siemens PLM Software.*

ENGINEERING COMPUTING



TEST

DESIGN

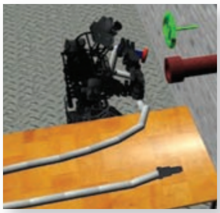


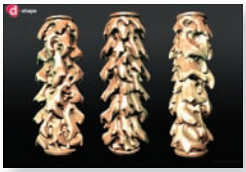
FOCUS ON COMPOSITES

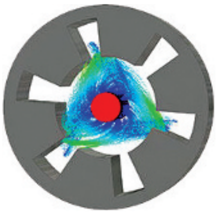
August 2013

VOLUME 18/ISSUE 12

DEPARTMENTS







deskeng.com

RAPID READY TECH BLOG
Read all about making digital designs physical @ rapidreadytech.com.

ENGINEERING ON THE EDGE BLOG
See the future of engineering technology @ engineeringontheedge.com.

MOBILE ENGINEER
Incorporate mobile technologies into your workflow.
@ mobileengineer.com.

VIRTUAL DESKTOP BLOG
Read Kenneth Wong @ deskeng.com/virtual_desktop for a closer look at lifecycle components via articles, podcasts and video reports.

NEWSLETTER REGISTRATION
Newslink; Editor's Pick of the Week; Check It Out; Virtual Desktop; Focus on Analysis and Simulation; Focus on Engineering IT & Computing; Focus on MCAD; and Focus on Rapid Technologies.

DE MOBILE BETA
Check out our mobile app for Android and iOS by visiting wbxapp.com/de-mobile on your mobile device, or scan the QR code to the right.

***DE* ON TWITTER**
Follow us @ DEeditor

LIKE *DE* ON FACEBOOK
Visit *DE* @ deskeng.com/facebook

DE Desktop Engineering®

EDITORIAL
Jamie J. Gooch | Managing Editor
Kenneth Wong | Senior Editor
Anthony J. Lockwood | Editor at Large
Heather Pittinger | Copy Editor

CONTRIBUTING EDITORS
Tony Abbey, Brian Albright, Mark Clarkson, David S. Cohn, Randy Frank, John Newman, Frank Ohlhorst, Beth Stackpole, Peter Varhol, Pamela J. Waterman

PUBLISHER
Steve Robbins | Publisher

ADVERTISING SALES
603-563-1631 • Fax 603-563-8192

Erich Herbert | Sales Executive (x263)
Jeanne DuVal | Sales Executive (x274)

ART & PRODUCTION
Darlene Sweeney | Director (x257)

A LEVEL 5 COMMUNICATIONS PUBLICATION
Steve Robbins | Chief Executive Officer
Thomas Conlon | President

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
E-mail: DE-Editors@deskeng.com
www.deskeng.com

SUBSCRIBER CUSTOMER SERVICE
***Desktop Engineering*® magazine**
PO Box 677 • Northbrook, IL 60065-0677
847-559-7581 • Fax 847-564-9453
E-mail: den@omeda.com

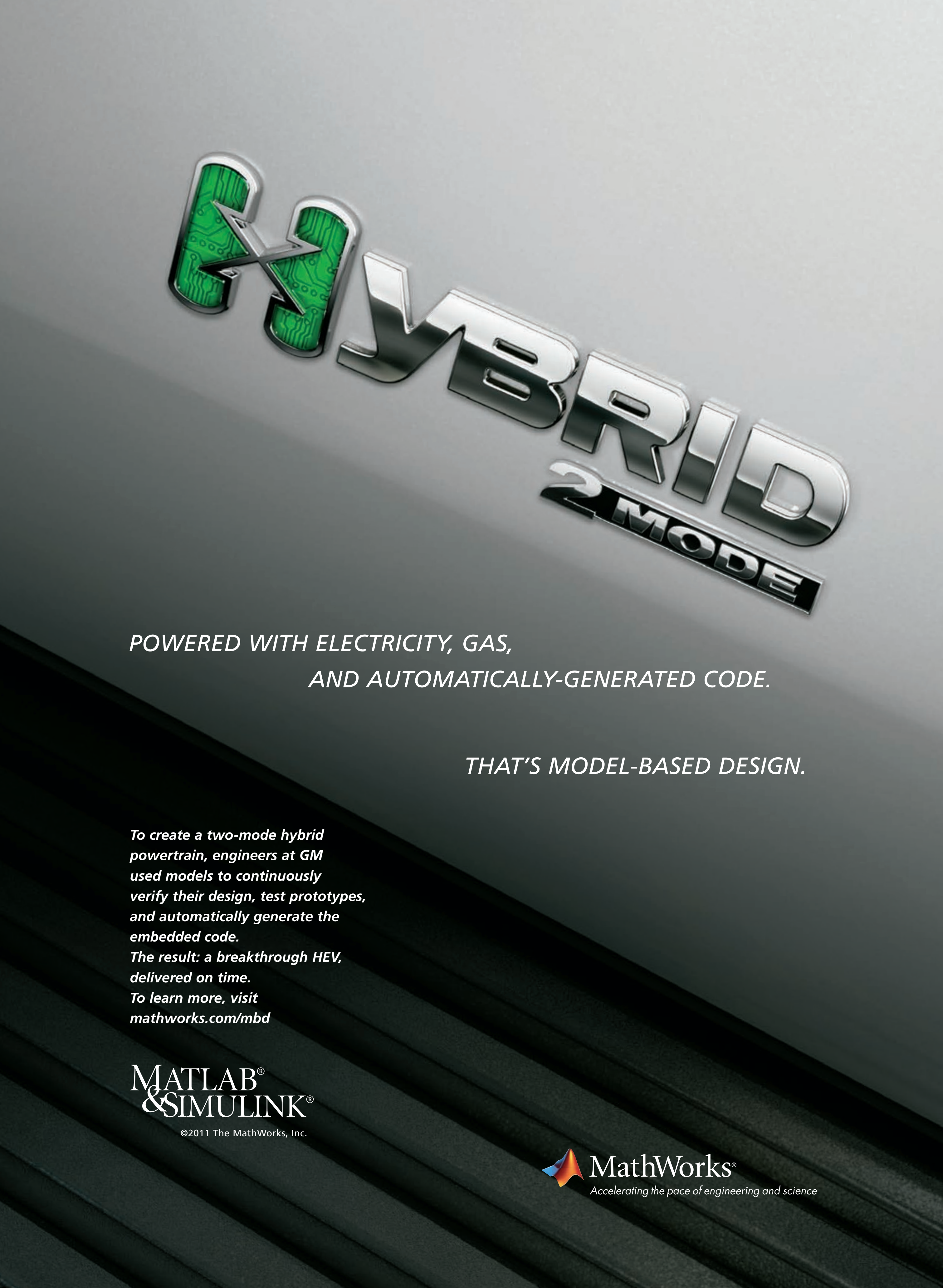
***Desktop Engineering*®** (ISSN 1085-0422) is published monthly by Level 5 Communications, Inc., 1283D Main Street, P.O. Box 1039, Dublin, NH 03444, 603-563-1631. Periodicals postage paid at Dublin, NH, and at additional mailing offices. Desktop Engineering® is distributed free to qualified U.S. subscribers.

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.

Address all editorial correspondence to the Editor, Desktop Engineering. Opinions expressed by the authors are not necessarily those of *Desktop Engineering*. Unaccepted manuscripts will be returned if accompanied by a self-addressed envelope with sufficient first-class postage. Not responsible for lost manuscripts or photos.


HYBRID
2 MODE
POWERED WITH ELECTRICITY, GAS,
AND AUTOMATICALLY-GENERATED CODE.
THAT'S MODEL-BASED DESIGN.
To create a two-mode hybrid powertrain, engineers at GM used models to continuously verify their design, test prototypes, and automatically generate the embedded code.
The result: a breakthrough HEV, delivered on time.
To learn more, visit mathworks.com/mbd
MATLAB® & SIMULINK®
©2011 The MathWorks, Inc.
MathWorks®
Accelerating the pace of engineering and science

by Kenneth Wong & Beth Stackpole

Making Smart Products Smarter

Apple iPhone's voice-enabled Siri gives you a glimpse into how you would issue commands to everyday devices in the future. But communication is a two-way street. Andrew Wertkin, PTC's senior vice president and chief technology officer, foresees the rise of devices that remember, learn from experience, and talk back — even if what they're saying is not instantly discernible to you.

"Vehicles are essentially big mobile devices," he told the crowd at the PTC Live Global 2013 user conference, which took place June 9-12 in Anaheim, CA. "They bring … in capabilities around active safety with vehicle-to-vehicle communication, vehicle-to-infrastructure communication, understanding how the vehicle is used, when it might need service."

PTC CTO Andrew Wertkin highlights John Deere's WorkSight, an example of a smart product that can gather diagnostic, vital stats and, if needed, schedule its own maintenance.

Wertkin offered two examples: the Roomba from iRobot "consistently uses its sensors to understand where there's dirt, where there might be a wall, stairs, a pet, a corner, when its battery is low;" and Philips IntelliCap, an electronic pill (still under development) that actually understands where it is in the body, with "tiny micropumps that pump out the medicine exactly at the right point, pills that are sensing body temperature."

Zipcar, the on-demand car-sharing service provider, also exemplifies the usage model Wertkin expects to become mainstream. Instead of perpetual ownership, tomorrow's consumers may choose on-demand rental and usage at a lower price point. Imagine, for example, refrigerators, ovens, beds and Blu-ray Disc players delivered as part of a subscription. The appliances would be repaired and refreshed every quarter, swapped out with newer models when they are worn out, and updated with firmware over Wi-Fi when needed. (Most Blu-ray Disc players already do that.) It's the jump from Software-as-a-Service (SaaS) to Products-as-a-Service (PaaS).

Evidently, some PTC customers have already taken the leap of faith.

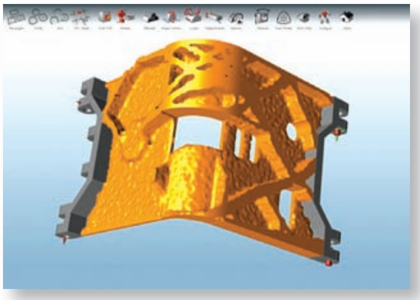
John Deere's WorkSight dirt mover, for example, comes with fleet management and machine diagnostic software, dubbed JDLink. This interconnected software-hardware setup makes it possible for the vehicle to issue transmission overheat alerts and radiator usage reports. The vehicle can monitor its tire pressures and measure its payload. The marketing video says, "It can make a mechanic appear out of nowhere, with the right information, parts and tools already in hand." It's a bit hyperbolic, but might not be too far from the truth. If a vehicle can monitor its own vital signs, it can also schedule its own maintenance.

PTC's prep work for this trend can be seen in its mergers and acquisition strategy. In 2011, the company acquired MKS, an application lifecycle management software maker. In 2012, it bought Servigistics, a service lifecycle management solution provider. MKS's flagship product Integrity has been rebranded PTC Integrity. Even Wertkin, the man now in charge of PTC's technology, is an acquisition: He was once MKS's CTO.

In mid-2011, PTC began a corporate re-engineering initiative, transforming its classic but overwhelming Pro/ENGINEER into a series of smaller, lighter Creo software modules. The company's current transition, apparent from its recent purchases, is to develop solutions for software-centric, service-oriented manufacturers.

— K. Wong

solidThinking Inspire 9.5 Adds Several New Features



Optimizing a transportation door hinge in solidThinking 9.5. Multiple parts can be defined as deign space.

The frustrating part about failed simulation jobs is, you can't communicate with the software. You can't initiate a postmortem analysis by asking, "Why can't you compute that scenario? What happened?" In that unexplained failure is a nugget of wisdom that may reveal something about your design's weakness.

In Altair's solidThinking Inspire 9.5, when computation fails during an optimization session, you have the option to open up the Violation Table and inspect several columns of listed reasons. If you have entered a safety factor that the design cannot physically accommodate (perhaps because there just aren't enough materials to trim to get to the desired results), you'll know. That's one of the improvements included in the new version of Inspire, Altair's optimization software targeting designers.

Also in the new version is the ability to optimize for desired stiffness. In addition to the option "minimize mass," you'll have the option "maximize stiffness." Other options in the optimization dialog box allow you to set frequency limit (the rate at which the design vibrates) or thickness. In other improvements, the displacement constraint setup allows you to set deflection value; the drag-enabled interface lets you visually define how much displacement you'll permit in the design.

For those with multicore workstations, Inspire lets you specify the number of cores you want to deploy to solve the optimization. Two cores are recommended, according to Andy Bartels, solidThinking program manager for Altair. Conversely, you may also deploy just one core if you need to reserve computing resources for other tasks.

"It's the way the software's algorithm works," Bartels adds. "You get the best performance from two cores. You can use more cores, but the speed increase may not be significant."

Inspire is currently not accelerated for GPU, but it's in the development road map. So is support for additional neutral 3D file formats beside STL. Learn more at solidThinking.com.

—K. Wong

SEAL Swim Band Team Dives into Design Challenges

Did you know the No. 1 cause of unintentional injury-related death in children under 5 years old is drowning, and that the whole incident can go down without a sound in as little as 20 seconds? It's a scenario all too familiar to emergency room physician Dr. Graham Snyder, who decided to take action with his new company, Thermocline Ventures, and its soon-to-be-announced product, the SEAL Swim Monitoring system. The crux of the SEAL Swim Band system is pretty simple: Because most kid-related drowning incidents involve a child who is out of sight and very still (not thrashing around, as conventional wisdom would have it), the system aims to draw attention to the child when there is prolonged submersion that is out of the ordinary.

The system is comprised of three main components: the SEAL monitor, which fits around a child's neck like a necklace; a similar band for the guardian or lifeguard; and a wireless hub that serves as a communications network, connecting the bands on the kids swimming in the pool with the bands worn by supervising adults. Custom-tuned to an individual's swimming abilities and tolerance for submersion, the SEAL monitor employs onboard sensors to determine whether a child has been submerged for too long — and if so, it delivers an alert by activating light-emitting diode (LED) strobe lights on the child's necklace as well as issuing a siren call from the hub.

Marrying the functional requirements for the board that holds the electronics with the curved shapes necessary for a desirable design was accomplished with Autodesk's Alias software.

"Using Alias, we were able to create a tight package that distributed components around and minimized size as much as possible," Hunt says.

The realism of the Alias 3D renderings also helped the team get buy-in and make design decisions quickly — a critical capability, considering the company is aiming to get the SEAL Swim System into production and to the market for next year's swim season.

—B. Stackpole

by Kenneth Wong & Beth Stackpole

Simulation Grabs the Spotlight at DARPA's Virtual Robotics Challenge

In the recent Virtual Robotics Challenge (June 17-21), a phase of the Defense Advanced Research Projects Agency (DARPA) Robotics Challenge (DRC), the 26 global teams that made the cut performed a series of pre-defined tasks using the Gazebo simulation environment, which was developed by the Open Source Robotics Foundation (OSRF). The participants were evaluated based on task completion and effective operator control of the robots in five simulated runs for three tasks addressing robot perception, manipulation and locomotion. The tasks included: entering, driving and exiting a utility vehicle; walking across muddy, uneven and rubble-strewn terrain; and attaching a hose connector to a spigot, then turning a valve.

These, and the remaining tasks slated for the subsequent DRC trials to be held in December 2013 and December 2014, are based on feedback from firefighters, police and nuclear engineers as to what they'd want a robot to do in the event of a disaster. In addition to simulating communications limitations that would be typical of a disaster zone, the challenge imposed a round-trip latency of 500 milliseconds on data transmission, as well as varying the total number of communications bits in each run.

Aiming for Robotic Autonomy

The objective of the multi-phase DRC is to challenge competitors to develop new robotics technology capable of executing complex tasks in dangerous and degraded human-engineered environments using common tools and vehicles. It is also designed to support supervised, autonomous operation so the robots can complete their actual mission from beginning to end. As opposed to human operators giving step-by-step commands in terms of motion, these robots have a higher level of intelligence to respond to task-level commands like "open the door" or "climb the stairs." This is necessary because of the degraded communications that characterize most disaster situations.

Gill Pratt, Ph.D., the DARPA program manager spearheading the competition, says the Gazebo environment showcases just how far realistic simulation has come.

"The technology has advanced to allow simulation to be sufficiently valid and realistic, so we can select the teams that will be most confident at running these tasks," he says.

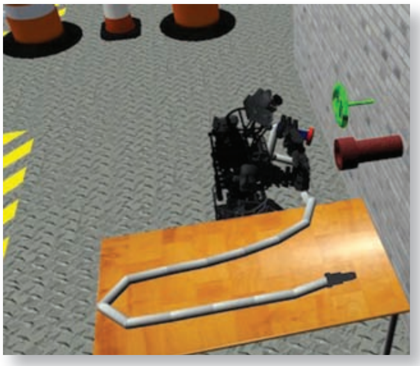
Simulating a Robot

Pratt credits the work of the OSRF, which in Gazebo has designed a general-purpose tool that allows teams to simulate any and all ideas they might have for these robots, including models for motors, actuators, sensors, cameras, inertial measurement units (IMUs), and 3D sensors.

"We want the simulation to be the best possible stand-in for a real robot," explains Brian Gerkey, Ph.D., CEO of OSRF. He says Gazebo may look and feel much like a video game, but its applicability goes much further.

"It should be the case that the teams that do well in the Virtual Robotics Challenge should be able to take their software developed for the simulation environment and run it almost unchanged on their physical robot," he says. "That is the test of how well we've done in building the software."

With that in mind, Gerkey says OSRF has put a lot of time in honing the interactive capabilities of Gazebo so that a human operator sitting at the computer controls will have the feeling he or she is controlling a physical system. The open-source Gazebo code will be available to any research, educational or private sector entity for incorporation in their product and for redistribution.



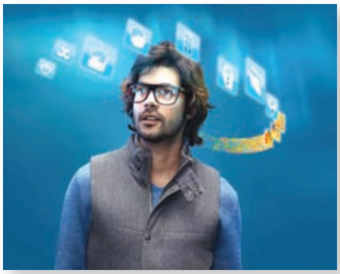
The OSRF's Gazebo is an interactive simulation environment that allows a human operator to feel as though he or she is controlling a physical robotics system. *Image courtesy of DARPA.*

"This is the most efficient development model for building a common platform the whole community can come to rely on," Gerkey says. "It's part of a broader effort to build a common ecosystem of software tools and libraries that everyone in robotics can use to do their work."

Of the 26 teams from eight countries competing in the Virtual Robotics Challenge, nine teams are moving forward, as opposed to the original target of six. The top six teams earned funding and an ATLAS robot designed by Boston Dynamics, which will allow them to compete in the subsequent physical competitions. In total, seven teams with ATLAS robots and DARPA support will be going to the DRC Trials, where they will compete with the Track A teams building their own robots. (*Editor's Note: For more information on the challenge, read "Robots to the Rescue" in our June issue.*)

— *B. Stackpole*

Powering High Velocity Decision Making



Armed with the right computing horsepower, engineers can transcend simple what-if analysis to simultaneously explore myriad design alternatives in simulation.

What-if analysis had led many an engineer down the path to an innovative design, but how about going further to simultaneously consider a greater number of alternatives in simulation in an attempt to explore what else is possible?

Think of this concept as high velocity decision-making—an approach that turbocharges the strategic process and leads engineering teams to the optimal product design. Investigating a wide array of design options in simulation concurrently increases the chances of zeroing in on a product design that requires less materials, costs less to manufacture, has less exposure to warranty issues, and can be delivered in a timely fashion.

Moreover, the ability to test drive ideas in a virtual world using simulation can have a dramatic impact on accelerating product development cycles while lowering overall costs. According to an Aberdeen Research study, 86% of companies following a simulation-based design approach met their product launch dates and cost targets while 91% of them hit their quality targets and design release dates. In addition, best-in-class performers in the study confirmed that strategic use of simulation-based design as a means to gain better insight into product behavior at the onset of the design process was a critical differentiator for their product success.

Consider the story of Dyson, best known for its innovative vacuum cleaner designs and more recently, for its fan-less fan products. During the development effort for the fan-less fan, Dyson engineers parlayed a high velocity decision-making approach to investigate 200 different design iterations using simulation-based design workflows. That target was 10 times the number that would have been possible with physical prototyping. It led the Dyson engineering team to a concept that improved fan performance by 2.5 times that of the original design concept.

Harnessing the Right Horsepower

Having access to the right computational horsepower is critical to an organization's ability to create a high velocity decision-making environment. Intel's Xeon-based E5 line of professional workstation processors can help drive performance beyond what's possible in a typical desktop at prices even small- to mid-sized companies can afford. By leveraging so-called "uncore technologies" like accelerated I/O performance, ECC memory, optimized cache utilization, and new architected data flow — and via the right combination of processors and cores — the Xeon E5 family is optimized for handling large data models and enhanced throughput on simulations.

Intel® Xeon® workstations foster a high velocity decision-making environment by providing the optimal horsepower for running simulations not just for single-point what-if analysis, but also for automated analysis of system performance improvements throughout the product life cycle. With the right computing platform, engineering teams can follow the constructs of projects like Sandia National Labs' DAKOTA, an environment for large-scale engineering optimization and uncertainty analysis. DAKOTA fosters a systematic, rapid approach to determining the optimal solution, leading to better designs and improved system performance, and reducing dependence on prototypes and testing.

A balanced workstation, which considers tradeoffs between processor, memory, storage, and graphics capabilities to deliver optimal performance at an optimum cost, can be an engineer's ticket to high velocity decision-making and a simulation strategy that propels them to compete at the next level. DE

intel inside Xeon

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

Google's Balloon-powered Internet

In its quest to provide Internet access to more users, Google has launched Project Loon, which will use balloons to create a network in remote regions.

Previous balloon-based networking solutions have run into the challenge of getting the high-altitude platforms

to stay in place. Google plans to let the balloons sail freely, controlling their path using wind and solar technology that came its way via a recent acquisition. Turbine power will be used in conjunction with algorithms to keep the balloons hovering over the areas Google has assigned to each balloon to ensure consistent coverage.

Google is testing Project Loon over the Canterbury area of New Zealand, with a pool of around 50 testers and at least 30 balloons hovering overhead.

MORE ➜ engineeringontheedge.com/?p=4834

Researchers Simulate Metallic Glass Failures

Metallic glass (amorphous metal) is a sturdy material that is finding its way into a number of applications. Sometimes, however, the material can crack or break. Researchers at Johns Hopkins University have been studying this development by using computer simulations to determine how much energy is required to crack the material, and how susceptible it is to breakage.

A process called cavitation causes the formation of tiny bubbles in the glass under high negative pressure, and can play a role in these failures. Using a computer model of a cube of metallic glass, the researchers looked at the conditions under which the bubbles form.

MORE ➜ engineeringontheedge.com/?p=4807

Autonomous Planes Enter Testing Phase

Autonomous Systems Technology Related Airborne Evaluation and Assessment has received nearly $94.6 million in funding from a combination of private investors and the UK government to test its autonomous Jetstream aircraft.

During the initial test, the modified plane traveled 500 miles, monitored by National Air Traffic Services to ensure the safety of other aircraft in the test area. The onboard pilot managed both the takeoff and landing sequences without issue.

Along with a general testing of the systems involved with flying an autonomous plane, the test also gave air controllers and regulators a chance to consider what sort of guidelines would need to accompany future pilotless flights. The test represents seven years of research into the technology.

MORE ➜ engineeringontheedge.com/?p=4778

Robotic Insects in Flight

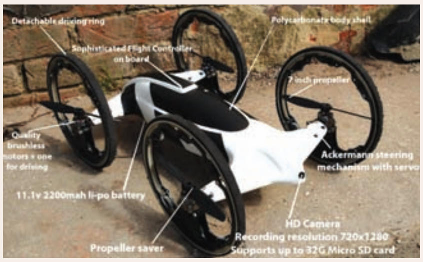
The tiny RoboBee robot recently took its first test flight at Harvard University.

The RoboBee is actually based on the biology of a fly, including membranous wings that flap up to 120 times per second. With a body constructed from carbon fiber, the entirety of the robot weighs under a tenth of a gram. For now, the robot is still tethered to a tiny line that serves to power it and supply directions, but Harvard is working on systems to make it fully autonomous.

"This project provides a common motivation for scientists and engineers across the university to build smaller batteries, to design more efficient control systems, and to create stronger, more lightweight materials," said Harvard Associate Professor Robert Wood, Ph.D. "... they all enjoy solving really hard problems."

MORE ➜ engineeringontheedge.com/?p=4720

Hybrid Car-Helicopter Redefines ATVs



A new remote controlled car-helicopter hybrid vehicle, dubbed simply the "B," hopes to overcome terrestrial obstacles by taking to the air.

The secret to the B is in the tires. The 220mm wheels offer the usual all-terrain vehicle (ATV) capabilities of a remote ATV, and are also large enough to fully encircle the 7-in. helicopter propellers contained within them.

If the B comes to something it can't roll over, the operator flips a toggle and the propellers begin to spin. The user can then guide the B up and over the sort of terrain features that would defeat other types of ATVs. The B also sports an HD camera to record its travels, along with room for a 32GB micro SD card.

MORE ➜ engineeringontheedge.com/?p=4822

➜ For daily coverage on the future of engineering technology, visit EngineeringOnTheEdge.com

AM Could Stabilize New York Waterfront

Monolite UK has won a New York City Economic Development Corp. (NYCEDC) construction competition. According to NYCEDC.com, the competition was "designed to provide innovative and cost-saving solutions for completing marine construction projects and maintaining waterfront infrastructure in New York City."

The problem with New York's waterfront is that the pilings that keep a fair chunk of the city from simply collapsing into the ocean are in generally poor condition, and are in need of either repair or replacement. That sort of project could cost the city billions.

Instead of just manufacturing new pilings, Monolite's idea is to make 3D scans of existing pilings and determine how best to shore them up with concrete

reinforcements. The reinforcements would be built by the D-Shape machine and transported to the waterfront to be installed. Monolite estimates its plan could save New York approximately $2.9 billion in construction costs.

MORE ➜ rapidreadytech.com/?p=4300

Stratasys Acquires MakerBot

Once the dust has settled, MakerBot will operate as a subsidiary of Stratasys, maintaining its own brand name and management. Its 3D design-sharing site, Thingiverse, will remain active. According to Stratasys, moving ahead the two companies will "develop and implement strategies for building on their complementary strengths, intellectual property and technical know-how, and other unique assets and capabilities."

"MakerBot's 3D printers are rapidly being adopted by CAD-trained designers and engineers," said David Reis, Stratasys CEO, via a press statement. "Bre Pettis and his team at MakerBot have built the strongest brand in the desktop 3D printer category by delivering an exceptional user experience."

"We have an aggressive model for growth, and partnering with Stratasys will allow us to supercharge our mission to empower individuals to make things using a MakerBot, and allow us to bring 3D technology to more people," added Pettis in a press statement.

The move gives Stratasys a stake in the home and small-business portion of the additive manufacturing industry. The merger allows MakerBot to access a larger distribution network and a stable source of funding for future growth.

MORE ➜ rapidreadytech.com/?p=4512

Microsoft to Support 3D Printing with Windows 8.1

Microsoft will be supporting additive manufacturing (AM) with Windows 8.1. Starting with that update, Windows will treat a 3D printer like any other printer: Just push a button that says "print."

Windows 8.1 is meant to offer a number of features to support 3D printing, including:

- driver model for 3D manufacturing devices;
- support for Windows Store device apps and extensions for 3D manufacturing devices;
- job spooling and queuing support;
- keywords for modeling device capabilities; and
- an application programming interface (API) for apps to submit 3D manufacturing jobs to your 3D printer.

In addition to supporting 3D printer builds, Microsoft is working with companies like 3D Systems, Autodesk, Dassault Systèmes, Formlabs, MakerBot, netfabb, Stratasys, Tiertime and Trimble to enhance and simplify the AM design process. Windows 8.1 will offer app-building support for AM, and a simple data capture program that works with the Kinect, providing a basic 3D scanner.

MORE ➜ rapidreadytech.com/?p=4602

AM Produces Microbatteries

A cooperative venture between the University of Illinois at Urbana-Champaign and the Wyss Institute at Harvard University has successfully built lithium-ion microbatteries the size of a grain of sand, using additive manufacturing (AM). According to the research team, this also represents the first time batteries have been 3D-printed.

To build the microbatteries, the team first mixed up two batches of electrochemically active inkjet material. Both contained nanoparticles of a lithium metal oxide compound; one was used to build the anode, while the other was used to build the cathode. The printer laid out the anode and cathode in interlocking comb shapes. From there, the proto-battery was packed into a container, which was filled with an electrolyte solution to juice up the battery.

Not only could these batteries power your gadgets in the future, they could also provide energy for life-saving medical implants, and a new generation of robotics. This could even lead the way toward entirely AM-built devices, starting with the shell and working inward on the electronics and battery.

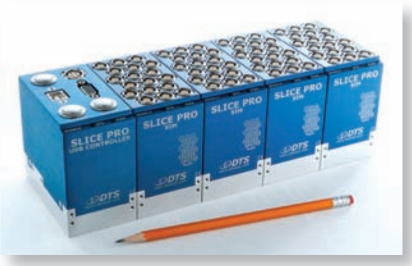
MORE ➜ rapidreadytech.com/?p=4490

➜ For more coverage of rapid technologies, visit RapidReadyTech.com

Editor's Picks

by Anthony J. Lockwood

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



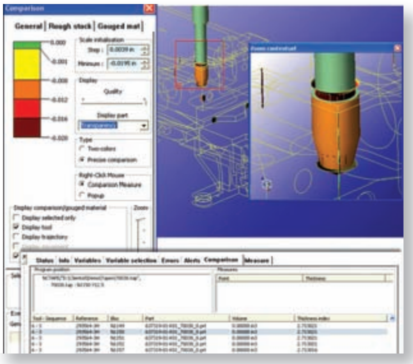
High-Shock Data Recorder Takes Mega-Samples

SLICE PRO data acquisition system can sample up to 1 million samples per second.

Diversified Technical Systems — DTS — has introduced its SLICE PRO, a small, modular, and shock-hardened data recorder system with mega-sample capabilities. SLICE PRO is available in 9- and 18-channel daisy-chainable configurations. It's designed for test applications measuring parameters such as acceleration, displacement, force, strain, and temperature.

SLICE PRO is small, as in miniature. It weighs 26 oz. (726 g) and measures some 2.1 x 3.5 x 3.15 in. (52 x 90 x 80 mm) in its 18-channel module. Miniature, however, does not seem to be an appropriate descriptor for the SLICE PRO's capabilities.

MORE → deskeng.com/articles/aabjwe.htm



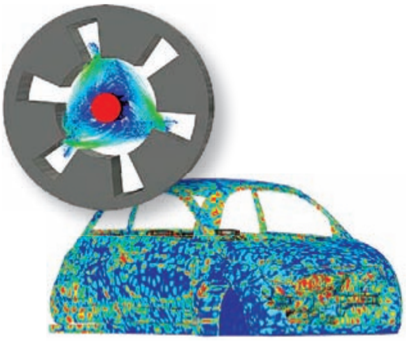
Mobile Viewing into Machining Processes

NCSIMUL Machine 9 provides a realistic graphical representation of the machining process and other NCSIMUL outputs right at the machine tool.

SPRING Technologies has come out with what it calls NCSIMUL Machine 9. This is a toolset for simulating, optimizing, verifying, and reviewing your CNC machining processes. It interfaces with major CAD/CAM applications like CATIA, Creo, EdgeCAM, and Mastercam as well as ERP and MES systems.

The company says NCSIMUL Machine gives you an end-to-end CNC control solution. You can integrate cutting tool libraries, debug NC code, optimize cutting conditions, and even produce documentation for the technicians and other stakeholders.

MORE → deskeng.com/articles/aabjxa.htm



Upgraded Simulation Toolset for Electromagnetics Ships

CST STUDIO SUITE 2013 features new ribbon interface, enhanced performance, and new analysis tools.

Computer Simulation Technology – CST for short – has announced the 2013 edition of its CST STUDIO SUITE, its six-module collection of applications for integrated electromagnetic simulation as well as thermal and mechanical effects and circuit simulation. The bulk of the enhancements appears to be concentrated in the CST MICROWAVE STUDIO (CST MWS) module, which provides specialized tools for 3D simulations of high-frequency devices, analysis of antennas, filters, couplers, planar and multi-layer structures, SI and EMC effects, and the like.

MORE → deskeng.com/articles/aabjyy.htm

National Instruments Updates VeriStand

Latest release adds functionality for developing real-time mechanical testing applications and validating embedded software.

NI VeriStand is intended for applications that involve things like embedded software validation, test cells, mechanical devices, and distributed testing across synchronized real-time controllers. But, really, it's for anytime you need to build a real-time application that has such criteria as high-speed data acquisition and logging, conditioned and deterministic measurements, customized channel scaling, real-time stimulus generation, and the like.

It provides the framework for building your real-time testing application, deploying it, and post-processing acquired data.

MORE → deskeng.com/articles/aabkae.htm

How to Configure the Ultimate Engineering Workstation

Why you need overclocking, SSD caching and dedicated rendering.

Most engineering applications, like SolidWorks, Autodesk Revit, or Autodesk Inventor, are frequency bound (meaning they predominantly use only one processing core), so their ideal hardware platform is a workstation with fewer cores but higher frequency. However, if your workflow also includes rendering and simulation (which use multiple cores simultaneously), you'll want more cores to run at peak performance. For most workflows, a quad core Intel® Core™ i7 processor is the optimal choice, especially if it's overclocked like those found in XTREME edition workstations from BOXX.

Overclocking Matters

While household name computer manufacturers focus most of their attention on mass produced, general use PCs, BOXX offers professional grade workstations custom configured and overclocked for 3D visualization. And with the ability to achieve 4.5 GHz, overclocked 3DBOXX XTREME workstations hold a decided advantage over competitors' top-of-the-line models that can only manage 3.7 GHz— the speed threshold since 2006.

Highly Recommended

3DBOXX 4150 XTREME is a liquid-cooled workstation, powered by an overclocked quad core, Intel® Core™ i7 processor running at 4.3 GHz. Available with up to two GPUs (NVIDIA Maximus™ technology) and support for solid state drive (SSD) caching for increased storage performance, 4150 XTREME is the industry's fastest single socket workstation for engineering and product design applications.

3DBOXX 4920 XTREME, another liquid-cooled BOXX workstation, includes an overclocked, six core, Intel® Core™ i7 processor also capable of speeds up to 4.5 GHz. 4920 XT is available with up to four GPUs (NVIDIA Maximus™ technology), and support for solid state drive caching for increased storage performance.

And if you're concerned regarding the effects of overclocking on a processor, rest assured knowing BOXX has shipped overclocked systems since 2008 and with thousands of systems in the field, the company has not experienced a processor failure rate any different from that of standard processor systems. And like all BOXX systems, XTREME systems are backed by a three-year warranty.

"It's the frequency plateau," says Tim Lawrence, BOXX Technologies' VP of Engineering. "Improvements to architecture have helped somewhat, but not enough. With processor speeds remaining virtually stagnant for six years, overclocking is the only way to significantly increase core speed and thus, performance."

Faster processes result in an accelerated workflow, greater efficiency, higher productivity, and a better user experience.

Critical Components

3DBOXX 4150 XTREME and 4920 XTREME performance is further enhanced by the option of Intel® Smart Response Technology whereby the system automatically learns which files users access frequently. The next time these files are requested, the system loads them from the SSDs. The result is faster booting, faster application loading, and accelerated performance.

In regard to system memory, you'll need at least 8 to 10 GB. With this amount, if your workstation is responsive and executes tasks quickly, you've made the right choice. If not, you may need to increase your RAM (in many instances) to as much as 16GB.

Although an NVIDIA Quadro 600 card is serviceable, BOXX recommends the NVIDIA Quadro 2000 as an ideal mid-range graphics card for most engineering workflows.

Because rendering is such a key aspect of engineering workflows (requiring substantial time and processing power), engineers should consider off-loading rendering tasks to a dedicated rendering system like BOXX renderPRO, a personal rendering solution for 3D graphics, animation and compositing workflows.

Increasing Productivity and Profit

The key to increasing productivity and profit is to accomplish more in less time. Faster turnaround means fewer employee hours invested and more time for new projects and clients. So when you configure the ultimate engineering workstation, consider solutions you won't find anywhere else delivering performance you can't get anywhere else—overclocked 3DBOXX XREME workstations.

INFO → BOXX Technologies:

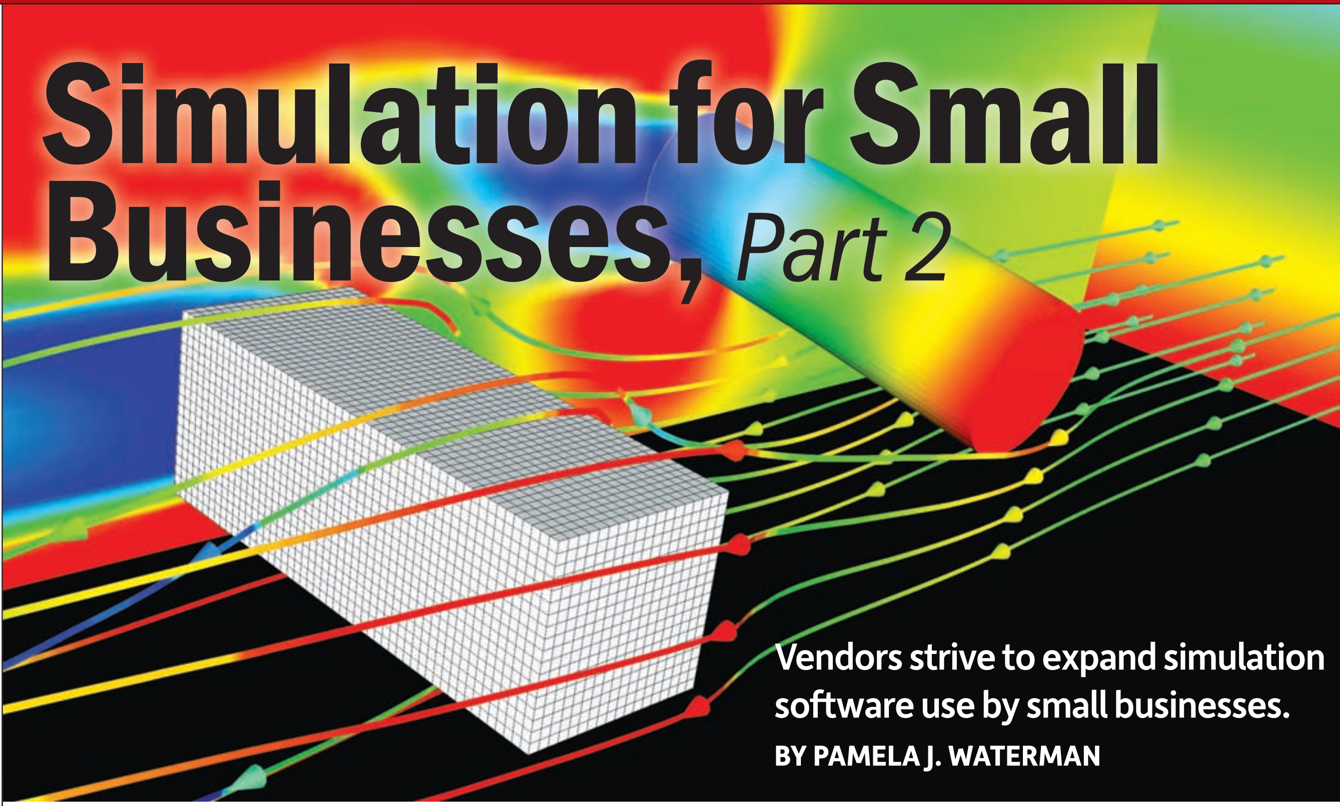
boxxtech.com/solutions/solutions.asp

For sales inquiries call: 512-835-0400

or email: SALES@BOXXTECH.COM

"Intel, the Intel logo and Iris are trademarks of Intel Corporation in the U.S. and/or other countries."

Simulation for Small Businesses, *Part 2*



Vendors strive to expand simulation software use by small businesses.

BY PAMELA J. WATERMAN

As illustrated in Part 1 of this article in the July issue, computer-aided design software vendors already offer an on-ramp to simulation for small- and medium-sized businesses (SMBs) via integrating simulation capabilities into their core design applications. Once thought of as simplistic add-ons, these programs are becoming more and more sophisticated.

For example, Kubotek says its KeyCreator Analysis with Sefea technology "allows designers with limited FEA (finite element analysis) knowledge to produce fast and accurate simulation results. And Simulation Analysts can produce sophisticated multi-physics analysis with speed and precision."

But vendors who develop dedicated simulation software are courting SMBs as well. Many smaller companies — and for that matter, non-traditional users even in large companies — elect to use separate packages for CAD design and mechanical or fluid analysis. Barbara Hutchings, ANSYS director of strategic partnerships, says the challenge is how to engage with the less expert, less dedicated-time users. For this group, whose needs vary across industrial sectors, she observes three challenges in making simulation work: 1. streamlining the workflow, 2. delivering training to ensure workforce readiness, and 3. having access to hardware and software precisely when needed.

Hutchings says making any simulation tools easier to use must start with the workflow, including a seamless interface to CAD. For ANSYS products, additional ease-of-use improvements include the automation of complex tasks in the company's Workbench product and support for its Application Customization Toolkit (ACT), the tool for customizing the mechanical interface within Workbench. The latter is useful, for example, when a methods group wants to add automation and customize the workflow of an oft-repeated design simulation. Users interact with a template layer, perhaps delivered through a web forum.

Hutchings says training is "a huge focus area at ANSYS. The mechanisms and the kind of training are evolving. As you move out to a less expert user, there are new delivery mechanisms. We need on-demand training and training on more fundamental topics to equip the user to understand what they're doing, rather than just using a particular software tool." (See "Promoting Workforce Readiness: Supporting Simulation Education," page 18.)

For improved access, Hutchings notes you must address total cost of ownership, from hardware and software to people and facilities. One way to lower this could be by accessing simulation through the cloud.

As the original commercial developers of NASTRAN FE analysis software (and one of the first 10 original software companies), MSC Software has seen its share of change in the simulation market. Leslie Bodnar, the company's senior director of global marketing, says that increased computing power, as well as the changing profile of the user — broadening to include non-transportation applications and SMBs — has prompted changes.

To address pricing/complexity issues, MSC created a series of software bundles called MSC NASTRAN Desktop at a lower entry price. Each package offers a subset of NASTRAN capabilities with options for upgrades.

For companies with limited resources, MSC offers quick-start services called Expert on Demand, whereby a client designs the model and MSC runs the simulations. The fee structure starts with 40 hours of service (on-site or remote). Consulting services are also available on an hourly basis.

Bodnar says another SMB-focused initiative is updated interface functions. She explains, "We focused on Patran, Marc and Adams, going to a more ribbon-style format and menu bar, with common tools better organized and easily displayed. We've also recently started offering plug-ins for new verticals like Adams/Machinery in the Adams 2013 release, adding wizards and removing the complexity of scripting."

Bodnar adds that MSC is also developing more web-based e-learning training courses, addressing users' increasing requests for convenience.

Over the years, NEi Software has made NASTRAN for SMBs a market priority, bridging the simulation/CAD connection with its own NEi NASTRAN In-CAD design/simulation package. The company also developed the first embedded NASTRAN solution for PTC Creo (NEi NASTRAN in Creo).

Mitch Muncy, NEi Software executive vice president, explains that SMBs are continually doing more with less, so his company's products give users access to advanced functionality.

"The real goal of any integration is to simplify the process going forward," he says. "By tying in simulation with CAD, you're hoping to improve the design process. But while embedded CAD solutions can be used as analysis tools, they certainly don't replace, for example, those of a standalone variety."

NEi Software also supports non-experts by focusing on training, support and consulting. That way, says Muncy, "our smaller customers can leverage our experience, since they might not have a team of in-house experts like we see in the larger companies."

Altair Engineering offers a somewhat different perspective on supporting simulation for SMBs. Ravi Kunju, Altair Enterprise Solutions head of strategy and marketing, says, "The biggest problem today for anybody doing virtual prototyping is having access to resources — basically, infrastructure: high-power networks and high-power machines to crunch the simulation. The second problem is access and affordability of the software, and the third is the ease of deployment. To easily deploy, get to speed and try out concepts before a competitor does is very relevant to SMBs."

Kunju gives the example of trying to run a large-scale computational job like a crash simulation requiring 200 cores. How does an SMB even get its hands on such a machine, and get all the support and management software deployed?

Altair supports CAE for the non-expert with vertical tools and design of experiment tools that automate many user tasks. In addition, the company offers an interesting licensing model called HyperWorks on Demand, where customers buy software tokens that can be exchanged to run hardware cycles. And, with HyperWorks 12.0, companies no longer need to have a license in-house: The license is in the cloud, yielding software portability across different data centers. Most recently, Altair launched a hardware/software "box" configuration called HyperWorks Unlimited. Users lease the box and gain their own private cloud, making it easy to handle large output files in-house.

Bringing CFD to the Masses

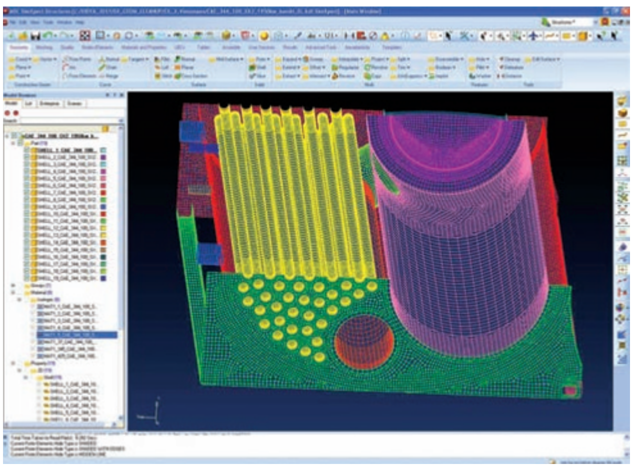
Many engineers who are comfortable with doing mechanical FEA shy away from simulations involving computational fluid dynamics (CFD), but some companies are making strides to change that situation. John Isaac, Mentor Graphics' director of market development, Mechanical Analysis Division, addresses the issue: "From Day One, we've been working on getting CFD software into the hands of SMBs — to design engineers, not just specialists, and making our software usable by the mere mortal."

Isaac explains that his company has done so by embedding its FloEFD cooling capabilities into several CAD systems (Siemens NX, PTC Creo, Dassault Systèmes Catia V5 and SolidWorks) where it is basically just another button. The environment offers an intuitive GUI, plus wizards that guide the setup process.

"Our CFD technology removes the engineer from the need to know the 'rocket science,'" he adds. "For example, it includes highly automated meshing that varies the size of the mesh across various sections of the design. Just that process removes significant time and expertise required in understanding CFD."

The Mentor Graphics CFD algorithm also understands when a model transitions between laminar and turbulent flow, and handles it accordingly. Additional user value is derived from parametric data stored in the software's Smart Parts library, and from the ability to easily conduct "what-if" design variations and parametric studies. The company is also expanding the availability of FloEFD training workshops specific to the CAD products.

Amir Isfahani, Flow Science director of business development, says that SMBs already comprise a good portion of his company's clientele. He notes that one way in which its FLOW-3D CFD software increases its usability (and therefore, productivity) comes from the developers continually improving the user experience. For example, intuitive graphical interaction in the user interface makes simulation setup possible in a fraction of the time it used to take. Also, he says the upcoming post-processing and visualization tool, FlowSight, will increase user productivity.



Geometry cleanup and meshing tools in MSC Software's MSC NASTRAN Desktop mechanical analysis software. ***Image courtesy of MSC Software.***

Supporting Simulation Education

Shane Moeykens, ANSYS strategic partnership manager, says his company is doing a lot of work at the university level to encourage the use of simulation in an engineering curriculum. One approach is for professors to reach out to the local SMB community and offer simulation work done as a senior project.

Another specific program is SimCafe, a wiki-based repository of learning modules for doing mechanical design simulation. It was started in 2008 by ANSYS founder John Swanson, Ph.D., and Rajesh Bhaskaran, Ph.D., a Cornell University professor of mechanical and aerospace engineering.

"The approach we are taking is that learning online is key, available to anyone anywhere," says Bhaskaran. "The ultimate vision is that the undergraduate education has given you enough of the fundamentals to hit the ground running."

Each tutorial uses the same steps, from pre-analysis through verification and validation – a process that is very important for critical thinking. To date, more than 110,000 unique users from 140 countries have accessed SimCafe modules. Learn more at https://confluence.cornell.edu/display/SIMULATION/HOME.

Application-specific versions of FLOW-3D, like FLOW-3D Cast Basic, streamline the CFD process for users who are only interested in a subset of capabilities relevant to their application. By contrast, FLOW-3D Cast Advanced and FLOW-3D ThermoSET offer the full set of CFD capabilities — but with the convenience of customized interfaces dealing with all aspects of metal casting or resin solidification, respectively.

"For usability within FLOW-3D, various pre-processing tools have been implemented," Isfahani says. "We have calculators for different types of casting applications so that you can do back-of-the-envelope calculations during the setup process, and checklists are provided to make sure you haven't missed anything in your setup."

Cloud usage of FLOW-3D is also underway, which would alleviate the headaches of an in-house cluster to run the distributed memory (MPI) version of the software, FLOW-3D/MP. This would also make it possible for the regular FLOW-3D users to run their occasional large problems on the cloud, and on a pay-per-use basis using FLOW-3D/MP.

CD-adapco (maker of STAR-CCM+ CFD software) says it is always striving for ease of use. Last year, the company began a project to revamp and modernize the user experience. David Vaughn, CD-adapco vice president, Worldwide Marketing, says, "We hired a 'user experience' team — a mixed bag of efficiency/human-factors programmers, including developers from TomTom (the navigation product company), who are used to really optimizing the interface between the human and the computer. And we're looking at more traditional issues — all the way from how you set up the problem to post-processing."

To CD-adapco, software pricing options are just about as important as usability. The company's licensing structure works three ways that greatly benefit cost-conscious SMBs:

1. The Power-Session license allows running one simulation across an unlimited number of cores for a fixed cost.
2. Power-on-Demand gives you unlimited simulation burst capacity by the hour, independent of process or core.
3. Power Tokens buy one process job on one CPU. For example, 100 tokens could run one session split across 100 CPUs, or 100 concurrent jobs each on one CPU. Tokens are reusable, too: When the job is done, others can start.

Vaughn says the company has just extended the use of Power Tokens to operate mix-and-match across all usage.

Helping SMBs become Experts

When design engineers check their decisions as they go, they learn why these decisions make sense. That's why making simulation available from the get-go is so helpful for producing the best possible designs.

NEi Software's Muncy offers a great perspective on why we should also be cautious that "improvements" do not slide into dumbing-down mode. He says, "We should be making everyone an expert, not the other way around."

Join in on a discussion of simplifying simulation software vs. dumbing down results going on at *Desktop Engineering's* Virtual Desktop blog, which includes a panel discussion on the topic moderated my Kenneth Wong at deskeng.com/virtual_desktop/?p=7293. **DE**

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

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

→ **ANSYS:** ANSYS.com

→ **CD-adapco:** CD-adapco.com

→ **Dassault Systèmes:** 3DS.com

→ **Flow Science:** Flow3D.com

→ **Mentor Graphics:** Mentor.com

→ **MSC Software:** MSCSoftware.com

→ **NEi Software:** NEiSoftware.com

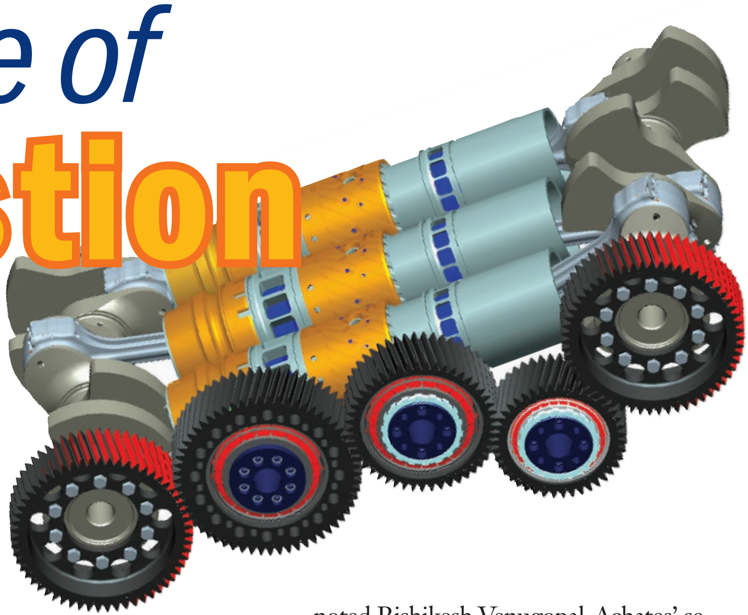
→ **PTC:** PTC.com

→ **Siemens PLM Software:** Siemens.com/PLM

→ **SolidWorks:** SolidWorks.com

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

The Science of Combustion



Achates Power uses CFD simulation and optimization to find the best opposed-piston engine design.

BY KENNETH WONG

Fabien Redon, VP of technology development at Achates Power (pronounced A-*kay*-tees), is currently prevented from revealing the recognizable commercial vehicle makers working with his company by confidentiality agreements. But if I want to get a sense of the energy and efficiency of his company's flagship products, opposed-piston engines (OPE), Redeon suggests that all I have to do is observe the stream of delivery trucks pulling in and out of large grocery chains.

Dubbed "An Engine That Uses One-Third Less Fuel" in *MIT Technology Review* (Jan. 14, 2013, TechnologyReview.com), Achates' engine bypasses the need for cylinder heads, "which are a major contributor to heat losses in conventional engines," according to the company. The OPE contains two pistons per cylinder, working in opposite reciprocating action. In a paper authored by Achates' staff, the company states that its opposed-piston, two-stroke diesel engine design "provides a step-function improvement in brake thermal efficiency compared to conventional engines while meeting the most stringent, mandated emissions requirements."

That significant advantage is one the reasons the trucking industry has been quick to adopt it. Other sectors deploying the same technology include military (for tanks), aerospace and marine ("Eight Companies Determined to Change Diesel Engines Forever," March 2012, *Diesel Power*, DieselPowerMag.com). Whereas Achates' clients rely on the company's OPE technology, Achates relies on CONVERGE Computational Fluid Dynamics (CFD), computer-aid flow simulation software, to study and perfect its engine design.

The Chemistry of Combustion

In the software the company was previously using, and in many other commercial codes available, using a combustion model including detailed chemical kinetic mechanisms wasn't an option, noted Rishikesh Venugopal, Achates' senior staff engineer. "CONVERGE is one of the earliest adopters of detailed chemistry," he adds. "It took too much time to simulate with detailed chemistry [in other software]. CONVERGE uses an automatic adaptive meshing technique, which lets us use not only detailed chemistry, but also reduces computing time."

Observing detailed chemical reactions in engine operations is important for Achates because the company is "not only trying to optimize engine performance but also emissions," says Venugopal. "Studying detailed chemistry reactions lets us understand, for instance, the oxidation of fuel through several reaction steps. If the chemistry is not detailed, then we can't capture the sensitivity of the emissions, such as nitrogen oxides and soot, when the engine's operating conditions change."

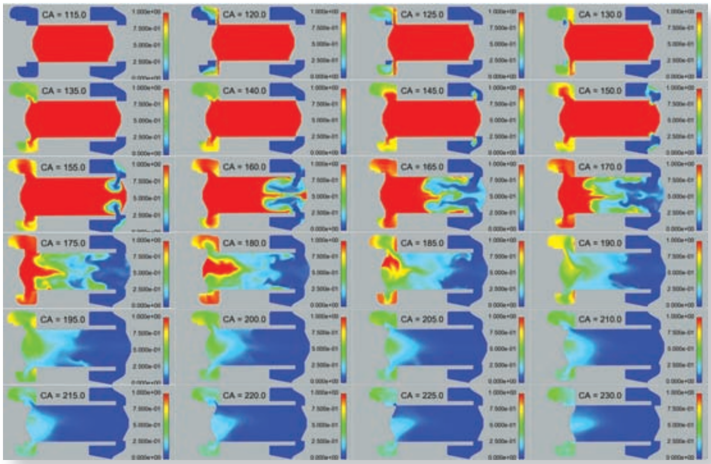
Adaptive Meshing

The simulation usually begins with a Pro/ENGINEER CAD model, converted into .STL format. Other than fixing a few triangulation problems that occur during the conversion process, Achates engineers seldom do any other additional work on the .STL model.

"We refined the process of developing the Pro/E model to make the .STL implementation into CONVERGE software easy," explains Redon. "It has taken us some time to refine that process to understand the characteristics of the Pro/E model we can readily use when converting to .STL."

"With CONVERGE, we don't need to clean up the .STL model as much as in other software," adds Rodrigo Zermeño, Achates' development engineer. "The automatic mesher takes care of the small features [details such as rounded corners, small holes and fasteners not needed for simulation]."

The adaptive mesher also makes the job easier by automatically using an appropriate degree of details for each region of the



To study the best possible configuration of its engine, Achates uses CONVERGE CFD software.

model. The software doesn't blindly apply fine meshes on the entire model, explains Venugopal. This method keeps the number of elements as low as possible, thus reducing computing time during simulation.

Known and Unknown

From experience and years of R&D, Achates has developed fairly accurate engine combustion data, such as the inside temperature of the engine walls — critical for calculating heat transfer in digital simulation. For the rest of the data needed for simulation, engineering judgment has to be used, Venugopal says.

"Take, for instance, the spray characteristics," Venugopal continues. "It requires very detailed breakup time-scale and droplet-dynamics related constants, which cannot easily be measured." For those, Achates relies on real-world tests conducted with fuel injectors in its state-of-the-art fuel lab to obtain the right approximations. "Physical lab tests guiding simulation" is the only way to remove uncertainties, Venugopal says.

Finding the Best Way to Combust

The purpose of simulating the engine is to "optimize combustion," Redon says. "We have so many combinations we can lay out our engine. So it's critical to use simulation tools to study the options we have."

During simulation of the engine scavenging process, Achates encountered a scenario the software couldn't faithfully replicate. The OPE has two sets of ports: one set for exhaust, another set for the intake.

"In an opposed-piston two-stroke diesel engine, the areas of the ports change as the pistons move past them, and this is a geometric feature that CONVERGE initially couldn't capture," explains Redon.

As robust as the software is, "when you have very thin regions with high-pressure flows, it's difficult to simulate the event in a mathematically stable manner," Venugopal says. So, in collaboration with CONVERGE, Achates engineers came up with a workaround. They shrank the pistons' diameter by 0.1% and added a thin layer of cells — called liner gaps — between the ports and the pistons. This allowed the fluid motion to occur.

"Using the disconnect triangle feature [in the software] and the liner gaps, we were able to simulate where the flow was occurring and where it was blocked when the ports were uncovered by the pistons," says Venugopal. "That was significant because we were able to observe the gas exchange happening in the open-cycle scavenging."

The workaround didn't compromise the fidelity of the simulation, but it did require diligent monitoring of the process, notes Venugopal. "We had to use two sets of geometry — with liner gaps, and without. So we couldn't run the entire scavenging cycle as one cycle. We split it into two simulations," he said. "We had to use good bookkeeping to make sure we were using the right geometry for the right phase."

This workaround is no longer needed because CONVERGE CFD now has a sealing feature that resolves the issue, according to Rob Kaczmarek, director of sales and marketing, CONVERGE.

Injection Innovation

The use of optimization driven by CONVERGE software's genetic algorithm (GA) has allowed Achates to find the best configuration of injectors, among others.

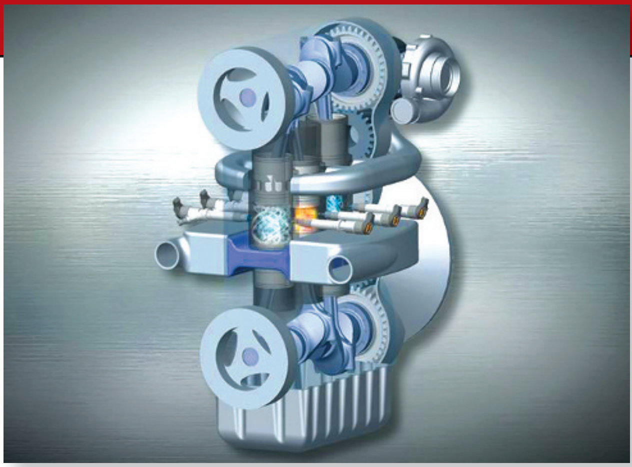
"Even though the solution was what we anticipated and it made sense, we also saw how far we could push it," Venugopal reflects. "It also showed that, even as we were pushing the design's limits, the engine was still giving good performance."

In keeping with its biological metaphor, the GA optimization begins with a set number of design options, and then spawn a greater number by varying different parameters.

"In one such GA run, I believe we ran about 200 to 300 designs before arriving at the desired solution," Venugopal recalls. "But the software wasn't running all [parameter] combinations at all times; it was only running those that were favorable, so it didn't waste time."

Achates uses a Linux cluster and Windows cluster to run the software. For optimization jobs, Achates relies on the Linux cluster because, Venugopal explained, the code is deeply rooted in the Linux environment, as it's often the case with combustion CFD codes. At Achates, a typical combustion simulation involves 100,000 to 200,000 elements, running on eight to 16 CPU cores. In larger jobs, it could involve a few million cells, running on 32 cores. The jobs can take anywhere from eight hours to five days.

"CONVERGE possesses extensive technologies to minimize the runtimes on high-performance computing platforms," says Kaczmarek. The company is also working with Lawrence Livermore National Laboratory, Cummins Inc., Indiana University and NVIDIA, and will be releasing CONVERGE with GPU



The design of Achates' opposed-piston engine in a rendered 3D model.

support later this year, he adds.

"Keep in mind that, after a certain number of cores, the performance benefits are no longer proportional to the number of cores you add because there'll be increased chatter," notes Venugopal, referring to communication between cores. "So it's really about balancing the number of licenses you have, the cores, and the job. We tried to take into account all these factors."

CONVERGE CFD's licensing policy is multicore-friendly, he says.

Reality and Simulation

"Our engine technology is much more complicated than conventional engines, so some of our strategies cannot be applied blindly," says Achates' Redon. "It's very important to anchor simulation in physical tests."

CONVERGE's Kaczmarek agrees: "While it's our goal to provide our customers with the most advanced CFD tools on the market, it's important to remember that simulation and validation must always coexist."

As the use of simulation gains popularity, there's a risk that designers might place unwarranted trust in simulation results. Achates' philosophy — always make sure simulation stays close to the physical response of the engine — serves as a good reminder not to lose touch with reality. DE

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

INFO → **Achates Power:** AchatesPower.com

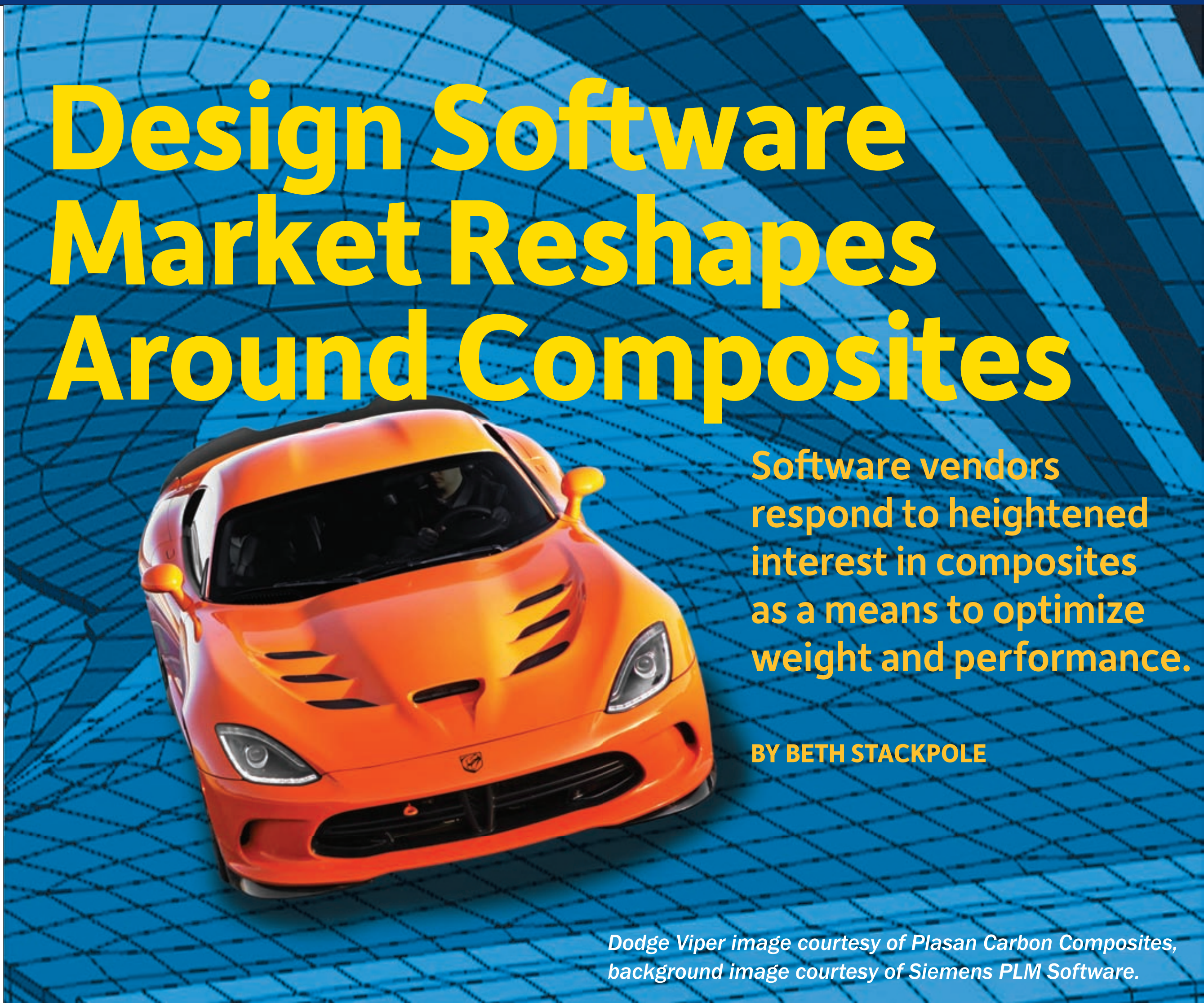
→ **CONVERGE CFD:** ConvergeCFD.com

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

Design Software Market Reshapes Around Composites

Software vendors respond to heightened interest in composites as a means to optimize weight and performance.

BY BETH STACKPOLE



Dodge Viper image courtesy of Plasan Carbon Composites, background image courtesy of Siemens PLM Software.

Well beyond their impact on modern aviation, the new-to-flight Boeing 787 and Airbus A350 are wielding a much broader influence: They're advancing the use of sophisticated composite materials across industries as a means to reduce weight while optimizing performance.

The A350 is the first Airbus aircraft to comprise more than 50% composite materials. The majority is leveraged in its fuselage and wing as part of the company's mission to save weight and reduce maintenance costs by eliminating corrosion and fatigue. Similarly, the Boeing 787 employs nearly half carbon fiber-reinforced plastic and other composites in its airframe and primary structure. This results in an average weight savings of 20%, compared to more conventional aluminum designs, according to Boeing officials.

The widespread attention paid to both of these development efforts is turning the spotlight on composites — and illustrating how the once cost-prohibitive and highly specialized materials now have broad applicability for mainstream use.

"The Boeing 787 and Airbus A350 brought awareness to composite materials," says Rani Richardson, a composite consultant with Dassault Systèmes. "Ten years ago, when the first lacrosse stick was made with composites, no one knew what it was. It's just a matter of awareness; now it's not the mysterious material that it used to be."

As familiarity with composites goes up and the price points for both the materials and production processes go down, companies outside of aerospace — including industries such as automotive, wind energy, marine and sports equipment — are actively jumping on the bandwagon and infusing composite materials into their overall design efforts. As a result, global demand for composite materials is on the rise: It's projected to reach $34 billion by 2019, according to market research company Lucintel. The firm estimates the market value of end-user products made with composite materials was $55.6 billion in 2011, and will soar to $85 billion by 2017.

CAFE Standards Drive Composite Use

The requirement for improved fuel efficiency and demand for high-strength, lightweight alternative materials are the principal drivers behind the heightened interest in composites. In the aerospace sector, for example, manufacturers are looking to lighten commercial jetliners with composite-built fuselage and wing structures in an attempt to reduce fuel costs and increase profits.

In the automotive space, the principal push toward composites stems from revised government-mandated Corporate Average Fuel Economy (CAFE) standards, which raise the average fuel efficiency of new cars and trucks to 54.5 mpg by 2025.

Not only do composites reduce the weight of a primary structure like a fuselage or car body, but they also have an impact on the size of the other components, notes Olivier Guillermin, Ph.D., director of product and market strategy for Siemens PLM Software.

"Composites have a cascading effect on the size of other components," he explains. For example, lighter composite wind turbine blades allows for a lighter hub, nacelle and tower to support those slimmer blades, he says.

In addition to being used to reduce the overall weight of a structure, composites also come into play to improve weight distribution. For example, a composite top deck structure lowers a ship's center of gravity, while the lighter ends of a composite empennage on an airplane can improve overall handling, Guillermin explains.

Formability and the need to streamline parts in the quest for better aerodynamics or hydrodynamics is another reason behind the surging popularity of composites.

"There's a growing drive within many industry sectors to use composites instead of metals, because composites are lighter and stronger than metals and can also be shaped in ways metals can never be shaped," notes Pawel Sobczak, Ph.D., technical applications manager at Safe Technology, a maker of software that analyzes the fatigue life of composite materials. "In the automotive industry, in particular, they need to make cars lighter, but still sustain the same strength. Composites are the perfect answer to that."

They may be the "perfect answer" today, but that wasn't always the case. The manufacturing processes to design and produce complex composite structures have become much more automated and reliable, and ready access to cheaper computing horsepower has finally made it possible to perform composites modeling. These were both critical steps for getting engineers onboard, suggests

Emmett Nelson, a software architect at Firehole Technologies. The company develops composites simulation software, and was recently acquired by Autodesk for incorporation into its digital prototyping portfolio (*Editor's Note: See* deskeng.com/virtual_desktop/?p=6929).

"When composites first started, there was a lot of hand layup and manual manufacturing. Each component required a lot of human touch," Nelson explains. "As the methods became standardized and composites production processes automated, it increased the speed and reliability of the materials, which is very important for markets like aerospace where safety is the biggest driver."

The Acquisition Rush

While product requirements may be calling for more serious consideration of composites, the lack of available and robust design tools, particularly in the area of simulation, has been one the greatest barriers to getting engineers comfortable with the complex materials. For years, engineers have been leveraging advanced simulation tools like finite element analysis (FEA) and computational fluid dynamics (CFD) to explore the structural integrity and aerodynamics of designs built around traditional materials in the digital world prior to building costly physical prototypes. However, those conventional CAD and CAE tools have not been able to sufficiently accommodate composites modeling, which is different in that the materials are not surface-based or volume-based, but are somewhere in between.

"There are all kinds of things that go into designing with composites that require different capabilities that you don't necessarily have with the CAD and simulation tools designed to work with basic metals," explains Ken Amann, executive consultant with CIMdata, a market research firm specializing in engineering issues. Specifically, design engineers need to consider the type of fiber and resin, whether the design will involve long or short fibers, and how to best structure the orientation of those layers or plies — and that's just a start, he says.

Recognizing both the gaps in their product lines and the escalating demand for design and analysis capabilities in this area, CAD and CAE vendors have been on a composites buying spree. In the last year, most of the major players have acquired small companies specializing in this technology area, including Autodesk's acquisition of Firehole Technologies, ANSYS' purchase of EVEN, Siemens PLM Software's buyout of Vistagy, MSC Software's acquisition of e-Xtream, and Dassault Systèmes' acquisition of Simulayt (*Editor's Note: See* deskeng.com/articles/aabcxe.htm, deskeng.com/articles/aabhba.htm *and* deskeng.com/virtual_desktop/?p=4482, *respectively*).

For ANSYS, the recent acquisition of longtime partner EVEN was about acquiring both the pre- and post-processing technology for analyzing composites — including the ability to fully understand the potential failure of product models as it relates to progressive damage delamination and cracking. But the acquisition was also about bringing hard-to-find composite talent and domain expertise into the company ranks.

"The main driver to acquiring vs. building or partnering is about the speed getting into the space, but it's also about talent," says Sin Min Yap, ANSYS' vice president of industry strategy. "Hiring and finding composite experts takes time and is very costly. It's not just about the product and technology, but it's about the people too, and mergers are a very effective way for talent acquisition."

ANSYS competitors Autodesk, MSC Software, Dassault Systèmes and Siemens PLM Software view their composite acquisitions in a similar light. Autodesk, which had some short-fiber composites capabilities as part of its Moldflow offering, gets more advanced layered woven and continuous fiber composite modeling capabilities with Firehole's technology. Siemens PLM Software and Dassault Systèmes view their respective acquisitions as a lever to deliver a complete suite of products for end-to-end engineering of composites, from preliminary design through detailed design and manufacturing.

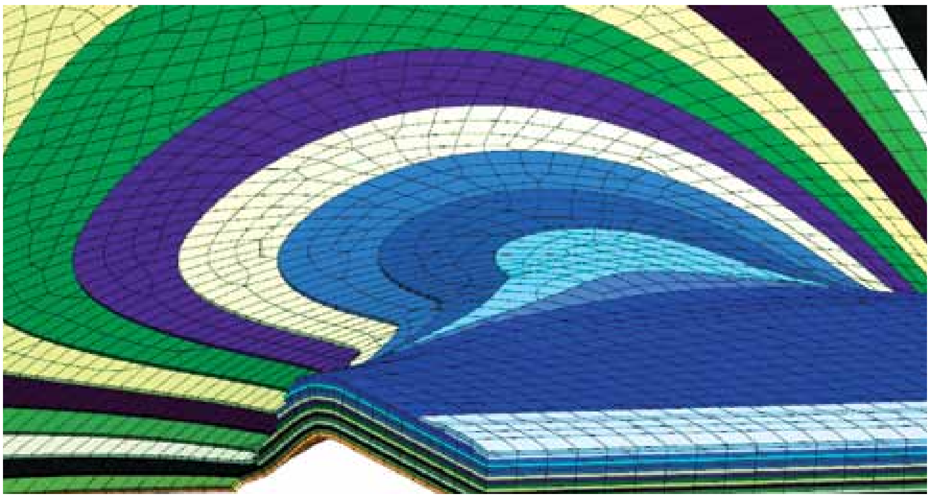
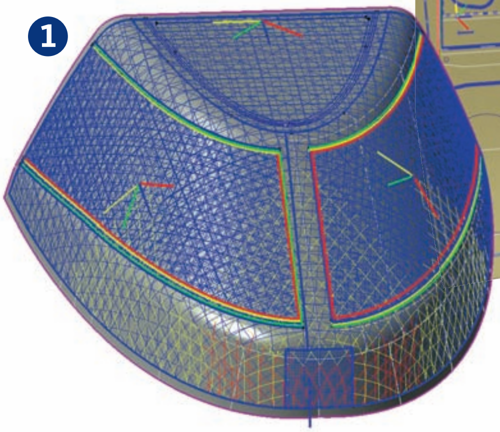


FIG 3: The layered composites add complexity to modeling and simulating composite-driven design. Shown here is a jet engine blade designed with composite laminates. ***Image courtesy of Siemens PLM Software.***



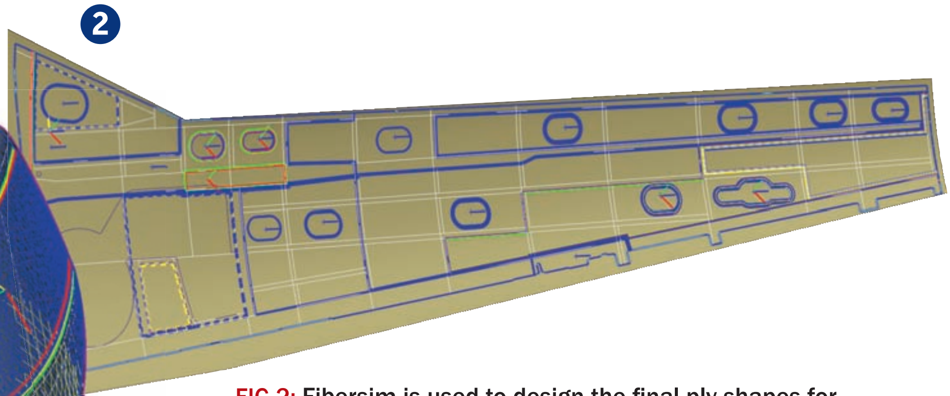


FIG 2: Fibersim is used to design the final ply shapes for complex aircraft composite wing skins, meeting the ply shape, orientation, sequence and stagger criteria set forth by the engineering and the manufacturing teams. *Image courtesy of Siemens PLM Software*.

FIG 1: This image shows Fibersim producibility simulation results for a composite canopy. True fiber orientations are computed based on the "drapability" of the materials and the manufacturing process. Red areas indicate a likely manufacturing problem, such as fabric wrinkling or bridging. *Image courtesy of Siemens PLM Software*.

For its part, MSC Software's acquisition of e-Xstream and its Digimat offering addresses one of the limitations of traditional FEA tools in this area: improving the accuracy and predictability of parts and systems FEA thanks to local, nonlinear, anisotropic modeling of the materials, according to Roger Assaker, CEO of e-Xstream, an MSC company. Consider the widespread adoption of fiber-reinforced plastics in automotive, he says: "During the injection molding process, the fiber orientations change, and that leads to anisotropic characteristics of the properties, which is important to know for the subsequent FEA that is done."

Most engineers treat fiber-reinforced plastics as metal, meaning isotropic, which doesn't deliver an accurate representation, he says. Digimat gives engineers an accurate and smart material model to be used in FEA simulation.

"Without it, the FEA results are less accurate," Assaker claims. "As a result, engineers tend to overdesign, which defeats the purpose of designing with fiber-reinforced plastics to begin with."

Without tools like Digimat and specifically, Dassault Systèmes' CATIA and Simulayt, engineers can only go so far in pushing the use of composites, says Gary Lownsdale, CTO at Plasan Carbon Composites, an automotive original equipment manufacturer (OEM) supplier that makes composite parts. Plasan is using Dassault Systèmes' 3DEXPERIENCE platform and the Simulayt tool to aid in composite design and fiber modeling, eliminating the trial-and-error design process so commonplace with composites — and thus greatly reducing the number of physical prototypes.

The lack of advanced simulation tools has been a significant barrier to composite adoption, however the flurry of new simulation tools now available levels the playing field, Lownsdale says.

"When designing in metal, you can pick up any manual or go to any database to get all the physical and test properties you need to be able to design parts effectively, but when composites came along, we had to start all over again because we didn't have those tools on the shelf," he explains. "As those tools come online, it's becoming much more practical for engineers to design in composites in the same way they've been able to design in metals." **DE**

Beth Stackpole *is a contributing editor to DE. You can reach her at beth@deskeng.com.*

INFO ➜ Autodesk: Autodesk.com

➜ **ANSYS:** ANSYS.com

➜ **CIMdata:** CIMdata.com

➜ **Dassault Systèmes:** 3DS.com

➜ **Lucintel:** Lucintel.com

➜ **MSC Software:** MSCSoftware.com

➜ **Plasan Carbon Composites:** PlasanCarbon.com

➜ **Safe Technology:** SafeTechnology.com

➜ **Siemens PLM Software:** PLM.automation.siemens.com

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

Beneath the Layers: Composite Complexity

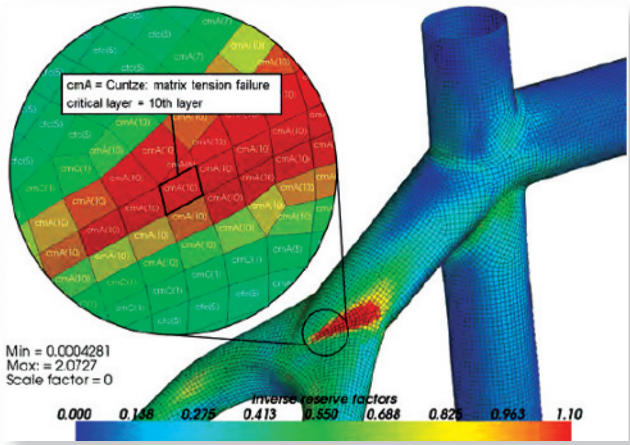
Ply orientation, drape simulation and wrinkle prediction are the keys to working with composites.

BY KENNETH WONG

Olivier Guillermin, Ph.D., director of product and market strategy at Siemens PLM Software, urged me to take a good look at the boats skipping along the San Francisco Bay in the America's Cup. (I happen to live in the area.) Many of them are examples of how composites can be used to create lighter, faster vehicles with aeronautic advantage, he pointed out.

But if I need some insights into how composites behave, I might have to study how a tailor works. In fact, technical literature on composites borrows heavily from the dressmaker's vocabulary: plies, patterns, draping, wrinkling, weaving and shrinkage. Simply put, composites are layers — sheets, if you will — created from two or more materials.

"The good thing about composites is, you can design your material. The bad thing about composites is, you have to design your material," Guillermin quips. And that may be the key to working with composites: The way they react to stresses and loads is inseparable from the way the materials are put together.



A close-up look at simulation results of a bike component covered with composite materials.

Beginning at Ply Building

At the fiber level, the weaving method determines the stretching, shrinking and expansion behaviors of composites. They're generally not isotropic: When reacting to forces and stresses, they don't expand, contract and stiffen uniformly in all directions. The more sophisticated composite users take that into consideration, and use that to their advantage.

In December 2011, Siemens acquired Vistagy, bringing the latter's composite-design software Fibersim into the Siemens software portfolio. The new software complements Siemens' existing NX design software suite, particularly the NX CAE Laminate Composites module for building FEA models of composite models. In early 2013, Siemens also acquired LMS International, including the Samcef Finite Element Analysis (FEA) software suite with a large spectrum of linear and nonlinear composites analysis and optimization capabilities.

Fibersim gives you insights into what happens during the manufacturing process. "For example, an automated fiber placement machine used to produce composite plies has a minimum course length," says Guillermin. "It cannot lay down less than a certain inch of fiber length. So the engineer has to design ply shapes a certain way to accommodate that." Such functions in Fibersim, Guillermin explains, "let you know whether you are designing manufacturable plies, or will have issues when producing them."

Materialistic Behavior

If you're using standard manufacturing materials — plastic or steel, for example — defining the material in simulation software could be as simple as picking the corresponding material from a library. But with composites, this option is not always available.

"We have composite materials in our software's library. It's in our database," notes Pierre Thieffry, Ph.D., ANSYS Software's lead product manager for Structural Mechanics. "However, everyone will use a different flavor of carbon or fabric, so they will have to characterize it on their own. That's one of the challenges with composites, because there's a huge variety."

The material properties you need for simulation (how much it expands, how it behaves at high temperature, and so on) may be available from the supplier, but if the supplier is not willing to part with this proprietary data, you may need to conduct lab tests — or hire a lab to do the testing — to obtain the data.

"This is a general problem in the industry," says Bob Yancey, Altair's senior director for global aerospace. "First of all, the amount of data that needs to be captured is at least an order of magnitude more than with isotropic material systems. Secondly, many companies that use composites create their own material databases and keep this information proprietary."

Last September, simulation software maker MSC acquired e-Xstream engineering, which specializes in material modeling.

"We have approximately 200 material models in our database from a number of material suppliers, as well as models we've created based on public data available from Campus," says Bob Schmitz, business development engineer for e-Xstream engineering. "We also offer the ability to encrypt the material models, so that a supplier can provide the end user an accurate representation of their material's performance without revealing the details of the material. For internal use within a company, we also provide control over who has access to upload or change material data. This is a level of quality control over material data management and an aspect that our parent company is implementing at a much larger scale with its new product, MaterialCenter."

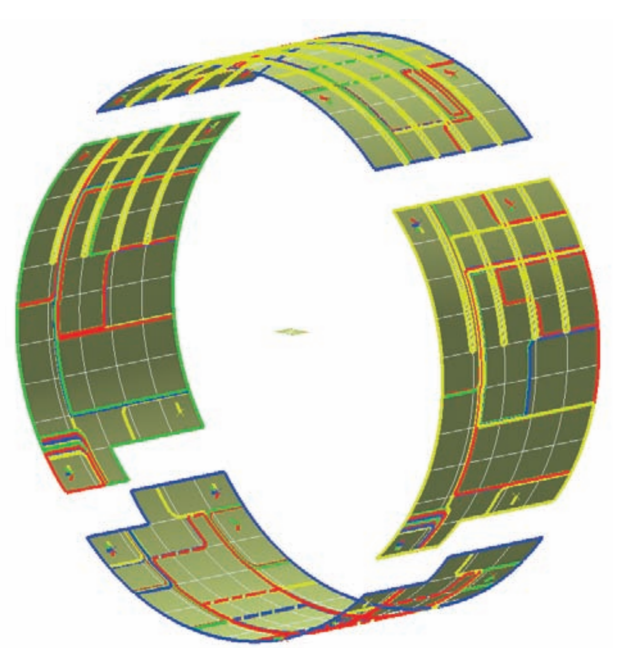
Layered Complexity

As Siemens' Guillermin observes, "most composite parts are over-designed." That's because designers have to compensate for the uncertainties involved with composite behaviors because of a lack of data. "There's currently still insufficient information about progressive damage, fatigue. There's ongoing research in this area," he adds.

The wear-and-tear prediction for composite is also made more difficult by the fact some of them behave like woven fabric, not metal.

"Because they're fabric, you don't always get consistent material properties," says Guillermin. "They differ from roll to roll. There might be some waviness in one roll, but not in the other. And transportation might affect the rolls." Not all composites are woven, Guillermin points out. In fact, aero structures use unitape or non-crimp fabric (NCF), which are stitched layers of unitape.

ANSYS' Thieffry points to layers as the reason for composite simulation's complexity. "With regular materials, you look for maximum stress, deformation, and so on," he says. "With composites, you have many layers, so you have to look at the results layer by layer."



Laying out the composite plies on an airplane fuselage in Siemens PLM Software's Fibersim.

Meshing

ANSYS' Thieffry says that most composite simulation requires surfacing meshing to address the layers. But some structures that are made up entirely of composites (some turbine blades, for instance) require a different meshing. "In the way we do it, to get the final volume mesh, we start from the surface mesh," he says, "then extrude it along a spline." It's a method that imitates how composites are built in the manufacturing process. Plies are manufactured by adding layers into a mold to build thickness along a profile.

The ANSYS Structural Mechanics suite includes Composite PrepPost. According to ANSYS, "Engineering layered composites involves complex definitions that include numerous layers, materials, thicknesses and orientations. The engineering challenge is to predict how well the finished product will perform under real-world working conditions. This involves considering stresses and deformations as well as a range of failure criteria."

"With composite meshing, you need to decide how detailed you want to get," says Guillermin. "If you're going to take a smeared approach [treat the stack of composite as a single homogeneous entity], then it's simpler meshing. But if you want to study each layer separately, you need specialized pre- and post-processors that use structured mesh that mimic or follow the layers."

Most of the time, the mesh does not detail each and every layer, Guillermin notes. It could be several layers at once, or a laminate per element thickness.

Altair's Yancey explains that "for thin composite structures, we have developed shell elements to model the laminate structure, which is good for predicting the stresses and strains in the individual layers, but they are poor for modeling the stresses and strains between layers and at laminate boundaries. For solid composite structures … if [the material] is anisotropic, which is often the case, the meshing method doesn't take this into account. To get the stresses and strains between layers and at laminate boundaries, solid element approaches are preferred, but this can lead to very long compute times. Advancements are needed to achieve detailed and complete results with computational efficiency."

Optimizing

In typical optimization exercises, the designers look for the best topology or geometry to counteract the anticipated load, pressure or force. But in composite part optimization, the emphasis falls on thickness. In software like Vanderplaats Research & Development's (VR&D) GENESIS, "You're looking to determine the number of layers you need for your design," notes Juan Pablo Leiva, the firm's president. "We call it thickness optimization. But since you usually know how thick each layer is, you're actually looking for the best number of plies."

Yancey reports that Altair has several exclusive capabilities for composite design optimization within OptiStruct, where the company can optimize the thickness and shape of individual plies and the stacking sequence for the laminate.

"Most engineers can tell you where you need to have material," Yancey says, "OptiStruct can help you understand where you don't need material, which helps you design structurally efficient systems."

Orientation

Because composites don't expand uniformly in the same direction, understanding the expansion behavior and orienting each sheet or layer to account for the anticipated expansion is also a critical part of composite design.

"For each fabric, you need to know what the reference is," says Thieffry, referring to the 0 mark in the virtual 3D space. "For each fabric, there's reference direction per element [mesh], because the direction changes depending on the curvature of the region it covers."

That means millions of directional definitions for a sheet of composite subdivided into millions of elements. For practicality, the process of defining these directions has to be automatic, not manual.

VR&D's Leiva says the composite fabric's expansion behavior is influenced "not only by the way the fibers in the fabric are woven, but also by the way the user lays them out. Our software recognizes that composites are anisotropic, so if you place a load, the FEA will produce a deflection, and you'll be able to see on the computer screen if there's going to be any warping."

Wrinkle Detection

In aerospace and automotive, speed advantage comes from subtle and complex geometry, designed specifically to reduce drag. Because composite layers hug these intricate curvatures, it's important to be able to predict where wrinkling could occur and fix these regions before moving into production.

"The fabric follows the curvature of the design," said Siemens' Guillermin. "It's very hard to predict what it's going to look like, even for an expert. An aspect of simulating the manufacturing process in Fibersim is the ability to simulate draping — so you can see possible areas of wrinkling, bridging or micro-buckling before you go and make the part."

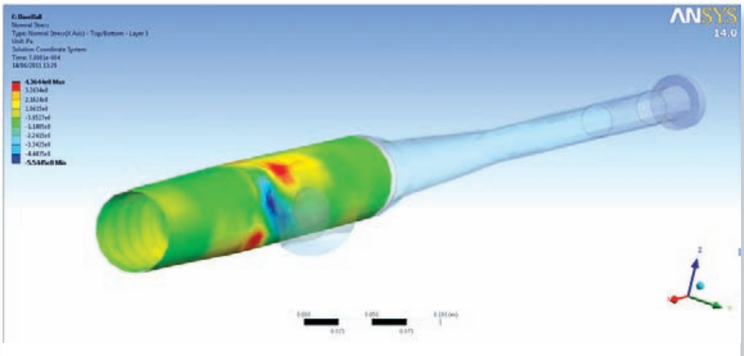
"In fact, in some Formula 1 cars, engineers take advantage of that twisting and warping behavior," says VR&D's Leiva. This is different from the unintentional deformation resulting from the tug and pull on composite fabrics (those are the ones you want to avoid). By strategically introducing deflections, "you can make the car to get stiffer when going straight, and to deflect more when turning to help with aerodynamics," Leiva explains.

Schmitz says that e-Xstream engineering's focus in Digimat, the company's nonlinear multi-scale material and structure modeling platform, is the modeling of the material performance. "In this case," he says, "we will use the material orientations from the draping simulation to predict the material performance of the as-manufactured laminates."

Some Composite Wisdom

Composite parts inherit the physical behaviors and chemical properties of constituent materials, so they can be produced to meet the desired flexibility, lightness, and strength — hence their appeal. The growing use of such materials is evident when you compare Boeing's programs for the 777 and the 787 Dreamliner. The 777 uses 12% composites, 50% aluminum; the 787 uses 50% composites, 20% aluminum. (*Editor's Note: For more, read Beth Stackpole's article "Design Tool Market Reshapes around Composites" on page 22.*)

"Since composites are manufactured materials, you cannot decouple manufacturing from design," Guillermin warns. "The way they're laid up and joined, the manufacturing defects inherent to the parts — they affect the design. With metal, somehow you might be able to treat the metal properties separately from the geometry of your design. But with composites, you cannot do that."



Simulation results of a baseball bat with composite materials, shown here in ANSYS software.

Altair's Yancey has found that over the last decade, modeling capabilities for composites have dramatically improved — "but there is still plenty of room for improvement. CAE modeling for isotropic materials has been developed over several decades. Real innovations will be required to achieve the modeling efficiency for composite structures that we now enjoy with isotropic material systems."

VR&D's Leiva says that while composite parts have become the norm in Formula 1 and other special vehicles, the relatively high cost of composites has prevented more widespread use in passenger vehicles. Through the use of optimization, designers can find the best places to put composite materials to get the best performance per dollar.

"Failure and progressive damage are two topics that are of high interest to our customers, and you will see more capabilities developed and refinement in these areas," predicts e-Xstream's Schmitz.

ANSYS' Thieffry agrees: "You'll be able to conduct detailed analysis, down to the fiber level. Maybe you'll even be able to go to the specific fiber in a layer where it might fail."

But is there any chance research might allow us to go even deeper? "We're not going down to the electron level," Thieffry concludes. **DE**

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

INFO ➜ Altair: Altair.com

➜ **ANSYS:** ANSYS.com

➜ **e-Xstream engineering:** e-Xstream.com

➜ **MSC Software:** MSCSoftware.com

➜ **Siemens PLM Software:** PLM.automation.siemens.com

➜ **Vanderplaats Research & Development:** VRanD.com

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

Solve Key Problems in Composite Simulation

Whether you are looking at pre-processing, post-processing or material testing, composites are orders of magnitude more complex than traditional materials such as metal and plastic.

BY MARK CLARKSON

Like a very tricky sandwich, composite materials are usually laminated structures, made up of layers (plies) of material, stacked one on top of the other. These layers often have fibers running through them, and the angle of those fibers can vary from layer to layer (0°, 45°, 90°, etc.). There can be dozens, or even hundreds of layers. There might be more layers in some areas, and fewer in others so the overall width of the structure varies from area to area. The final properties can be hard to predict.

"If you don't have a balanced, symmetric laminate, your part can twist when you apply a tensile load," says Alastair Komus of Composites Innovation Centre. "You can take advantage of that in some parts; other times you want to avoid it entirely. But it's a complication that your software needs to be able to predict."

On a curved part, the effective angle of the fibers can change from place to place. That orientation is a huge factor in analysis, according to Komus: "Siemens NX allows you to define a starting point on your part and, as you drape your material over a curved surface, the program tells you how the alignment of those fibers changes."

Taking a Look

Just being able to see what's going on in a composite structure can be a big challenge, notes Altair Senior Director Robert Yancey, Ph.D.: "Composites add one or two more orders of magnitude to the information you have to be aware of when you analyze a structure."

The same issue persists on the post-processing side, he says.

"Damage usually initiates at a single layer, and you want to be able to quickly home in on where that damage is occurring," Yancey explains. "With Altair, you can color-code the layers. But if each layer has a different fiber orientation and you want to visualize the fiber orientation of a particular layer, you've got to select that layer [and look at it separately]. It works fine, but it's not a very intuitive process right now. I believe there will be more efficient ways of integrating that data."

Analysis of composite compressed natural gas tank doors on a transit bus.
Images courtesy of Composites Innovation Centre.

Optimization Offers Advantage

Yancey points to Altair's optimization technology as being able to guide users with respect to the general structure of the laminate.

"We can tell the designer which angle ply should be where, what angle ply should dominate where in the structure, where you can get away with dropping off some plies, or where you might need to build up some plies in order," he says. "We've been able to demonstrate to many of our customers that you can develop a composite laminate design that can save 15% to 30% of weight over a traditional composite design."

In addition to saving weight and saving materials, think about the complexity of the composite itself, advises Altair Business Development Manager Giuseppe Resta.

"You may have hundreds of plies of different orientations and different thicknesses. The question is, where do you start? There are so many solutions that, in theory, give you a satisfactory design, but where does the engineer go to get the best out of it?" Resta continues. "Optimization guides you to what may not be an intuitive design. Optimization is not just an add-on to improve something that you've already done; it can be a design strategy that you adopt at the beginning to gain insight into how to use this expensive material at its best."

Errors in your Model

"What makes design space exploration possible is a tool that's reliably accurate over the entire design space," observes Scott Leemans, principal engineer at Advatech Pacific. "You have to quantify the uncertainties over the entire design space to ensure that is true."

In general, he says, for complex systems such as aircraft, the traditional finite element analysis (FEA) approach leads to models that are tuned to match tests as the project progresses.

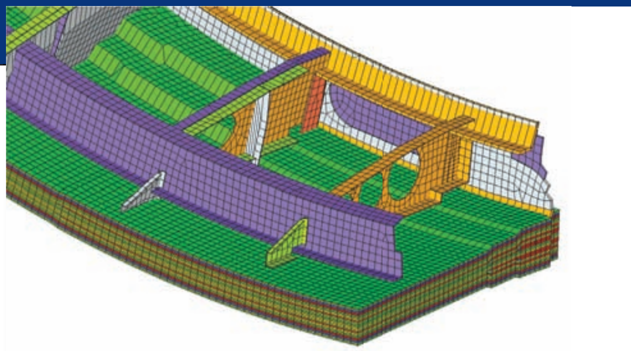
"In other words," says Leemans, "the individual errors are not identified and then quantified over any significant portion of the design space. I do not believe that error quantification is adequately addressed — or even adequately facilitated by most packages. It is left to the user to decide when and how they ensure the accuracy of their models.

"We calibrate, verify, and validate all of the analysis models that go into our tools with testing," he adds. "We use a test matrix that covers the same design space over which the tools are valid."

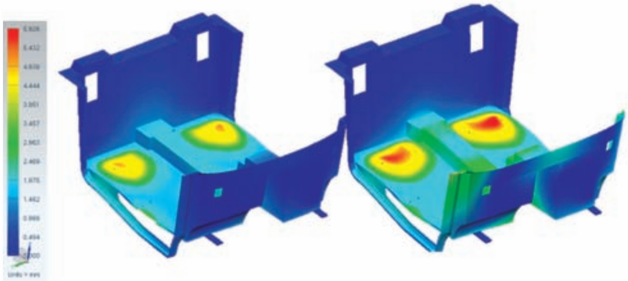
Material Property Problems

There's another problem lurking at the very heart of composite simulation: garbage in, garbage out.

"In CAE, you need a proper input to get a proper output," says Altair's Resta. "We need to have a mature material

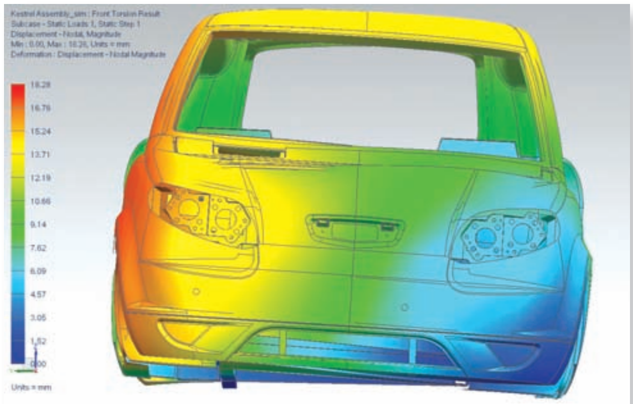


Altair's HyperWorks includes many features to help model and analyze complex composites parts, including 3D representation of plies.



Seat pull analysis for the front tub of the Kestrel concept vehicle.

Roof crush analysis of the Kestrel concept vehicle.



Torsion analysis of the Kestrel concept vehicle.

Basis Values Basics

By Elizabeth Clarkson, Ph.D. and Mark Clarkson

A-basis and B-basis values (sometimes called allowable values) are statistically computed confidence bounds on estimates of a material property, usually strength. Composite material properties can vary, which makes definitions of material properties somewhat fuzzy. That's where basis values come in. For example, we can say with 95% confidence that 99% of the material will meet or exceed the A-basis value, and 90% of the material will meet or exceed the less-conservative B-basis value. Or can we?

Material property basis values can be computed from tests using three batches of material, all from the same manufacturer. It's like throwing three darts at a wall, then drawing two concentric circles around them. The circles are your acceptance region (inner) and basis values (outer). When subsequent manufacturers step up and throw, their darts must hit the inner circle or risk their materials being rejected.

Within the acceptance region, we cannot tell any significant difference among the samples; if your sample lands in that region, it's considered identical and accepted. But that circle is small and hard to hit. In fact, these computed acceptance criteria are frequently unrealistic for many composite part manufacturers (CPMs). These unrealistic expectations have significant repercussions for the industry.

You might think the problem stems from the small sample size (three batches) initially used to compute the basis values. But, because of the way basis values are computed, adding more samples makes matters worse. With more samples, we become better at telling differences among batches. Thus, our acceptance region shrinks. This could, theoretically, result in many, most or even all material samples being rejected.

Generic Basis Values

With generic basis values, the acceptance region is defined first, from a much larger set of samples from multiple manufacturers, such that at least 90% of CPMs will produce acceptable product by following documented procedures. Basis values are then computed for this acceptance region.

This gives us a much larger acceptance region, and lower basis values, than traditional methods. But, and this is key, it gives us basis values that CPMs can actually meet. In fact, we can conclude with 95% confidence that their materials will support the generic basis values. This is a stronger claim than that which is currently used to certify materials, and can result in unequivocal certification of composite parts for the majority of CPMs using a material's generic basis values.

Elizabeth Clarkson *is chief statistician for the National Institute for Aviation Research. Visit her site at BethClarkson.com.*

Altair's set of simulation tools for composites analysis is integrated into HyperWorks' optimization framework. Here, an IndyCar chassis from Dallara is shown.

on which to apply CAE design. Material knowledge is the basis of composite design."

You can't get good results without good material data — and unfortunately, when it comes to modern composites, good material data is sorely lacking. The reasons are manifold. Just as analyzing composites is orders of magnitude more complex than analyzing traditional materials, testing composite materials is orders of magnitude more difficult, and produces correspondingly more data. (*Editor's Note, see "A composite Sketch of ACMs" on page 34 for more information.*)

In the aerospace industry, says Yancey, "every laminate configuration you're going to use has to be tested. If you've been using a six-ply laminate and you want to change to a 10-ply laminate, you've got to repeat all those tests." That's thousands of tests. This makes composite materials extraordinarily expensive to test. Projects like the Boeing 787 or F-35 Joint Strike Fighter accrue tens of millions of dollars in composite materials testing expenses alone.

"Because of the expense of testing those materials," says Yancey, "and the fact that composite usage is relatively new in many industries, a lot of that material data is considered proprietary." For example, Boeing isn't anxious to spend $100 million qualifying a material and process, and then give that information to Airbus (and the rest of the industry) for free.

This also means changes can be almost prohibitively expensive to contemplate, even when a potentially superior material appears.

Simulation to the Rescue … Eventually

"We see CAE as a way to limit the actual material testing necessary," says Resta. "You're going to use the physical testing for the extreme cases and then, once you have confidence in CAE, you can extrapolate to the other, less-severe conditions. That's what's going to be required for companies to switch to new material systems as improvements are made."

Non-woven biofiber mat is used as composite reinforcement.

Composite structure of the Kestrel concept vehicle, supported by a metallic chassis.

There is an active community working on virtual simulation of materials for qualification, but it's a new idea. "It will take some time to get better accepted in the industry," says Yancey.

It's not a Composite until it's a Part

"Aluminum is aluminum before you turn it into a part," says Advatech's Leemans. "Composites aren't. It's not a composite until it's been built."

Composites are very, very process-dependent, and variations in the manufacturing process can have profound effects on the final long-term behavior of a part. Change suppliers or build on a hotter day, cure a part a bit longer, and you can wind up with surprisingly large differences in material properties. "We in the industry don't do a good job of modeling the idiosyncrasies, part by part, [arising from] the manufacturing processes," says Leemans.

Those idiosyncrasies include wavy or missing fibers, porosity and voids, and spring-back — the tendency of a composite part to change shape when removed from the mold.

"I worked on one part that was a simple front panel," recalls AlphaSTAR senior scientist Jonas Surdenas. "But the edges were a different laminate than the center and it bowed. When you heated it up, the bow disappeared. It's a mismatch between the coefficient of thermal expansion and the modulus. If there's enough interplay between the different parts, it can cause deformation or residual thermal stresses in there."

Some of these things are immediate problems: Spring-back might mean the two halves of your engine nacelle don't mate, for example. On the other hand, porosity might not be a problem for months or years, but it will ultimately shorten the part's life.

"The effect of these defects is a major concern," says AlphaSTAR Founder Frank Abdi, Ph.D., noting that FEA "cannot account for all these things."

Computer simulations generally assume a perfect build; it's hard to anticipate random voids and plug them into the model.

"Engineers use reduction factors and things like that," says Abdi, knocking down the computed strength of composites to account for manufacturing defects. "That causes overweight parts."

The Complexities of Failure

Composite materials don't fail the way that metallic materials do, and different types of composites fail differently.

"When we're using NX," says of Composites Innovation Centre's Komus, "there are about six different failure theories you can select from. Some are good for directional materials; others are good for woven materials. Some are better for some load cases than for others. You definitely have to be very careful in terms of what failure criteria you use."

Advatech's Leemans observes that designers could perhaps get a little closer to the edge than they currently do if they had better tools. For now, though, they can't predict exactly how a failure will initiate.

"The failure modes jump around," he adds. "How do you capture that? Is it matrix failure or a fiber failure? Is it both? Is it an interface between the two? The heterogeneity of the problem at multiple scales really adds complexity. A few companies out there — like Firehole Composites [now part of Autodesk], AlphaSTAR — are working on progressive failure analysis, trying to figure out when cracks initiate, when the matrix starts to break down and degrade, how the de-lamination progresses."

"There's still a pretty big disconnect between the as-designed and as-manufactured composite structures," says Altair's Yancey. "Advances are being made in manufacturing simulation of composites, but there's a lot of room for new capabilities and innovation for better understanding the manufacturing process." DE

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

INFO ➜ **Advatech Pacific:** AdvatechPacific.com

➜ **AlphaSTAR Corp.:** AlphaSTARCorp.com

➜ **Altair:** Altair.com

➜ **Autodesk:** Autodesk.com

➜ **Composites Innovation Centre:** CompositesInnovation.ca

➜ **Siemens:** USA.Siemens.com

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

A Composite Sketch of ACMs

Advanced composite materials earn the right to replace alternatives through physical testing.

BY RANDY FRANK

With their distinct (laminated fiber) construction, composite materials have the capabilities to provide significant weight reduction in higher efficiency, energy-conscious applications. With proper design and validation testing, they frequently replace alternative materials, delivering higher reliability and solving other problems such as corrosion. Depending on the application, however — airplanes, automobiles or wind turbine blades, for example — extensive testing for tensile and other stress capabilities may be required.

FIG. 2: A universal tester measures tensile and other properties of composite materials for specified geometries.

Cases in Point

An award-winning thermoplastic composite horizontal tailplane is a main load-bearing primary structure of AgustaWestland's twin-engine AW169 helicopter. Weighing 15% less than other composite solutions, this structure decreases both emissions and fuel consumption for the helicopter. The material also has inherent flame-retardant properties that allow it to meet stringent safety standards specified by the aircraft industry (see Fig. 1).

FIG. 1: As a new generation of helicopter technology, the AgustaWestland AW169 horizontal tailplane has a length of 9 ft. and uses thermoplastic material, a high-performance engineering polymer and carbon/polyphenylene sulfide (PPS) semipreg and plate material. *Image courtesy of AgustaWestland.*

Aerospace is just one of the industries taking advantage of the capabilities of advanced composite materials (ACMs) to change its products. The automotive industry also has composites high on its list of key materials for future vehicles:

- BMW has identified carbon fiber reinforced plastic (CFRP) as its favorite lightweight material.
- General Motors has replaced underhood components that are subject to a temperature environment as high as 302°F with ACM. An aluminum component replaced with a glass-filled polyamide allowed the carmaker to shed between 7 and 9 lb. from a V6 engine. Every pound adds up quickly, so vehicle weight reduction is a key strategy for meeting emission regulations and reducing fuel consumption.

Testing Challenges

In fact, ACM is changing many industries. "Composite materials are lighter than metallic materials and have superior corrosion resistance. That leads to increased efficiency in aerospace, marine and automotive applications," says Henry Patts, Ph.D., a materials engineer at Westmoreland Mechanical Testing & Research (WMT&R). "That's why we're getting significantly more interest in composites testing. I've been here for seven years, and it's grown exponentially in that time."

WMT&R deals with testing for a wide range of industries, and performs testing to meet the requirements of numerous industry standards. In business since 1967, WMT&R is one of the largest independently owned test labs in the world.

Because of their distinct laminated fiber and other reinforcing structural designs, different tests are required for composites. In addition to tensile strength, users are interested in modulus and strain, according to Kimberly Stuart, marketing and sales manager for Plastics and Composites Services at Intertek. Intertek provides quality and safety solutions including materials testing to several industries worldwide.

Intertek's tensile testing services include a wide range of tensile test methods for a variety of composite constituents and materials applications (see Fig. 2). Some of these tests are defined and specified by ASTM International and the International Standards Organization (ISO). Elevated and reduced temperature tensile test procedures are available for tests such as:

- Tensile testing of polymer matrix composite materials ASTM D3039, ISO 527-5
- Tensile strength of sandwich constructions ASTM C297
- Tensile strength (open hole) of polymer matrix composite laminates testing ASTM D5766
- Tensile testing of plastics per ASTM D638 and ISO 527

With ACM, products can be designed to achieve strength requirements in specific directions. Because it can be designed in, a lot of simulation is performed during the design process. However, the verification and validation of physical testing is necessary to determine that the results are delivered in the end product — "to validate what was simulated in finite element analysis," says WMT&R's Patts.

Unlike metals, the characteristics of these highly engineered materials are not nearly as well documented. "It's not like we're dealing with testing of 7050 aluminum or Inconel, where there is 100 years of history on it," notes Charles Boyle, quality assurance inspection supervisor, WMT&R. "This is new stuff."

One of the issues is predictability. "They don't know what the values are usually for tensile strength, for bending strength, or for sheer strength — the typical properties," Patts points out. "When we are assisting customers, one of the challenges to us is picking up where the customer might not be so knowledgeable about the tests that they are asking us to do, as it relates to their material."

For example, a customer may need to test a unidirectional carbon fiber, high-strength modulus material using ASTM D695 or ASTM D6641 as the compression standard. "As a test engineer, you have to know that for unidirectional materials you have to reinforce those gripped ends or you are likely to get an unacceptable failure," says Patts.

Being able to reliably perform the test is merely one aspect. With today's increasing use of ACM, time is of the essence. To avoid longer-than-expected time-to-test results, service providers must have sufficient capacity to perform the required

FIG. 3: Instron's universal machine's test results can be analyzed using the company's BlueHill Software, which is compatible with several of its machines.
Image courtesy of Instron.

tests: Boyle advises that a 100-hour test run at a company with only two machines vs. a 100-hour test run at a company with 18 machines can provide significantly quicker turnaround, for example.

Tools of the Trade

Companies offering test services rely on equipment suppliers such as Instron, which provides testing equipment designed to evaluate mechanical properties of materials and components.

"The most important material to us now is composites," says Ian McEnteggart, composite marketing manager at Instron.

Those who have strictly dealt in the testing of traditional materials have a few challenges as they move into the testing of ACM, he adds: "If you are coming from traditional materials, the key thing is that traditional metallics and polymers are essentially isotropic; their properties are the same in all directions."

By contrast, long fiber ACM can be highly anisotropic; their properties can be highly directional. "That can be a huge advantage in design because you tailor the properties of the material to stress patterns in your composite," says McEnteggart. "From a design point of view, although you have that power, you have a much more complex set of parameters required to define that material and to model."

With anisotropic materials, a large set of parameters is required for complete characterization. Not only are the materials anisotropic, they are two-phase. There are fiber, matrix and fiber-matrix bonding properties. As a result, a range of mechanical tests is required to extract information on all those different parameters.

"With a traditional material such as a metallic material, the majority of the testing that would be done is simple tensile testing," says McEnteggart. "With complex materials, you need to perform tensile/multi-directional tensile tests. You need to conduct compression tests, shear tests and other specialist tests, like open hole bearing load tests."

FIG. 4: Instron hydraulic and electrodynamic fatigue testing machines allow customers to conduct fatigue tests.
Image courtesy of Instron.

The starting point for ACM testing is a versatile universal test machine.

"A universal test system can be fitted with a wide range of test accessories, which conform to ASTM and also other standards to carry out that range of tests," says McEnteggart.

In addition to multi-phase and anisotropic behavior, another aspect to these materials is their sensitivity to the environment. "They don't rust, but they are sensitive to humidity," explains McEnteggart. Usually the material is conditioned in the humid environment to absorb the moisture, and then tested at temperature but not under humid conditions.

While the universal tester can conduct the whole range of tests with the right fixturing, there are special considerations for the test processes.

"They are all fairly demanding," says McEnteggart. "They do all require accurate alignment to apply the load in the right direction." To accomplish this, the testing needs precise fixturing and, in some cases, a temperature-controlled environment, he cautions.

McEnteggart says he sees environment simulation, looking at the test environment more, fatigue testing, and greater concern for environmental factors, temperature and humidity as increasingly important factors for ACM.

"In addition to the static properties, there is a whole lot of complexity once you get into the world of fatigue," he concludes. "Because the materials are complex, the matrix of possibilities is just enormous." **DE**

Randy Frank *is a contributor to* DE. *Send e-mail about this article to DE-Editors@deskeng.com.*

INFO → AgustaWestland: AgustaWestland.com

→ **Instron:** Instron.com

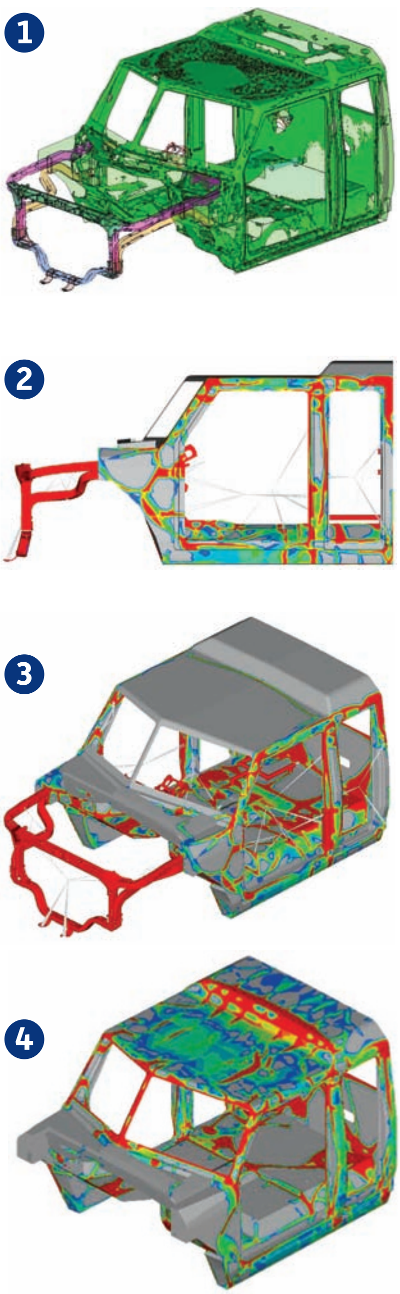
→ **Intertek Group plc:** Intertek.com

→ **Westmoreland Mechanical Testing & Research Inc.:** WMTR.com

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

Lighter Weight Makes Heavier Duty

TPI Composites and Altair ProductDesign help create an innovative, minimum mass composite structure for border patrol vehicles.



Defining the cab's design space (1). Optimizing and studying the shell's topology (2-4).

Off-road patrol vehicles are used to police the border between the U.S. and Mexico to restrict the number of immigrants attempting to enter the country illegally. The varied terrain between the two territories can be highly demanding on vehicles patrolling the area; they often need to drive at high speed over the rocky tracks.

The vehicles are put through a punishing series of use conditions, far beyond what a normal off-road vehicle would be expected to withstand. As a result, the current vehicles used by the U.S. border patrol services typically last just six months before they need to be taken out of service.

Recent prototype border patrol vehicles have aimed at improving upon the six-month lifespan of existing vehicles, while still meeting the required performance characteristics. While the results have been positive, further performance and lifespan improvements could be made by reducing weight to enhance the chassis durability. Improvements in this area could result in a reduction in the overall cost of ownership.

The U.S. Military Tank Automotive Research Development and Engineering Center (TARDEC) supported a project to explore the potential weight advantages of using composite materials as an alternative to traditional steels for a patrol vehicle's cabin and detainee box. The project was contracted to TARDEC's established composites development partner, the University of Delaware Center for Composite Materials (CCM). Because of the extensive scope of the project, CCM worked closely with TPI Composites and Altair ProductDesign to assist with the program.

Concept Optimization

TPI Composites has a wide experience of the application of structural composites products for the wind energy, military and transportation markets. By combining its composite materials experience with Altair ProductDesign's vehicle development expertise, a team was formed that could meet the challenges of creating lightweight, high-performance composite versions of the vehicle's driver cab and detainee box.

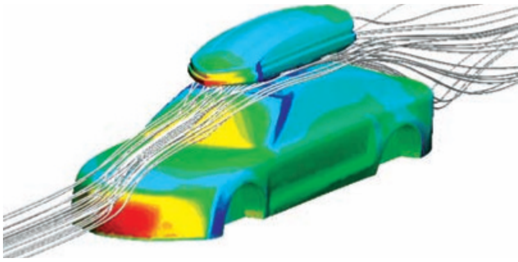
A constant requirement throughout the development process was to ensure that the end product be as lightweight as possible while still meeting performance targets. To achieve this goal, Altair ProductDesign performed a series of optimization studies that suggested where material was required in both structures and where it could be left out to save weight.

To perform the initial "concept optimization" process, the team used Altair's OptiStruct technology, the design optimization solution found within the Altair HyperWorks suite of simulation tools. In this process, performance targets and load cases that the vehicle would experience during a variety of use conditions were provided — along with the strength, stiffness and other characteristics of the composite material.

Finally, the design space was defined, outlining where the optimization technology can and cannot add material to meet the design requirements.

MORE ➜ deskeng.com/articles/aabkrn.htm

➜ For the complete application stories visit deskeng.com/fastapps



Precious Cargo

Thule leverages IMAGINiT's CFD analysis services to design a new cargo box.

Established in Sweden in 1942, Thule is a global company that designs and manufactures products that allow people to bring sports and other gear with them. Their product lines include roof racks, bike and water sport carriers, as well as rooftop cargo boxes.

The Challenge

Thule's design team was tasked with the tall order of producing a new design that would push the top end of the cargo box market. The outdoor industry trade show season required the new "Sonic" line to launch well before the spring cargo box purchasing surge. The combination of aesthetics and performance that Thule brings to cargo box design commands premium prices, so the designers wanted tangible performance improvements that would permanently raise the bar across the premium cargo box industry.

"People respond positively to our designs because they are both highly functional and visually beautiful," says Thule Product Manager Ian McLeran. "We knew that by leading in aerodynamics, we could benefit the cargo box consumer more than ever before, but we needed help to define the shape that would take us there."

Thule sought out IMAGINiT's Computational Fluid Dynamics (CFD) Analysis Consulting team because they wanted a local service provider that had CFD expertise with aerodynamic applications.

"We wanted to get almost instant feedback and make immediate progress," McLeran explains. "Our timeline was tight and the work performed would have an impact on everything downstream regarding this product line, so we needed to get answers fast. Tooling on thermoplastics is complex, and just a couple of extra days in turnaround would affect the whole project timeline. After speaking to the IMAGINiT team a couple of times, I could tell they understood our business and the specific goals of this project. There was frequent communication and discussion between our teams, and in the end it didn't feel like we were working with an outside company at all."

The Solution

Thule hired the IMAGINiT CFD team to work alongside its engineering and design staff ...

MORE → deskeng.com/articles/aabkrk.htm

Design in a Snap (Fit)

Novo Nordisk uses realistic simulation via Dassault Systèmes' SIMULIA software to improve the product integrity of injection pens, from design to manufacture.

Many medical conditions can be treated with tablets, but others require injections under the skin for therapeutic drugs to reach the bloodstream. In the case of insulin administration for diabetes treatment, patients need to self-inject the drug daily.

Making those injections easy and safe is of prime importance for Novo Nordisk, the Danish company that has been a world leader in the production of insulin ever since Canadian scientists discovered it in the 1920s. The company innovated beyond standard syringe technology to produce the world's first patient-friendly self-injection system, the NovoPen, some 25 years ago.

With more than 350 million diabetics worldwide — almost 5% of the global population — and growing, demand for insulin pens will likely remain strong into the foreseeable future. Because effective control of the disease is dependent on consistent use of the drug, these delivery systems need to be portable, easy-to-use, reliable, and even resistant to minor misuse by patients.

Small Device, Big Design Task

An insulin pen may be small, but it is a precision instrument with a number of complex parts that must work in tandem. Some pens are durable, containing a replaceable drug cartridge, while other disposable ones come pre-filled with the drug.

Injection typically involves twisting a short needle onto the pen, turning a dial to the required dose, and pushing a button to deliver the medication under the skin. After a given number of doses are injected, the cartridge is exchanged for a new one (with a durable device) or discarded (with disposable pens).

Audible clicks that occur at key stages of this procedure reassure the patient that he or she is engaging the device correctly at each step. It looks pretty easy, but every one of those reassuring clicks represents a challenge that has been overcome by the engineers who created the pens. So do the clicks the patient never hears: those that occur as the pen parts are assembled in the factory before use.

MORE → deskeng.com/articles/aabkrm.htm

→ For the complete application stories visit deskeng.com/fastapps

Impact, Drop and Crash Testing and Analysis

Impact analysis, virtual drop testing and virtual crash analysis are important finite element analysis tools in use throughout the vehicle, mobile phone, appliance and many other industries.

BY TONY ABBEY

Editor's Note: Tony Abbey teaches the NAFEMS FEA live classes in the United States, Europe and Asia throughout the year, and teaches e-learning classes globally. Contact tony.abbey@nafems.org for details.

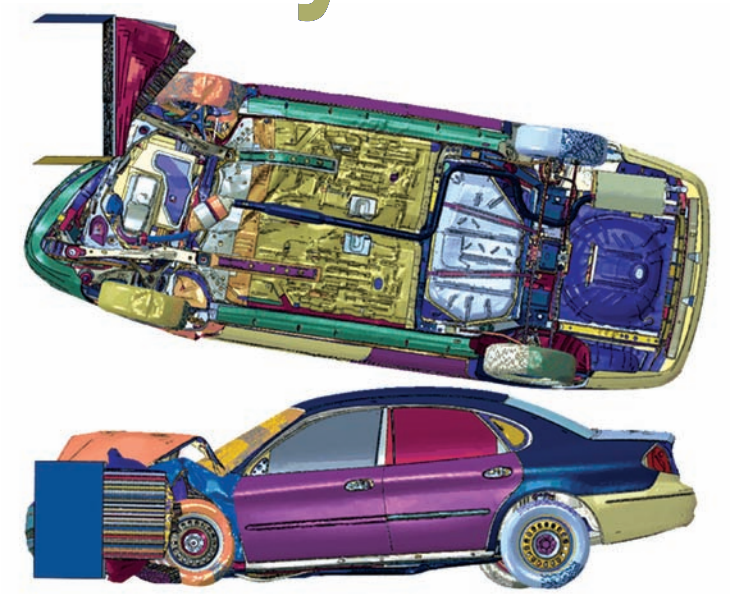


FIG. 1: Vehicle crash simulation. *Image courtesy of Dassault Systèmes SIMULIA and NCAC.*

Many companies have mature and well-understood techniques for simulating new products using such methods as impact analysis, virtual drop testing and virtual crash analysis. However, years of test and analysis correlation lie behind this. Companies new to the field now have user-friendly finite element analysis (FEA) tools, but the challenges of the fundamental engineering and simulation methods remain. Here are a few of the important areas to consider.

Impact Analysis

It is useful to consider vehicle impact speeds to describe the different physics involved and that we wish to simulate.

Consider a minor bump, such as overrunning a parking spot and hitting a lamppost. At around 5 mph, the resultant damage is not excessive. The hood may permanently buckle, and the front grille and bumper become dented. The simulation required here is relatively straightforward: We model the external contact between the lamppost and car, and also the internal contact between the car components. There may be as few as five or six.

Clearly, we need nonlinear material and plasticity — the bumper and hood are permanently deformed. The low impact speed is not producing strain rate effects in the material. We can assume there is no fracture or tearing present in the components. It is a dynamic situation, where the inertia effects of the vehicle and components are important. This all adds up to a nonlinear transient solution with straightforward contact, large displacements and material plasticity.

Alternatively, imagine a Formula One car hitting a crash barrier at 200 mph. At this speed, the strain rate effects of the materials involved are significant.

Strain rate can be demonstrated by using a lump of plastic modeling clay: Pull slowly to get one form of deformation; pull fast to get a completely different response. A large and complicated deformation of the structure results, with components contacting in unpredictable ways. Fracture or tearing of components and failure of bolts, spot welds and bond lines will also occur.

This all adds up to a highly nonlinear transient solution with complex contact behavior, large displacements, material plasticity and strain rate effects and failure of components and connections.

Implicit and Explicit Solution Choice

An initial objective in our analysis of any drop, impact or crash scenario is to assess what level of physical simulation we have to use. The first choice we have to make when considering the simulation technique is whether to use an implicit or explicit solution. Both methods are mainstream FEA simulation techniques, but they are very different in their backgrounds and implementation.

The low-speed vehicle bump could well be analyzed using an implicit solution, thanks to the simplicity of the contact scenario, lack of strain rate effects or material failure. If we can

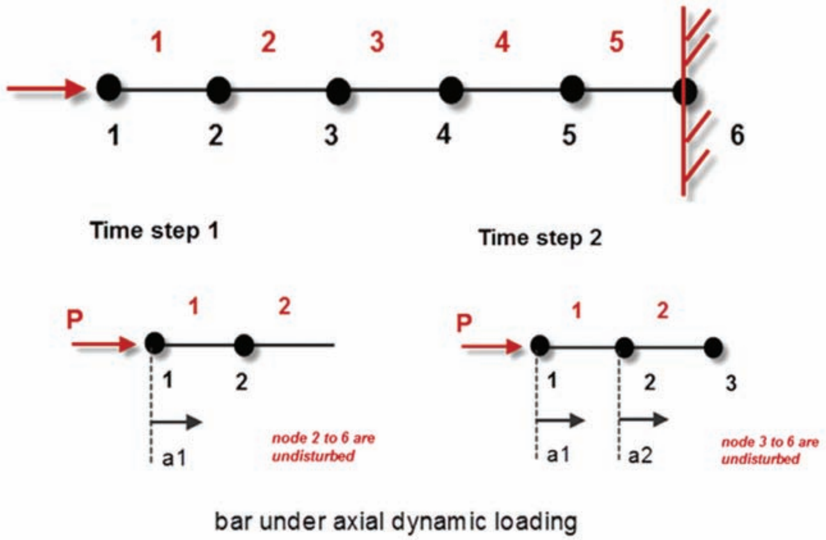


FIG. 2: Bar under axial loading, explicit approach.

use an implicit solution, there are some big advantages.

The high-speed crash, on the other hand, will require an explicit solution. Complex contact behavior, strain rate effects and component failure are all very much the forté of explicit solvers.

It is difficult to give an exact point at which we would migrate from an implicit to an explicit solver, but any object impact above 15 mph is probably in the explicit domain.

Implicit Solvers

FEA's traditional definition implies the implicit solution. The structure is idealized by finite elements and the stiffness and the mass of each is calculated. The overall structural representation is then created by assembling all element stiffness and mass terms into one big system matrix for solution. Displacements at each of the connecting nodal points are calculated. Dynamic analysis differentiates the displacement through time to get velocities, and the velocities to get accelerations. At each time step, stresses and strains are derived from displacements.

We can characterize this type of solution "heavy lifting" up front to solve for the system equations, and then use those equations in the subsequent time history analysis.

Explicit Solvers

An explicit solution is set up in a similar way to the implicit solution. We can even share the mesh between the two solutions if needed. However, the underlying process is different. Instead of solving a set of very large system matrices, elements and connecting nodes are treated on an individual basis.

For example, Fig. 2 shows a simple rod impacted at one end. The first node in contact sees the force being applied; it has mass. By using Newton's second law (force = mass x acceleration), we can calculate the acceleration. We can now calculate its velocity and displacement over a very brief time interval.

The first node will then impact the second node, transmitting a force and imparting acceleration. The acceleration, velocity and displacement of nodes 1 and 2 are updated — and so on. The fundamental calculation at each node is the acceleration. From this a velocity, and hence strain rate is derived. From this a strain, and hence stress is derived.

As mentioned above, we can characterize the explicit solution as needing no heavy lifting up front, but it does require a lot of housekeeping as we march forward. Accelerations are fundamental quantities, and strain rate effects are a key part of the process. Stresses and strains at a point in time require two lots of integration.

Advantages and Disadvantages

The big advantage of explicit solvers is that they handle highly nonlinear simulations required for many drop, impact and crash situations. In addition, complex material models are easily implemented. Without a fixed up-front system matrix calculation, the solution is very adaptable. Elements can be deleted from the solution, and tearing and fracture are easily modeled — as shown in Fig. 3.

The solution cost of the explicit model generally scales proportionally with size, in terms of number of elements or degrees of freedom. In the implicit solver, the solution cost is proportional to model size squared.

The disadvantages of an explicit solver include the time step size. This tends to be much smaller than the implicit solver, and is a function of the smallest element size and material density. We have to be cautious in modeling very fine detail: A tiny fillet, tooling hole or other unimportant feature can result in higher cost. Review the meshing strategy and the resultant mesh carefully.

Short events, with durations measured in milliseconds, are ideally suited for explicit analysis. Soft impact implies a long-duration event. If in the order of seconds, it can become a serious computational burden. A free-fall phase of a drop would never be modeled, for example. The object would be modeled in position, just prior to impact. The velocity and impact orientation must be carefully assessed. Rebounds are simulated by freezing the object so it has an inelastic response with rigid body mechanics.

Initial Loading State

Many impact events occur during operational loading conditions. For example, a bridge may have normal gravity and traffic loading at impact. We can't just apply the normal loading at time zero, as dynamic analysis starts with a bang. Traffic and gravity loading is impulsively applied at time zero, giving a dynamic response.

Two approaches are used to avoid this. In the first, the static load is slowly applied, ramping up over a long time. System damping dissipates dynamic response. After stable static load distribution is achieved, impact loading can begin. Keep in

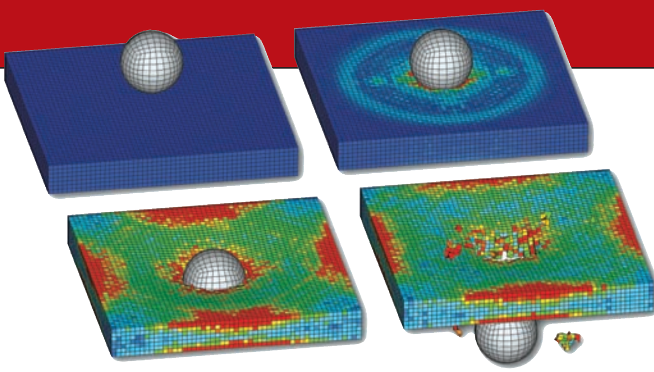


FIG. 3: Impactor penetrating through plate. *Image courtesy of NEi Software.*

mind, however, that it can take more resources to establish the static load distribution than to carry out the impact analysis.

An alternative uses implicit results from static loading of a common mesh. This is also ramped up to avoid dynamic response; however, it is often easier to use this approach. The tricky part is ensuring the stress and strain distribution is mapped accurately and appropriately to the explicit model.

Model Checking

An explicit solver is more versatile than an implicit solver because the large system matrices and cumbersome solution process are largely avoided. The main downside is that stability of the solution is not guaranteed.

Instability associated with element formulation results in hourglassing. This is an internal element mode that has no physical meaning. It can affect results and destroy the accuracy of the overall model. However, the energy associated with hourglassing can be plotted as a function of event time. Kinetic energy (due to motion) and potential energy (due to deformation) can also be plotted through time. The interchange of these energy forms — in total and on the component basis — are very valuable checks.

A checking technique for initial motion direction and contact orientation increases the density of all components by an arbitrary factor of, say, 100. This renders the analysis meaningless, but allows fast initial configuration verification because the time steps are 100 times bigger.

Checking will follow many aspects of implicit analysis, such as mesh distortion, cracks in the model, etc.

Data Output and Post-processing

An explicit solver has two streams of output. Full plot states are output sparingly to give an overall impression of the impact and subsequent behavior. XY plot data is typically a nodal or elemental result against time.

The nodes or elements have to be chosen up front, so it is important to review the model carefully and decide where this information will be most useful. This is a very good discipline, and is analogous to strain gauging. With good planning, a great deal of useful response information will be gathered.

Accelerations are a fundamental output; derived quantities such as displacement and stress are more approximate. In addition, the solution gives noisier output than an implicit solution. Responses are filtered to remove extraneous simulation noise. Stress contours will also be more ragged than implicit solutions. Care is needed with the interpretation of stress contours, etc., at a particular time step.

Predicting stress-based failure is complicated. The results are transient. It is a matter of interpretation whether sufficient energy has been absorbed by a bolt, for example, to cause actual rupture.

The uncertainties with filtering and failure prediction mean that comparative tests should always be made when using explicit analysis in a drop impact or crash scenario.

My recommendation when embarking on explicit analysis is to allow sufficient time to go up what can be a steep learning curve. Keeping in touch with reality is essential in what is a demanding level of simulation, so comparison with test or previous analysis should always be made. **DE**

Tony Abbey *is a consultant analyst with his own company, FETraining. He also works as training manager for NAFEMS. Send e-mail about this article to DE-Editors@deskeng.com.*

INFO ➜ FETraining: FETraining.com

➜ NAFEMS: NAFEMS.org/e-learning

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

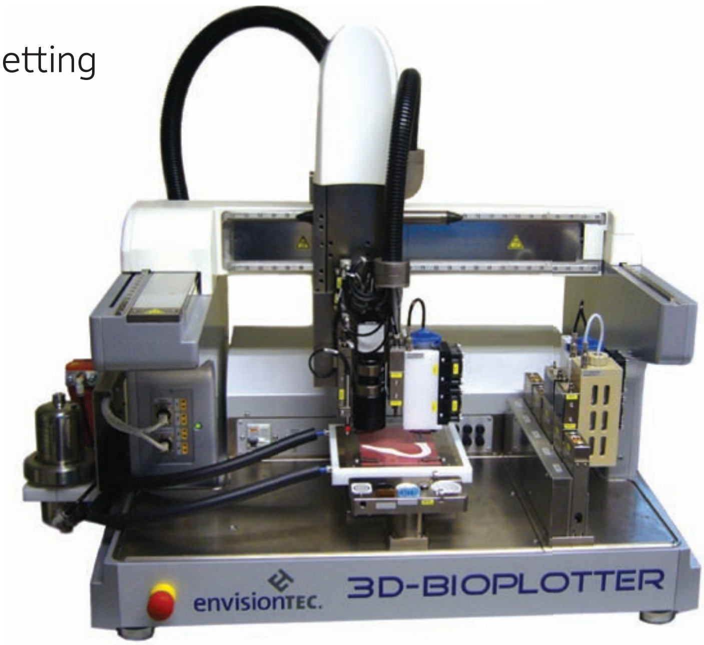
3D Bioprinting: Moving Beyond 2D Cell Culture

This approach to tissue engineering is getting really exciting (unless you're a robot).

BY PAMELA J. WATERMAN

Less than a decade ago, if you had searched online for "3D bioprinting," you would have found that the entries would pretty much all point to links at academic institutions, with the exception being pages from EnvisionTEC and nScrypt. Today, a similar search reveals an explosion of work on the subject — encompassing not only corporate-academic partnerships, but also week after week of popular news items explaining the latest progress toward printing functioning organic tissue.

Numerous biological functions, such as developing human tissue, forming human organs, healing wounds and maintaining a stable biological system, depend on the specific architecture of cells and matrix within a given tissue type. The scope of the field in which bioprinting plays a role includes the combination of living cells, with or without supportive scaffoldings, and the technologies that make such creations viable.



EnvisionTEC 3D Bioplotter, showing one material cartridge in use, and two additional material cartridges at the right side. Five cartridges can be used to create elements of a single build. ***Image courtesy of EnvisionTEC.***

In the Beginning

How did this new field of science and engineering progress so far in such a short time? Some of the earliest work went on behind the scenes in the 1990s, when a handful of companies and university researchers started using software-driven dispensers to create carefully assembled cell structures. EnvisionTEC, a German-based company with a strong North American presence, began developing its 3D-Biplotter in 1999; it installed the first commercial unit in 2001. The company is also known for its additive manufacturing (AM) systems based on Digital Light Processing (DLP) projection; scan, spin and selectively photocure (3SP) technology; and liquid resins.

The 3D-Bioplotter system uses a syringe-type dispenser, driven by air pressure, to deposit a wide range of materials that build up and fill/coat well-defined structures. Interchangeable cartridges can be loaded with up to five materials for use in one build. For soft-tissue biofabrication and creating 3D structures that mimic human organs, users can load a dispenser with (but not limited to) living cells, agar, gelatin, chitosan, collagen, alginate or fibrin. For investigations into bone regeneration enhanced by growth-stimulant medications, researchers can combine hydroxyapatite and tricalcium phosphate particles with various resorbable scaffold structures. They can even produce pure ceramic objects.

"The Bioplotter is now in its fourth generation, introduced in 2009," notes Carlos Carvalho, who is currently lead engineer at EnvisionTEC for process and development. "The accuracy has increased from 50 microns to 1 micron, and reproducibility has also increased, so these systems are now being used in production facilities."

Carvalho adds that customers are free to choose their materials, many of which are approved by the U.S. Food & Drug Administration (FDA): "The Bioplotter is an open system, so users can control temperature, pressure and speed as desired."

Build volume for the 3D-Bioplotter is 6x6x5.5 in.; typical structures are created in grid or cylinder form on a baseplate that can be heated or cooled. Customers include Northwestern University and North Carolina State University.

Another relevant company you may not have encountered is nScrypt, a Florida-based resource for 3D conformal printing tools that has also been developing and marketing tissue-engineering (TE) systems since the early 2000s. The TE subseries of nScrypt's Tabletop dispensing tool is a laboratory-ready system that can build true 3D scaffolds of cell clusters, with varying sizes for precise placement and layering. Users can vary the microporosity depending on materials and printing commands, and dispense materials with viscosities that range from a few centipoise to 1 million centipoise.

nScrypt terms its technology computer-aided biology/computer-aided manufacturing (CAB/CAM), and offers an interesting perspective on how it can support great developments in tissue engineering.

"We can lay down high-definition cells and matrix, or just a matrix itself, and generate a complex three-dimensional structure that very closely mimics the microarchitecture found in the body," explains Cynthia Smith, an nScrypt bioengineer.

Build volume for the Tabletop system is 12x6x4 in. A particularly helpful aspect of the system is that nScrypt's software interface is designed for bio-oriented users, not computer scientists or traditional CAD experts. The website includes an extensive list of bioprinting materials and their properties.

During this same timeframe, Stuart Williams, Ph.D., was also working on the 3D bioprinting challenge. As founder of the Biomedical Engineering program at the University of Arizona, where he was a professor, he used nScrypt dispenser pumps to build the first version of what he called the BioAssembly Tool, or BAT. With it, Williams 3D-printed one of the earliest examples of a microphysiologic system: a section of lymph node tissue about the size of a dime, deposited into a Petri dish. It was evaluated *in vitro* and responded to stimuli.

Williams now serves as the executive and scientific director at the Cardiovascular Innovation Institute, a joint collaboration of the University of Louisville and the Jewish Heritage Fund for Excellence. The BAT system, which won an R&D 100 award in 2004, now operates in its next-generation form and is in daily use.

One of Williams' current projects is working toward creating a total "biofícial" heart built from a patient's own cells, to serve as a cure for cardiovascular disease. First steps include printing and organizing tissue grown in the lab to build networks of small blood vessels. Thanks to a 2007 grant from the National Institutes of Health (NIH), his group recently printed and implanted some of these vessels and heart tissue into mice.

Discussions of 3D bioprinting must include mention of the work by Thomas Boland, Ph.D., who, in 2004 (then at Clemson University), showed that producing cardiac tissue with off-the-shelf inkjet technology can be improved significantly by using simultaneous scaffold-building and precise cell placement. Previously, a less-efficient process was used to add cells to prefabricated scaffolds.

A jawbone scaffold. *Image courtesy of EnvisionTEC.*

The Commercial Viewpoint

One 3D bioprinter that's making a splash in the public eye is the MMX bioprinter from Organovo of San Diego. Founded in 2007, Organovo and its products are the outgrowth of 3D organ-printing research work led by Gabor Forgacs, Ph.D., director of the Frontiers of Integrative Biological Research Program at the University of Missouri, Columbia.

While the hope is to eventually create actual human organs, Organovo's current work fills an important gap in the development of new drugs. The MMX bioprinter, running with what's termed the NovoGen process, creates three-dimensional structures that replicate the native form and function of real human tissues. That means biomedical researchers could potentially use the tissue to test drugs or investigate the effect of certain diseases, bridging the gap between in vitro single-cell cultures and larger-scale animal studies.

Michael Renard, executive vice president of Organovo's

More than Just a Printing Project

Researchers at Organovo understand that the physical construction of 3D biostructures is just the first step. Growing human cells outside the protective, nurturing environment of the body is definitely a challenge.

Michael Renard, vice president of Organovo, talks about making the process viable: "Not only does printing using living bio-inks need to be carefully controlled in order to prevent harming the cells, but the post-printing care and feeding of 3D tissue constructs is also very important. Through proprietary processes, we ensure that essential nutrient, gas composition, sterility and temperature requirements are met and carefully controlled.

"There are really two steps in forming any tissue: One is the fabrication process itself, and the other is the maturation/conditioning of that structure over the course of a couple of days to a week or more," he adds. "Maturation requirements are very tissue-specific, and we do spend time working out the proper media and conditioning regimen for each tissue."

The scope of these post-processing requirements would seem to make 3D bioprinting not for the faint of heart. But, if you've been waiting to try this at home, stay tuned to HyRel 3D (hyrel3d.com). The company says it is working on adding a bioprinting extruder to its Kickstarter-funded system.

—*PJW*

One of Organovo's tissue engineers oversees the construction of a vascular tissue construct on the Novogen MMX Bioprinter. ***Image courtesy of Organovo.***

The Novogen MMX Bioprinter prints fully human, architecturally correct 3D tissue in a variety of different formats — in this particular case, into multi-well plates. Bio-ink or hydrogel can be dispensed from each of two printheads. ***Image courtesy of Organovo.***

commercial operations, explains the process: "We print scaffold-free using biological building blocks (bio-ink spheroids) composed of human cells and/or mixtures of human cells and appropriate proprietary hydrogels. Our first-generation printer has two materials on deck at any one time, and additional materials are switched in during the printing process as needed. Printing is generally conducted at room temperature — although the printer does include temperature control, which is required for some of our proprietary materials."

The bio-ink spheroids eventually fuse together, rearranging themselves to into appropriately functioning regions, such as fibroblasts migrating to the outside of functioning blood vessel tissue. The resulting tissue can be 20 cell layers thick.

Renard points out that Organovo definitely understands the challenges inherent in dealing with living cells — and so worked with dispenser developer nScrypt, system manufacturer Invetech and cell provider Zenbio to move beyond 2D cell culturing to 3D printing.

"Our bioprinting process incorporates unique features that ensure successful creation of functional tissues, such as low-shear deposition mechanisms and fabrication speeds, that are rapid enough to prevent destruction of the bioprinted tissue due to nutrient or oxygen deprivation," he explains.

The company has been in the news quite a bit in recent years regarding a number of its research topics, one of which is the combination of three types of liver cells into a three-dimensional structure similar to that found in a human liver. It's not yet an actual, transplantable liver, but it possesses critical liver functions, including albumin production and enzymatic activities, so the direction is hopeful. Organovo provides its technology on a selective basis to strategic collaborators; its 3D bioprinting technology has already been honored as one of the "50 Best Inventions of 2010" by *TIME* Magazine.

Worldwide Research

Another major researcher involved in 3D bioprinting is Dr. Anthony Atala, director at the Wake Forest Institute for Regenerative Medicine (part of the Wake Forest Baptist Medical Center, an academic medical center in Winston-Salem, NC). The Center's goal is to apply the principles of regenerative medicine to repair or replace diseased tissues and organs. Atala is known to the public for giving several TED talks in 2009 and 2011 discussing growing complete human organs such as a kidney. His group has already created an artificial bladder by coating a laboratory-grown (but non-3D-printed) structure with a patient's own cells.

Now Atala's group is working with its own type of 3D bioprinter. It's an adapted version of ink-jet printing technology to build and study a variety of bioprinted applications, including on-site "printing" of skin for soldiers with life-threatening burns.

Here's a sampling of other 3D bioprinting efforts currently underway:

- Cornell University — Lawrence Bonassar, Ph.D., is 3D-printing replacement intervertebral spinal discs, with successful results in lab rats. He has also printed collagen/cartilage ears.
- Oxford University — Hagan Bayley, Ph.D, Gabriel Villar and Andrew Heron have constructed materials via computer-control resembling biological tissues that consist of thousands of connected water droplets. The droplets are encapsulated within lipid films, and can carry out the functions of tissues.
- University of California, San Diego — Nanoengineer Shaochen Chen, Ph.D., is using dynamic optical projection stereolithography (DOPsL) to generate microscale 3D blood vessels. The approach uses a computer projection system and micromirrors to direct light onto selected areas of photosensitive biopolymers and cells.
- University of Toyama Facility of Lifescience and Engineering, Japan — In the late 2000s, Makoto Nakamura, Ph.D., used an Epson printer to print cells into bio-tubes similar to blood vessels; he continues to develop this process.
- University of Michigan — At C.S. Mott Children's Hospital, pediatric ear, nose and throat specialist Dr. Glenn Green and biomedical engineer Scott Hollister, Ph.D., 3D-printed a biodegradable plastic splint to provide a growth-structure support for an incomplete bronchus in a three-month-old boy. At press time, the now-toddler is doing fine.
- Massachusetts Institute of Technology — Linda Griffith, Ph.D., is continuing work begun by Therics using the MIT-patented 3DPrinting process, on microscale engineering of tissues and organs.
- University of Kentucky — Master's student Amanda Peter Hart worked with bioactive resorbable silica-calcium phosphate nanocomposite, processed using a 3D rapid prototyping technique and sintered at different temperatures to create porous scaffolds. The project produced ulna bones for implant in rabbits.

CAD for Bioprinting

With all this varied activity, it probably makes sense that in December 2012, Organovo partnered with Autodesk Research to explore the integration of Autodesk software capabilities with the tissue fabrication hardware. Their work centers on designing a new user interface. So far, the program is for internal development only, but it demonstrates how this field is attracting mainstream interest. **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.*

Resources:
Journals and magazines for further reading: *Biomaterials, Biofabrication, Tissue Engineering* and *Trends in Biotechnology.*

INFO → Cardiovascular Innovation Institute: CV2i.org/research-programs/regenerative-medicine

→ **Clemson University:** Clemson.edu

→ **Cornell University:** Cornell.edu/portraits/lawrence-bonassar

→ **EnvisionTEC:** EnvisionTEC.com

→ **Invetech:** Invetech.com.au/portfolio/life-sciences/3d-bioprinter-world-first-print-human-tissue

→ **Massachusetts Institute of Technology:** web.MIT.edu/lgglab/research

→ **nScrypt:** nScrypt.com

→ **Organovo:** Organovo.com

→ **Oxford University:** Bayley.chem.ox.ac.uk/hbayley

→ **University of Arizona:** bme.Arizona.edu

→ **University of Kentucky:** uknowledge.UKy.edu/gradschool_theses/199/

→ **University of Louisville:** Louisville.edu/speed

→ **University of Missouri:** Organprint.Missouri.edu

→ **Wake Forest Institute for Regenerative Medicine:** WakeHealth.edu/WFIRM

→ **Zenbio:** Zen-bio.com

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

And the New Speed Champ Is…

The Ciara Kronos 800S single-socket system beats all previous workstations.

BY DAVID COHN

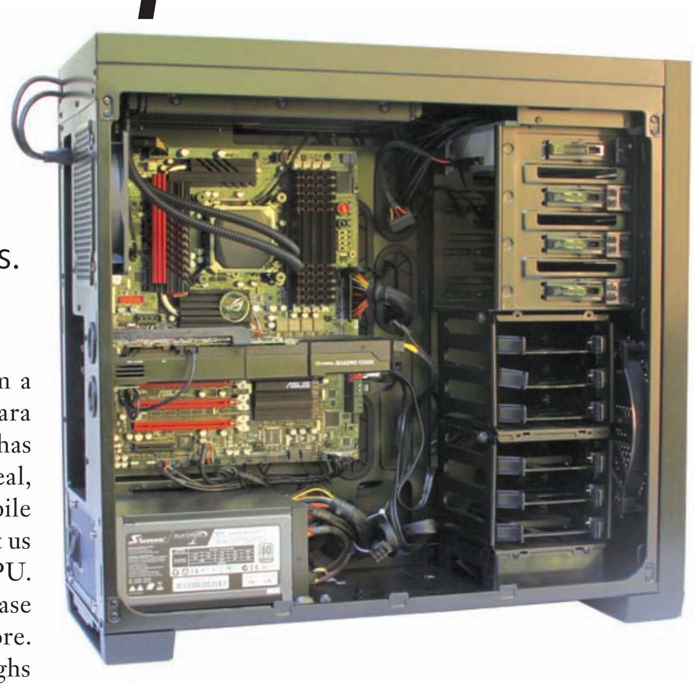
We recently received a new workstation from a company we had never reviewed before. Ciara Technologies, a division of Hypertec Group, has been around since 1984. Based in a suburb of Montreal, the Canadian company sells systems ranging from mobile devices to high-end supercomputers. The company sent us a Kronos 800S based on a single over-clocked Intel CPU.

The Kronos 800S comes housed in a large tower case — and had a number of features we've never seen before. The all-black case measures 9 x 21.5 x 20.5 in., and weighs in at 39 lbs. Four accessible drive bays are centered in the upper portion of the front panel, with a removable air intake grille below covering an 8-in. fan. The grille also includes a small Ciara logo.

The top-most bay contains a DVD+/-RW drive. Above this, a space equivalent to another bay houses a large round power button, a smaller reset switch, and a hidden panel that hinges open to expose two USB 3.0 ports, two USB 2.0 ports, headphone and microphone jacks, and an IEEE 1394 FireWire port. Curiously, when I first attempted to use the front-panel USB 3.0 ports, they didn't work.

Because of the lack of any type of product manual, a small panel on the top of the system also puzzled me. This panel can be slid open, to expose what turned out to be a hot-swappable plug-and-play hard drive port. The top of the case also has a large grille over a pair of 4.5-in. cooling fans — part of the CPU cooling system.

The rear panel offers an abundance of ports, including eight USB 3.0 ports, two eSATA ports, a PS/2 keyboard/mouse combo port, six audio jacks (line-in, front, center/subwoofer, side and rear speakers) plus an S/PDIF out port, two RJ45 network connections, and one USB 2.0 port that can also be switched to become a Republic of Gamers (ROG) Connect port that can then be used to connect the system to another PC from which you can tweak the speed of the system. There are also buttons for clearing CMOS, toggling the ROG Connect port, and turning the Bluetooth module on and off.



The interior of the Kronos 800S. Note the liquid cooling system, as well as the two USB cables routed to rear USB ports to activate the USB 3.0 ports in the front panel. ***Image courtesy of David Cohn.***

There was also a pair of USB cables extending out from a small hole near the top of the rear panel. After puzzling over these cables for a while, we finally contacted Ciara and learned that they extend from the two front-panel USB 3.0 ports. They are meant to be plugged into rear-panel USB ports if you want to be able to use the two front-panel ports.

Bring on the Power

Removing the side panel reveals a spacious, well-organized interior. In addition to the four front-panel drive bays, there are also six internal drive bays. In our evaluation unit, two of those bays contained identical 250GB Samsung solid-state drives (SSDs) configured as a redundant array of independent disks (RAID) 0, so that the two drives appeared as a single 500GB hard drive. Had these been standard mechanical hard drives, we would have reminded readers that although a RAID 0 can improve hard drive performance, it also doubles the risk of data loss (the failure of either drive results in a total drive failure). But with the mean time between failures (MBTF) of SSDs measured in millions of hours, that's probably not an issue here.

The system also supports RAID 1, 5 and 10, and Ciara offers other hard drives ranging from 500GB to 2TB. A Seasonic 1,250-watt 80 Plus Gold power supply, located in the bottom rear of the case, provides more than enough power for any expansion needs.

The Ciara Kronos 800S is built around an ASUS Maximus IV Extreme-Z motherboard and an Intel Z68 chipset. A single CPU socket supports Intel second-generation Core i7 and Core i3 processors, but Ciara doesn't offer any choices. All Kronos 800S systems come with an Intel Core i7-2700K CPU. While Intel specs this quad-core processor at 3.5GHz, Ciara over-clocks its systems to 5.0GHz. The processor rests beneath a liquid cooling system, with its hoses routed to a large radiator located at the top of the case. The fans in that radiator can be seen below the grille on the top of the case.

The motherboard provides four dual in-line memory module (DIMM) sockets, all of which were filled with 4GB DDR3 modules, for a total of 16GB of RAM. The Ciara website indicates that this is the standard Kronos 800S configuration, and does not list any other memory options.

The motherboard also provides a total of six expansion slots: four PCIe 2.0 x16 slots (three of which can house graphics cards) plus a PCIe 2.0 x4 and a PCIe 2.0 x1 slot. One of the x16 slots in our evaluation unit contained an NVIDIA Quadro K5000 GPU, offering two DVI and two display ports, plus a stereo 3D connector routed to an adjacent expansion port back panel bracket. According to the Kronos 800S spec sheet, Ciara also offers other GPU options, including the Quadro 2000, 4000, or 6000, as well as up to two NVIDIA Tesla cards.

Bring on the Noise

With its CPU over-clocked by nearly 43%, we certainly weren't all that surprised when the Kronos 800S turned in the fastest benchmark results we've ever recorded. But on

Workstations Compared

		Single-Socket Workstations				Dual-Socket Workstations	
		Ciara Kronos 800S one 3.5GHz Intel Core i7-2700K quad-core CPU over-clocked to 5.0GHz, NVIDIA Quadro K5000, 16GB RAM	**Lenovo E31 SFF** one 3.3GHz Intel E3-1230 quad-core CPU, NVIDIA Quadro 400, 8GB RAM	**Lenovo S30** one 3.6GHz Intel Xeon E5-1620 quad-core CPU, NVIDIA Quadro 4000, 8GB RAM	**HP Z1** one 3.5GHz Intel Xeon E3-1280 quad-core CPU, NVIDIA Quadro 4000M, 16GB RAM	**BOXX 8980 XTREME** two 3.1GHz Intel E5-2687W eight-core CPUs over-clocked to 3.82GHz, NVIDIA Quadro K5000, 64GB RAM	**HP Z820** two 3.1GHz Intel Xeon E5-2687W eight-core CPU, NVIDIA Quadro 5000, 32GB RAM
Price as tested		$5,714	$1,093	$2,614	$5,625	$13,454	$9,984
Date tested		5/31/13	12/29/12	8/18/12	6/29/12	5/9/13	7/16/12
Operating System		Windows 7	Windows 7	Windows 7	Windows 7	Windows 7	Windows 7
SPECview 11	higher						
catia-03		96.39	18.15	48.21	39.46	78.01	51.69
ensight-04		83.26	11.08	32.18	26.19	80.25	44.13
lightwave-01		103.15	46.79	64.47	60.76	77.07	59.02
maya-03		153.01	40.36	84.50	78.65	125.16	101.67
proe-5		22.87	10.29	11.93	12.69	16.14	11.72
sw-02		84.51	31.54	53.53	47.24	67.16	57.48
tcvis-02		77.82	16.53	37.66	30.79	71.58	44.52
snx-01		83.21	13.25	33.87	27.70	81.35	44.86
SPECapc SolidWorks 2013	Higher						
Graphics Composite		3.89	n/a	n/a	n/a	2.69	2.15
RealView Graphics Composite		4.1	n/a	n/a	n/a	2.86	2.37
Shadows Composite		4.1	n/a	n/a	n/a	2.86	2.36
Ambient Occlusion Composite		8.37	n/a	n/a	n/a	6.16	5.19
Shaded Mode Composite		3.79	n/a	n/a	n/a	2.62	2.27
Shaded With Edges Mode Composite		3.98	n/a	n/a	n/a	2.77	2.03
RealView Disabled Composite		3.15	n/a	n/a	n/a	2.11	1.45
CPU Composite		4.92	n/a	n/a	n/a	4.84	4.50
Autodesk Render Test	Lower						
Time	Seconds	58.33	64.00	63.80	87.92	38.00	41.00
Battery Test	Higher						
	Hours:min	n/a	n/a	n/a	n/a	n/a	n/a

Numbers in blue indicate best recorded results. Numbers in red indicate worst recorded results.
Results are shown separately for single- and dual-socket workstations.

the SPECviewperf test, which focuses solely on graphics performance, the Kronos 800S wasn't just faster, it was nearly twice as fast as the fastest single-socket workstation we've tested to-date — and 18% faster than the fastest dual-socket system.

For our SolidWorks test, we recently switched to the new SPECapc SolidWorks 2013 benchmark. As a result, we don't have that many systems yet with which the Kronos 800S can be compared. But stacked up against those systems we have been able to test thus far, the overclocked CPU boosted the Ciara workstation's SolidWorks performance by approximately 43%, as expected.

It was only on the AutoCAD rendering test, which clearly shows the advantages of multiple fast CPU cores, that the Kronos 800S didn't beat the field. It was still the fastest single-socket workstation we've ever tested, however, completing the rendering in 58.33 seconds.

Curiously, when the Kronos 800S arrived, Ciara had configured it with hyper-threading disabled. We were able change that in the basic input-output system (BIOS), but it was a strange aspect of this workstation. The system also arrived without a keyboard or mouse — and indeed, Ciara only offers these as extra-cost options. However, the Ciara website does not actually list options. Apparently, customers are supposed to use an email link to request price quotes.

We were also curious about Ciara's claim that the 800S has an "ultra-quiet noise level." When we powered on the Kronos workstation, those two fans on the top of the system — plus the other fans on the rear panel, front panel, GPU and power supply — caused the noise level in our lab to go from around 34dB to 64dB, an increase of 3X. For comparison, consider that conversation in a restaurant averages around 60dB; the sound of a vacuum cleaner or standing 50 ft. from a busy freeway would be around 70dB. Quiet? No.

Ciara quoted a price of $5,983 when it first shipped us the Kronos 800S. By the time we reviewed it, however, the price had been reduced to $5,714. That cost includes Windows 7 64-bit Professional, but no input devices. Ciara's warranty covers all parts for three years and provides support Monday through Friday from 9 a.m. to 6 p.m., Eastern Time.

It may not yet be a household name, but Ciara certainly knows how to build an incredibly fast workstation. **DE**

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

INFO ➔ Ciara Technologies: CiaraTech.com

Ciara Kronos 800S

- **Price:** $5,714 as tested
- **Size:** 9.0 x 21.5 x 20.5-in. (WxDxH) tower
- **Weight:** 39 lbs.
- **CPU:** Intel Core i7-2700K (quad-core) 3.5GHz (over-clocked to 5.0GHz)
- **Memory:** 16GB DDR3 at 2,133MHz
- **Graphics:** NVIDIA Quadro K5000
- **Hard Disk:** Two 256GB Samsung 840 PRO SSD (configured as RAID 0), six internal drive bays
- **Optical:** DVD+/-RW Dual-Layer
- **Audio:** Integrated Realtek ALC898 7.1 channel high-definition audio (microphone and headphone on front panel with jack re-tasking; microphone, line-in, front, center/subwoofer, side, and rear speakers, plus S/PDIF out on rear panel)
- **Network:** integrated 10/100/1000 LAN with two RJ45 sockets
- **Other:** Two USB 2.0, two USB 3.0, one IEEE 1394 (FireWire) on front panel; eight USB 3.0, one USB 2.0 (switchable to ROG Connect), two eSATA, and PS/2 keyboard/mouse combo port on rear panel; Bluetooth module; hot plug-and-play hard drive port on top panel
- **Keyboard:** none
- **Pointing device:** none

Advertising Index

Storage Is Key to HPC

Often overlooked in the bandolier of high-performance computing components is storage, where speed equals results and reliability equals success.

BY FRANK J. OHLHORST

There is much more to high-performance computing (HPC) than raw processing power. After all, all the teraflops in the world don't add up to much if you can't feed data in and out of the system fast enough. Nowhere is that axiom more applicable than in the world of storage, where network attached storage (NAS), storage area networks (SANs) and local storage devices feed a hungry HPC environment.

All storage is not created equal. Different types of storage solutions are applicable for different types of applications. Vendors of storage technology are keenly aware of those nuances and are striving to offer solutions that can balance speed against scale. One of the more important elements affecting HPC storage today is the increased adoption of Lustre, a parallel-distributed file system, generally used for large-scale cluster computing. Lustre derives its name from the combination of Linux and cluster, is commonly used with supercomputers, and is highly scalable.

Lustre can support multiple compute clusters with tens of thousands of client nodes, tens of petabytes (PB) of storage on hundreds of servers, and more than a terabyte per second (TB/s) of aggregate I/O throughput. That makes the Lustre file systems a popular choice for businesses with large data centers.

Of course, there are multiple paths of delivering stored data to HPC solutions. The type of HPC environment in use normally dictates those paths. For example, a single HPC cluster or workstation may benefit most from local storage, in the form of cache cards and internal negated and (NAND)/ solid-state drive (SSD) options. Other environments, such as those used for big-data analytics, where multiple systems participate in the parsing of data, normally leverage SAN- or NAS-based file systems that distribute data across multiple machines.

When it comes to HPC and storage, there is no-one-size-fits-all solution, although vendors are developing platforms that can be used across as many scenarios as possible.

The Vendor Battlefield

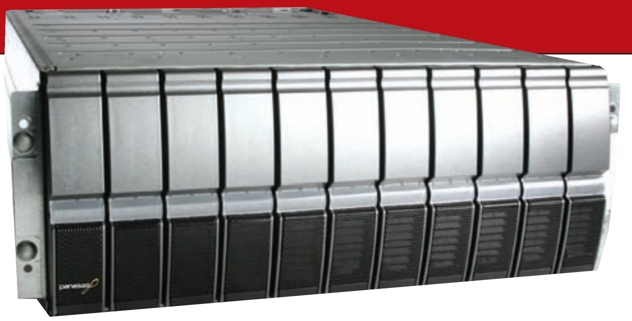
Dozens of vendors dominate the field of high-performance storage solutions, many offering their own take on how storage should interact with HPC jobs. Some of those differences are subtle, while others entail a paradigm shift that reinterprets how data flows to and from storage devices on the network.

Take, for example EMC, which offers its Isilon storage platform for HPC environments. EMC's Isilon is designed as a NAS solution. The advantages offered by NAS over SAN are debatable; however, in Isilon's case, NAS hits its stride in scalability (as much as 15 petabytes per cluster), speed (more than 100 gigabytes per second throughput) and flexibility (data replication, failover, fallback, hot swap drives).

EMC Isilon Platform Nodes and Accelerators offer scale-out network-attached storage that promises to increase performance for file-based data applications and workflows.

Isilon natively supports the Hadoop Distributed File System (HDFS) and offers support for many industry standard protocols.

EMC competitor NetApp offers several options under its E-Series Storage Platform, the latest of which is the NetApp E5500, a module storage system that is available in either 2Uor 4Uform factors, with the ability to hold as many as 60 drives, for a stacked



The Panasas ActiveStor parallel storage systems are available in a variety of configurations, including shelves and racks.

total of 360 drives. The E5500 series sports eight 6GB serial attached small computer system interface (SAS) and four 40GB InfiniBand ports, and uses a SAN ideology for connectivity into the network. NetApp say the E5500 Series offers performance 2.5 times faster than competitors, and reports the platform can deliver 8,855.70 SPC-2 MB/s. (SPC-2 is the latest tested methodology used by the vendor-neutral Storage Performance Council.)

Other hardware manufacturers, such as Supermicro, also offer storage solutions for the HPC market. The company offers several products, many of which are adaptable to HPC storage needs. Take, for example, the company's 3Urackmount SuperServer series, which can house 16 3.5-in. hard drives. Supermicro's storage unit features multiple network connectivity controllers, such as dual 10 Gigabit Ethernet interfaces. Supermicro's storage solutions allow buyers to custom configure the servers and integrate them into the HPC network. Other offerings from Supermicro include a product line of SuperStorage Solutions, which are available as stackable 2U, 3U and 4U form factors.

Industry giant HP has long been a player in the HPC field, offering everything from servers to data center-level processing to software solutions. HP tackles the HPC storage market with the X9000 series of storage products. The X9000 scales up to a 5U enclosure that can house 70 drives, and can be configured to offer as much as 16 petabytes of storage. HP offers its own StoreAll OS, which can integrate 1,024 nodes into a single global namespace to simplify management.

Dell is offering its Terascala HPC Storage Solution to HPC operators. The company claims that performance reaches 6.2GB/s read and 4.2GB/s write sequential throughput per each active/active base object storage server pair. It sells the Terascala as a "complete, pre-configured and tested solution and provides on-site installation, configuration and customer training to help minimize deployment time." Its management software simplifies Lustre-based storage management.

Specialty vendor Fusion-io offers multiple products for the HPC market. However, when it comes to storage, it is pretty hard to ignore the company's Acceleration line of products. When speed is a primary component for HPC, Fusion-io offers Direct Acceleration hardware, which comes incorporated into hardware cards designed for PCI slots. Several different cards are available; all feature integrated NAND flash hardware and storage. As a card-based solution, Fusion-io's acceleration technology is designed for individual servers and workstations, eliminating much of the latency that is found in NAS- or SAN-based solutions.

Boutique vendor Padova Technologies offers customized supporting products for HPC environments. Along with the company's HPC cluster and supercomputing products, Padova markets its enterprise SAN, redundant array of independent disks (RAID) and storage systems. At the top of Padova's storage pinnacle is the Infortrend ESVA Enterprise Storage product line, which incorporates Fibre Channel and iSCSI SAN connectivity. However, Padova's top contribution to the HPC market comes from the company's N-series of servers and cluster solutions, which incorporate high-speed local storage to accelerate HPC tasks.

HPC storage vendor Panasas has made a name for itself with its Activestor line of products. Activestor offers multiple shelf configurations that provide as much as 168GB of cache per shelf, and address as much as 83TB per shelf. The shelves are also available as customized implementations, tuned for a given HPC environment. The company offers its PanFS operating system, which enables high-speed, parallel access to a single file system via DirectFlow, NFS and CIFS protocols.

A well-known name in personal computing storage, Western Digital recently shipped its first rack-mount storage system. The WD Sentinel RX4100 is a 1U rack-mount storage server targeted at smaller businesses. It promises simplified connectivity, automated back-up and restore, and collaboration via its "on-premise cloud storage" accessibility. The Sentinel RX4100 comes in 8TB, 12TB and 16TB configurations with pre-installed Western Digital hard drives that are factory configured in RAID 5.

Of course, the vendors mentioned here are only a sample of what is becoming a large market segment. After all, fast storage systems are needed by more than just the HPC environments of the world, especially with the growth of cloud services, virtualized data centers and virtual desktop infrastructures, all of which need speed, economy, scale and ultimately — reliability. **DE**

Frank Ohlhorst *is chief analyst and freelance writer at Ohlhorst.net. Send e-mail about this article to DE-Editors@deskeng.com.*

INFO ➜ **Dell:** Dell.com

➜ **EMC:** EMC.com

➜ **Fusion-io:** Fusionio.com

➜ **Hewlett Packard:** HP.com

➜ **Lustre:** Lustre.org

➜ **NetApp:** NetApp.com

➜ **Padova Technologies:** PadovaTech.com

➜ **Panasas:** Panasas.com

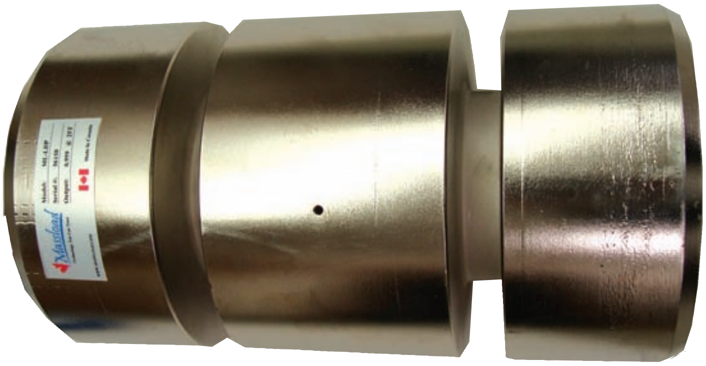
➜ **Storage Performance Council:** StoragePerformance.org

➜ **Supermicro:** Supermicro.com

➜ **Western Digital:** wd.com

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

Watching Your Weight



What design engineers need to know about measuring weight or force with load cells, load pins and tension links.

BY DEL WILLIAMS

In industries from mining and manufacturing to construction, transportation and agriculture, the need to weigh or measure inputs, outputs and applied force has grown in recent decades to improve production safety and control costs.

"Design engineers are responding as complex systems such as mine lift equipment, construction cranes, industrial tanks, grain silos and locomotives — which may have lacked weight or force-sensing capability in the past — are being upgraded to include load pins, load cells and tension cells," says Riley Phillips, a mechanical designer at Massload, a Saskatoon, Saskatchewan-based manufacturer of weighing systems. "These sophisticated weight- and force-sensing devices can help maximize production load efficiency, while offering some of the enhanced safety features that are increasingly required by regulation, such as automatic shutdown if a load exceeds capacity."

What follows is a quick primer on what design engineers should know about measuring weight or force with load cells, load pins and tension links (also known as tension cells) — and why working and consulting with the right vendor partner can be a critical choice in the process.

The Basics

A load cell is a transducer that changes force into a measurable electrical output. There are many varieties of load cells, of which strain gauge-based varieties are the most common. Load cells can range from a versatile single-ended shear beam, which can be used in weighing applications such as blenders, hoppers and floor scales, to a double-ended shear beam, which can be used in applications such as tank weighing and large-capacity platforms.

"Load pins and tension links are actually subcategories of load cells," explains Phillips. "Load pins can be substituted anywhere there is a structural pin and there's a need to know the shear force on it. Tension links are a type of load cell that measure force in tension applications such as cables, chains and pulleys. These are often used in lifting, pulling and winching applications such as for cranes, line wire tension and man safety cages in mines."

Standard load cells and tension links are typically used if the system is standard, or an engineer can adapt the system to an off-the-shelf item. This tends to occur in applications where there's some flexibility in the early stages of design. Most load cells, load pins and tension links are custom when they must be adapted to fit existing systems. Additionally, designers should consider the benefits of custom load cell solutions for new designs where their use enhances the overall system integrity, safety or performance.

Avoiding Pitfalls

Planning a superior weighing system or retrofitting an old one on existing equipment can present challenges to even veteran design engineers. Bringing in your weighing system vendor during the planning stage can allow you to improve safety and control costs while meeting any code requirements.

"There are a lot of issues," notes Nathan Heppner, mechanical engineering team lead at Massload, which has refined its standard and custom design process over the past decade. The important thing is to look at the design process upfront to maximize reliability and manufacturability while minimizing cost.

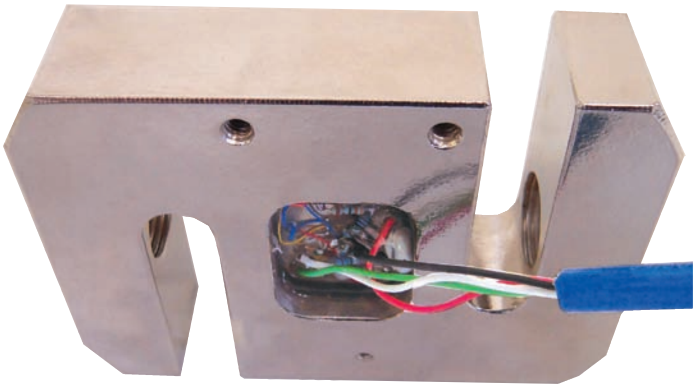
"For instance, fit is critical on load pins because they normally have to interface with tight tolerances," adds Phillips. "Depending on where the load is applied, if the supports, loading area, pin diameter, or other factors are off, the load pin may not work as expected."

To avoid pitfalls, it is advisable for engineers to insist on a regulatory-approved quality management system that traces the load cell manufacture at each critical step from start to finish. Engineers should also request a design flow checklist from any weighing system vendor to ensure that nothing critical or even desirable is missed.

"CAD modeling is not always straightforward, and sometimes you have to think beyond software's presentation," says Phillips. "A stress concentration in the CAD modeling may look artificially high in one area, but may be masking a stress pattern in another area. You need accurate data on stress patterns throughout the component."

Design engineers would benefit from asking their weighing system vendor to validate the output of their load cell component against simulated real-world conditions. This could be done by simply requesting a digital photo of the test set-up, when possible, for enhanced accountability.

"The design specifications, loading, testing, and application must be aligned," explains Heppner. "It's critical to get accurate CAD modeling and test data to predict how the product will perform, but it must be backed up by actual testing. A mistake as simple as modeling with the wrong supporting restraints could artificially strengthen load pin CAD results. If testing doesn't catch it, the component may not perform at its stated capacity."



Tension links are a type of load cell that measures force in tension applications such as cables, chains, and pulleys.

To ensure output stability, engineers also need to know how the load cell output may vary depending on material strain over time, according to Phillips. Conducting a creep test to determine how stable the output is over time can also be important.

Because the accuracy of any load cell is only as good as its calibration, it is vital that the reference cells in any testing system be traceable to a trusted standard, such as that of the National Institute of Standards and Technology (NIST). To guarantee that your supplier complies with the Verified Conformity Assessment Program (VCAP), a program proposed by the National Conference on Weights and Measures, it is also a good idea to ask for a copy of the VCAP auditor's report.

"When warranted, it's advisable for a vendor to cross-check the results against an independent, third-party engineering firm as an added layer of reliability and quality assurance," notes Phillips, whose company sometimes does this for more-complex components or situations to "bulletproof" the end product.

The right vendor partner will also pay attention to small details that will streamline manufacture of the weigh system component, Phillips says, such as bonding, grounding, sealing and gauge selection to ensure lasting performance and resistance to water intrusion.

Phillips points to the importance of knowing the correct location where load cells, load pins, or tension links are supported "because if you over-support a load cell, it won't have the output you'd expect." Placement of internal electronic components, such as bondable or trimmable resisters, can also affect device performance, he says.

In addition, they should be paying close attention to the details, Phillips says. "The customer may require a countersunk bolt arrangement to hold lids on, if during operation bolt heads could be sheared off because they're close to walls or equipment," he offers as an example. "Even details such as putting scribe lines on where to place components can ease manufacturing. When these sorts of details are overlooked, they can require the manufacturer to rebuild a load pin or load cell before it's done right."

According to Phillips, the right weigh system vendor partner will also consider finer points that will affect field performance and maintenance.

"It's important to include loading direction arrows, because once a product like a load pin is sealed and symmetrical, the customer won't know which way to place it in their equipment otherwise," explains Phillips. "To enhance field performance, it's also necessary to specify the right type of connector — whether hardwired, wireless or quick disconnect."

As design engineers respond to the growing need to weigh or measure inputs, outputs and applied force to improve production safety and control costs, working and consulting with the right vendor partner can be a critical choice in designing weigh systems with the optimum load cells, load pins or tension links. **DE**

Del Williams *is a technical writer based in Torrance, CA. This article was written on behalf of Massload. Send e-mail about this article to DE-Editors@deskeng.com.*

INFO ➔ Massload Technologies Inc.: Massload.com

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

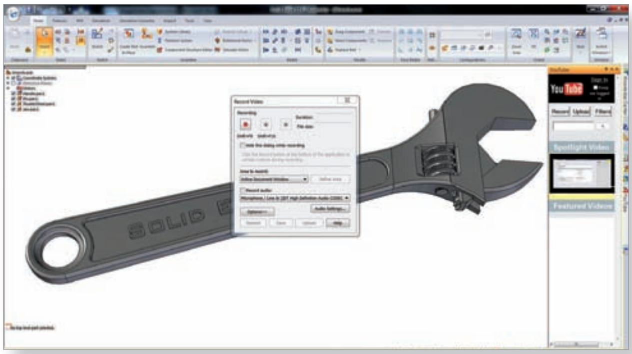
Solid Edge Comes Out **Swinging** with **ST6**

New release aims to attract new users by focusing on improving productivity and collaboration.

BY JAMIE J. GOOCH

Innovation can be a double-edged sword for computer-aided design software vendors. Rolled out too early, it disrupts a design engineer's workflow before adding significant value. Rolled out too late, and customers have already settled on a competing solution.

Finding that sweet spot is part of what Chuck Grindstaff, CEO of Siemens PLM Software, alluded to when he said, "We strive not to have technology disruptions, unlike some competitors," during the opening presentation of Solid Edge University 2013. The other part of that statement was likely directed toward the company's main rival to its Solid Edge design software, SolidWorks, which is owned by Dassault Systèmes.



Solid Edge ST6 now includes the ability to capture design steps and directly upload to the user's YouTube account. Audio can also be captured so narration can be added. A panel embedded in the Solid Edge user interface lists popular Solid Edge videos. *Image courtesy of Siemens PLM Software.*

Shots Across the Bow of SolidWorks

SolidWorks has been battling rumors that it will be changing its kernel ever since a photo surfaced in the blogosphere showing a future version of SolidWorks titled "SolidWorks V6" (a naming convention closely associated with Dassault's CATIA products) in 2010. That's despite an official blog post titled "Setting the record straight on the future of SolidWorks Mechanical CAD" bylined by Dassault Systèmes SolidWorks CEO Bertrand Sicot. In the post, he explained that the new SolidWorks Mechanical Conceptual product, announced at SolidWorks World in January, would be built on the Dassault Systèmes 3DEXPERIENCE platform, as opposed to the Siemens Parasolid kernel that SolidWorks has used since 1995. However, he said SolidWorks Mechanical Conceptual complements, and isn't intended to replace, SolidWorks Mechanical CAD.

"SolidWorks Mechanical CAD will continue to leverage the Parasolid kernel. There is no plan to change the kernel," he wrote. "The complementary nature of SolidWorks Mechanical Conceptual reinforces our commitment to SolidWorks Mechanical CAD. As we have stated previously, we will continue to develop and improve SolidWorks Mechanical CAD, and have no end-of-life plan for the tool that so many of our customers use and depend on today."

Those assurances didn't stop Grindstaff and other Siemens PLM Software employees from attempting to cast doubt on its competitor's plans. (As a side note, one of Solid Edge's newest employees is Matt Lombard, former SolidWorks advocate and author of *The SolidWorks Bible*. Part of his duties will be to help SolidWorks users migrate to Solid Edge.)

"We're hearing a lot of questions is about as much as I can say," says Bill McClure, vice president of Development for Mainstream Engineering Software. "A lot of users are asking us about the direction of the future of SolidWorks and the CATIA platform. It has given us the opportunity to talk with those customers and advance what we offer when they're deciding whether to make a switch."

Siemens PLM Software wants to make it easy for existing CAD users to try Solid Edge ST6. Starting this month, engineers in the US, UK and Japan can rent Solid Edge on a monthly basis. This will not only allow them to evaluate the software for longer than the 45 days granted via the trial version, it will also let users work on a short-term project using Solid Edge without investing in a long-term license.

The Pace of Innovation

It's not difficult to understand why Solid Edge has painted a target on SolidWorks' back. The challenge software vendors face is convincing existing CAD users (2 million of whom are using SolidWorks, according Sicot's blog post) that their product is innovative enough, and will increase their productivity so much that it is worth the pain of learning a new user interface, new commands and even a different approach to the way they design.

So, what are the ST6 innovations that Solid Edge developers hope will lure customers away without scaring them away?

The chief innovation in Solid Edge is Synchronous Technology, which combines push-pull direct editing while automatically synchronizing geometry, parameters and rules, according to the company. Synchronous Technology has been incorporated in Solid Edge for years, but because it presents a radically different approach than history-based modeling, it is still an "Aha" moment when design engineers realize its benefits, according to Bob Mileti from Trlby Innovative, a Connecticut-based product development company.

"It's frustrating at first," he says of switching from a history-based approach. "You're used to doing things a certain way and then it requires a different mindset. I realized I was just accepting that a customer change would blow up my history tree and I'd have to fix it. With Synchronous Technology, I saw all that extra work was not OK. I'm so much more productive now."

Productivity is Paramount

Productivity was addressed again and again at Solid Edge University 2013. "The biggest pain point for engineers is productivity," says McClure. "Every engineer today is being asked to do more in less time."

It was obvious that productivity enhancements are intended to be the centerpiece of ST6. The company claims that its "new surfacing functions help create stylized designs up to four times faster, and its new sheet metal capabilities help create stamped parts up to five times faster, based on internal testing." ST6's new simulation and optimization capabilities are also designed to speed design by automatically finding an optimal design alternative. The new version also includes features designed to make working in larger assemblies more efficient.

Productivity was also cited as the driver behind incorporating Geometric's CAMWorks machining capabilities and Microsoft's SharePoint data management functionality into Solid Edge.

"With Geometric's patented Feature Recognition technology running in real-time to capture machined features and automatically generate or update the toolpath, manufacturing-driven design changes can be made to any CAD model using Synchronous Technology. This dramatically streamlines what has traditionally been a time-consuming process," according to Geometric's press release.

Solid Edge SP (aka, Solid Edge for SharePoint), was announced last year as Solid Edge with Insight XT. The new name is intended to alleviate confusion some customers had about Insight XT being a separate product, according to Karsten Newbury, senior vice president and general manager, Mainstream Engineering Software, Siemens PLM Software. The functionality is embedded into Solid Edge, allowing it to take advantage of Microsoft SharePoint. SharePoint is used by some small- and medium-sized businesses that may not be ready for a full product lifecycle management (PLM) solution, such as Siemens' Teamcenter, to manage their data.

Expanding Collaboration

But productivity isn't just about designing faster. It can also be time-consuming to share designs and communicate their intent. With that in mind, Solid Edge ST6 also allows users to transfer their work directly to GrabCAD, an online repository of 3D models that can be shared publicly or privately with colleagues.

The GrabCAD integration allows Solid Edge to dip a toe into the Cloud, again without worrying users that it could lead to a disruption of their workflow. "Solid Edge will remain a desktop product," Newbury was quick to offer during Grindstaff's presentation, perhaps to distance ST6 from Autodesk Fusion 360, a rival CAD program available as a Cloud-hosted solution. The distinction is noteworthy as Autodesk also recently struck a partnership with GrabCAD, which allows Fusion 360 users to publish models directly to GrabCAD.

Another new feature in ST6 intended to enhance collaboration is the ability to capture audio and video from within Solid Edge, and then post it to YouTube via a built-in user interface.

Finally, the Solid Edge Mobile Viewer is also being released for Android devices and the iPad mini, in addition to the iPad version available now. The 3D viewer can help engineers share designs with clients and colleagues who are not accustomed to using CAD software.

The improvements mentioned here are among the top features from the more than 1,300 user-requested improvements Siemens PLM Software says have been incorporated into Solid Edge ST6. **DE**

Jamie Gooch *is managing editor of* Desktop Engineering. *Send e-mail about this article to de-editors@deskeng.com.*

INFO → **Autodesk:** autodesk.com

→ **Dassault Systèmes SolidWorks:** solidworks.com

→ **Geometric CAMWorks:** camworks.com

→ **GrabCAD:** grabcad.com

→ **Microsoft SharePoint:** office.microsoft.com/en-us/sharepoint

→ **Siemens PLM Software:** plm.automation.siemens.comen_us/

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

Commentary

by Josh Fredberg

The Innovation Advantage

At ANSYS, we're consistently seeing our customers adapt to today's hyper-competitive market. They are migrating from a linear and prescriptive planning design process toward rapid prototyping and design experimentation, all to facilitate innovation. Products are getting "smarter." They adapt to their environments and to their users. For example, most people think of smart consumer electronics, but a wind turbine blade — which twists and flexes depending on wind conditions — is also a smart product.

With these smarts, however, comes complexity. Products are increasingly becoming an intricate and intermingled combination of software, electronics and hardware, yet they must be delivered to market with quality at a record pace. Extremely complex to design and build, smart devices incorporate thousands of parts that have to work together — putting systems-level engineering front and center.

The way simulation is deployed in organizations needs to change.

The engineering challenge remains to ensure these products will operate as expected in the real world, despite their increasingly smaller size and number of multiple physics components. Products that take the market by storm — like the newest tablet or hybrid automobile — go hand in hand with leading-edge development processes that can quickly transform conceptual ideas into scalable, reliable and cost-effective products.

Integrating Analysis into the Design Process

We believe that immersing simulation into the design strategy can stimulate innovation; we call this Simulation Driven Product Development (SDPD). At the foundation of SDPD is the concept of virtual prototyping, in which real-world product performance is predicted and studied with simulation models instead of expensive, time-consuming hardware prototypes. However, gaining an edge in a competitive environment takes more than simply using simulation software — it requires the ability to rapidly test hundreds, even thousands, of designs in a short amount of time, and technology that is integrated into an entire product development process.

The reality remains that many companies perform simulation as a function separate from design, with engineers throwing projects over the wall to an analysis group. Often, this occurs in the final phases of product development, when changes require considerable time and money to perform. Moving simulation earlier in the conceptual stages of product development can shorten time to market and lower product development costs. In this way, SDPD elevates the role of analysis from a standalone troubleshooting tool to that of an integrated design approach for quickly creating and refining innovative designs.

Implementing SDPD

The pervasiveness of smart products and their complexities, combined with the need to do more with less, is a sign that it's no longer business as usual — that the way simulation is deployed in organizations needs to change. To keep up with increasing market demand for these products, simplified simulation in a single-user environment allows non-expert users to leverage the technology, helping to decrease time to market.

Engineering simulation technology and its associated processes are critical to facilitating upfront simulation, efficient evaluation of alternative designs, iterative modification of designs based on simulation, and collaboration among different groups. Through the ability to quickly perform what-if studies and evaluate alternative configurations, simulation provides insight into product behavior and gives free reign to the imagination of product team members. In such an approach, simulation guides the direction of the design to optimally satisfy such requirements as performance, reliability, sustainability and cost. Hundreds of concept alternatives can be evaluated with simulation before detailed design is begun.

One of the greatest values of simulation-driven design for manufacturing companies is facilitating experimentation — and in turn, innovation. Senior executives know that innovation in product development as well as manufacturing processes is key to a company's long-term potential in the market. In this respect, engineering simulation has been elevated from that of an obscure technology understood only by dedicated analysts to a critical component of a company's corporate market strategy. The bottom line can be significant time reductions, cost savings, quality improvement and product design innovation.

That said, these and other necessary organizational changes require a significant investment in time and effort. This level of commitment defines how companies individually leverage simulation, and determines which firms will most likely lag behind while others reap the greatest business value from SDPD. **DE**

Josh Fredberg *is vice president of marketing for ANSYS. Before joining the firm in 2009, he was senior vice president of product and market strategy at Parametric Technology Corp. (PTC), and has held leadership roles with both ARIBA and Andersen Consulting Strategic Services. Send e-mail about this article to DE-Editors@deskeng.com.*