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Crash Test Collaboration

Partnerships promote simulation throughout the design cycle.
P.18, 22

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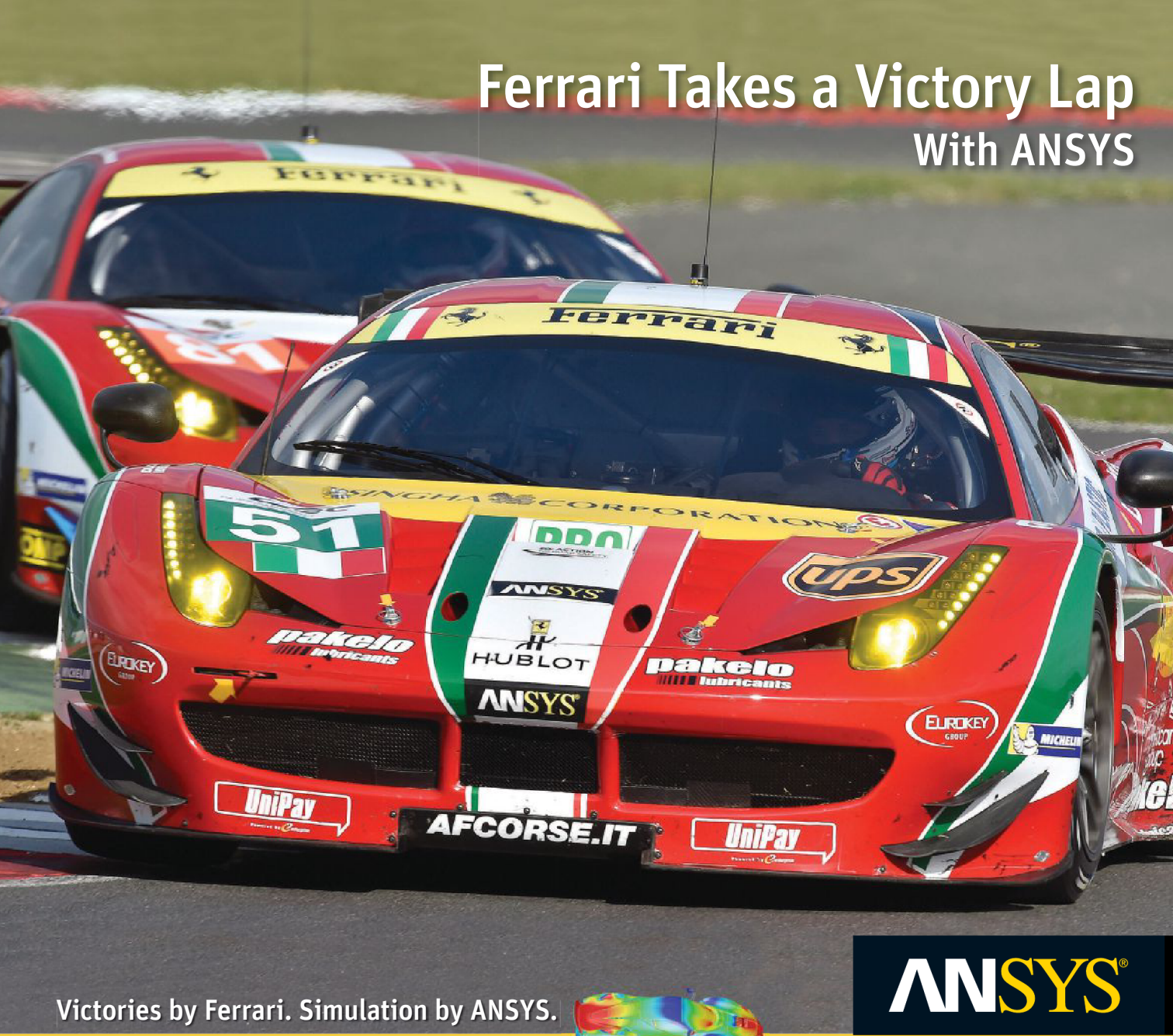

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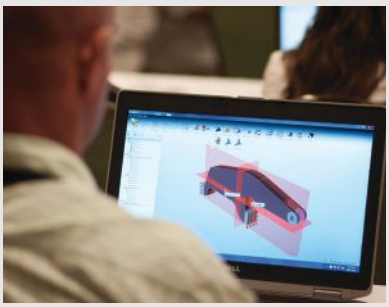

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by Jamie J. Gooch

Innovation is a Team Sport

As I write this, The Ohio State University Buckeyes just beat Oregon in the College Football Playoff National Championship. Being from Ohio, it was mandatory to stay up and watch the game. It was an impressive display of athleticism, but something Ohio State's quarterback, Cardale Jones, said after the game got me thinking about the value of collaboration to design engineers.

At the beginning of the season, Jones was the third-string quarterback. He was thrust into the starting role after the team lost its first- and second-string quarterbacks to injuries. The championship game was only Jones' third college start, so naturally many people wondered if he would crack under the pressure. In a post-game interview with confetti falling across the field to celebrate Ohio State's victory, he was asked how he had kept the moment from "getting too big."

"I knew I didn't have to do too much," Jones said. He put faith in his team.

Build your dream team via public and private partnerships.

We often write about the increasingly intense pressures faced by design engineers. You're expected to continually innovate while employing ever-changing technologies across various engineering disciplines in tighter and tighter product design cycles. It's all on you, or is it?

Drafting Your Team

With today's complex product design requirements, no one person, one department or even one company needs to be solely responsible for creating innovative products. If you're feeling that pressure, it may be because you don't have a team in place, or a team that works the way it should. Even larger companies, with their global networks of suppliers, don't always collaborate as well as they might.

Why? A corporate culture that rewards individual effort rather than teamwork could be to blame in some cases, but the solution may be as simple as expanding your team to include people with diverse backgrounds and resources. That's the idea behind the National Network for Manufacturing Innovation (NNMI).

The NNMI will consist of regional hubs of private industry, academic and government representatives working together to accelerate manufacturing technologies. While a bill to create such a network — The Revitalize American Manufacturing and Innovation (RAMI) Act — was not making much progress in Congress, President Obama used executive orders over the past two years to launch five innovation hubs. In December, RAMI was finally signed into law as part of the omnibus spending bill. It funds the expansion of the NNMI to include 15 hubs.

The latest hub, the Institute for Advanced Composites Manufacturing Innovation (IACMI), was officially launched last month via a $259 million investment. The Department of Energy and a consortium of 122 companies, nonprofits and universities led by the University of Tennessee-Knoxville made the investment, more than $189 million of which came from non-federal funds. IACMI's goal is to develop low-cost, high-production, energy-efficient manufacturing and recycling processes for composites.

Get Involved

While the details surrounding how to participate in IACMI are still being worked out, it may follow the lead of the first innovation hub, America Makes, which launched in 2012 to advance 3D printing. America Makes has three levels of membership and has engaged non-members with project calls that award funding to address a particular challenge, an online forum and a member matching service to promote collaboration.

The other innovation hubs that have already been established have similar collaboration opportunities. They include the Next Generation Power Electronics Manufacturing Innovation Institute headquartered at North Carolina State University, the Digital Manufacturing and Design Innovation Institute based in Chicago and the Lightweight and Modern Metals Manufacturing Innovation Institute based in Detroit. The other NNMI hubs supported by the recent passage of RAMI have yet to be named. They will go through a selection process, but will likely include similar opportunities for engagement.

The idea of public-private partnerships is not new, of course. Perhaps the most high-profile arrangement can be seen in NASA's work with private companies to launch missions to the International Space Station. We also feature two public-private partnerships benefitting design engineers in this issue (see pages 18 and 26).

There are many ways to build a better team and innovate via collaboration, whether from federal initiatives like NNMI or smaller partnerships that tap into municipal and local academic resources. The key is to recognize the value of collaboration and work toward building a team you can rely upon. DE

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

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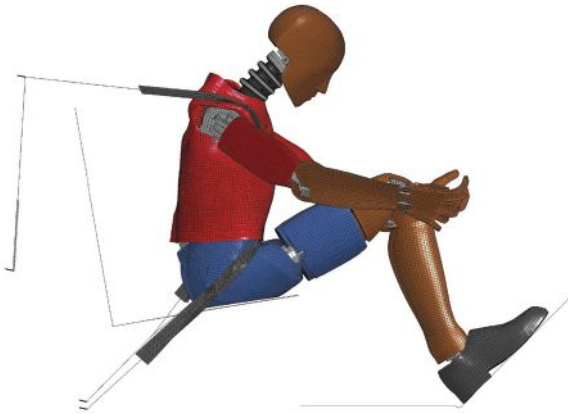
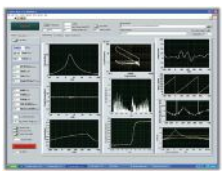


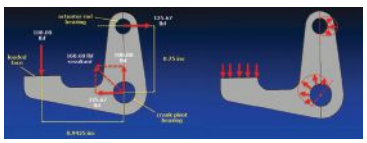
18 Crash Test Collaboration

The Center for Collision Safety and Analysis helps automotive, aerospace and transportation industries keep current with simulation and testing methods.

By Mark Clarkson

SIMULATE





ON THE COVER: 3DEXCITE's DELTAGEN Real Impact is used to share the results of a crash test simulation. Image courtesy of Dassault Systèmes.

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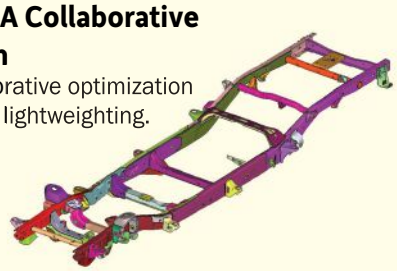

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by Kenneth Wong & Beth Stackpole

Engineering Students Take Flight with Drone Design at ASME Competition

From unmanned aerial vehicles (UAV) carrying out defense missions to new consumer models being tapped for aerial photography, drones are drawing interest across the board. The fascination with this "hot" technology isn't lost on the American Society of Mechanical Engineers (ASME), which gave drones the starring role in its latest student competition.

An international contingent of teams, including representatives from the U.S., Europe, China, India, Peru, Turkey and a host of other countries, gathered at the International Mechanical Engineering Congress & Exhibition in November where they unleashed their knowledge and training to create a drone design that could best the competition. The 2014 student design competition called for the teams to design and build an original drone, pilot it through a series of high and low obstacles, complete a targeted payload drop and then return to the starting line — all the while, remaining in one piece.

To build their UAV, the University of North Dakota team used modeling software, CNC machining and 3D printing. ***Image courtesy of the University of North Dakota.***

Teamwork Was Tantamount

For the University of North Dakota, which took first prize, the challenge was all about learning to work together as a team with some pretty serious lightweighting design training folded in. The team struggled with how much weight its drone should carry, while still being able to fly sufficiently. The process involved adding and subtracting motors to find the optimal configuration, said Christopher Borseth, a member of the team. Each time the team added a motor to increase performance, it had to fabricate brackets, do wiring and test performance.

"It became a game of trial and error to optimize the performance of our 'copter to succeed at the competition," he explained.

To design the winning drone, the North Dakota team used PTC's Creo 3D modeling software in the initial stages of development and to make certain that clearances were optimal. "Without 3D modeling, when each piece is brought together in the shop, they may not fit exactly right," he explained.

A Varied Build

To produce the finished drone, the team used basic shop hand tools as well as CNC (computer numerically controlled) machines. There was also a 3D printer used to create the payload dumping bucket, the pull handle of the kill switch and a protective case to surround one of the batteries.

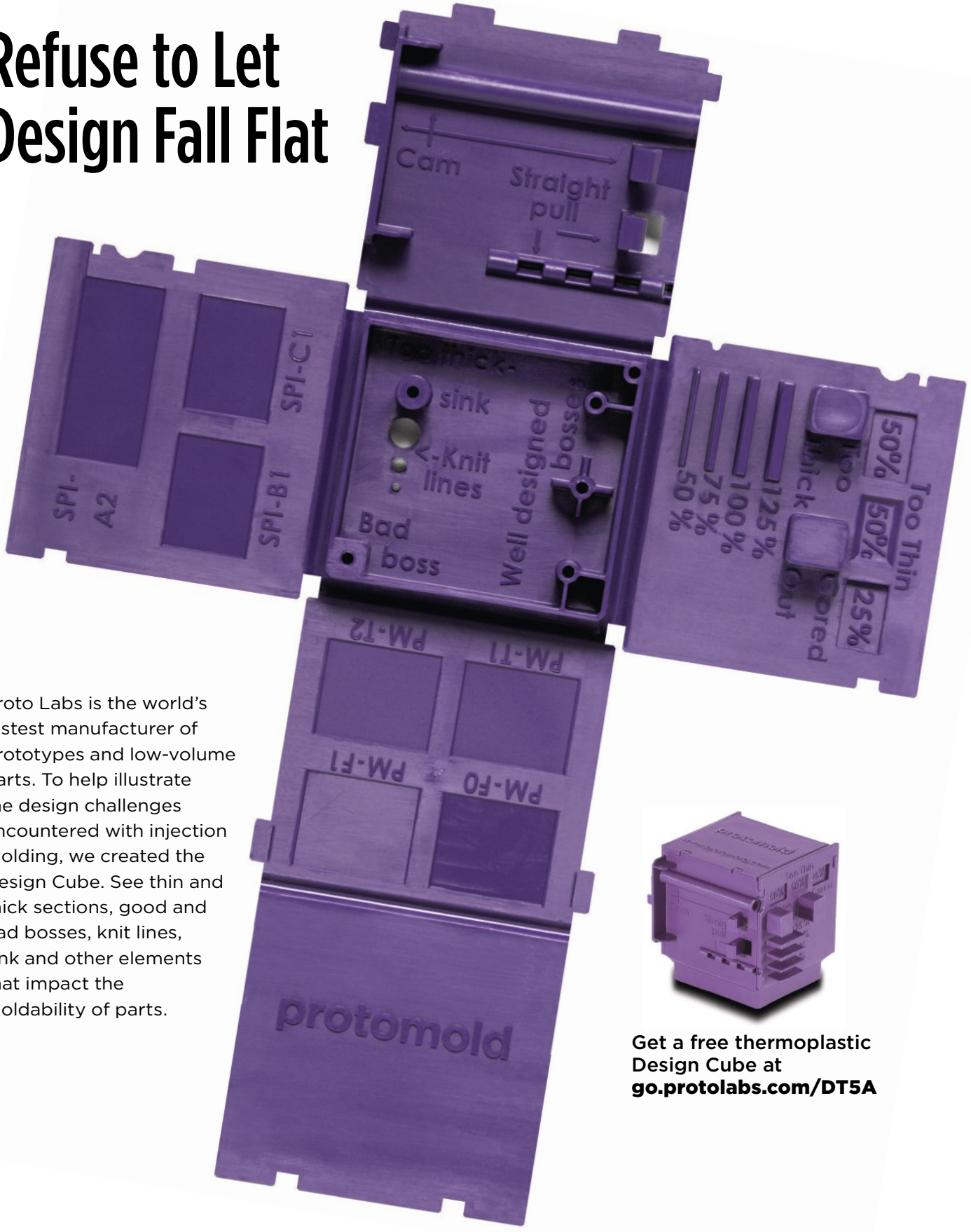
The runner-up team from California Polytechnical Institute didn't rely on CAD or 3D printers as much as the Noth Dakota team, because most of its components were commercially available. Overall, the competition gave team members great exposure on how to work together effectively as a multidisciplinary team, officials said.

For the winning University of North Dakota team, the experience definitely advanced expertise on a variety of levels, Borseth said.

"As a team, we learned how to work together and build relationships with each other," he said. "Our fabricating skills improved along with our 3D modeling skills. It made us better engineers."

—B. Stackpole

Refuse to Let Design Fall Flat



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by Kenneth Wong & Beth Stackpole

Automotive Rendering Artist Shares Tips

Doug Didia, a 3D artist who works in the automotive industry, is a graduate of the College for Creative Studies in Detroit, with 35 years of experience. To create photorealistic 3D images of vehicles for his clients, he uses a mix of Autodesk Maya, Luxion KeyShot and Adobe Photoshop. So when he heard about the KeyShot Auto Render Competition, he thought he had a good shot at winning. In November, when the winners were announced, Didia's "Storm Trooper" entry topped the list. Here, he shares his workflow and approach to rendering. His secret is in the care he takes with the background image.

Doug Didia combines photo sources to create the dramatic backdrop he needs.

Desktop Engineering: *Most of our readers work with CAD data, and many found it to be too rich, too detailed for a rendering program. Any tips on how to treat it so it can easily be managed in KeyShot?*

Doug Didia: The challenge to effectively reduce hundreds of gigs of data down to 3 or 4GB is huge. There is software that will tessellate the geometry, but a lot of time and effort goes into manually cleaning and prepping many of the pieces where you just leave the bare minimum visible shell of the objects — A-sides only, B-sides removed. There is no 'easy-button' way to end up with a manageable vehicle data set.

Speaking of managing large data, updates in KeyShot 5 will allow Instancing. Imported vehicles can be duplicated and each one altered, within the same file, without slowing down my computing performance. I can now create a whole dealership parking lot of vehicles in every color and trim level with ease. Pretty cool!

DE: *What's the difference between using a professional rendering and animation program like 3dx Max or Maya and using KeyShot?*

Didia: It's interesting to me that there is a misconception that KeyShot is somehow unprofessional. As an artist, complexity of the interface within 3D software scares the hell out of me. I want something fast, easy to use, that produces instant real-time high-quality results and allows me to play creatively without getting bogged down with a tsunami of menu calculations. If a piece of software takes five steps to do something vs. one step in another program and you achieve the same result, why would you want more steps?

DE: *What are the specs for your PC?*

Didia: It's custom-built, with (Intel) i7-4770K Quad-Core 3.5GHz CPUs (with Hyper-threading), 32GB RAM (Memory) and NVIDIA GPU. The sample image for Storm Trooper took about 3 hours to render at 5,000 x 2,664 pixels. I could have set the finished render up as high as 20,000 pixels if I wanted a wall wrap application.

DE: *What do you use to combine various different elements (ominous sky, dirt tracks, and snowy-dusted road) into a single image for the Storm Trooper project?*

Didia: I combined multiple photos to create an exquisite back plate that suited my layout and assignment needs. More to the point, I utilize 35 years of perspective drawing, painting and composition experience, combined with honed skills in Photoshop to successfully achieve a natural environment or dramatic mood. People believe that by possessing Photoshop, it automatically makes them capable. Photoshop, like KeyShot, is just another tool that levels the playing field. When placed in the hands of a talented artist, a simple tool can generate amazing results.

DE: *Any tips for novice KeyShot users who are not experienced animators or visual artists but, are primarily CAD designers?*

Didia: KeyShot is not built for modeling. But you can use it throughout the product development process to make design decisions and quickly create variations of concepts. Don't be afraid to just play. It's a visualization tool; it's up to you to push it to your advantage.

— K. Wong

Cloud-Service Facilitators Blur Boundaries

In October 2014, between sessions and keynote talks at the Virtualize Conference, Nikola Bozinovic, founder and CEO of Mainframe2, tapped me on the shoulder. "We have something to announce soon, but I can't talk about it publicly right now," he said.

A few weeks later, the announcement came, from the floor of AWS re:Invent 2014, an industry gathering centered around Amazon's cloud services.

"Until now, it's been very difficult for makers of rich graphics apps to expand to the cloud. Mainframe2 makes it easy. We built the first self-service, global, production-ready platform that provides end-to-end support to customers on their journey to SaaS (software-as-a-service). There's nothing like it on the market," said Bozinovic, in a press release.

Mainframe2 has begun offering cloud services to vendors who want to deliver SaaS products.

Defining a Market

Mainframe2 belongs to a class of vendors that have yet to be classified. Their products target software makers looking to transform their desktop offerings (for example, CAD and visualization software titles) into SaaS products, deliverable and billable in the new cloud model. I call them cloud facilitators. A close rival of Mainframe2 may be OTOY's X.IO, described as an app-streaming platform. Another example of a cloud-facilitator technology is Numecent, which offers "cloud-paging" of applications to stream native programs over the web.

Mainframe2's plans for software vendors begin at $199 a month. (There's a one-time 100-hour trial plan for $99, but that realistically won't be sufficient to deploy and deliver a program to multiple users.) In addition, Mainframe2 also offers on-demand cloud infrastructure for educational institutions and businesses that want to deploy and deliver virtual desktops to students and employees. Bozinovic revealed that the company has recruited about 20 schools to use its products in the current invite-only Beta program. This year, the company plans to launch an Early Access program with wider access.

One distinguishing characteristic of Mainframe2 is GPU (graphics processing unit) acceleration, made possible by its partnership with NVIDIA. "We are thrilled that NVIDIA GRID technology is the key enabler of this new approach to bringing professional graphics software to the cloud," says Jeff Brown, vice president and general manager, Professional Visualization, NVIDIA. The feature is expected to make a difference in the performance of 3D visualization programs that take advantage of the GPU's co-processing power.

"CAD doesn't place a big demand on the graphics processor. You don't need a whole lot of GPU processing to do CAD. But you need an enormous amount of GPU processing in media and entertainment, oil and gas [exploration], and simulation … CAD, even though it doesn't have a huge lead in graphics demand, does have a lead in virtualization," says Jon Peddie, president of JPR, on the market-driving forces for virtualization.

Remote Questions

During a panel on remote desktop adoption, a number of questions were raised. "Who actually owns the virtual desktop within IT?" says Bob O'Donnell, founder and chief analyst, TECHnalysis. "We can talk about technology till we're blue in the face, then we'd have to address IT and the turf they own within the organization … If you're a traditional IT organization, you have a desktop team, network team, server team, storage team, and so on. When you move into virtualization, those walls get blurred."

The blurred boundaries notwithstanding, the use of remote desktops, application streaming, and other variants of virtualization appear to be picking up momentum. "In 2015, our platform will expand to reach a much broader set of customers including IT departments in education and business who want a better way to deliver and manage their apps," writes Carsten Puls, chief product officer, Mainframe2.

— K. Wong

Solar-Powered Plane Collaboration

Dassault Systèmes and Solar Impulse have extended their partnership to continue research and development of a solar-powered airplane. The Solar Impulse 2 aircraft was launched in April and completed its first successful test flight in June 2014.

To create the aircraft, Solar Impulse uses the 3DEXPERIENCE platform to design, build and validate its designs. The first iteration was a test bed for the technologies required to fly with solar power during day and night. The goal of the second plane is to complete a flight around the world this year.

"For over a century, pioneers have been pushing the limits of aviation and transforming ideas into 'firsts,' from the first human flight to balloon flights and space missions once thought to be impossible," said André Borschberg, co-founder, CEO and pilot, Solar Impulse. "We continue to apply this entrepreneurial spirit to engineering and research programs that blend 21st century technologies like the 3DEXPERIENCE platform with a mission to improve mankind's impact on the environment."

MORE ➜ deskeng.com/de/?p=21818

ZEISS Launches Virtual Reality Headset

ZEISS has launched its mobile virtual reality (VR) headset, the VR ONE. This device works with smartphones equipped with display sizes between 4.7 and 5.2 in. To operate it, the user places their phone into the headset and launches the appropriate app. The technology is compatible with the Samsung Galaxy S5 and the iPhone 6. The company plans to make it available for more phones in the coming months.

Media Launcher and Cinema

applications are currently available. The Cinema app provides users with a virtual movie theater to view 3D films. With the Media Launcher app, users can select and install VR-compatible applications.

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Velodyne LiDAR Helps Develop RoboSimian

Velodyne LiDAR has helped build the RoboSimian, a headless, ape-like robot. The device is in training for the 2015 DARPA Robotics Challenge, which consists of several disaster-related tasks. The company has provided its HDL-32E LiDAR sensor for the top of the unit.

The robot is being developed by NASA's Jet Propulsion Laboratory (JPL) for the competition. The sensor can rotate a full 360° up to 20 times per second as well as between 10° up and 30° down.

RoboSimian moves on four limbs, making it ideal for travel over complex terrain. JPL researchers are working on improving the robot's speed.

"The NASA/JPL robot was developed expressly to go where humans could not, so the element of sight — in this case, LiDAR-generated vision — is absolutely critical," said Wolfgang Juchmann, director of sales & marketing, Velodyne.

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Technology Connects Cycle Helmets With Cars

In a new collaboration, POC, Ericsson and Volvo Cars have created technology that connects car drivers and cyclists out on the road. The connected car and bicycle helmet establish communication through the Cloud. With this connection, the car will provide proximity alerts to the driver and cyclist as a way to avoid accidents.

If a possible collision is detected, both users will be warned, the company states. Drivers will receive a display alert within the vehicle and the cyclist is notified via a helmet-mounted alert light.

"The partnership between Volvo Cars, POC and Ericsson is an important milestone in investigating the next steps towards Volvo Car's vision to build cars that will not crash. Today our City Safety system, a standard in the all-new XC90, can detect, warn and auto-brake to avoid collisions with cyclists. By exploring cloud-based safety systems, we are now getting ever closer to eliminating the remaining blind spots between cars and cyclists and by that avoid collisions," said Klas Bendrik, vice president and group CIO at Volvo Cars.

MORE ➜ deskeng.com/de/?p=21543

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Integrating Solar Power in Drones for Longer Flights

Alta Devices has partnered with Airware to enable manufacturers of small unmanned aerial vehicles (UAV) to integrate solar power into their aircraft. Alta Devices' record solar cell efficiency is 28.8% and can increase flight endurance by more than four times. With certain designs, the company's technology can help a UAV fly all day under sunny conditions.

Airware offers hardware, software and cloud services for the development and operation of commercial drones. With this partnership, according to the company, designers and manufacturers will be able to use Alta Devices' AnyLight solar cell technology in a variety of applications.

MORE ➜ deskeng.com/de/?p=20178

Lockheed Martin, BAE Systems Advance Exoskeleton Design

A collaboration among the National Center for Manufacturing Sciences, Lockheed Martin and BAE Systems is testing and developing exoskeletons at U.S. Navy Shipyards in Washington state and Virginia. The goal is help reduce worker fatigue while workers remove sound abatement from hulls of Navy submarines.

Because some cutting and grinding tools can weigh as much as 36 lbs, using them for extended periods of time can cause muscle and joint strain, increase risk of injury and decrease productivity.

An exoskeleton allows for weight to be transferred from the worker's body to the ground. This redistribution of weight can make a heavy tool essentially weightless.

Lockheed's Mantis prototype moves with the worker's body as he/she stands, kneels and walks. Tests conducted with the prototype exoskeleton have already shown a 300% reduction in muscle fatigue and productivity gains of two to 27 times, a press release states.

MORE ➜ deskeng.com/de/?p=21164

Adept Technology Wins Innovation Award for Mobile Robot

Adept Technology, a provider of intelligent robots, has won an Innovation Award at the 2014 Emballage exhibition for its Lynx Conveyor mobile robot. The exhibition ran from Nov. 17 to 20, 2014, in Paris.

The Lynx Conveyor robot combines an autonomous intelligent vehicle (AIV) base with a motorized conveyor platform. This creates a robot that can receive, transport and deliver goods. It can, according to the company, self-navigate, avoid obstacles and select the best path to complete the task. They are well suited for environments such as warehouses, distribution centers and factories.

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BeBop Sensors' Wearable Smart Fabric Technology

The BeBop Wearable Smart Fabric Sensor is an ultra-thin wearable sensor that measures aspects of physicality, including bend, location, motion, rotation, angle and torque.

BeBop's sensors are able to measure physicality to sense and display 3D maps of data. They provide real-time reporting on force, X/Y location, bend, twist, size, stretch and motion. The technology offers possibilities for wearable products such as controllers, smart yoga and gym mats, grip sensors, weight lifting gloves, cycling shoe inserts and foot volume sensing.

The company is also now offering custom turnkey sensor solutions for original equipment manufacturers to incorporate into their products, which range from basic sensors to complete wireless solutions.

MORE ➜ deskeng.com/de/?p=20328

Nixie Wins Intel Make It Wearable Challenge

Intel has named Nixie the grand-prize winner of its first Make It Wearable challenge. The competition focuses on encouraging creativity and having innovators enhance personal computing with Intel Edison, which combines a small, adaptable hardware platform and partner ecosystem with software compatibility and a supportive online environment, according to the company.

Nixie is a wearable camera that has the ability to turn into a quadcopter and can follow behind its owner to take photos.

As winner of the competition, Nixie was awarded $500,000, which it will use for device refinement in areas such as the overall size and propellers, according to iQ by Intel.

The second- and third-place winners of Intel's challenge were Open Bionics and ProGlove, respectively.

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NASA Emails, 3D Prints Wrench Design in Space

NASA took delivery of a Made In Space 3D printer on the International Space Station in November and successfully output multiple replacement parts. This latest endeavor takes things a step further as the ratchet wrench was the first "uplink tool," meaning the design file was emailed to the space station and printed on demand during the actual space mission.

The wrench, measuring 4.48 x 1.29 in., was designed by Made In Space and output on its zero-gravity printer in four hours.

Made In Space engineers created a 3D model of the wrench in Autodesk Inventor, converted it to G-code, and later emailed it through NASA's Huntsville Operations Center to the ISS team for output — a first in a design workflow that NASA hopes will become routine, especially for longer journeys like those to Mars.

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Additive Manufacturing Goes Big with 3DP Unlimited

Illinois-based 3DP Unlimited has designed and developed an AM (additive manufacturing) system based on open source principles that are capable of printing large-scale pieces. 3DP Unlimited calls the system the 3DP1000, and has priced it under $20,000.

So how big is big? The 3DP1000 has a build envelope of 39 x 39 x 19 in. (1 x 1 x 0.5 m). The open source design extends to software, where customers are offered the option of working with Repetier, Slic3r or Simplify 3D.

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International CES 3D Printing Roundup

3D printing's presence at the International Consumer Electronics Show doubled since 2014, with more vendors in the 3D Printing Marketplace this year. There was also a full 3D printing conference track featuring speakers from Shapeways, MakerBot, 3D Hubs, Formlabs and Autodesk.

The flashiest announcement was actually a wearable computer offering from Dutch designer Anouk Wipprecht called the Spiderdress 2.0 that was built using 3D printing. The dress uses robotics and sensors for self defense, tracking body language, behavior and the wearer's respiration to initiate a jab against interlopers using one of several plastic legs.

In other CES news, Voxel8 partnered with Autodesk to develop a new design tool called Project Wire for creating 3D electronic devices printed on the company's platform that will allow designers to create parts with embedded circuitry. Voxel8 also announced pre-order availability of its Voxel8 Developer's Kit.

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New Inks Enable 3D Printing of Fuel Cells

Ceramic fuel cells can provide clean energy for high-temperature applications by converting gas into electricity. Researchers at Northwestern University have come up with a way to 3D print the fuel cells using special inks.

The new inks can create the individual components of the solid oxide fuel cell, and are a mixture of ceramic particles, a binder and solvents that evaporate at different rates.

As the machine prints, a volatile solvent in the ink evaporates, speeding the transition from liquid to solid. Other solvents in the ink evaporate later, so the printed piece is soft enough to meld with the next line. While the printing is done at room temperature, the finished piece has to be fired under high temperatures.

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Marvell Targets 3D Printing with New SOC

Marvell, a provider of microprocessor architecture and digital signal processing, has developed a new system-on-chip (SOC) specifically for AM (additive manufacturing). According to the company, the SOC could help drive further adoption of 3D printing by providing improved performance from AM systems.

The SOC is intended for both home and industrial AM systems, with a design that has been tailored for AM. It provides processing architecture that is ready to go as soon as it's plugged in to a system, which gives AM companies the option of either developing their own electronics, or going with Marvell's product. In general, Marvell intends for its SOC to make AM easier to use and develop.

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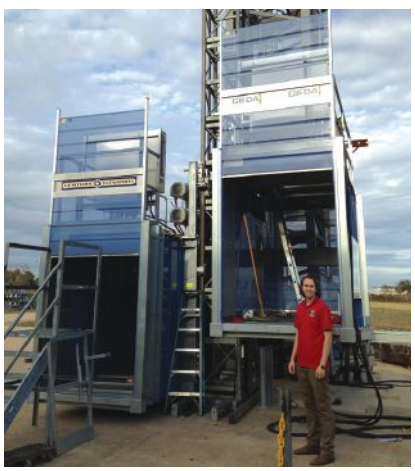
Mojo 3D Printer Winner Reaches New Heights

BY PAMELA J. WATERMAN

Mechanical engineers generally consider themselves experienced after they've designed hundreds of parts and brought them from initial concept into final manufacturing. Gaining that experience often takes years to achieve, but Jacob Skaggs, a recent college graduate and project engineer at Century Elevators in Houston, TX, got an accelerated start. While on a manufacturing engineering internship at Invent-a-Part, a Utah service bureau, he did CAD designs for a range of prototypes and saw them produced on Stratasys Fused Deposition Modeling (FDM) and PolyJet equipment.

This familiarity with 3D printing systems and put Skaggs in the perfect position to appreciate winning his own Stratasys Mojo 3D printer in the third annual *Desktop Engineering* Rapid Ready Sweepstakes, sponsored by Stratasys. The Mojo system and its WaveWash 55 support-removal system sit side-by-side in his office with a workstation on which he



Skaggs in front of one of Century Elevators' lifts. He designs custom tie-in brackets and struts to connect the elevators to steel truss setups.

designs typically one-of-a-kind machined parts for industrial elevator installations.

The Mojo unit arrived two days before Thanksgiving, so Skaggs downloaded some appropriate holiday-motif 3D CAD files for an initial test. "I was actually surprised at how easy [the Mojo] was to set up," says Skaggs. "In a couple of hours, I was ready to print."

His first 3D print run quickly produced sample table place-card holders shaped as — what else — a turkey and a classic Pilgrim hat. From there he was ready to try the system on a real part, figuring it would help him speed up manufacturing parts he commonly designs. It's actually helped do much more.

Creating Better Designs

Projects at Century Elevators can be an interesting challenge because every installation is different. Focused on industrial and commercial lifting systems for construction sites, refurbishments and maintenance jobs, the company works on everything from power plants and petrochemical facilities to bridges and commercial buildings. While the elevators are self-contained units, the company must design custom tie-in brackets and struts to connect them to steel truss setups reminiscent of giant-sized Erector-brand toy sets. Each tank, silo or building framework is constrained by different geometry and space limitations.

Oftentimes, a customer will provide basic project descriptions over the phone, saying the elevator needs to run a certain number of stories tall, transport so many pounds of materials and personnel, and fit into a footprint of x square feet. Skaggs, along with colleague Erik Nordfelth, lead engineer and project manager, must

Jacob Skaggs with the Stratasys Mojo 3D printer he won as part of *Desktop Engineering*'s Rapid Ready Tech Sweepstakes.

translate those specifications into detailed designs and define the connecting hardware. Machining a basic prototype can take several days, and the part may need several revisions after site visits highlight further requirements.

On his second day with the Mojo, Skaggs printed a two-part prototype eyebolt bracket based on a verbal description. The 4 x 3 x 2 in. sections took about eight hours to print and easily fit into the Mojo's 5 x 5 x 5 in. build envelope. "I was able to design something based on what they told me, and then I was able to check my design and make sure we were on the same page, that my concept would work," he said.

Skaggs says the Mojo will help manufacture everything from prototype brackets to a missing machine knob.

"When you have this technology, it changes the way you think about projects and what you can do," he says. "Before, we were always trying to think of the simplest way to take care of something. Now you can change your mindset to think of the best way." DE

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INFO ➜ Century Elevators: CenturyElevators.com

➜ **Stratasys:** Stratasys.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.

Stratasys Launches 10 New 3D Printers

The company also announced its ULTEM 1010 thermoplastic.

Just before EuroMold 2014, Stratasys announced a slate of 10 new 3D printers and a thermoplastic material. Each of the 3D printers feature triple-jetting technology.

The Objet260 Connex and Objet350 Connex series comprise six of the new printers; three models in each series.

The Objet30 Prime and ObjetEden 260VS equip users for both professional and consumer applications.

The Fortus 450mc and Fortus 380mc production systems have a new touch-screen interface that lets you adjust print jobs without disrupting operations.

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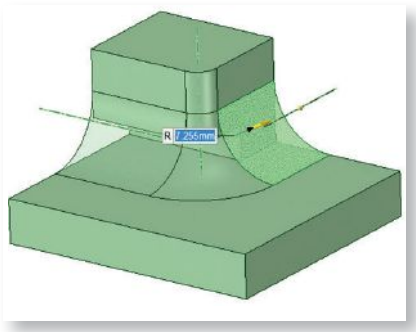

SpaceClaim 2015 Released

The platfom now offers tighter integration with ANSYS Workbench.

With SpaceClaim 2015, users gain a tighter integration of SpaceClaim and ANSYS Workbench. What this means for analysts is that you can easily do a lot of your own geometry prep using SpaceClaim's direct modeling tools.

SpaceClaim 2015 also has some other tools to do its part in simulation-driven design. Among these are new simulation cleanup and detection tools for short edges, overlap faces and corrupt faces as well as tools that provide better control over connections between parts.

The software has also updated its 3D printing and machining modules.

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3D Systems Announces New 3D Printing Systems

The new line of printers supports SLA, SLS and DMP manufacturing methods.

The new 3D production-level systems from 3D Systems (3DS) are the ProX 800, the ProX 500 Plus and the ProX 400.

The ProX 800 is an SLA (stereolithography) machine that will let you build fab-grade plastic prototypes, end-use parts, casting patterns, rapid tooling, fixtures and more.

The ProX 500 Plus SLS (selective laser sintering) system is an enhanced version of the widely deployed ProX 500 3D printer.

Also released are new materials for 3DS' professional-level ProJet 1200 and its ProJet 5500X MultiJet 3D printers.

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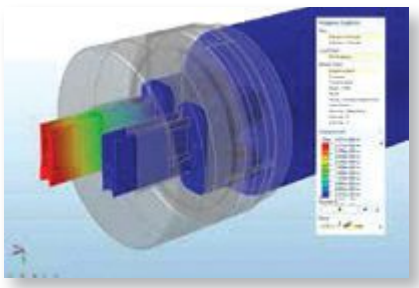

HyperXtrude 2015 Now Available

This release can work with large mesh models of up to 4 million nodes.

HyperXtrude lets you set up a model in a CAD-like environment. What this means is that die designers, engineers and manufacturing experts on the shop floor can validate die designs using CAE techniques directly from CAD models.

HyperXtrude 2015 comes with Simplify/Patch tools so that you can clean up geometry problems before running the analysis. It also has tools for measurement and mass calculations as well as support for different unit systems.

For metal extrusions, users can now mesh a model with the mandrel offset and the solver.

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Handheld 3D Scanning Makes Its Mark In Mainstream Design

A new generation of high-precision, cost-effective handheld 3D scanners is marching into the mainstream, allowing even smaller shops to reap the productivity benefits of streamlined engineering and quality control practices.

3D scanners have long been used by large players in industries like aerospace, defense and automotive, but their large, fixed footprints have limited their uses and kept the technology out of reach for small- and mid-sized companies.

The introduction of new handheld 3D scanners is challenging the limited use case scenario, opening up the technology and helping to transform several key engineering processes for mainstream companies. Handheld 3D scanners can deliver benefits for a variety of core design tasks, including reverse engineering and quality control, while having broad applicability for industrial applications as well as for the manufacture of orthopedics and prosthetics. Given their smaller and mobile footprint, they can also be used alongside tablet devices to do scanning work in the field.

Consider the role of a handheld 3D scanner in the reverse engineering process, for example. In the automotive sector, companies create physical models in styrofoam or clay, which are then recreated in 3D CAD software — a time-consuming effort that requires a fair degree of 3D modeling expertise. Deploying a handheld unit to capture a quick 3D scan of a prototype can jumpstart this process, redirecting the time and energy devoted to recreating models in CAD to the actual iterative design work. Handheld 3D scanners are also being tapped to recreate documentation and in some cases, finished parts, for retired systems — a scenario made much more difficult with stationary 3D scanning technology.

Leveraging handheld 3D scanners in quality control applications can have similar advantages. Here, handheld 3D scanners can be put to work directly on the shop floor to compare production goods with their 3D CAD model counterparts, helping to eliminate manufacturing errors and automating the process of detecting measurement deformations. In another quality control example, handheld 3D scanners can be used to scan industrial objects in the field, analyzing the results of changes over time and harnessing that data to correct degradation problems in subsequent designs.

Software Makes it Simple

At the forefront of advancing handheld 3D scanning technology into such mainstream applications is Artec, a leader in 3D scanning technology. Through its unique software approach and proprietary algorithms, Artec is able to deliver a line of handheld, high-precision 3D scanners that are cost effective for smaller companies.

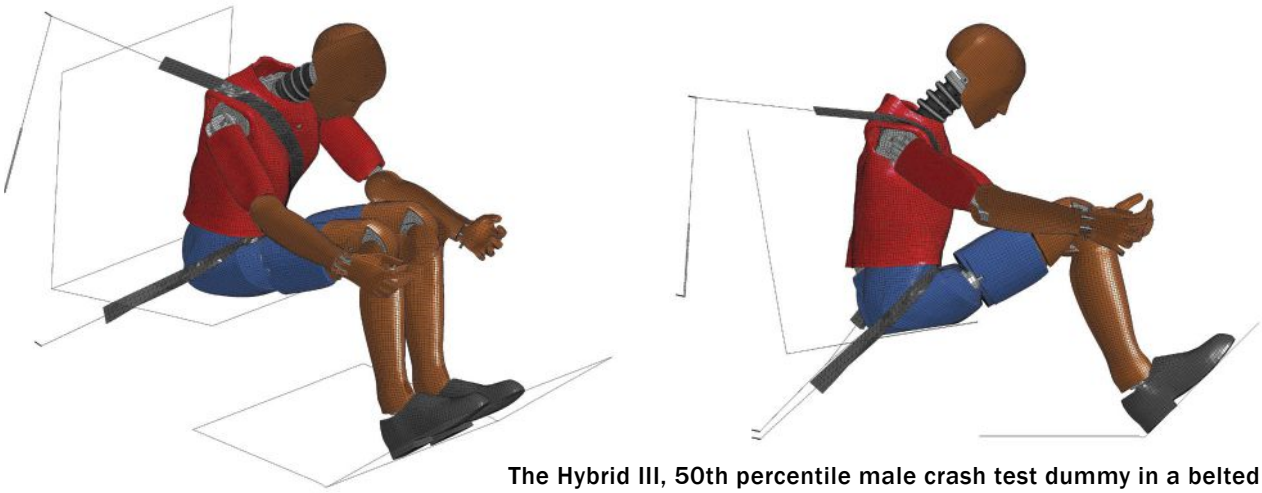
The company's Spider and Eva models deliver high resolution, high accuracy scanning of objects, making them a fit for a wide range of industrial applications. Spider, which offers a more limited field of view compared to its Eva counterpart, is best suited for mass production and rapid prototyping applications that require higher-precision scanning (0.05 millimeter point accuracy) of objects with sharp edges and intricate details. In comparison, the Eva 3D scanner trades slightly less precision (its 3D point accuracy is 0.1 millimeter) for a wider field of vision, making it ideally suited for shop floor applications or quick-turn rapid prototypes.

As Artec and others continue to push the envelope on price/performance, handheld 3D scanning is poised to become an integral part of mainstream engineering practices — not just a competitive edge for the big guys. To find out more about Artec's line of high-precision, affordable handheld 3D scanners, go to www.artec3d.com/scanners.

CRASH TEST COLLABORATION

The Center for Collision Safety and Analysis helps automotive, aerospace and transportation industries keep current with simulation and testing methods.

BY MARK CLARKSON



The Hybrid III, 50th percentile male crash test dummy in a belted sled test. ***Images courtesy of Livermore Software Technology Corp.***

Professor Cing-Dao "Steve" Kan is the director of the Center for Collision Safety and Analysis (CCSA) at George Mason University in Fairfax, VA. He's been at the forefront of using computer simulation for vehicle crash analysis for two decades.

CCSA works with government agencies, auto companies, aerospace companies, roadside hardware (e.g. highway safety barrier) manufacturers, computer companies and software companies as well as suppliers that feed into all those industries.

"CCSA is a neutral technical place where government and industry are working together on technical issues in order to move forward with legislation, regulations or technical specifications. We get everybody on the same page," says Kan.

The private companies CCSA works with often have plenty of data, but may not have the right data or know the best way to analyze it. CCSA can help on both fronts.

"One [auto manufacturer] came to us because their accident and injury rate was higher than their competitors' and they didn't know why," Kan says by way of example. "They wanted a data analysis, comparing their vehicle with their competitors' vehicles to give them some input on why their accident and injury rate is higher. So we do those type of analyses."

Those analyses involve crashing a lot of virtual cars. The data available from physical crash testing is, in some ways, surprisingly limited. A government regulation may specify a vehicle traveling at 30 mph into a rigid wall but, in reality, cars rarely smash head first into rigid walls. They hit trees and utility poles, crash into embankments and sideswipe highway barriers. "We do a lot of simulations to mimic these real-world accidents," says Kan.

CCSA also works closely with the National Highway

Traffic Safety Administration, as well as state Departments of Transportation, providing technical expertise when it's time to review or update standards. CCSA works with state DOTs, for example, to evaluate the performance of highway safety barriers. "We've been using simulation to evaluate different systems," says Kan. "In that capacity, we work with state DOTs as well as the manufacturers that provide this hardware."

CCSA's testing isn't all virtual, notes Kan. "We currently operate a crash test facility at the Federal Highway Administration in McLean, VA, where we run actual vehicles into different types of barrier systems at up to 80 mph."

The Aspect of Injury

In addition to simulating vehicles and barriers, CCSA is concerned with the integrity of any human occupants. "We actually model crash test dummies," says Kan. These crash test dummies aren't virtual humans; they're virtual crash test dummies.

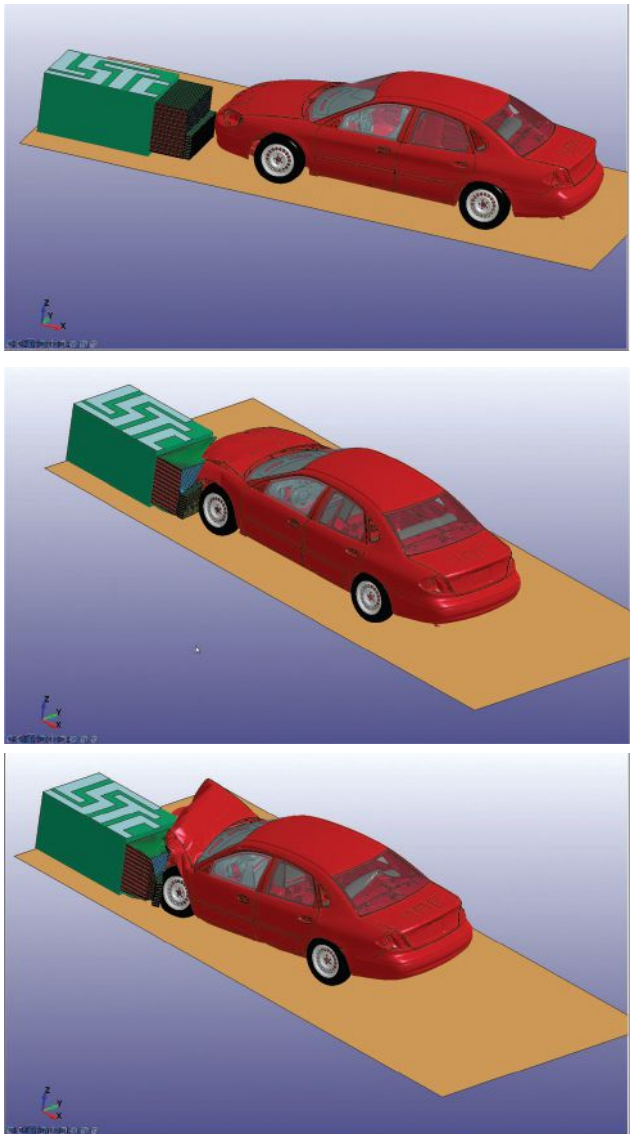
"That's exactly the point," says Livermore Software's Christoph Maurath, "To predict what the physical test is going to look like, before I build anything physical." Because physical tests will involve crash test dummies, so should the simulations. Livermore and CCSA collaborate on developing the virtual dummies, which are available to licensed LS-DYNA users at no additional cost.

The next generation of anthropomorphic testing device is a virtual human, with muscles, joints and organs.

"We try to take a holistic view of transportation safety issues," says Kan. "We look at it from the vehicle's side, from the highway's side, and from the occupant's side."

It's not always done that way, he says. "People who design the highway look at a vehicle as a rigid block of mass smashing into their barrier systems. When people look at the cars, all they care about is that the car is going to smash into a wall based on government test specifications. They don't worry about hitting trees or other things. And on the occupant side, they are looking at specific mechanical dummies. So when you do engineering analysis, using modeling and simulation, each of these are separate groups of people."

In contrast, says Kan, CCSA tries to simulate the entire event. "Maybe," he says, "the vehicle runs into a guard rail or bridge rail. How does the barrier perform? Or maybe the vehicle hits an embankment and rolls over. How is the vehicle performing in these situations? Is it absorbing enough energy? Is the cage protecting you



This series of images shows a simulated car crash into a static barrier.

from head injuries during roll incidents? In a side impact, is a utility pole going to cut into the vehicle?

"At the same time, we also look at the occupants. What type of injuries will they sustain? Today, we're able to use computer simulation to simulate the whole event, to look at all three of these together, using a more integrated analytical approach."

Staying Ahead of the Curve

"The auto industry is very production driven," says Kan. "They don't have time to take care of specific material issues, or integration issues, and that is usually where we come in. We say, 'Hey — this method is available and cost effective.' And if they're interested, we work with them."

Perhaps an auto manufacturer wants to use an aluminum chassis, but isn't sure how to simulate the welds, or adhesive joints. "We tell them that we have a new method of modeling all this," Kan says

Or maybe an auto manufacturer is interested in using virtual humans in their simulation. "They'll say, 'You're using human models,'" says Kan. "We want to give you a project to help us flesh out our in-house methodology, and to migrate from dummy analysis to human analysis.'"

A Helping Hand with Hardware and Software

"On the modeling methodology side, we're working with hardware and software vendors to help them implement certain features," says Kan. "For example, we work with LS-DYNA very closely. We constantly implement new features. That's one of the reasons that auto companies are interested in working with us — to improve methodology, particularly in terms of materials. We develop the models, which are implemented into LS-DYNA. And once hard-coded in there, the features are available to all these aerospace and automotive companies.

"For hardware companies, we look at their system's performance levels. By running our benchmark models

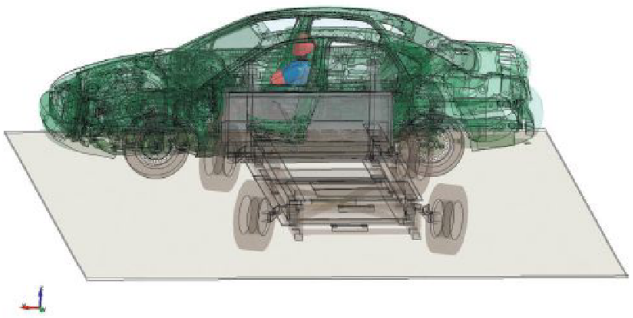
NCMS Wants to Bring Analysis Expertise to More Companies

The past 20 years haven't been kind to America's manufacturing industries. Enter the National Center for Manufacturing Sciences (NCMS). NCMS is trying to revamp the American manufacturing industry by providing their members with technical support as well as technical and computational resources.

One emerging problem in the manufacturing industry is the kind of work that OEMs (original equipment manufacturers) are farming out to small and medium size manufacturers, says Cing-Dao "Steve" Kan, director of the Center for Collision Safety and Analysis (CCSA) at George Mason University.

"Today, when Ford goes out for a bid on a bumper, the specification calls not only for the actual parts, but for computer models and simulation results as well," he says. "Many smaller companies can do manufacturing, but don't have a dedicated in-house analysis group that can use new, sophisticated software, or the computational resources to do the analyses."

That's where NCMS comes in, says Kan, "using our research center and bringing computer software and computer hardware companies together, to help them. It's almost like an industry consortium."



The WorldSID 50th percentile side-impact dummy sits in a Ford Taurus model. Image via LS-DYNA.

— like three vehicles colliding — we can see what kind of throughput the system is capable of, and help them debug it."

Looking ahead, CCSA hopes to focus on the next generation of engineers.

"We want to educate young engineers in the safety field," says Kan. "We have a specialist education program, so students are coming here specifically to learn about modeling vehicle impacts, accident investigations and government safety regulations.

"In the past 20 years, we've graduated around 180 students, who are embedded in the automotive and aerospace industry throughout the world." **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

- **Center for Collision Safety and Analysis at George Mason University:** ccsa.gmu.edu
- **Federal Highway Administration:** fhwa.dot.gov
- **Ford Motor Company:** Ford.com
- **Honda:** Honda.com
- **Livermore Software Technology Corp.:** lstc.com/products/ls-dyna
- **National Center for Manufacturing Sciences:** ncms.org
- **National Highway Traffic Safety Administration:** nhtsa.gov

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Mimicking Reality in Product Development

Immersive 3D experiences touted as the foundation of a new kind of collaboration.

BY KENNETH WONG

If you want to know what it feels like to be an astronaut inside a space capsule, here's a tip from David Markham, vice president of Advance Programs at Lockheed Martin Space Systems. "Put on your oven mitts and try to operate your TV remote control," he suggests.

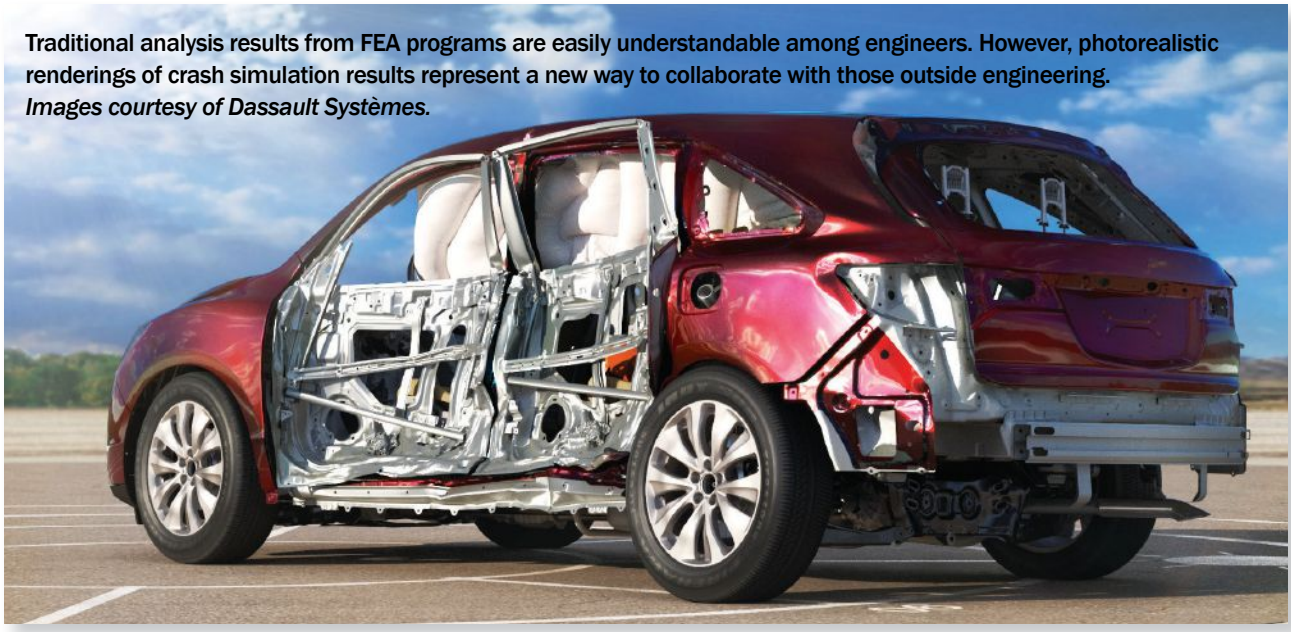
That's an inexpensive way to mimic what Lockheed Martin engineers do with their test subjects in the Human Immersive Laboratory, or "the dunk tank," as Markham calls it. The lab incorporates head-mounted displays, motion-capture technology and haptic gloves. By observing prospective space travelers' behavior in the dunk tank and listening to their complaints, Markham and his colleagues gain valuable design insights they might otherwise overlook in the design process.

"The dashboard inside [the space capsule] had to be operated while you're wearing massive gloves," Markham said. "Imagine your fingers are about four times the normal size, and you have to push the switches on that dashboard. Even if you knew what to push, you couldn't, because your fingers were too big." That's the type of potentially costly errors digital simulation alone won't reveal, but an immersive experience would.

Markham was speaking to the audience at the 3DEXPERIENCE Forum (Nov. 11-12, 2014, Las Vegas). Dassault Systèmes, the host of the event, also happens to maintain several immersive environments, known as VR Caves. The type of lifelike simulation possible in those virtual environments offers clues to the principle that underlies Dassault's approach to collaborative product development. The rich, reality-mimicking digital experiences are at the heart of its 3DEXPERIENCE.

Entering the Experience Economy

Dassault Systèmes brands like CATIA and ENOVIA are well established in aerospace and automotive. With the acquisition of MatrixOne in 2006, Dassault Systèmes tiptoed into fashion and apparel. With the more recent purchase



Traditional analysis results from FEA programs are easily understandable among engineers. However, photorealistic renderings of crash simulation results represent a new way to collaborate with those outside engineering. ***Images courtesy of Dassault Systèmes.***

of Accelrys in June 2014, Dassault Systèmes significantly accelerated its activities in the life science and consumer packaged goods sector. The company's expansion into new markets had a profound impact on the character of its software offerings.

When Dassault Systèmes' primary customers were from the engineering and manufacturing sectors, CAD assembly models and PLM (product lifecycle management) dashboards were sufficient tools for collaboration. But the outreach efforts in fashion, apparel, footwear, retail and life sciences demand a more intuitive communication medium, unencumbered by a mechanical CAD modeler's parametric input fields and more inviting than a traditional PLM system's rows and columns.

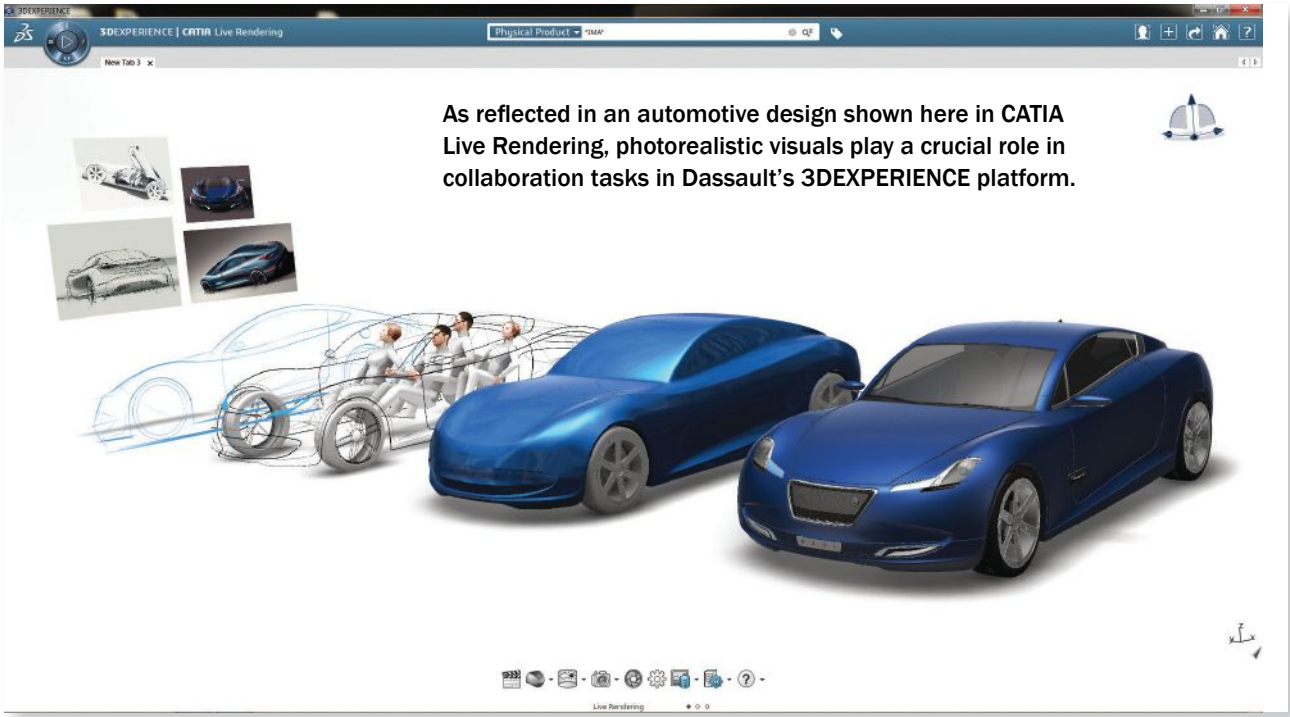
In classic manufacturing, tech-savvy engineers and designers are the primary decision makers at the center of the product development universe. In the new markets Dassault Systèmes is courting, the end users — the consumers — play a critical role. Their preferences are part of the feedback loop in the iterative design process. They show a willingness to pay extra for a good experience, defined by the convenience of ordering online, customization options and available add-ons. Rich multimedia content pumped out in social media outlets have a better chance of attracting those who cater to the fashionistas. Immersive 3D visuals augmented with stereoscopic hardware could facilitate a straightforward discussion with a heart surgeon the way CAD models couldn't. So Dassault Systèmes decided lifelike experiences must be the lingua franca of its universe.

The watershed moment came in 2013, when the company renamed its annual customer conference as 3DEXPERIENCE Forum, and rebranded CATIA, DELMIA, ENOVIA and other titles as part of its 3DEXPERIENCE platform. "This is about looking at the world in a different way, a different perspective, looking at it from the future … Welcome to the world of experiences," said Bernard Charles, CEO, Dassault Systèmes, at the forum.

Tablet and Cloud

In CATIA V6, Dassault Systèmes introduced a new sketching tool called CATIA Natural Sketch. The application is specifically developed for the tablet-stylus combo. The sketching mode replicates the experience of drawing on paper. The hand-drawn 2D sketch can easily be transformed into 3D volumes, ready for further development in CAD. At the same time, the application also lets you sketch directly on 3D surfaces, which is especially useful for industrial designers who work with complex surfaces and organic shapes.

The stylus-friendly Natural Sketch anticipates the popularity of mobile tab-



As reflected in an automotive design shown here in CATIA Live Rendering, photorealistic visuals play a crucial role in collaboration tasks in Dassault's 3DEXPERIENCE platform.

lets powerful enough for professional usage, such as Microsoft Surface Pro. And 3DEXPERIENCE's cloud-centric architecture lets you easily share the data or launch an online session to discuss the concepts with remote collaborators.

Competitors as Collaborators

Part of product development is surveying the competitive landscape, scouting out what rivals are developing for the same market segment. To capture the general vibe for a product, you may use Dassault Systèmes' Netvibes Dashboard Intelligence, which searches and aggregates information for your product, be it a washing machine or a new sports utility vehicle.

Acquired by Dassault Systèmes in February 2012, Netvibes culls data from news groups, user forums, social media feeds and corporate archives — a combination of public and private sources — to provide guidance for product designers. The intelligence you gather could include online chatter about your competitors' products currently in development.

Consumers as a Resource

Perfect Shelf, an industry experience from Dassault Systèmes Consumer Packages Goods (CPG) group, is a good example of the kind of solution developed for delivering products and an experience. The underlying 3D modeling technology also powers Dassault Systèmes CATIA, used by engineers from Boeing and BMW, but you won't get any hint of the plant floors and assembly lines in Perfect Shelf. In a drag-and-drop interface, Perfect Shelf lets store display designers assemble and populate virtual retail displays using ready-made 3D content. That makes constructing 3D models of shelves stuffed with shampoo bottles and cosmetics easy enough for someone who has never used a CAD program.

In a similar fashion, the CPG group also offers Perfect Package, a 3D modeling solution to prototype appealing, eye-catching packages. Perfect Package incorporates 3D sketching functions from CATIA Natural Sketch, simulation tools from the SIMULIA brand, and Illustrator-like vector drawing tools. The ability to test virtual shelf setups and 3D mockups of packages with real consumers allows brand owners to understand how seemingly trivial details—like eye level, label visibility, and reach—can influence buying decisions in the store.

"CPG brand manufacturers and retailers can imagine and quickly deliver superior shopping experiences … It transforms the way they collaborate and innovate — for and with consumers," says Marc Truffault, director, Solution Experience for CPG.

Realistic Crash Simulation

Traditionally, simulation results are meant to be shared, viewed, and critiqued among advanced automotive engineers; therefore, the crude mesh models with color-coded stress distribution and displacement regions are more than enough. But such engineering-focused visuals may not adequately convey the severity of the problem or the nuances in the design flaws when communicating with those outside engineering.

Is it a good idea to produce crash simulation results as photorealistic animations and high-resolution renderings? (The simulation uses 3D models of test dummies, so there's no blood and gore.) RTT, now 3DEXCITE, a high-end visualization solution supplier acquired by Dassault Systèmes in May 2014, is certain that's the way to collaborate with stakeholders who are

not engineers and won't easily be convinced by typical analysis screenshots. It came up with DELTAGEN Real Impact, a product that made an impact on the Crash Safety Group of Honda R&D Americas Inc.

Describing its work with Honda, 3DEXCITE says it enables "Honda engineers to quickly produce visually stunning and credible imagery from 3D simulation results with little effort, allowing them to communicate complex structural analysis results in an intuitive way." The software, according to 3DEXCITE, uses "a custom LS-DYNA translator and assemblies in DELTAGEN. Using the system, Honda can rotate the view of the simulation, strip away parts and isolate a component for closer analysis. Additionally, both real-time interaction of simulation states, as well as production of offline movies of the complete crash sequence are possible."

Immersion with Some Limits

True immersive reality — one that's virtually indistinguishable from reality itself — is a tall order, perhaps a utopian concept better left to science fiction. Immersive caves, or sophisticated virtual reality rooms, are a reality today; however, the cost remains prohibitive for many. Immersive experiences add a new dimension to the collaborative workflow, but those without the budget of Lockheed Martin may have to be content with limited immersion.

For some, it might mean a creative tabletop setup that combines stereoscopic display and special eyewear, like the zSpace running Dassault Systèmes' CATIA software. For others, facilitating the virtual walk-through of a 3D store model that replicates the real retail store's look and feel might be sufficient. These lifelike experiences, even if constrained by cost and space, are essential in the type of collaboration that involves customers and consumers outside engineering.

"Spending time watching your customers in these immersive environments, and listening to what they say — listening to their 'I wish I had' and 'I wish I could,' " says Markham, is the best way to develop a product that meets their expectations. DE

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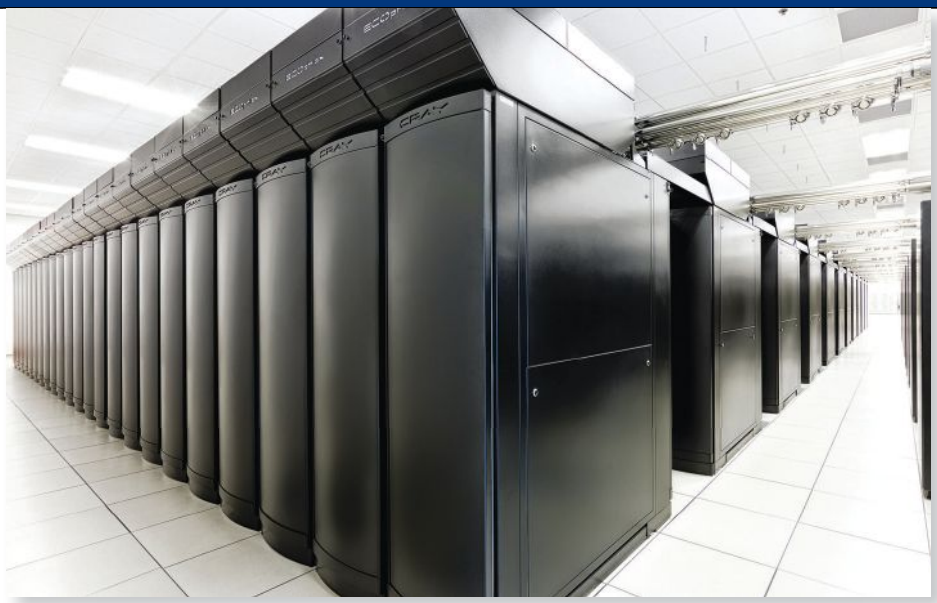
INFO

- **Human Immersive Lab:** Lockheedmartin.com/us/aeronautics/labs/human_immersive.html
- **Dassault Systèmes:** 3ds.com
- **Honda Research:** hondaresearch.com
- **zSpace:** zspace.com

Share Alike

The NCSA wants to share its supercomputing resources with private industry.

BY FRANK J. OHLHORST



The Blue Water supercomputer is equipped with about 1.5 petabytes of memory.

Wandering the halls of the NCSA (National Center for Supercomputing Applications), one can just imagine the prideful voice of HAL 9000 computer from "2001: A Space Odyssey" boasting that it became operational at the HAL Plant, located at the University of Illinois at Urbana-Champaign's Coordinated Science Laboratory, which is just 500 ft. away. The massive computing power of the HAL 9000's artificial intelligence remains steeped in the lore of science fiction, but the echoes of its voice are a reminder of the enormous computing power available at the NCSA.

NCSA, which is supported by the state of Illinois, the University of Illinois and the National Science Foundation (NSF), is willing to share the power of its supercomputing resources with external researchers, private manufacturers and engineering companies in an effort to democratize access to supercomputing resources and fuel collaboration. That willingness to share has spawned some impressive collaborative efforts that have helped private companies ranging from the Fortune 500 to small and midsized businesses overcome significant engineering challenges.

Democratizing Supercomputing

The star of the show is the NCSA's Blue Waters supercomputer, which is built on the latest technologies from Cray Inc. In its current configuration, Blue Waters uses hundreds of thousands of computational cores to achieve peak performance of more than 13 quadrillion calculations per second.

"If you could multiply two numbers together every second, it would take you millions of years to do what Blue Waters does each second," says Daniel Bodony, Blue Waters engineering professor. NCSA's published specs on Blue Waters, claim that the supercomputer offers:

- More than 1.5 petabytes of memory, enough to store 300 million images from your digital camera.
- More than 25 petabytes of disk storage, enough to store all of the printed documents in all of the world's libraries.
- As much as 500 petabytes of tape storage, enough to store 10% of all of the words spoken in the existence of humankind.

Pairing that computing power with private sector collaboration has spawned some impressive results. In November of 2014, NCSA announced that that they had scaled ANSYS Fluent (a computational fluid dynamics simulation software package) to 36,000 compute cores. That feat, NCSA claims, is an industry first that could lead to greater efficiencies and increased innovation throughout manufacturers' product development processes.

"NCSA is unique in connecting the industrial users, the hardware and software vendors and the domain expertise of our staff," says Ahmed Taha, project leader, NCSA. "In addition, this level of scalability for a commercial fluid dynamics solver is unprecedented on our system, especially considering the complexity of the model physics with transient, turbulent flow, chemical species transport and multiple non-reacting flows."

"While most organizations don't have access to 36,000 cores today, it won't be long before these extreme core counts are commonplace. And even today's users who are running at much lower core counts will see direct benefits through considerably greater efficiencies. The results will be more amazing products delivered to customers much faster than ever," says Wim Slagter, product manager, High-Performance Computing (HPC), ANSYS.

While the results of the ANSYS and NCSA's collaboration are impressive, that project proves to be just one example of NCSA's ability to collaborate with the private sector, as evidenced by two other projects being undertaken with private sector participation:

1. **Epistatic Interactions for Brain eGWAS in Alzheimer's disease:** This project is dedicated to analyzing data from about 400 human subjects, measuring levels from approximately 24,000 transcripts that were part of an expression array. The brain gene expression levels of these transcripts were previously tested for

association with 300,000 genetic variants. The gene expression measurements were done in two different brain regions: temporal cortex and cerebellum.

2. **Scalability Analysis of Massively Parallel Linear Solvers on the Sustained Petascale Computing System of Blue Waters:** This project, in collaboration with Anshul Gupta of IBM, involves porting the Watson Sparse Matrix Package (WSMP) solver to Blue Waters and performing full-scale benchmarking tests using assembled global stiffness matrices and load vectors ranging from 1 to 20 million unknowns extracted from commercial and academic implicit finite element analysis applications. The results will open the door to solving large multiphysics problems on petascale machines, both in academia and industry.

Those projects, as well as many others, would not have been possible without the computational power offered by Blue Waters. However, there is much more to NCSA's collaborative efforts than hardware. The NCSA offers other resources in the form of highly trained professionals, operators and program managers, working under the careful guidance of a group of the university's senior professors.

The NCSA has demonstrated that private sector collaboration via the NCSA's Private Sector Program (PSP) can lead to some impressive results that benefit all involved, as well as the public at large.

Private Sector Access

Although, most of the NCSA's supercomputing resources' users are researchers from universities and academic research centers, the supercomputers (including Blue Waters) are available to more than just academia. The NCSA's PSP grants access to private sector partners, boasting some 26 partners from sectors such as manufacturing, oil & gas, finance, retail/wholesale, biomedical, life sciences, astronomy, agriculture and technology. Additionally, access isn't just limited to those onsite, NCSA offers researchers the ability to access the computers remotely.

For the private sector, the PSP's core mission is to help its partner companies gain a competitive edge through expert use of modern, high-performance digital and human resources. The PSP creates a collaborative environment where traditional sponsored research projects are complemented by:

- Dedicated, non-government high-performance computing resources
- A high-tech, mobile consulting team
- Software/hardware benchmarking and development in production environments
- Code-performance teams
- Public-private partner leadership
- Blended partner applied research and development

The PSP also hosts annual meetings, which are designed to

The NCSA built the iForge cluster to process jobs for its Private Sector Program.

bring together representatives from industry (including but not limited to current partner organizations), University of Illinois research faculty and the NCSA's staff for presentations and discussions of shared challenges and new paths to innovation.

One of PSP's primary goals is to fuel the collaboration and cooperation between academia, industry and government. "We are now able to bring together industrial, academic and government scientist to do stupendous things. Working with our PSP clients has given us ample evidence of what multi-physics and multi-scale HPC applications are capable of," says Merle Giles, director of PSP. "American OEMs (original equipment manufacturers) that understand HPC are pushing the envelope and are solving problems involving high-end science across multiple disciplines."

NCSA's PSP offers several benefits to the private sector and HPC computing in general, including:

- Industry-driven science and engineering
- High-performance software, data and hardware
- Development, demonstration and deployment
- Accelerated faculty research
- Partnerships, services and consulting

According to Giles, some 40% of the Fortune 50 and 60% of Fortune 100 manufactures have partnered with NCSA via the PSP. To meet the demands placed upon NCSA's supercomputing resources, NCSA brought iForge online, a supercomputer for industry. iForge was purposely developed without any government funding, allowing it to be dedicated to the PSP's work with industry and to address the ever growing queues that are present on the NSF-funded Blue Waters. iForge offers over 3500 cores and 7700TB of DDN storage allowing it to function as a development and production workhorse.

"[The] PSP helps to eliminate barriers to supercomputing, as well as code development, by allowing ISVs (independent software vendors) to scale their off-the-shelf code for high core densities," says Giles. He says PSP partners with several technology vendors, such as Dell, Intel and Microsoft, but adds, "We tell every vendor that wants to partner with us that they must take off their vendor hat and think about what we can do together instead." Simply put, collaboration is fuel that drives a project.

Private sector businesses looking to access PSP's resources will need to fill out an application and provide a PDF of their proposal. For Blue Waters, that application can be found at http://goo.gl/cg46wO. For info on accessing the iForge Cluster, interested parties can visit ncsa.illinois.edu/industry/iforge to gather more information. DE

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

INFO ➜ ANSYS: ANSYS.com

➜ **National Center for Supercomputing Applications:** ncsa.illinois.edu

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iForge Cluster	Intel "Ivy Bridge" Xeon E5 v2 2680 10-core CPU, 3.2GHz, 25MB L3 cache	AMD "Abu Dhabi" Opteron 6380 8-core CPU, 3.4GHz, 16MB L3 cache	Intel "Ivy Bridge" Xeon E7 v2 4890 15-core CPU, 3.2GHz, 37.5MB L3 cache
Cores/Node	20	32	60
Total Nodes	144	18	2
Total Cores	2,880	576	120
FLOPS/Node	496 GFLOPs	640 GFLOPs	1,536 GFLOPs
Memory/Node	64 or 256GB, 1.86GHz	256GB, 1.6GHz	1.5TB, 1.6GHz
Memory/Core	3.2 or 12.8GB	8GB	25.6GB
Memory Bandwidth	120GB/sec	102GB/sec	205GB/sec
Storage	700TB on network filesystem (IBM GPFS)		
Interconnect	QDR InfiniBand (PCIe 3.0), 40 Gb/sec bandwidth, 100 ns latency		
OS	Red Hat Enterprise Linux 6.4 (other OSes upon request)		

The NCSA's iForge high-performance computing cluster for its industry partners features three distinct hardware platforms, each configured for different computational needs. *Source: NCSA*

3D Printing Helps Launch Satellite Mission

NASA's Jet Propulsion Lab turned to additive manufacturing to lower cost and weight of new satellite antenna array supports.

BY BRIAN ALBRIGHT

For the aerospace industry, additive manufacturing holds the promise of helping companies reduce cost, weight and complexity for a variety of applications. NASA's Jet Propulsion Laboratory (JPL) recently collaborated with 3D printing services company RedEye to do exactly that as part of the upcoming FORMOSAT-7/COSMIC-2 satellite launch.

In 2006, a consortium of U.S. research universities and the Meteorological Society of the Republic of China (Taiwan) collaborated on the original Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) project, using satellites to collect temperature, moisture and pressure data. A follow up project, the FORMOSAT-7 COSMIC-2 satellite mission, will gather even more weather-realted data. That mission will launch six satellites into low-inclination orbits in 2016, along with another six satellites in high-inclination orbits in 2018. The atmospheric data provided by the satellites will support research in hurricane analysis and prediction, climate processes and other areas.

The Global Navigation Satellite System (GNSS) radio-occultation (RO) payload is being developed by NASA JPL and will be capable of tracking up to 12,000 high-quality profiles per day once both constellations are fully deployed. NASA began its development work in 2011, and additive manufacturing quickly entered the mix.

RedEye used fused deposition modeling and the ULTEM 9085 thermoplastic to create an array that matched NASA's specifications.

Control Cost, Increase Speed

Key components of the satellite are actively steered, multi-beam, high-gain phased antenna arrays. COSMIC-2 would use 30 of these traditionally expensive custom arrays, and NASA JPL wanted to find a way to minimize manufacturing costs and assembly time. NASA approached Minneapolis-based RedEye, a Stratasys subsidiary that provides rapid prototyping and additive manufacturing services, to work on the project.

The antenna array supports are usually machined from a composite mate-

NASA's JPL is developing the antenna arrays to place on FORMOSAT-7 COSMIC-2 satellites. The mission will collect atmospheric data.

material called astroquartz, but the COSMIC-2 design would be expensive to produce that way. "Machining those parts was time consuming and costly, and that raised concerns about validating and testing the design," says Joel Smith, strategic account manager for Aerospace and Defense at RedEye.

"We're seeing a move in aerospace from traditional manufacturing to additive manufacturing, where it makes sense," Smith says. "Different companies are using FDM (Fused Deposition Modeling) to make brackets and retainers that are not load bearing. They can take out weight and reduce assembly steps by producing single-unit parts."

Using Stratasys FDM equipment, RedEye could produce the structures as a single unit out of ULTEM 9085 thermoplastic. By doing so, NASA's JPL could quickly create prototypes for testing at a lower cost, and reduce the overall cost and time required to manufacture and assemble the final products.

"The array originally would have been produced in separate parts, and then assembled," says Trevor Stolhanske, senior application engineer at RedEye. "They wanted to produce the arrays as one unit. They had a rough CAD model, and we worked with them to ensure the specifications would work well with the FDM process."

"We could also provide flexibility for design changes," Smith adds. "With additive manufacturing, you can reduce the cost of producing prototypes and end-use items."

Most 3D-printed parts in the space program have not been for external use on a spacecraft. To create the antenna array supports, NASA and RedEye would have to test and validate the material and the parts to ensure their performance in that environment.

Thermoplastics in Space

When NASA JPL approached RedEye, they had already identified ULTEM 9085 for the application. The material is a thermoplastic that is as strong as aluminum, but much lighter. More importantly, it had already been vetted and approved for aerospace applications.

"It's a flight-certified material, and one of the more robust materials for additive manufacturing," Smith says. "It was also a good fit for radio and antenna applications."

The material had never been used on the exterior of a spacecraft, so the parts had to be tested for antenna beam pattern, efficiency and impedance match, as well as for NASA class B/B1 flight hardware requirements. Those tests included susceptibility to UV radiation, atomic oxygen, outgassing, thermal properties (including compatibility with aluminum panels), vibration/acoustic loads and compatibility with the paint and primer used on the structure.

A high emissivity protective paint was used on the plastic structure to reflect solar radiation and optimize thermal control of the antenna operating conditions.

Big 3D Printed Build Enables Lockheed Martin to Simulate Fuel Tank

The FORMOSAT-7 COSMIC-2 project was not RedEye's first time working on a space-related build. Last year, the 3D printing services provider partnered with Lockheed Martin's Space Systems Company (SSC) to 3D print two large fuel tank simulators for a satellite form, fit and function validation test and process development. With the biggest tank measuring nearly 7 ft. long, the project marked one of the largest 3D printed parts RedEye had ever built.

With RedEye's Fused Deposition Modeling (FDM) technology, the team says it developed the fuel tanks within a condensed time frame and at about half the cost of machining the parts.

"With RedEye's machine capacity and engineering support, we were able to successfully build these tank simulators in a fraction of the time and at a fraction of the cost," said Andrew Bushell, senior manufacturing engineer at Lockheed Martin Space Systems Company, via a press statement.

The larger tank was built in 10 different pieces and the smaller in six different pieces using polycarbonate (PC) material. Combined, the fuel tanks took nearly two weeks to print, taking roughly 150 hours per section. Based on the sheer size of the parts, customized fixtures were required to support the structures as they were bonded together and shipped to be machined to meet specifications. Once all of the pieces were machined, the final assembly required 240 hours.

"This project is unique in two ways — it marks the first aerospace fuel tank simulation produced through additive manufacturing and is one of the largest 3D printed parts ever built," stated Joel Smith, strategic account manager for aerospace and defense at RedEye, in a press statement.

Lockheed Martin first embraced the design benefits of additive manufacturing with RedEye in 2012 and has invested in in-house 3D printers from RedEye's parent company, Stratasys. RedEye has worked with Lockheed Martin on various tooling and additive manufacturing projects that support its Space Systems Company.

Collaborative Design Process

The JPL began with a CAD model based on the original machined antenna array design, which was then altered for the FDM process. NASA and RedEye worked primarily in SolidWorks, Magic and Stratasys' Insight software.

One critical change was the inclusion of 45°, self-support overhead angles in the design to avoid using breakaway support material. That reduced machine run time, increased the printing speed, and minimized part breakage during support removal.

"By eliminating the support material, that creates less havoc when you are removing the support," Stolhanske says. "You don't have to remove material from complex areas, and the run time is drastically reduced. The head on the FDM machine does not have to toggle back and forth, layer over layer. You have a twofold savings of run time and support removal, along with minimizing potential damage."

RedEye and the NASA JPL conducted numerous conference calls and onsite meetings throughout the project to collaborate on the final design. NASA conducted testing of each prototype throughout the process, and would come back to RedEye with any design adjustments.

"With every iteration, there was a design review and modifications made to the drawing and the printed version," Smith says. "Each part we delivered was a complete component, so they were able to do mock-up assemblies for form, fit and function tests, as well as more detailed changes. They had an end-use part throughout the prototyping phase."

Between March 2012 and April 2013, RedEye produced 30 of the structures for testing. The JPL and RedEye engineering teams collaborated to process STL files and ensure the parts met exact tolerances. RedEye deburred parts, stamped each with an ID number, and provided a material test coupon, as well as reaming holes for fasteners that would attach to the aluminum panels and small channels in the cones for wiring.

According to Stolhanske, a key challenge was ensuring the wiring holes met the exact tolerances. "The holes had to be a specific dimension that was not too big or too small, and we had to ream precise holes for them," he says. "It was a challenge because they had to be within a certain spec on their drawings in order to work."

Each of the antenna arrays requires roughly 55 to 60 hours to manufacture using FDM. RedEye was able to deliver the completed antennas for final testing and integration, and has been added to the JPL Approved Supplier List.

In addition to reducing weight, saving time and reducing costs, NASA was also able to validate the FDM process and materials for use on future projects.

"The aerospace and defense markets are really entrenched in traditional manufacturing, so it takes some understanding and education to make the move to something like FDM," Smith says. "We were able to provide support for NASA so they could move from concept to finished part, and be able to make design changes without all the cost and time penalties of traditional manufacturing." DE

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INFO

Dassault Systèmes SolidWorks Corp.: SolidWorks.com

Lockheed Martin: lockheedmartin.com/us/ssc.html

NASA JPL: jpl.nasa.gov

RedEye: RedEyeOnDemand.com

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

Centralizing CAD and PLM Workflows

Ocap SpA uses Teamcenter to help streamline data from across the globe.

Ocap SpA, a provider of automotive part design and manufacturing, is managing and sharing design information from multiple computer-aided design (CAD) systems using Teamcenter from product lifecycle management (PLM) specialist Siemens PLM Software.

Ocap-branded ball joints and other steering and suspension system parts are sold in 147 countries for use in cars, tractors, trucks and tractors. The company uses Solid Edge software, a hybrid 2D/3D CAD system that uses synchronous technology — as well as Femap software, a simulation solution. Both solutions are from Siemens PLM Software.

Multiple CAD and PDM Systems

A contract with agricultural equipment manufacturer John Deere required Ocap to develop CAD models using PTC's Pro/ENGINEER. A similar requirement came from automaker Lamborghini.

"We used Pro/ENGINEER for OEM (original equipment manufacturer) product development, while continuing to use

I-deas for aftermarket product design and simulation," says Jean-Jacques Tomas, Ocap engineering manager. "So, we ended up with two CAD systems and two big product families developed in parallel using different systems."

Managing the product data led to some issues.

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Edgecam Drives Sports Car Development

Great British Sports Cars uses the CNC machining software to create custom parts and increase time to market.

Great British Sports Cars, a specialist sports car manufacturer, recently acquired a Hardinge Bridgeport 4-axis machining center, and is programming it with Edgecam to produce complex components as part of its expansion plans.

The company manufactures up to 85 vehicles a year in kit form, and a number of factory builds to order.

Around 2,000 components go into each car, and GBSC's development plans include manufacturing the majority of those parts on-site. "It became clear that we couldn't develop the car in the way we wanted to in terms of improving design and speed of production by continuing to buy some parts off-the-shelf, and sub-contracting others

out," says Richard Hall, director.

GBSC consulted Engineering Technology Group, who recommended the Hardinge Bridgeport GX 1000 programmed with Edgecam.

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Man Meets Software: A Collaborative Optimization Culmination

EDAG enlists the HEEDS collaborative optimization platform as a partner in vehicle lightweighting.

BY BETH STACKPOLE

Using HEEDS, the EDAG team was able to determine that a multi-material design for the frame was the optimal lightweighting strategy for a pick-up truck. *Images courtesy of EDAG.*

Lightweighting a production vehicle design is a laborious process demanding all hands on deck. So when the Environmental Protection Agency (EPA) called on EDAG to help vet the impact of more rigorous Corporate Average Fuel Economy (CAFE) standards, the engineering services firm teamed up its best experts with collaborative optimization software technology to get the job done.

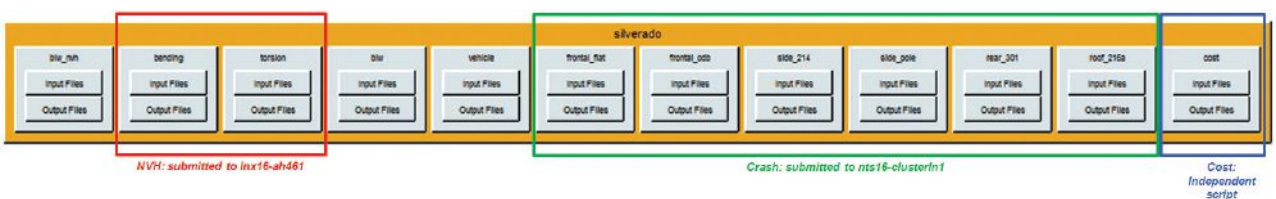
With so many variables to consider and with deadline pressures looming, manual design studies were out. Traditional optimization software could lend a hand automating the exploration process, but there were limits to what could be accomplished without human intervention.

EDAG found middle ground in the form of Red Cedar Technology Inc.'s HEEDS multi-disciplinary cooperative optimization software, a platform that lets engineers' know-how guide the optimization process to come up with the best possible designs in the most expedient fashion.

"When we just have the computer do the optimization analysis, it could take three to four weeks to get the results and after all that, it may not be right or might not satisfy everyone on the team," says Javier Rodriguez, EDAG's director of vehicle integration. "HEEDS allows us to get human intelligence into the [optimization] analysis while it's running. That way, we can make modifications based on engineers' input and keep things going. It's a very collaborative resource."

A Lightweighting Framework

Before the government pulls the trigger on more aggressive fuel economy standards — including the 2012 mandate to raise the average fuel efficiency of new cars and trucks to 54.4 miles per gallon by 2025 — a team of engineering services companies such as EDAG are selected to ensure the proposed levels are reasonable, both from a design and cost stand point. "They want to make sure they are not too onerous and can be accomplished," Rodriguez says. "They contract us to do engineering studies and get feedback from OEMs (original equipment manufacturers) before they issue the new directives."

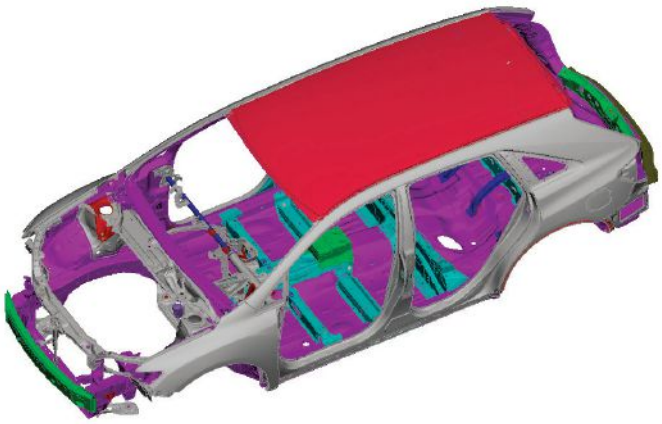


The HEEDS multi-disciplinary cooperative optimization software lets engineers' knowledge and experience guide the optimization process to come up with the best possible designs quickly.

This particular weight feasibility reduction study involved the Toyota Venza, a mid-sized cross-over utility vehicle (CUV), and a pick-up truck. There were a range of parameters governing the lightweighting exercise, including that only technologies and techniques that were currently feasible for manufacturability could be considered, and the options had to be cost effective for model year 2017 and model year 2020 high-volume production vehicles. Moreover, the existing vehicle noise, vibration and harshness (NVH) modal characteristics and crash performance had to be maintained as did the overall vehicle safety performance. Compounding the challenge: The total cost impact of the lightweighting changes had to be minimal, not exceeding increases of more than 10%.

Requirements became even more complex considering the scope of what could be lightweighted. In addition to the body-in-white (BIW), a prime system that typically comprises 20% to 25% of the total vehicle curb weight, the body-on-frame was fair game in the pickup truck as was closures, bumpers, doors, fenders, the hood and the tailgate of both vehicle types.

"The question the government or EPA is asking is relatively simple, but you need to deal with a lot of variables," Rodriguez says. "There's the potential to change



EDAG was able to achieve a 14% weight reduction on the body-in-white for the Venza CUV, amounting to a cost impact of $3.06 per kilogram.

250 parts in a body structure of a car — each part's thickness can be changed or its material composition altered. Every change effects weight and performance."

With so many variables and possible answers, the end result isn't one answer, but several scenarios that optimally solve the problem — from changing the grade of material to something like high-strength steel or doing a wholesale switch to an alternative like composites or aluminum. Other target areas included geometry changes, spot welds and alternative manufacturing technologies. "There is not one possible solution, but different solutions with different costs," he says. "Some could give us a 5% weight reduction with a 5% cost increase while others could provide a 10% weight reduction with a 20% cost increase. We needed help analyzing the possible solutions and design concepts quickly."

A Human Touch

Help came in the form of HEEDS, which factors human expertise and participation into the optimization process unlike some competitive tools, which rely solely on their own algorithms and search routines to analyze results. "The clear difference between HEEDS and other tools is that while it's running, we encourage users to actually watch the results versus waiting and letting it run in batch mode," says Angelo Flemings, vice president, Worldwide Business Development at Red Cedar. "Humans have insight and intuition, and no computer software has that."

Human interaction is particularly important when large and complex models are involved, as in the case with lightweighting design work, Flemings says. "Since these are very large models, you don't want them to just run and run and run because you might not come up with

any feasible designs," he says. "A human can apply their knowledge or inject input from other successful designs or projects into the optimization. Collaborative engineering in this fashion ends up having real benefits by shortening the amount of time it takes to come up with good solutions."

In addition to the collaborative aspect, HEEDS facilitates the optimization process in several ways. It provides process automation capabilities to link tools together to come up with optimal designs; it assigns the various software tools the appropriate computing resources; and it has a robust search strategy for efficient design exploration, Flemings explains.

Consider the 2011 Venza lightweighting study using HEEDS to drive a variety of CAE and analysis tools, including Nastran, LS-DYNA for crash tests, Excel costing models and several CAD tools to consider upwards of 484 variables. With some traditional optimization software, the team would have had at least 10 full vehicle models and nearly 5,000 evaluations to consider, Flemings says. With HEEDS' collaborative optimization approach, the team was able to narrow that down to about 250 evaluations, which in the end, produced 49 feasible designs.

Optimization for All

On the lightweight truck project, the initial thinking was that high-strength steel was the way to achieve the best lightweighting results, but after a week's worth of analysis, it became clear that aluminum or composites might be a good option. "We ended up with a mix of materials, and the fact that HEEDS allowed us to make that shift was very important," Rodriguez explains. "In a different [optimization] product, we'd have to stop the analysis and start everything from the beginning."

Ease of use was another key differentiator of HEEDS compared with other multidisciplinary optimization platforms. HEEDS was easier to set up than other programs, both in its ability to interface with the core CAE tools and in how to refine and drive the actual optimization studies, Rodriguez says. While the typical users of the software were CAE engineers, they were not PhDs in optimization techniques or in optimization software.

"There were people with quite a lot of years of experience, but they were not specifically trained for simulation and optimization," Rodriguez says of the lightweight truck project team. "Once we established the processes, we could make them available for everyone and it was a very collaborative environment."

Thanks to the collaborative HEEDS optimization effort, the EDAG team was able to come up with a range of designs that achieved significant weight savings goals yet remained within the cost targets. For the Venza compact SUV, EDAG was able to achieve a 14% weight reduction on the body in white (for a total of 18% to 20% when factoring in the doors and hood) with a cost impact of $3.06 per kilogram. On the pick-up truck, the efforts yielded a 29% weight reduction with a cost impact of $4.71 a kilogram.

Not only did the collaborative optimization approach help yield a broader number of optimized designs faster, it also has been a critical tool for evaluating various scenarios and keeping constituents on the same page.

"HEEDS helps us come to consensus," Rodriguez says. "There isn't one optimized, perfect solution, there are several. HEEDS gives us a range of solutions, allows us to look at them, and have everyone work together to choose the one that is best." **DE**

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INFO ➜ EDAG: EDAG.de

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

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Look into the Flames

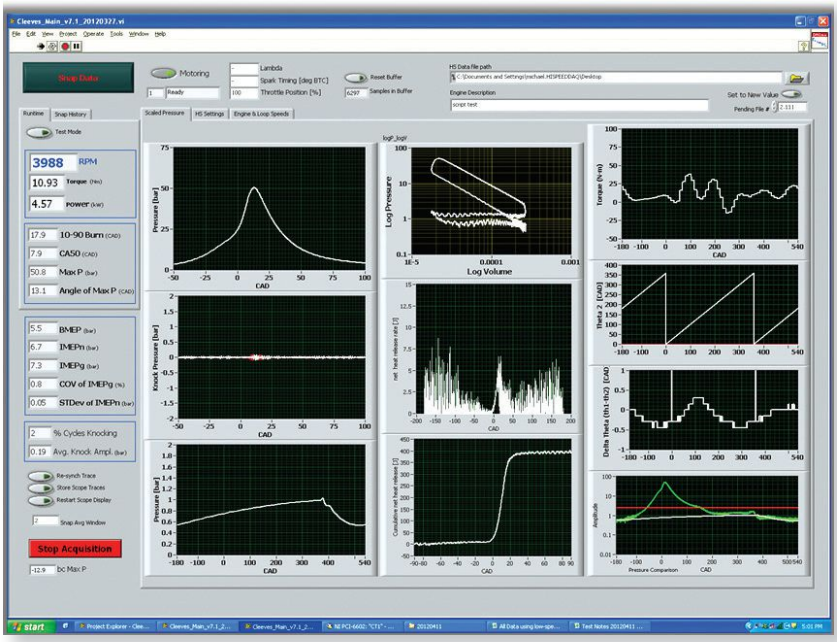
Pinnacle Engines uses an on-demand computing infrastructure to simulate opposed-piston engines.

BY KENNETH WONG

You can learn a lot about the inner working of an engine from physical tests — how it heats up, cools down, behaves during acceleration and more. Looking at the test cell data from a dynamometer, Tony Willcox, director of simulation and controls at Pinnacle Engines, can gauge the engine's average performance characteristics such as torque, power, fuel flow, and emissions. He can examine crank-angle-resolved data to analyze cylinder and port pressures, rotation speed and piston position during a series of combustion events. But Willcox and the simulation team at Pinnacle are also interested in what they cannot see or measure.

To extract every last joule of energy from fuel, they would need to peel off the engine cover and look inside to reduce energy loss from spark to exhaust. And that's where they run into the limitations of physical tests. "Optical engine technologies exist that enable some visibility into the cylinder," he says, "but they present their own sets of challenges. For example, their configurations are limited, and it's very expensive to implement them."

Another option is digital simulation. Using an advanced computational fluid dynamics (CFD) software program, Willcox can digitally recreate the fuel spray, mixing, air motion and combustion event to match the values collected from the physical test. Once he's done that, he essentially has a digital version of the event, constructed in pixels — terabytes of them. This gives him the ability to see on a computer screen what's happening inside the engine at every slice of time and space.



Studying test-produced engine data gives Pinnacle Engines some insights into the combustion behavior. But the company wants to look inside the flames, which would require digital simulation of a series of combustions inside an engine. ***Images courtesy of Pinnacle Engines.***

Converging on Combustion

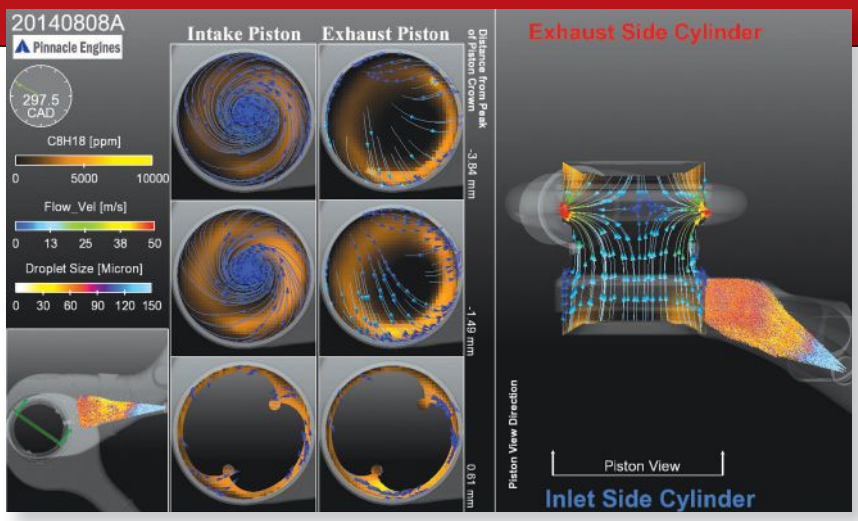
"There are things we can't measure in a test, but can mimic in simulation," Willcox says. "For instance, we could turn off heat transfer to see what the engine's efficiency would be without heat loss in the cylinder. Or we could turn off the leakages through the piston rings. With these options, we can better understand the impact of different factors on our design."

Pinnacle Engines specializes in four-stroke, spark-ignited, opposed-piston, reciprocating sleeve-valve engines. The company states its mission as developing "engine architecture that provides 30–50% improvements in fuel economy without the typical cost penalty." Its choice of software is CONVERGE CFD from Convergent Science, Madison, WI.

"We picked CONVERGE because it has a reputation for accuracy and it includes a detailed chemistry flame propagation model that enables predictions on our architecture without heavily relying on empirical models developed around conventional systems," Willcox said. "There are characteristics in CONVERGE that don't exist in other software, or are not as well-developed. For instance, CONVERGE's chemistry model that estimates flame propagation using detailed chemistry in a sensible timeframe."

Experimenting in the Cloud

Pinnacle Engines' opposed-piston design has lots of design freedom. In a design optimization project, everything — from the shape of the piston crown to the induction and exhaust port shapes to the position and timing of the fuel delivery — is a candidate for revision. To arrive at the best geometry, Willcox and his colleagues can experiment with the digital model to see what happens to



Simulating the activities inside the engine using CONVERGE CFD gives Pinnacle Engines valuable insights into how a piston crown shape affects the flow of fuel.

the engine's efficiency, or how the flames propagate inside the cylinder. For that, Pinnacle Engines needs to conduct what's known among the simulation experts as Design of Experiments (DOE).

Pinnacle Engines has a 172-core cluster onsite, dedicated to running two simultaneous 24/7 simulation jobs. Even if the company is willing to put its day-to-day simulation tasks on hold to run a DOE on the server, it still must address the need for additional software licenses. Typical simulation software licenses allow you to run simulation jobs one at a time. Some special HPC (high-performance computing) licensing programs allow you to distribute one large job on multiple machines — an ideal setup for those with in-house data centers. But DOE demands more than that. To be effective and timely, DOE sessions have to consider many design variations running in parallel on many computing cores.

"Is it possible to run the jobs one parameter at a time? Yes, possibly, but not within the timeframe we want the answer back," says Willcox. "When we need an answer, we need it in a matter of days. We can't wait for weeks. There are too many parameters to sweep, so even if we had the hardware, we wouldn't be able to investigate all of them." Unless the design parameters can be calculated in parallel.

The answer is on-demand computing infrastructure, specifically designed for DOE-type simulation. The answer, in this case, also turns out to be just 40 miles away from Pinnacle Engines' San Carlos, CA, headquarters. San Francisco-based Rescale, a cloud simulation supplier, offers a scalable on-demand platform — a combination of software and hardware — for those seeking to do precisely what Pinnacle Engines wants to do. The company makes its solution directly available in the web browser. It also has a partnership with Convergent Science, which simplifies acquiring additional licenses for parallel simulation runs.

On its website, Rescale provides a chart that serves as a guide to calculate the cores and licenses you'd need to run a DOE and the associated cost.

"If you intend to run a certain type of simulation over and over, it makes sense to buy the hardware and bring it in-house with upfront investment," Willcox says. "But that still limits you to doing one simulation at a time. It won't let you do anything else in parallel."

Crowning Achievement

From the simulation and seeing the flame propagation, Willcox and his colleagues gain valuable insights. "We found that one piston crown shape was causing the flame propagation to not reach certain regions of the cylinder, which resulted in unburned (wasted) fuel," says Willcox. "Subsequent simulations on other piston shapes and test data showed matching and significant improvements in fuel economy. With such an open architecture, there are unique opportunities to improve engine performance by coupling un-measurable three-dimensional phenomena that are not obvious when simply measuring average test data such as hydrocarbon emissions or cylinder pressure."

Willcox and his colleagues are now verifying a new piston-crown design through simulation and physical testing. "We ran simulation first [on the new design], saw an improvement, and then followed with testing the hardware," he says. "Simulation predicted [a] 9.5% improvement in BSFC (brake-specific fuel consumption), test data was 10% at that load and speed. [The difference] was due to reducing unburned fuel (HC) emissions with new the new piston geometry by not inhibiting flame propagation near the end of the combustion event."

Pinnacle Engines is undertaking an ambitious project to calibrate the CFD model to match its physical data. "[It] is not a simple or short process," Willcox says. "We have been focusing on model tuning and calibration for more than one year (approaching 1 million CPU hours) and still do not have what I would deem an acceptable match to test data."

Conventional use of internal combustion engine simulation has been, at best, an approximation — "a tool for relative accuracy," Willcox says. But the ability to examine a sweep of parameters within a reasonable time makes simulation model tuning much more accurate. "We're getting closer to accurately matching and predicting all measured channels ... which leaves us with confidence in the calculated values of the parameters that are not measurable inside our engine," he says. DE

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

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The Best Bang for Your Buck — Again

The latest over-clocked workstation from @Xi Computer delivers fantastic price/performance.

BY DAVID COHN

California-based @Xi Computer Corporation (pronounced "at-ex-eye") recently shipped us the latest version of its Xi MTower PCIe workstation. In many ways, this new workstation is an updated version of the identically-named Xi MTower PCIe workstation we reviewed more than three years ago (see *Desktop Engineering* August 2011, deskeng.com/de/?p=3915). Like the previous system, the workstation we received came housed in a mid-tower case manufactured by Cooler Master and powered by an Intel CPU.

This time around, however, our @Xi workstation was encased in a black HAF XM case that measured 9.9 x 20.9 x 22.8 in. (W x H x D) and weighed in at 36 lbs. A hexagonal power button is centered in the top-front edge of the case and flanked by a reset switch and a fan LED on/off switch. A small panel at the top of the front bezel contained four USB ports — two USB 2.0 and two USB 3.0 — as well as a pair of audio ports for headphone and microphone. Below this are three 5.25 in. drive bays with front panel access. The top-most bay contained a 74-in-1 Rosewill USB memory card reader with an additional USB port. Although a DVD reader comes standard in the base configuration, our system included a dual layer DVD+/-RW optical drive, which filled a second bay. An optional Blue Ray read/write drive is also available. The front panel also provides access to a pair of 3.5 in. drive bays. A perforated screen with a large @Xi logo takes up the lower portion of the front panel and conceals a large 6 in. fan that cools the internal drive bays.

The rear panel provides four more USB 2.0 ports, six more USB 3.0 ports, a PS/2 mouse/keyboard port, RJ45 LAN port, an optical S/PDIF out port, and five audio jacks including line-in, line-out/front speaker out, microphone, center/subwoofer and rear speaker out. And the NVIDIA graphics card in our evaluation unit provided two DisplayPorts and two DVI-I connections. The case has no handles, however, and no internal speaker.

Lots of Choices

Everything about the Xi MTower PCIe workstation, including the case itself, is customizable, and @Xi offers lots of choices.

The well-organized interior of the @Xi workstation hosts an ASUS motherboard, with an over-clocked Intel Core i7 processor hidden beneath a sealed liquid cooling system and eight memory sockets, four on either side of the CPU. ***Images courtesy of David Cohn.***

In fact, we counted more than 30 different tower and rack mount case options on the company's website in addition to the one that housed our evaluation unit. On our system, the left panel of the case was held in place by two non-captive thumb-screws. After removing these and putting them safely aside, we lifted a latch and removed the panel, revealing a well-organized interior with six additional 3.5 in. drive bays.

Pricing for the Xi MTower PCIe workstation starts at just $1,079, but that is for a configuration based on a 3.1GHz Intel Core i5 processor with an integrated graphics card, 4GB of RAM, a 500GB SATA drive, DVD reader, mouse, keyboard, a completely different case and 20 in. monitor. At the heart of

The Xi MTower PCIe workstation is housed in a Cooler Master HAF XM case with five front panel bays and six more internal drive bays. The system is quiet in spite of multiple fans and cooling grilles on the top, front and sides.

our evaluation unit was an ASUS X99-A motherboard based on an Intel X99 Express chipset, although @Xi offers 20 different choices. The X99-A board, which adds $199 to the base price, has a single CPU socket flanked by eight DIMM sockets, four to either side of the CPU.

@Xi also offers a choice of 25 different CPUs. Our evaluation unit came with an Intel Core i7-5930K CPU. While this processor has a base frequency of 3.5GHz and a maximum turbo frequency of 3.7GHz, the K designation indicates that the CPU has an unlocked multiplier, making it easier to over-clock. That is exactly what @Xi did, boosting our system to 4.32GHz with a 2800MHz RAM and a Corsair sealed water cooling system. That CPU added $995 to the base price.

Four of the eight memory sockets were filled with 4GB DDR4 quad interleave DIMMs, for a total of 16GB of RAM, adding an additional $399. The system can accommodate up to 64GB of memory.

One of the internal 3.5 in. bays contained a Samsung 500GB SSD (solid-state drive), which added $269 to the base price. But again, @Xi offers a choice of 25 different drives ranging from a 250GB SSD up to a 4TB SAS drive. You can configure your workstation with multiple drives as well as various RAID arrays.

The ASUS motherboard provides three PCIe 3.0/2.0 x16 slots, two PCIe 2.0 x1 slots, and a PCIe 2.0 x16 slot. One of the slots in our evaluation unit housed an NVIDIA Quadro K5200 GPU (graphics processing unit) with 8GB of DDR5 memory and 2304 CUDA parallel-processing cores. The GPU's thickness blocks access to one of the adjacent PCIe x1 slots, and its 150W power consumption means that it needs an additional power connection. Of course, the 1000 watt Rosewill 80 Plus Bronze series power supply nestled at the bottom of our case, yet another option, provided plenty of power to spare. That's a good thing, because the motherboard also has eight SATA 6.0 Gb/s ports and one SATA Express port.

The motherboard also provides Realtek ALC1150 8-channel high-definition audio and support for gigabit LAN. Though @Xi also offers other higher-end sound cards, network cards, speakers, and more.

The rear panel of the Xi MTower PCIe workstation provides lots of expansion options.

@Xi Computer Corporation: xicomputer.com

Xi MTower PCIe workstation

- **Price:** $4,985 as tested ($1,079 base price)
- **Size:** 9.9 x 20.9 x22.8 in. (WxHxD) mid-tower
- **Weight:** 36 lbs.
- **CPU:** 3.7GHz Intel Core i7-5930K over-clocked to 4.32GHz
- **Memory:** 16GB DDR4 at 2800MHz
- **Graphics:** NVIDIA Quadro K5200 w/ two DisplayPorts and two DVI ports
- **Hard Disk:** 500GB Samsung 2.5-inch SSD
- **Floppy:** None
- **Optical:** 18X DVD+/-RW Dual Layer
- **Audio:** Integrated HD audio (front panel: microphone, headphone; rear-panel: line-in, line-out, microphone, rear, center/sub-woofer, and SPDIF out)
- **Network:** Integrated gigabit Ethernet, one RJ45 port
- **Modem:** None
- **Other:** Nine USB 3.0 (3 front/6 rear), six USB 2.0 ports (2 front/4 rear), PS/2 keyboard/mouse port, 74-in-1 card reader
- **Keyboard:** 104-key Lenovo USB keyboard
- **Pointing device:** Lenovo USB optical wheel mouse
- **Power Supply:** 1000 watts, 80%
- **Warranty:** Three years parts and labor

Single-Socket Workstations Compared

		Xi Mtower PCIe One 3.7GHz Intel Core i7-5930K 6-core CPU over-clocked to 4.32GHz, NVIDIA Quadro K5200, 16GB RAM	Lenovo P300 One 3.6GHz Intel Xeon E3-1276 v3 quad-core CPU, NVIDIA Quadro K4000, 8GB RAM	Digital Storm Slade PRO One 3.4GHz Intel Xeon E3-2687W v2 eight-core CPU, NVIDIA Quadro K4000, 32GB RAM	HP Z1 G2 One 3.6GHz Intel Xeon E3-1280 v3 quad-core CPU, NVIDIA Quadro K4100M, 16GB RAM	HP Z230 One 3.4GHz Intel Xeon E3-1245 v3 quad-core CPU, NVIDIA Quadro K2000, 8GB RAM	Lenovo E32 SSF One 3.4GHz Intel Xeon E3-1240 v3 quad-core CPU, NVIDIA Quadro K600, 8GB RAM
Price as tested		$4,985	$2,072	$5,804	$5,918	$2,706	$1,479
Date tested		12/13/14	11/9/14	5/10/14	5/3/14	11/24/13	11/10/13
Operating System		Windows 8.1	Windows 7	Windows 7	Windows 7	Windows 7	Windows 7
SPECviewperf 12	higher						
catia-04		98.53	38.19	34.81	42.23	n/a	n/a
creo-01		86.66	34.31	33.15	30.82	n/a	n/a
energy-01		3.49	0.65	0.60	1.74	n/a	n/a
maya-04		72.18	32.31	31.28	33.79	n/a	n/a
medical-01		28.84	12.38	10.75	10.34	n/a	n/a
showcase-01		48.98	22.64	20.65	21.12	n/a	n/a
snx-02		150.42	36.79	34.12	40.37	n/a	n/a
sw-03		126.08	69.37	50.78	38.66	n/a	n/a
SPECviewperf 11	higher						
catia-03		99.1	67.84	69.41	63.80	46.17	25.14
ensight-04		148.83	48.80	47.76	61.56	29.32	15.47
lightwave-01		100.99	88.54	76.90	82.76	87.98	75.52
maya-03		99.44	132.59	101.12	128.09	92.05	51.32
pro-5		18.19	21.34	16.29	17.18	20.25	15.61
sw-02		88.89	72.05	63.66	67.75	57.31	41.99
tcvis-02		78.64	55.66	54.26	58.99	38.78	23.74
snx-01		134.51	53.24	52.98	65.58	34.09	19.56
SPECapc SolidWorks 2013	higher						
Graphics Composite		8.82	6.29	5.37	5.67	4.38	3.14
RealView Graphics Composite		10.03	6.88	5.90	6.16	4.69	3.09
Shadows Composite		10.05	6.89	5.85	6.13	4.68	2.96
Ambient Occlusion Composite		17.58	9.65	9.46	8.48	5.81	2.90
Shaded Mode Composite		8.95	6.17	5.30	5.55	4.75	3.25
Shaded with Edges Mode Composite		8.69	6.41	5.45	5.79	4.04	3.02
RealView Disabled Composite		5.28	4.39	3.70	4.08	3.35	3.31
CPU Composite		4.50	4.18	3.70	3.12	4.15	4.27
Autodesk Render Test	lower						
Time	seconds	42.33	64.08	38.25	45.00	49.00	48.66

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

Great Performance

Thanks to its SSD, the @Xi workstation booted up very quickly. And although it had lots of fans — two on the top of the case attached to the liquid cooling system, the large fan in the front panel, another large fan in the rear panel and fans on the GPU and power supply — the workstation was nearly silent after its initial startup.

Thanks to the NVIDIA Quadro K5200 GPU, the Xi MTower PCIe workstation performed great on the SPECviewperf benchmark, turning in the best results we've recorded to date for a single-socket workstation.

On the SPECapc SolidWorks benchmark, the system also delivered top scores. It was only on the multi-threaded AutoCAD rendering test that the Xi MTower PCIe workstation didn't take top honors. This rendering test clearly shows the benefits of multiple CPU cores, so while the Xi workstation with the equivalent of 12 CPU cores (with HyperThreading enabled) took just 42.33 seconds on average to complete the test rendering, that was 4 seconds slower than the Digital Storm Slade PRO, a system with a slightly slower CPU, but the equivalent of 16 CPU cores.

We also ran the SPECwpc workstation performance benchmark. We have now run this new test on a half-dozen systems, and while we still do not have enough results to understand the subtleties of all of its data, it is abundantly clear that the Xi MTower PCIe workstation delivered the best results thus far on nearly every one of the individual tests in this extensive benchmark.

@Xi pre-loaded Windows 8.1 Professional 64-bit, adding $59 to the system price. Here again, the company offers lots of choices, including various flavors of Linux as well as several versions of Microsoft Windows. A free one-year license to McAfee AntiVirus Plus was also included. The company rounded things out with a Logitech 104-key USB keyboard and Logitech USB 2-button wheel mouse.

A one-year warranty with express advanced parts replacement is standard, but our evaluation unit came with a three-year warranty, adding $99 to the total cost. Warranties of up to five years are also available.

Although @Xi advertises a starting price of $1,079, once we added all of the higher-end components, our evaluation unit priced out at $4,985 without a monitor. But when you consider that price is more than $800 lower than the only single-CPU system we have tested that turned in faster performance, the Xi MTower PCIe workstation once again delivers more bang for your buck. DE

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Top 5 Training Trends

What skills will be most important for engineers in the coming year?

BY JIM ROMEO

Form follows function. This certainly holds true in design engineering, where a changing work environment is always upon you. New technology comes with advanced design tools, as well as new ways of communicating and collaborating. Along with it all comes the need to train engineers in new technologies and accompanying skills to meet the demands of increasingly complex products and their design. But where to start? To gage the training needs for design engineers in the year ahead, *Desktop Engineering* talked to experts in the field to gain insight into what training will be needed.

1 Security

Security training is tops on the list of training topics for design engineers, especially given the rise in recent high-profile hacking. Rod Mach of engineering IT provider TotalCAE says security at and around engineering firms is critical, as is training workers engaged in product design. Such firms are often targets for hackers who seek everything from trade secrets to promoting their viewpoints via unsecured devices.

Mach is not alone in his outlook.

"Design engineers need more training on security, security standards and best practices," says Alan Grau, president and co-founder of Icon Labs, a provider of security solutions for embedded devices. "Security needs to be considered from day one, not added as an afterthought, and there is no better place to start than with training."

2 The Internet of Things

The IoT, in which sensor-laden, connected devices communicate with one another — often via the cloud — makes security training even more critical. It also means many engineers should brush up on the requirements of the "smart," connected devices that comprise the IoT.

"IoT design engineers need training in IoT and protocols and standards, especially wireless communication protocols," Grau says. "Other topics include designing scalable systems, and distributed data management and cloud computing. For engineers building the IoT devices themselves, as opposed to those building the cloud portion, training in embedded systems design and technology is an important consideration."

3 Mobility

Security, privacy, configuration, updates and field maintenance are apropos training topics for designers of mobile devices, says Brent Ward, global marketing director, Econais, a company that specializes in embedded Wi-Fi system solutions. However he emphasizes that having a "working knowledge and experience with the use of a Wi-Fi module to imbue any product with wireless capabilities will separate merely good design engineers from truly great design engineers."

In addition to communications and associated design factors, mobile devices need untethered power, often in the smallest possible design envelope. As a result, mobility requirements introduce a host of specialized training needs, from radio frequency and electromagnetic interference concerns to battery and thermal issues.

4 Big Data

Mobility and the IoT are often ways to gather more information to drive what is being called a revolution in Big Data. But data in and of itself doesn't have much value. It's the management and analysis of the data that matters.

"Data management has always been big, but recently companies are moving beyond just using it to manage their CAD models," says John Carlson, technical training director with Rand 3D. "Companies are now looking to use it to manage all data related to a design. They are also beginning to use the built-in capabilities for change control management, notifications and sign offs, to be able to replace other systems they had been using. This had always been the big selling points of these systems, but few companies actually tried to use them."

Carlson says implementation was often the issue. Information was fragmented and locked away in silos that were inaccessible to the larger enterprise.

"It has now moved beyond just the engineering department …" he says. "The biggest advantage of this is the increased flexibility for analyzing the large volumes of data being generated on devices. Server-side hardware and software have seen huge advances in both open-source software and new, powerful hardware — making them ideal for analyzing the large volumes and variety of data being generated on devices today."

Bobby Johnson, CTO of Interana, a creator of data analytic solutions, agrees. Understanding data — specifically the amount of data that can be collected, aggregated and processed — is a prerequisite to data processing and analysis. Sending raw data server-side gives companies an increased amount of flexibility because they now rely on massive compute resources and advanced software, he says. This enables more in-depth analysis and the freedom to explore and discover data without having to worry about summarizing data on devices.

Today's design professionals need skills to not only manage the data, but also analyze it, says Chuck Behm, director of training for Meridium Inc., a firm specializing in plant performance monitoring. He says they will need to leverage software tools that enable statistical analysis of asset operational data. In particular, design engineers need to make full use of such tools in order to better understand the impact of their design decisions on specific assets and on the overall system.

> **"Thanks to sensor and software technology advances, design engineers today have access to considerably more asset performance data, and more accurate data."**
>
> ***— Chuck Behm, Meridium Inc.***

"They need to study past performance of individual assets and systems as a path to enabling continuous improvement and contributing to operational excellence efforts," says Behm. "Thanks to sensor and software technology advances, design engineers today have access to considerably more asset performance data, and more accurate data. The value of focusing on that data is the ability to improve the reliability of both individual assets and plant and enterprise systems."

Asset performance management (APM) encompasses the tools, knowledge and competencies to yield significant business impacts, according to Behm.

"As a first step, asset benchmarking is vital to developing a complete understanding of an asset's overall impact to an organization, as well as how the competitive landscape around them is changing," he says. "Because of the availability of these new data sources, engineers are being forced to think beyond just electrical or mechanical engineering — and today consider both operations and competition from more of a marketing perspective. The goal of training, in turn, should be to acquire a big picture perspective of asset and system reliability and the competitive landscape — capabilities encompassed in APM methodologies."

5 Interaction

While technology trends are critical, fast-moving targets that require continuing education, training needs in softer skills are also needed.

"What design engineers need to incorporate in their training is an understanding of cognitive psychology for understanding the behavior of the end customer that will be using what design engineers design," says Valeh Nazemoff, author of *The Four Intelligences of the Business Mind*.

Technology is as good as the end users who use it. End users, however, come from many different cultures and backgrounds. They interact with technology differently, so communication skills can benefit today's design professional who is working with a global team and/or designing a product for an end user from a different part of the world.

"Measurement is a common example of the types of variation engineers might encounter in different parts of the world," says Ian Henderson, CTO of Rubric. "The prominent example is the United States using Fahrenheit while other parts of the world uses Celsius. Engineers might also get caught up by basic punctuation. In the U.S. you might write one thousand as '1,000' whereas in France it would be '1 000.' Another big difference is how information is presented. While an American engineer would read a flow chart from left to right, in the Middle East, engineers expect flow charts to move from right to left. The same is true for test results and user interfaces. If you are localizing English content into any other language, you can make things easier and cheaper for yourself by separating text from illustrations. And while you can translate certain content into other languages — such as a product's user interface — you should keep other items in English for when the product needs to be reviewed, audited or updated. Audit trail messages, for example, should be left in their original form."

To succeed in 2015 and beyond, training resources should be directed toward trends emerging in most every sector of design engineering: security, IoT, Big Data, mobility and human factors. Incorporating any or all of these trends and topics into a training plan is a best practice as engineers take on new challenges. DE

Jim Romeo is a freelance writer based in Chesapeake, Virginia.

INFO
- **Econais:** Econais.com
- **Icon Labs:** IconLabs.com
- **Interana:** Interana.com
- **Meridium Inc.:** Meridium.com
- **Rand 3D:** Rand3D.com
- **Rubric:** Rubric.com
- **TotalCAE:** TotalCAE.com

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Free-Floating FEA Models

Apply equivalent pressure distributions on a structure without needing direct constraint boundary modeling with the 3-2-1 method.

BY TONY ABBEY

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

Background

Last month we looked at difficulties with boundary conditions when setting up a realistic FEA (finite element analysis) model. The three basic options are shown again in Fig. 1. The conclusions were:

- Defining equivalent pressure distributions as in Method 1A can ensure conservative loading is applied. Upper and lower bound variations can be used.
- Applying 'hard' constraints as in Method 1B produces singularities at the edge of the constraints that will disrupt the FEA stress results. Constraints tend to over stiffen the structure.
- General contact and glued contact methods as in Method 1C rely on the FEA method producing realistic and conservative bearing footprints.

We are aiming for loading that has adequate moment offset to cater for uncertainties in the line of loading action. For instance, it may be better to imagine a triangular pressure distribution footprint in 1A so that the net force line offset is 2/3 of the latch width and not 1/2 of latch width. Fig. 2 shows these options.

This month we look at the extreme approach to applying equivalent pressure distributions throughout a structure to achieve balance, avoiding any direct constraint boundary modeling and rigid body motion. This powerful technique is the best way of setting up some FEA models.

The Scuba Tank Conundrum

Imagine you are tasked to carry out an FE analysis of a scuba tank. The loading represents no problem; an internal pressure, with external ambient pressure ignored. Similarly, the meshing and material definitions are straightforward. The objective is to check the stress concentrations around the nozzle and corner of the base.

The problem is — how do we constrain the model? We cannot run a static FE analysis with just a load balance, we need a constraint set that will remove all rigid body motion and ground the structure properly. In reality, the scuba tank does not need external constraints, but the FEA will not work without them! Throughout my career, this was known as the "skyhook problem." We need a skyhook that will ground the model, but not introduce unwanted load paths and incorrect stress distributions. Welding the base by constraining it to the ground will introduce over stiffening of the base. Only the local nozzle area will have a reasonable stress distribution. Similarly, "inventing" large grab handles and grounding them will introduce local stiffening in the walls and the stresses will be incorrect. The tank will not be free to expand radially between the grab handles.

The model should be grounded in a minimum way — but how? I have seen ship models welded to concrete waves and whole aircraft models propped up with tortuous beams and springs!

There is an elegant way to achieve the 'skyhook' – it's called the 3-2-1 method.

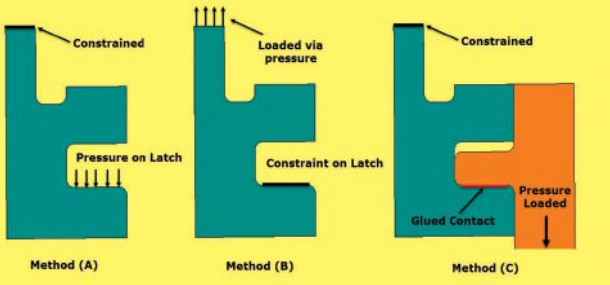

FIG. 1 (ABOVE): Loading and constraint methods.

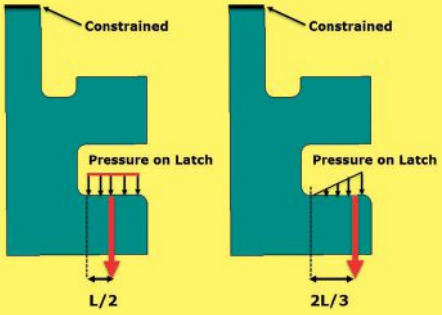

FIG. 2 (RIGHT): Net force line variations.

The 3-2-1 Method

The 3-2-1 technique, applied to a full component without symmetry, uses three nodes. The nodes should be well spaced and orientated carefully as described.

- Fig. 3A: The first node has all three translational degrees of freedom (DOF) constrained. That gets rid of the three translational Rigid Body Modes (RBMs), but leaves the three rotational RBMs.
- Fig. 3B: The second node is positioned. Imagine a line connecting node 1 to 2. Node 2 has two translational DOF constrained in the two directions which are normal to this line. That gets rid of two rotational RBMs, but not the RBM "spinning" about the line. It has also allowed relative translational displacement to exist along the line node 1 to node 2.

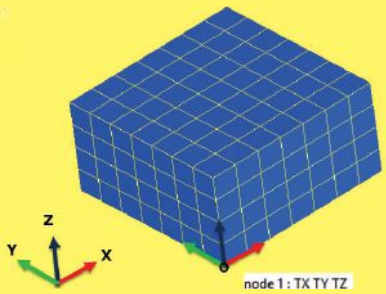

FIG. 3A: First Node

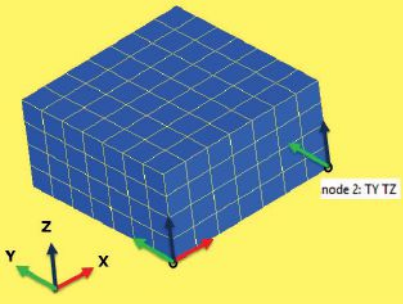

FIG. 3B: Second Node

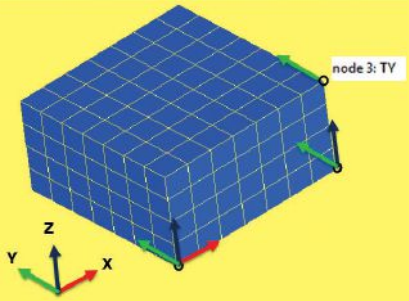

FIG. 3C: Third Node

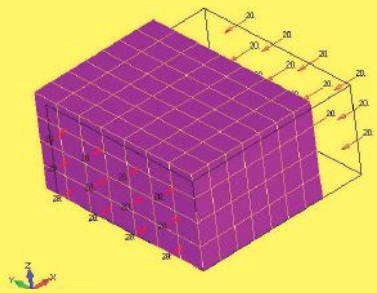

FIG. 4: Constant stress on deformed shape.

• Fig. 3C: The third node is positioned and a single DOF is constrained normal to the plane of nodes 1, 2 and 3. This eliminates the final spinning RBM. This also allows relative translational displacement between any of the three nodes.

If we now apply a balanced pressure load to the YZ plane faces, then a constant stress state is created and no local stress raisers occur (Fig. 4). The constraint reactions each become zero. This is an important point as it allows proper constraint of the model, but does not introduce any "external" constraint reactions.

An Example of the 3-2-1 Method

Fig. 5 shows an actuator crank. Vertical load of 100 lbf is applied to the flat surface, creating a moment about the pivot point. The vertical load is reacted by the pivot bearing. The moment created is reacted by a couple consisting of horizontal 125.67 lbf forces between the pivot point and actuator rod attachment point. This is typical free body diagram used to check the force balance in the system. Do a quick check yourself by making sure the vertical forces, horizontal forces and moment about the pivot all balance.

It is essential that the applied loads balance as closely as possible. If there are any out of balance, then we create a net reaction force at the constraints. These reactions will cause enormous local stresses (each will become a stress singularity) and will wreck the model.

After balancing the load, we apply the 3-2-1 constraints. Fig. 6 shows the system chosen for the crank. There are many convenient combinations of three nodes we could have chosen; a set of three in a planar face is always a good starting point. If no convenient nodes exist you will have to create suitable locations. Slicing the geometry to create vertices where nodes will be generated is a powerful method. Be careful to get the relative node positions accurate as any small offsets or misalignment of the 3-2-1 system will cause reaction imbalances with huge local stresses.

The result of the FE analysis of the crank is shown in Fig. 7. The peak Von Mises stress is 69,437 psi. The location is at the inner transition radius. Stress vector plots confirm the peak local stress is a tensile stress tangent to the surface as expected. Material is steel with a yield stress of 215,000 psi, so the design is adequate.

In checking this analysis, we need to make sure the loading has been applied appropriately and accurately. A full report would include loading breakdown, loading assumptions and supporting FEA preprocessor model plots to show where the loading was applied.

The vertical applied load shown in Fig. 5 is assumed distributed over the rectangular face. However, we could be more conservative and assume a line of action closer to the free edge, giving a larger moment arm. This was tried out with line of action at 25% of surface length versus original 50%, and new balancing forces calculated. The peak local stress is now 77,748 psi, which is acceptable.

The pivot bearing reaction force and line of action has been calculated as shown in Fig. 5. This is applied as a bearing distribution over an arc of 180° about the line of action. Care is needed here to make sure the correct line of action is used and that the loading does properly conform to the required distribution. If checking an analysis, evidence is needed. A typical assumption would be a sine distribution of normal pressure, with the peak value aligned along the 90° line. There are other empirical distributions you could use and many FEA pre-processors have these 'hard-wired', together with methods for defining line of action and distribution angle, which is a great convenience.

The actuator attachment bearing point is treated similarly. The assumption here is that the line of action is horizontal. A small error of 5° raises the peak stress only to 69,573 psi, so it is not that critical. How-

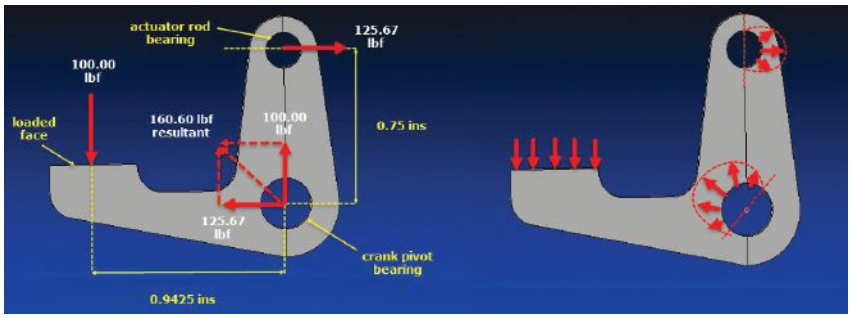

FIG. 5: Applied load balance on the actuator crank.

ever, sensitivities should be checked to make sure they are low.

If the actuator angle is significantly different then the load balance and stresses will change.

Indeed it would be possible to include this component in an independent kinematic analysis using a Multi Body Dynamics System (MBDS) tool. A range of reaction force sets could then be calculated as part of a full assessment of an operational cycle. Each reaction set from the MBDS analysis could then be applied as an independent load set in a 3-2-1 constrained FEA model.

Some FEA solvers can automate the connection of a component such as the crank, to a rigid link representation of the rest of an assembly. In normal usage the connection points are constrained to the rigid links. However it would be possible to recover the balancing forces, and use these to apply to an independent FE analysis using the 3-2-1 method.

The 3-2-1 relies on the provision of an accurate and realistic load balance. If the loading is not in balance, the model will wreck itself. If the loading distribution is not thought out it can become unrepresentative of the real world scenario.

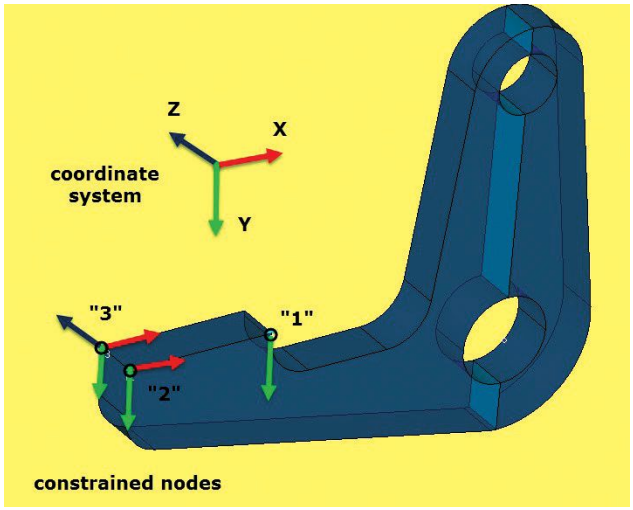

FIG. 6: 3-2-1 constraint system applied to the crank.

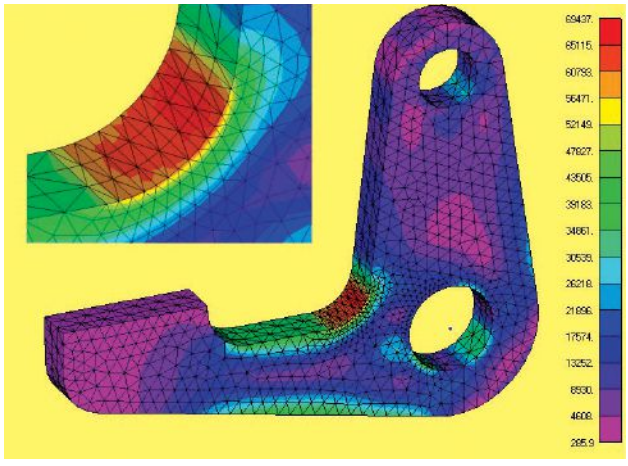

FIG. 7.:Von Mises stress distribution of the crank.

If the loading becomes complex, this is probably the limiting factor on whether it is convenient to use the method. If the crank loaded face is offset, then out of plane moment is created which must be reacted through the two pins. This becomes awkward to represent as an equivalent bearing loading. Similarly if the pins are tapered, calculating reactions and mapping to equivalent pressure loading gets tricky. My advice would be to drop this method if the loading balance becomes difficult to calculate.

The set of three nodes should be widely spread to avoid large local couples and should avoid highly flexible parts of the structure (don't use a node on a whip antenna!). The positioning of the nodes relative to each other must be accurate. The stiffness of adjacent components is ignored, such as the connecting pins in the crank arm. The influence of this should be assessed.

Geometric nonlinear analysis can't be used with this method as the configuration and the load balance can change. The constraints will start to pick up non-zero reactions as the balance changes. However, material non-linearity and contact should be possible, but the method may introduce stability issues. DE

Tony Abbey *is a consultant analyst with his own company, FETraining. He also works as training manager for NAFEMS, responsible for developing training classes, including a range of e-learning classes.*

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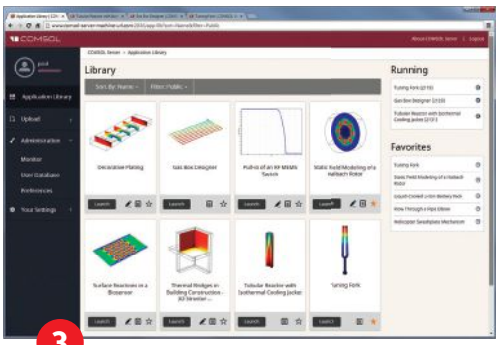

1 Haptic Stylus
3D Systems' Touch haptic 3D stylus has a software developer kit (SDK) for digital design and virtual gaming. The stylus comes with Cubify Sculpt software for virtual sculpting and design. 3DS has also partnered with Topcoder to create a series of challenges in gaming, education, art, digital jewelry design, medical and more.
3dsystems.com

Radio Chip, Modules for Internet of Things
GreenPeak Technologies has launched the GP691 ZigBee communication controller chip and GPM6000 integrated ZigBee Modules for Smart Home and Internet of Things networks and devices. The GP691 communication controller provides IEEE Standard 802.15.4-compliant spectrum data and is able to run ZigBee applications. The ZigBee 3.0 module is capable of a variety of home, automation and smart energy. It can also support large networks made of many devices.
greenpeak.com

Model-Based Design
MathWorks has expanded its partnership with Siemens Automation Systems to increase its offerings for model-based design. Engineers can now generate code in Simulink and use it in Siemens SIMATIC S7 modular PLC (power line communication) controllers and SIMATIC WinAC RTX software controllers.
mathworks.com

2 Next-Generation ThinkServer Systems
Lenovo's next-generation ThinkServer portfolio includes the entry-level 1U ThinkServer RD350 and the 2U ThinkServer RD450. Both are aimed at small- to medium-sized businesses. The servers include a redesign and space-optimized drive trays, chassis and system boards that provide additional storage density and I/O capability in 1U and 2U form factors. Both are equipped with up to two 12-core Intel Xeon E5-2600 v3 series processors and can be configured to hold up to 512GB of memory.
lenovo.com

PartMaker 2015
Delcam has released PartMaker 2015, its software for programming CNC (computer numerically controlled) mills, lathes, wire EDM equipment, turn-mill centers and Swiss-type lathes. This release includes expanded support for the latest generation of multi-tasking tools, more effective milling and turning functionality and capabilities for multi-axis turn-mill centers. There are also a variety of productivity enhancements.
delcam.com

3 COMSOL Server
COMSOL Inc. has launched its COMSOL Server, a product for running and sharing applications built specifically with the Application Builder. Part of Multiphysics 5.0, the Application Builder enables users to build a user interface and program around a specific simulation model. The Server allows these applications to be distributed for design teams, production departments and others via a Windows-native client or Web browser.
comsol.com

SmartCAM 2015
SmartCAMcnc's SmartCAM 2015 includes a new Knowledge-Based Machining (KBM) repository, High-Speed Machining strategies and a usability improvements. The software is made for computer numerically controlled (CNC) milling, turning, fabrication and wire EDM. The new KBM functionality enables users to store frequently used toolpath process parameters and apply them later. High-Speed Machining improvements include new roughing and finishing toolpath capabilities.
smartcamcnc.com

4 BenchVue Software
Keysight Technologies has released the next generation of BenchVue. The software provides multiple instrument visibility and data capture, eliminating the need for instrument programming, the company states. This release adds expanded data logging capabilities and compatibility with new instruments such as data acquisition units and power sensors.
Keysight.com

by Barna Szabo

A Case for Simulation Governance

I recently visited an assembly plant of a major corporation. I was impressed with the efficiently coordinated activities, as well as the meticulous attention to quality and safety. I saw manufacturing governance in action.

My own field is computer-aided engineering (CAE) and I could not avoid noting the sharp contrast between what I saw in the assembly plant and the casual, even chaotic practices in simulation and analysis (S&A) that I have witnessed. Recognizing that S&A is increasingly important in guiding engineering decisions, I would like to make a case for simulation governance.

There are substantial economic incentives to reduce reliance on physical testing and increase reliance on numerical simulation. Testing is expensive and time consuming, and the results of physical experiments are tied to the specific conditions under which they are performed. Testing without planning on how the results will be interpreted and generalized makes no sense.

Using Mathematical Models

Reliable generalization of test results is possible through numerical simulation. Simulation is the imitative representation of the functioning of one system or process by means of the functioning of another. Let's consider the functioning of mechanical and structural systems and their imitative representation by mathematical models. Mathematical models are also used for inferring information that cannot be observed in physical experiments.

Finite element modeling is not numerical simulation.

The formulation of mathematical models imposes certain restriction on the input data. For example, point constraints are inadmissible in models based on the theory of elasticity, except when rigid body constraints have to be imposed.

Unfortunately, using inadmissible data can be intuitively plausible and can even produce credible numerical results. Nevertheless, the numerical solution will be an approximation to a non-existent solution and therefore useless.

How is this possible? Take the simple example of connecting two plates or shells by rivets or bolts. The analyst, not wanting to bother with the details of holes, bolts and rivets, simply assumes that it is OK to connect nodes instead. Rigid or spring elements are often used for this purpose. By using this intuitively plausible simplification, the analyst produces a numerical problem with a solution that does not correspond to a well-defined mathematical model. The numerical solution will be credible because the results will be close to what could be expected and the nodal forces will be in equilibrium with the applied loads. However, they will depend on the mesh.

Many analysts mistakenly believe that equilibrium of nodal forces is an indication of solution quality. The equilibrium of nodal forces is satisfied independently from the finite element solution. Even if we replaced the finite element solution with numbers from a random number generator, the nodal forces will be in equilibrium!

Finite Element Modeling vs. Numerical Simulation

The purpose of validation is to test the predictions based on a mathematical model against the outcome of physical experiments. When there is no mathematical model, validation is not possible. The analyst is practicing finite element modeling, not numerical simulation. This means that instead of thinking through how to simulate the physical reality of the object of interest by mathematical means, the analyst simply selects elements from an element library and connects nodes. He creates a numerical problem that does not correspond to a mathematical model.

How is it possible that even though there is no mathematical model, the results appear to be credible? There are two very large errors that nearly cancel one another. There is the conceptual error of using inadmissible data and there is a large error in the numerical solution. This makes it impossible to generalize the results of experiments outside of the range of experiments.

The purpose of physical experiments is either to calibrate or validate a mathematical model, not to tune a "finite element model" so that two large errors almost perfectly cancel one another. Therefore, one cannot generalize the results of experiments with justifiable confidence when there is no mathematical model to justify generalization. Finite element modeling is not numerical simulation.

Implementation is Key

Engineering organizations need to institute simulation governance. This means that management has to understand that finite element modeling is not numerical simulation and begin to exercise command and control over all aspects of numerical simulation. This includes adoption of the best available simulation practices, solution verification, data verification, model validation and revision of mathematical models in the light of new information collected from physical experiments. The primary goal of simulation governance is to ensure and enhance the reliability of predictions based on numerical simulation. DE

Barna Szabo *is co-founder and president of ESRD, Inc. Contact him via barna.szabo@esrd.com.*

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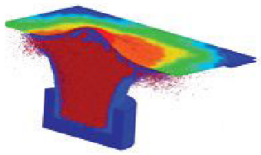
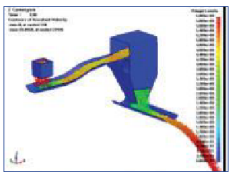
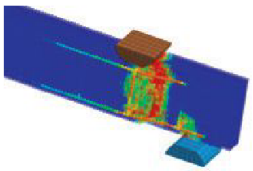


Four New Solvers for Multiphysics Purposes



Discrete Element Sphere (DES)

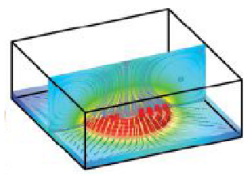
The DES (Discrete Element Sphere) is a particle-based solver that implements the Discrete Element Method (DEM), a widely used technique for modeling processes involving large deformations, granular flow, mixing processes, storage and discharge in silos or transportation on belts. In LS-DYNA, each DE particle is a FEM node, making it easy to couple with other rigid or deformable structures by using penalty-based contact algorithms. The DE is highly parallelized and is capable of simulating systems containing over several hundred-million particles.



Here are some distinct features of the bond model:

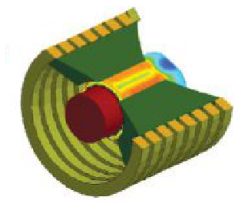
1. The stiffness of the bond between particles is determined automatically from Young's modulus and Poisson's ratio.
2. The crack criteria are directly computed from the fracture energy release rate.
3. The behavior of bond particles is particle-size independent.

Incompressible CFD



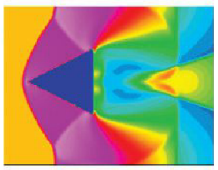
The incompressible flow solver is based on state of the art finite element technology applied to fluid mechanics. It is fully coupled with the solid mechanics solver. This coupling permits robust FSI analysis via either an explicit technique when the FSI is weak, or using an implicit coupling when the FSI coupling is strong.

Electromagnetics



The Electromagnetism solver calculates the Maxwell equations in the Eddy current (induction-diffusion) approximation. This is suitable for cases where the propagation of electromagnetic waves in the air (or vacuum) can be considered as instantaneous. Applications include magnetic metal forming, welding, and induced heating.

CESE/Compressible CFD



The CESE solver is a compressible flow solver based upon the Conservation Element/Solution Element (CE/SE) method, originally proposed by Dr. Chang in NASA Glenn Research Center. This method is a novel numerical framework for conservation laws.

Upcoming Classes in Michigan

- **March 3** ICFD_Day 1: Intro/CFD & CFD Applications
- **March 4** ICFD_Day 2: Focus on FSI/Heat Transfer
- **March 5** Electromagnetism
- **March 23** Intro to LS-PrePost
- **March 24-27** Intro to LS-DYNA
- **March 30-31** NVH & Frequency Domain Analysis

- **April 2-3** Contact LS-DYNA
- **April 9-10** Intro to LS-OPT (2 days)
- **April 21-22** Advanced Impact Options in LS-DYNA
- **April 23-24** Composite LS-DYNA

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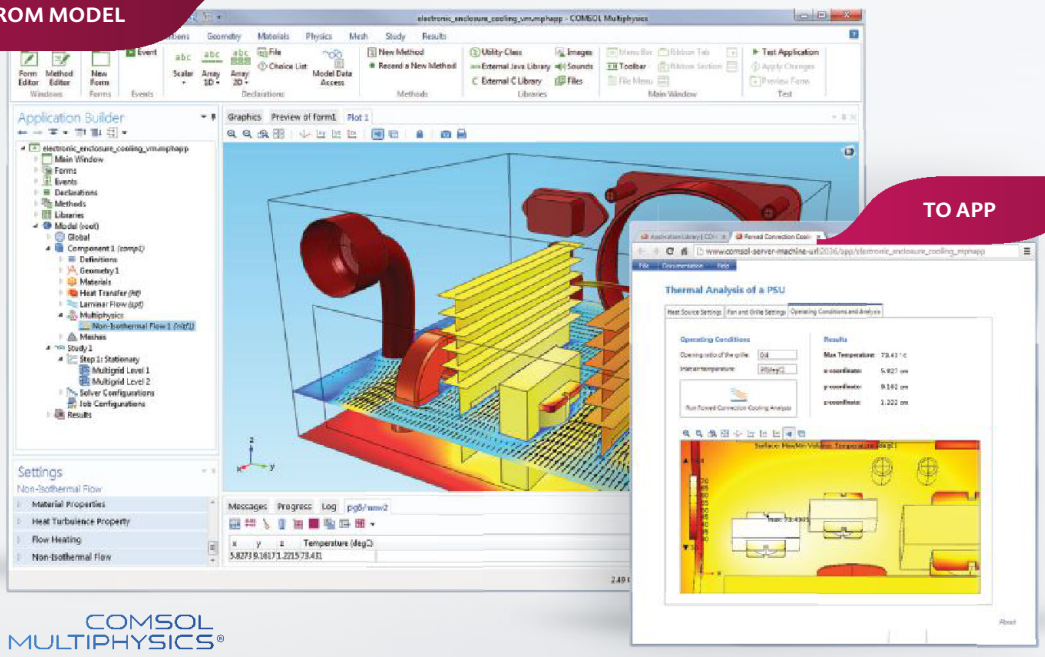

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