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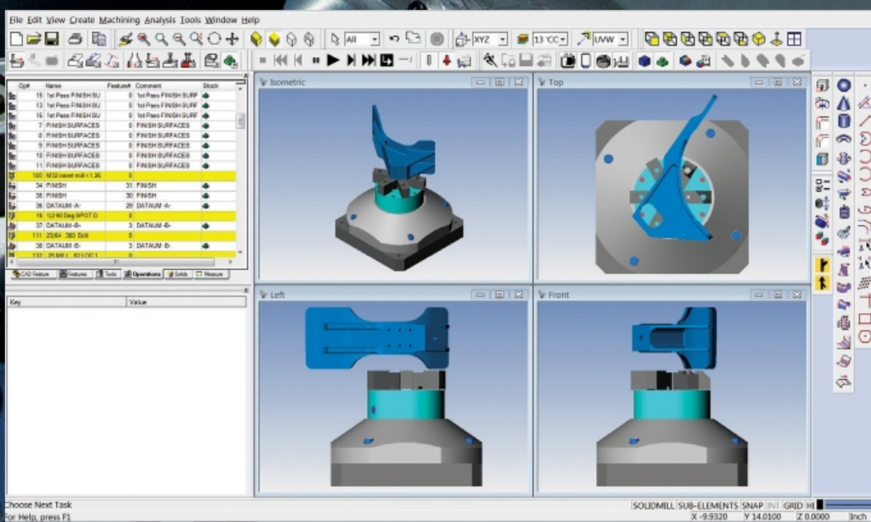
TECHNOLOGY FOR DESIGN ENGINEERING

June 2014 / deskeng.com

FOCUS ON: Prototyping

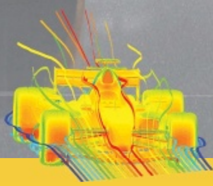
CAD to CAM

Reinforce simulated machining with real-world CAM experience. P. 20



Infiniti Red Bull Racing Wins for the 4th Consecutive Year

2010, 2011, 2012, and 2013 Formula One World Constructors' and Drivers' Champions



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Winning the Formula One World Constructors' Championship is a monumental accomplishment. Winning it four times in a row is practically unheard of. But for Infiniti Red Bull Racing, it was just another day at the office.

Using ANSYS simulation technology, Infiniti Red Bull Racing is creating virtual prototypes of its race cars, so engineers can quickly and inexpensively optimize everything from aerodynamics to brakes to exhaust systems. Infiniti Red Bull Racing is delivering on its product promise by remaining dominant in one of the most competitive environments imaginable.

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Degrees of Freedom

by Jamie J. Gooch

Seeing is Understanding

Every day, many of us do the same basic types of tasks. As we often highlight in *Desktop Engineering*, there are amazing advantages to using technology to complete those tasks faster and better. However, there is a danger in focusing on improving the efficiency of the routine: It's easy to get into a rut.

Innovation comes from designing a new and different way for people to interact with the products you're modeling and simulating. To do that requires empathy for the end users of the product, according to David Kelley, a former engineer and founder of IDEO. Kelley's global design firm is famous for its human-centered approach, dubbed "design thinking." The approach, which Kelley teaches at the "d.school" Hasso Plattner Institute of Design he created at Stanford University, considers what people need, what technology is capable of doing and how the design can succeed from a business standpoint.

A Prototype is Worth 10,000 Words

If a picture is worth a thousand words, what is the value of a prototype when it comes to sharing your ideas, collaborating on a particular project or understanding how people will interact with a design? The book *Creative Confidence: Unleashing the Creative Potential Within Us All*, which Kelley wrote with his brother Tom, illustrates that value via several examples. Tom Kelley is an IDEO partner and the author of the best-selling book *The Art of Innovation*. Their thoughts on design thinking might challenge your definition of prototyping.

The freedom to prototype and create is a key tool of design thinkers.

"We often build physical prototypes. But a prototype is just an embodiment of your idea," they write in *Creative Confidence*. "It could be an array of Post-its to simulate a software interface. It could be a skit in which you act out a service experience, such as visiting the emergency room at a hospital. Or it could be a quick version of an advertisement describing a product or service or feature that doesn't yet exist."

If you have trouble convincing your bosses that you need a 3D printer or desktop milling machine to help you develop better products, maybe they'll change their tune when you start reserving the conference room to act out skits. Whether through traditional or more unconventional means, the freedom to prototype and create is a key tool of design thinkers. In fact, the Kelleys call it the "best way to make progress toward your goal."

That freedom is not something every organization supports, even if it's inadvertent, which tends to permeate a company's culture to the point of diminishing design confidence and therefore efficacy. In a live video chat from the d.school about his book, David Kelley said he has seen people at IDEO who were insecure or defensive about their creativity, which kept them from being effective and limited their ideas.

"(Creative confidence) means you're no longer afraid of being judged by your peers that you're doing something that doesn't make sense or it's too grandiose," he said. "You stop that voice inside of your head that's judging you because you have this confidence."

Art, Design and Engineering

The culture at IDEO was obvious when, earlier this year, I heard the company's president and CEO Tim Brown speak at the 2013 South by Southwest conference in a session called "The Future of Making." One example of design thinking he shared focused on a project by Neri Oxman, a professor at the Massachusetts Institute of Technology's Media Lab and an internationally recognized artist. The SpiderBot being investigated by Oxman and her research assistant Benjamin Peters in MIT's Mediated Matters group uses a web of cables to hoist and move extrusion devices to place material where it's needed on a large scale. It is a prototype for a very large 3D printer, but it's also something more.

"She's working on an art exhibit now, that actually the extrusion devices are lit by LED lamps and they slowly place things," Brown said. "It's a design exploration as much as it is a fabrication exploration."

Getting out of the routine to think big doesn't mean you need to create a prototype that fills a room. A rapid prototype is a simple way to jumpstart design thinking. It can help you get an idea across, understand how people will use a product or see how a part really fits into a system. You don't need to be an artist to create one, either. In fact, if you think of yourself as an analyst or an engineer or a manager, and not as a designer, as David Kelley did early in his career, you may be missing the inspiration to create the next big thing. **DE**

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

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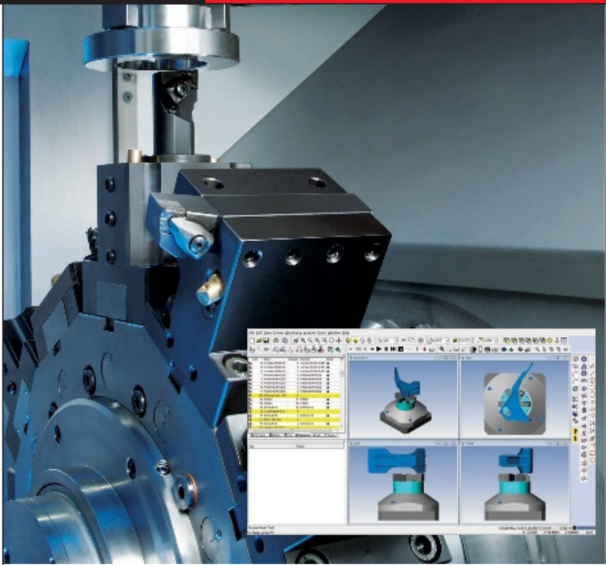
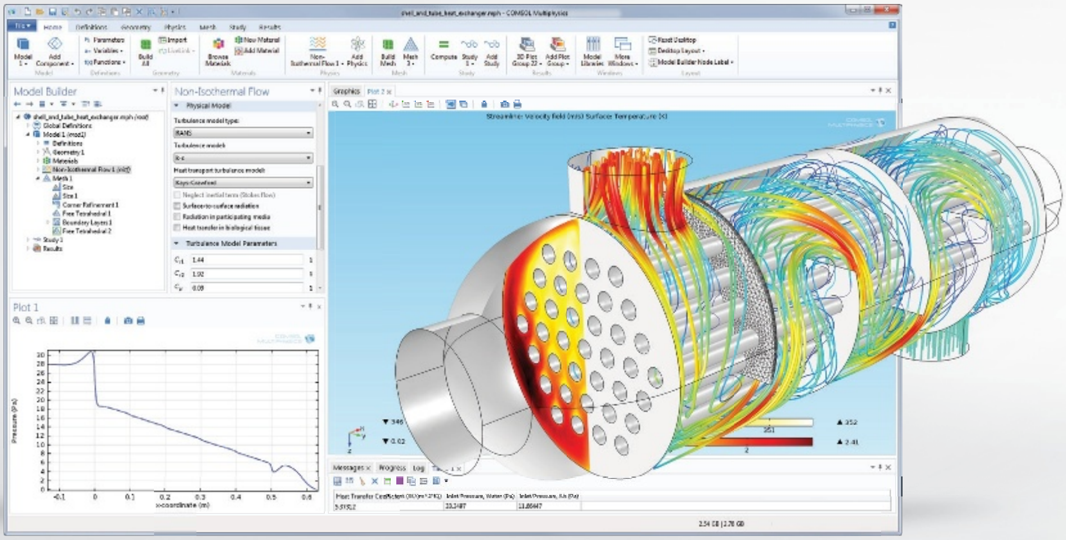


ON THE COVER: EMAG Group's VL 2-4 courtesy of EMO Hannover (background). LSA Manufacturing uses DP Technology's ESPRIT CAM software (foreground) to create operations to machine a part.

HEAT EXCHANGER: Model of an air-filled shell and tube heat exchanger with water flowing through the inner tubes. Simulation results reveal flow velocity, temperature distribution, and pressure within the vessel.



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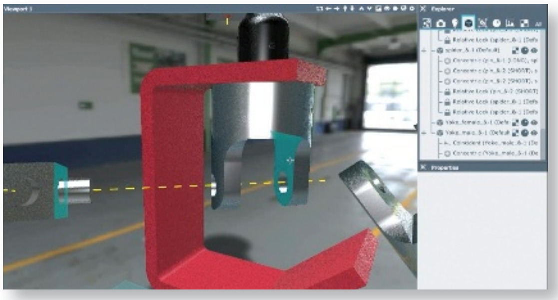
Feature-Based CAD Coming to a Browser

You might know Lagoa as a browser-based interactive rendering software, but soon, you may have to recalibrate your understanding of the software. It's about to become a CAD package.

Lagoa's CEO and cofounder Thiago Costa is a post-production artist. He's responsible for Lagoa Multiphysics, a particle effects generator developed on the Softimage ICE (Interactive Creative Environment) platform. (Softimage is now part of Autodesk.) Costa is looking beyond Lagoa's current target market — visualization — to tackle conceptual design and assembly management. That means adding tools to create and edit geometry and build complex assemblies.

"To see the industry from a new perspective, we have to start from scratch," said Costa at his Congress on the Future of Engineering Software (COFES) demonstration. "Physics should be part of the design tool, not a special tool."

Like Lagoa's current rendering product, its CAD program is expected to work in the cloud —"feature-based modeling from a browser," as Costa put it. The software demonstrated at COFES offers drag-and-drop assembling functions, much simpler and more intuitive than the way current CAD products use mating conditions to do the same. Since cloud-hosted rendering is part of the product, you may also work in a fully ray-traced, interactive mode during geometry creation and editing. In the desktop environment, the intense computing toll exacted by interactive visuals on the CPUs is significant; therefore, most desktop CAD users activate it sparingly.



Assembling parts in Lagoa's new CAD program, also cloud-based. ***Image courtesy of Lagoa Inc.***

When it's available, Lagoa's new CAD product will be offered in three tiers: free, $50 per month per user, or $200 per month per user. The pricing is bound to stir debate, if not anxiety, among traditional CAD vendors offering their products at roughly $2,500 to $5,000, with an annual maintenance fee. A particle physics engine can be used to simulate the behaviors of clothing, water, fluid, powder and similar phenomenons. Integrated physics in Lagoa design tools could be a departure from the current finite-element analysis or simulation tools embedded in CAD. Lagoa's approach could make mechanical simulation easier and less intimidating to designer engineers.

– K. Wong

ANSYS Acquires SpaceClaim for $85 Million

For all intents and purposes, direct modeler SpaceClaim is already part of ANSYS's portfolio. The ANSYS SpaceClaim Direct Modeler is the outcome of a partnership between two companies: simulation software maker ANSYS and direct modeling software developer SpaceClaim. The corporate handshake began in 2009, when simulation software companies came to the realization that an easy CAD geometry editor was the key to broadening their outreach. In late April, the ANSYS-SpaceClaim partnership became an acquisition.

ANSYS paid $85 million in cash to buy SpaceClaim. Explaining the transaction, ANSYS writes, "SpaceClaim can help simplify and automate what has traditionally been a time-consuming process of preparing geometry for use in a simulation system."

Typically, direct modelers are easier to learn and use than traditional parametric CAD packages. Some direct modelers have found a modest following even in the consumer market. For simulation software users with limited exposure to CAD, direct modelers offer an easy way to refine, edit, perfect and defeature CAD files without owning or learning a professional CAD program.

ANSYS SpaceClaim Direct Modeler and ANSYS DesignModeler serve as good examples of the two companies' efforts to integrate technologies. The bidirectional associativity between the programs ensures that geometry changes made in one are reflected in the other with a simple update command.

SpaceClaim users will hardly see any changes to the way the company operates or supports them. In the blog post that addresses the acquisition (spaceclaim.com/en/blog), SpaceClaim writes, "We will continue to develop enhancements our customers have requested and continue to innovate to bring quality products and solutions to the market. Going forward, we will continue to develop, support and innovate for SpaceClaim Engineer and its modules. In fact, with ANSYS's resources behind us, we will be better positioned to deliver industry changing products faster than we have been before."

– K. Wong

Granta Spearheads Materials Data Consortium Aimed at Automotive Sector

Thanks to the steady adoption of simulation-driven design practices and a constantly changing regulatory climate, automotive engineers are in constant need of accurate materials data. Yet, the reality is, materials data is complex, hard to manage and oftentimes spread across disparate resources.

A recently announced industry effort hopes to change that reality. The Automotive Material Intelligence Consortium (AutoMatIC), launched by Granta Design, a leader in materials data, aims to bring together original equipment manufacturers (OEMs) and suppliers in the automotive and off-highway vehicle sectors to develop best practices for materials information and its use. The consortium is charged with optimizing tools that will help organizations manage all of the diverse materials-related data required, including amassing it in one place, capturing information about the relationships between linked items of data and applying the information to help solve practical engineering problems, according to Beth Cope, a Granta spokesperson.

“Many auto producers or suppliers don’t have best practice systems in place to achieve this task, and as a result, data can get lost, can be time-consuming to find or fails to get made available to all of the people who could use it,” she says.

The result of ineffective materials data management can be significant, including productivity problems such as wasted time looking for data or unnecessary duplication of tests, Cope adds. “Most of all, it means that organizations aren’t making the best decisions they could be, simply because they aren’t working with all of the available information,” she says.

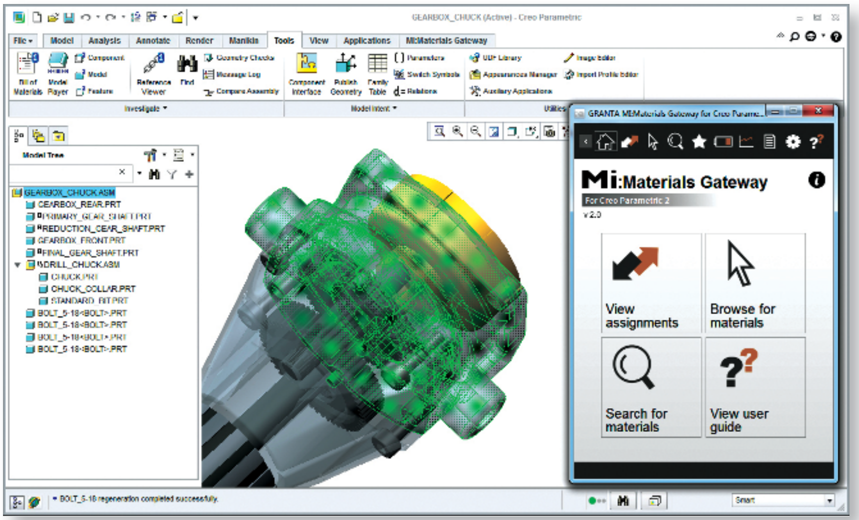
Integrating the many different types of materials data required during the design process is a challenge the consortium hopes to address in its efforts. Today, design teams need access to data on plastics, metals and composites, but the information is typically available from disparate sources, thus is hard to centralize in one place, Cope says.

Dealing with restricted substances is another process automotive OEMs and suppliers have trouble with, and Granta also hopes to address this through the consortium’s efforts. “Companies need to combine information on the materials in their own products with data on the restricted substances that might be present in those materials (or in the processes or surface treatments applied to them),” she says. “They also need to add in information on the regulations that might impact those substances now or in the future, and this is a difficult thing to do.”

AutoMatIC is modeled after similar collaboration efforts, including the Material Data Management Consortium (MDMC) and Environmental Materials Information Technology Consortium, both aimed at the aerospace and defense and energy industries. Like those other initiatives, AutoMatIC members will share lessons learned and evolve best practices along with providing Granta guidance on how to optimize its MI:Materials Gateway portfolio of tools for automotive applications — for example, improving the materials models used as input for simulation codes or identifying industry priorities for reference data on steels, composites or particular classes of restricted substances, Cope says.

In supporting the work of the consortium, Granta will provide members with access to its tool set and collaborate with members to prioritize CAD, product lifecycle management (PLM) and simulation tool integrations.

– B. Stackpole



MI:Materials Gateway is the standard for accessing and applying managed materials data across a broad range of engineering software.
Image Courtesy of Granta Design.

ACE 2014 Focuses on Community

The Aras Community held its annual ACE 2014 event this year in Chicago from April 29 to May 1. The product lifecycle management (PLM) conference included a trade show, presentations, networking and round table discussions.

"We see it as a user conference, it's not a sales conference, we call it a community event because our product is enterprise open source," says Terri Delfino, vice president of marketing communications at Aras. "It's really an opportunity for them to collaborate, network (and) find out what other people are doing with the software."

A Plethora of Presentations

Gathering business, technology and engineering professionals, ACE 2014 highlighted best practices for PLM and industry trends. Over 430 registrants attended the three day conference, representing over 24 countries.

The conference offered presentations for multiple degrees of PLM: basic, business and technical users. Presenting companies included Schrader Electronics, General Electric Aviation, xLM Solutions and Sandia National Laboratories.

"There were a lot of high points, I would say very much that people like the user presentations, this year the GE presentation was of particular excitement, as was the MEN Diesel," Delfino says. GE discussed its production supply chain process and integrating EBOM and MBOM into a single view in "Engineering Definition and Supply Chain BOM Management for Complex Configurations."

Simon Floyd of Microsoft headlined ACE 2014 with his "Product Development & Manufacturing Technology Trends" presentation, which focused on how technology trends like cloud, big data and social media influence product development and PLM software.

Schrader Electronics, a manufacturer of automotive valve and sensing solutions, presented on deploying an enterprise-level PLM solution. Highlights included learning practices for identifying and gauging the need for PLM, deploying a single system for product development and project, quality and cost management.

In addition to the featured presentations, participants attended a variety of 30-minute presentations, including:

- The Business Value of CAD Connectors: How the Aras CAD framework functions.
- PDM (Product Data Management) Process Configuration for CAD: Adapting Aras for out-of-the-box CAD and user specific scenarios such as CAD document numbering and security.
- Tackling ECAD: Learning all about Aras' electronic computer-aided design strategy.
- A Medical Device's Journey to Fewer Systems & Greater Consistency: Seeing how Auditdata is addressing regulation and compliance with Aras for design history files, device master records and more.

Building Community

Honoring the spirit of collaboration, ACE 2014 also included After Hours Product Strategy community input sessions. These hour-long programs discussed ECAD, Tech Pubs and ALM (application lifecycle management).

This sentiment continued with the round table discussions, where Delfino saw major established customers from GE, Ford and others, "who didn't come to the round table to learn, they came to give, to share their experiences. They could have been sitting in another session that could have been more interesting to them, but they came to share their knowledge and be part of the community."

The conference also announced the Collaborate & Contribute Awards, which are given to individuals and companies for outstanding contributions to the Aras Community. The 2014 winners were Sandia National Laboratories for smart file extension handling designed for file check-ins, Minerva for a new form layout for PolyItem advanced search and Hitachi for its Japanese enterprise search with recommendation engine.

"It's amazing how many different types of applications the software can have," Delfino says. "I had people from aerospace and defense companies to food businesses to fashion and apparel. Basically anybody that has product information they need to manage, organize and control."

The conference closed with two major presentations from "Aras: What's New from Aras" and "What's Ahead: Aras Vision & Roadmap."

The next ACE 2014 events include ACE Europe and ACE Japan, which will take place this fall.

– J. Lulka

Battling Robots Help MathWorks Get Aspiring Engineers in its Corner

Two-week competition gives participants a look at Autodesk, MATLAB and more.

An epic battle. Access to one of the country's largest makerspaces and the latest in design tools and fabrication technologies. A mere two weeks to build and design an autonomous robot that will take down the competition.

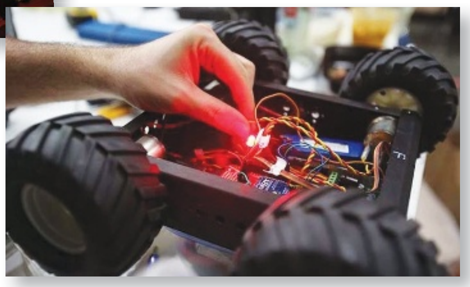
No, this is not a Discovery Channel TV competition, but rather a local, in-person event sponsored by MathWorks, Autodesk, Artisan's Asylum and SparkFun Electronics. The Autonomous Robot Design Challenge, which kicked off in Somerville, MA, in April, is the latest in MathWorks' ongoing efforts to court up-and-coming engineers with a variety of in-school and out-of-school learning initiatives.

In its second year, the Autonomous Robot Design Challenge invites students, engineers and would-be makers to take part in a two-week contest in which they are charged with conceiving and constructing an autonomous robot from the tools and technologies provided on site at the competition.

Two Weeks, One Robot

The event is held at the Artisan's Asylum, a non-profit, 40,000 sq. ft. community workspace that provides members with access to tools they wouldn't necessarily be able to afford on their own. Engineers, artists and entrepreneurs can get their hands on technologies such as 3D printers, computer numerically controlled (CNC) machines, a full computer lab, welding bays, wood shops and 3D design tools, including Autodesk's Fusion 360 CAD software, and MathWorks' MATLAB and Simulink technical computing software.

Unlike other robotics competitions where teams have a long lead time and do prior work on their entries, this event asks challengers to build the robots with only the tools that are available in the Artisan Asylum makerspace during its hours of operation over the course of two weeks.



The red LED (below) lets participants know when the robot is activated. This will be especially useful after the robots are fully equipped. *Image Courtesy of The MathWorks Inc.*

"With most technical competitions or engineering challenges, students take a semester or two to prepare for the competition," says Paul Kassebaum, who handles maker community relations at MathWorks, and helps orchestrate the competition. "This is in sharp contrast — people will walk in off the street with nothing and in two weeks, they'll design an autonomous robot without having any institutional knowledge built up."

Participants were furnished with basic hardware like motors and sensors, and there were tutorials offered to cover the basics of using Autodesk Fusion 360 or MATLAB as part of the robot design.

The partnership with the maker community is instrumental in proving how shallow the learning curve has become for using critical design and engineering technologies, says Kassebaum. In addition, the maker movement also exposes MathWorks software to a broader segment of the market, he says.

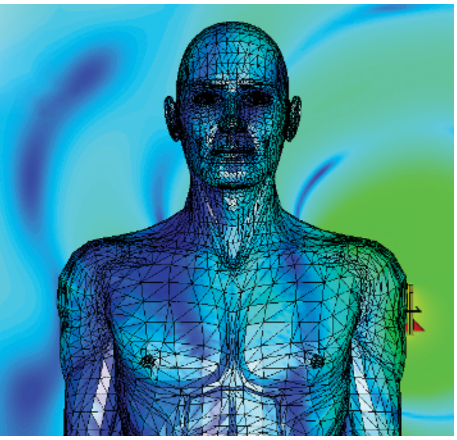
The Autonomous Robot Design Challenge is just one of 27 competitions MathWorks is hosting this year, according to Tom Gaudette, the company's principal academic evangelist.

"We see the makerspaces as an example of really great hands-on project-based learning where students come in, get trained on the tools, and are learning through that exercise," he explains. "Through that process, they learn more than they would in traditional classroom learning."

In addition to sponsoring out-of-classroom events like the Autonomous Robot Design Challenge, MathWorks also sponsors in-classroom training, working with professors to help integrate MathWorks software into the curriculum.

"We want to enable students to get comfortable using industry-standard tools to solve problems repeatedly in different classes," Gaudette says. That way, they can concentrate on learning the topic of the class rather than focusing on learning the tools, he explains.

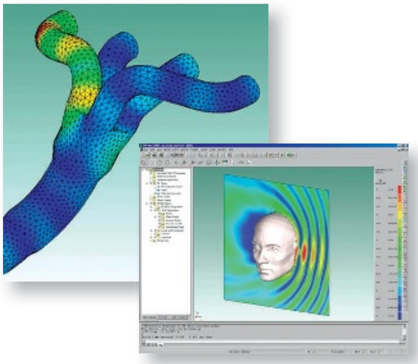
– B. Stackpole



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.



Vibro-Acoustic Simulator Updated

Updates for VA One include support for engine run-ups and Speech Clarity module.

ESI Group's VA One is an "all-in-one" system for predicting and resolving potential noise and vibration problems upfront in the development process. This analysis and design software can couple statistical and deterministic modeling methods in a hybrid manner, letting you simulate noise and vibration across the full frequency range.

It can combine, finite elements methods (FEM), boundary element methods (BEM) and statistical energy analysis (SEA) in a single model. Core modules include acoustic BEM methods, acoustic FE methods, multi-pole methods, poro-elastic materials, SEA and structural FE.

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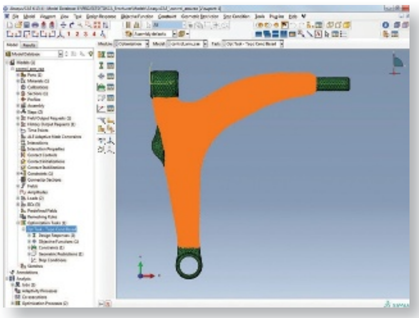

Optimize Sheet Metal Structures Efficiently

Dassault SIMULIA releases Tosca Structure 8.0 for non-parametric structures.

The key enhancement in SIMULIA Tosca Structure version 8 is a new sizing module called Tosca Structure. sizing. It lets you optimize sheet metal components by adjusting individual sheet thicknesses of single-layered shells.

You can dive into design issues like volume, mass, displacements, reaction forces, reaction moments, natural frequencies, center of gravity and frequency response analysis results (amplitudes, phases, velocities and accelerations). Tosca Structure.sizing also offers various symmetry constraints (plane, rotational, cyclic) and link conditions.

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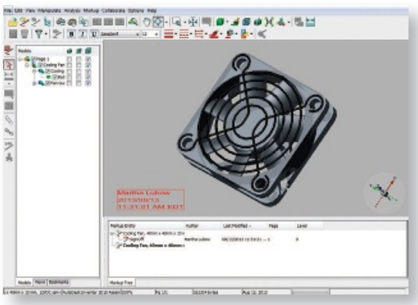

Adept 2014 Updated with New Integrations

New Related Fields module allows for creation of automated responses and filtering.

Adept 2014 SP1 has all sorts of enhancements, ranging from a re-engineered version of its Viewer powered by the Oracle AutoVue enterprise visualization solution, to a Task Pane tab that lets you search, sign in/sign out, open, insert and replace components as well as see status information about parts, assemblies, drawings and configurations from within Inventor, SolidWorks and other supported design systems.

In total, Adept 2014 SP1 has over 200 enhancements. More than 130 of these are client-requested fixes, improvements and polishes, according to Synergis.

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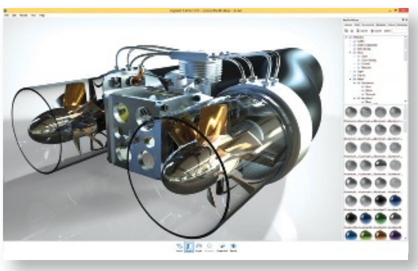

IronCAD Integrates Photorealistic Rendering

KeyShot provides over 700 predefined materials and multiCAD rendering capabilities.

KeyShot integrates across the range of IronCAD 3D and 2D design applications. You can fire it up from the Add-in Ribbon bar in IronCAD. Your data and details go over to KeyShot, where you start adding textures, adjusting lighting, applying realistic materials, making animations and so on.

KeyShot for IronCAD comes with over 700 predefined materials. IronCAD includes the KeyShot integration with the IronCAD suite of products in its 2014 Server Patch 1 release as a fully functional 30-day evaluation. Users can also update and change designs in IronCAD and have those changes reflect in the rendered image automatically.

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Mac Design **No Match** for BOXX Professional-Grade Performance

Mac Pro falls short on extensibility, power.

Apple's capacity for artful design and technology innovation may make it the dominant force in consumer electronics, but its mastery doesn't necessarily transcend to the world of professional-grade workstations.

After years of letting its once-lauded Mac Pro take a back seat to development efforts for the iPhone and iPad, Apple late last year introduced a widely anticipated and totally redesigned successor to its workstation product, claiming the system was "built for creativity on an epic scale" and earning accolades for its ground-breaking cylindrical design.

Yet as revolutionary and visually stunning as the Mac Pro's new footprint may be, a look under the covers reveals some serious gaps specific to the power and extensibility required by professionals in the engineering and media and animation space. Unlike workstations designed from the ground up to meet the needs of a professional audience, the Mac Pro lacks some fundamental capabilities, from support for a limited number of cores and GPU options to a dearth of high-end CAD and simulation software certified and optimized to run in the environment.

The BOXX Advantage

In comparison, BOXX Technologies is all about designing and building workstations architected from the ground up to help professionals in the visualization and engineering markets solve problems. With a system architecture and set of capabilities that prioritize performance over style, a BOXX workstation is the reliable workhorse that gets simulation and rendering jobs done quickly while allowing design teams to efficiently collaborate on multiple design iterations.

Let's take a look at four critical areas where BOXX workstations offer significant advantages compared to the Apple Mac Pro:

1 Number of cores. The redesigned Mac Pro supports Intel's Xeon, but only a single processor with up to 12 cores. In comparison, the BOXX 8950, which supports the most advanced configurations, features dual Intel Xeon E5-2600v2 series processors (up to 24 cores and 48 threads)—a combination primed to handle multiple professional applications and complex workflows.

2 GPU support. Go with the Mac Pro and your GPU options are limited to AMD. Even then, there is only accommodation for two units. In contrast, BOXX workstations support a wide range of GPU and co-processor choices (from AMD, NVIDIA, and Intel), and the systems can accommodate up to five add-ons.

3 Memory capacity. While the Mac Pro's capacity tops out at 64GB of RAM, BOXX workstations can be stocked with up to 512GB of RAM.

4 Overclocking and liquid cooling. These are capabilities common to most BOXX professional-grade workstations, but not the Mac Pro. BOXX's overclocking technology squeezes every ounce of performance from its workstations to accommodate robust applications like Dassault Systèmes CATIA, SolidWorks, ANSYS, and Autodesk Inventor and 3ds Max while liquid cooling capabilities ensure the machines run cool and quiet, even at full throttle.

Professional engineers require a lot more than workstation style and slick packaging to get the job done. Only a workstation designed from the ground up for performance can serve as a reliable workhorse for today's demanding design and simulation applications.

To get a look at how BOXX workstations stack up against the Apple Mac Pro, visit boxxtech.com/landing-pages/mac-pro-no or call 1-877-877-BOXX.

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Crossing the Threshold from Design to Manufacturing

Where CAD ends and CAM begins, simulated machining must be reinforced with real-world equipment experience.

BY KENNETH WONG

About two years ago, Guy Nelson, who owns and operates Anvil Design & Manufacturing in Fargo, ND, picked up a CAD-CAM bundle: SolidWorks and SolidCAM. The deal was irresistible. He's always planned to offer CAM-related services as part of his business, but the right opportunity never came along. This April, it came in the form of a client who wanted him to help produce a whammy bar, the sound effect-producing handle on an electric guitar.

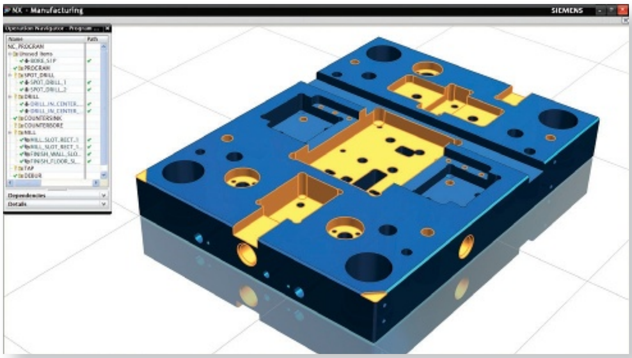
"Once we started using the CAM package, we changed our design," said Nelson. "Once we got into it, we realized that the area where we placed fillets apart, having a fillet somewhere, or the size of the fillet, affects production. So we went back to engineering."

In crossing the threshold from design to manufacturing, Nelson is discovering the difference between simulated machining and real-world machining. "Without machining background, coming from just designing the part, we had to learn what the people on the shop floor are looking for," he said. "Understanding the tool, knowing whether it might break, knowing how to hold the tool — those are areas we had to work our way through."

The emergence of integrated CAM packages — programs that let you visualize machining operations from inside CAD — makes it easy for designers and engineers to understand how they might produce a part. In theory, CAM reduces unanticipated manufacturing glitches by preventing designers from introducing features and forms that are difficult — or, in the worst cases, impossible — to build.

But to delve into real-world machine, the CAM software operator must be willing to literally face the physical equipment. Michael Huggins, president of PCS engineering, cautioned, "You can learn a CAM package like you might a video game, but you really need to know what you're doing with the tool."

Derek Hart, Siemens PLM Software's marketing manager, manufacturing engineering, noted, "Operating the CAM software is not difficult. But the interaction of the tool and the material is a difficult learning curve. There are so many ways it can go wrong — pockets that cannot be machined, a small change in the diameter of a feature that makes the valley impossible to cut, the way the chips must be ejected properly."



In NX's integrated CAM module, the software automatically identifies the geometric features suitable for machine.

Getting to Know the Machine

Nelson's client is planning to manufacture the whammy bar with a Tormach-brand CNC machine. Anvil Design has been contracted to generate the G-code, used by computer-controlled machine to cut the part. This is new territory for Nelson and his colleagues, who feel much more at home in SolidWorks CAD than in SolidCAM.

"We did our research to understand the machine the client bought," recalled Nelson. "We learned the coordinate direction, how it operates. We're learning how to best make the part, how to setup fixtures, and how to build multiple parts at the same time."

A standard feature of CAM systems is a library of industry-accepted machines that come preloaded with the software. The selectable list allows you to specify which machine you'd use to produce the part. When generating the tool path or the G-code, the software takes into account the specific machine's tooling area, material holding method, the shape and length of its tool arm, and the way it cuts and drills. On complex parts, the choice of cutting direction, angle and speed — tooling strategy — determines the effectiveness of the job. Therefore, to be a good CAM programmer requires knowledge of the equipment itself.

"If we were to do it all over again, we would have been in contact with SolidCAM tech support a lot earlier," reflected Nelson. Shaun Mymudes, COO of SolidCAM, would have welcomed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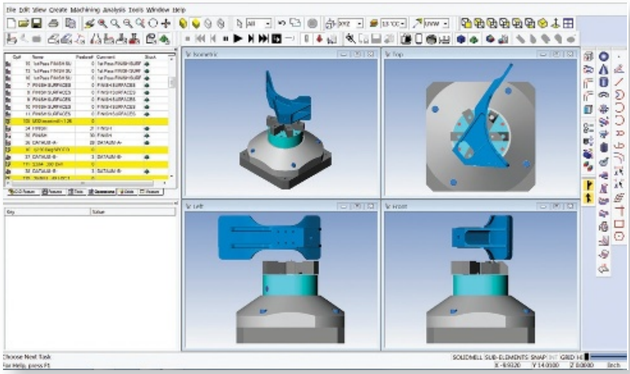
The DFM module automatically checks and identifies potential production problems based on CAD geometry.



LSA Manufacturing uses DP Technology's ESPRIT CAM software. The operation table shows there are more than 112 separate operations to machine this part. Some are created automatically; most are based on the programmer's decision. Therefore, the programmer's experience with the equipment plays an important role.

Nelson's outreach. "We have 30 people," he said. "Out of those 30, we only have seven salespeople and three administrative. The rest — 20 of them — are involved in some kind of support."

For a SolidWorks user like Nelson, SolidCAM is "a natural extension," said Mymudes. He added, "The 'common platform' approach drives a bidirectional information flow between the designers and the manufacturers … both can use CAM simulations to illustrate their suggestions and opinions."

To make CNC programming easier, SolidCAM offers the iMachining feature, a patented wizard-based approach to generate tool paths and specify optimal feed and speed. Mymudes explained, "[The iMachining feature] completely controls chip thickness, making sure the tool load is perfectly optimized through the entire cut, ensuring the best possible tool life."

A Good Programming Job

Todd Paul, president of Land Sea Air (LSA) manufacturing, observed, "You can machine a part 50 different ways. The end result might be the same, but one way by one guy might take one hour; another way with another guy may take 100 hours."

Having worked with many CNC programmers, Todd can often spot telltale signs of inefficiency. "You look to see whether there are bad [machine] moves, whether the machine breaks tools because it's moving too fast, whether the speeds and feeds are right or wrong," he said.

About 80-90% of LSA's clients are from the aerospace industry, which widely uses Dassault Systèmes' CATIA CAD program. Todd and his staff use ESPRIT CAM software from DP Technology. Todd's CAM reseller is PCS Engineering, based in Timonium, MD. Its owner Michael Huggins once wrote CAM software manuals (at the time such manuals were still distributed in printed form). Huggins said, "In ESPRIT 2014, when you start a new file, it asks what machine you'd be using. Based on that input, the software sets all the machine parameters right away."

The latest release, ESPRIT 2014, incorporates a cloud-hosted database to let the software recommend the best tool options. Based on uploaded information about the geometric features that needed to be produced (pockets, shoulders, slots, and so on), the software automatically creates a list of best-fit tooling options, ranking them in the hierarchical order.

On complex programming jobs, Todd doesn't hesitate to call Huggins. "He [Huggins] uses Go To Assist [a remote desktop control program developed for tech support]," said Todd. "With it, he's usually talking to me within 60 seconds. He can [virtually] take over my desktop to show me how to program a job correctly."

"It's pretty much impossible to make the first part right. Invariably, the programmer or the machinist might make a mistake," noted Todd. "But with a good programmer, when the job is up and running, it can run as many as 1,000 parts and the last part is exactly the same as the first part."

Longer Lifespan for Tools

Tools break. That's the unavoidable part of real manufacturing where metals — not pixels — cut into each other. But according to Todd, something called Profit Milling, facilitated by ESPRIT CAM software, is defying the usual lifespan of cutting tools.

"We have a tool that we're cutting materials with," said Todd. "According to the tool manufacturer, its life is between 30-120 minutes. We're getting 1,200 minutes with this tool. It's strictly because of a tool cycle that ESPRIT calls Profit Milling."

Daniel Parry, DP Technology's application engineer, explained in a company-produced video that "Profit Milling is a 2-, 3-, 5-axis rough machining strategy … We have seen cycle time reduction along with five to 10 times the tool life compared to traditional pocket milling cycle." The operation, Parry pointed out, is a tricordial motion characterized by "consistent cutting conditions" and "dynamic feed rate" — the machine adjusts itself to maintain constant chip load to keep the results consistent. This gives you the uniformity that spans from part No. 0001 to No. 1,000 — what Todd views as one of the telltale signs of a good CNC programming job.

Spellcheck for Manufacturability

"CAM software are getting easier, but the physics of metal cutting is the learning curve," observed Siemens' Hart. "The real knowledge of manufacturability comes with experience. You have to break tools, make scraps to get it."

Some of that knowledge can be encapsulated in the software itself. One product that fits the bill would be DFMPro from Geometric, a partner product of Siemens. Think of it as the equivalent of a spell checker for manufacturing operations. The company writes, "DFMPro assists design engineers in identifying features of a design which are difficult, expensive and impossible to manufacture, at the design stage itself. This helps in avoiding downstream issues which impact cost, quality and time to market. DFMPro covers various commonly used manufacturing processes like machining (milling, turning, drilling), injection molding, casting, sheet metal fabrication and assembly."

DFMPro's checklist extends beyond the simple act of production. It also considers whether your part, designed as it is, will permit easy disassembly for repair when it starts to show wear and tear. The company writes, "The rules take into account various Design for 'X' (DFX) issues which typically occur later in product lifecycle such as serviceability, assembly etc."

CAD files routinely get passed over to CAM software operators and machine programmers, but the flow of knowledge from the opposite direction — CAM knowledge traveling upstream to designers using CAD — is currently not the norm. That knowledge flow — seeming going against the traditional current — may offer an opportunity to cut down unintended production hiccups.

Hart acknowledged, "Manufacturing is hard." He added, "But that doesn't meant people shouldn't try to learn it." DE

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

INFO → **Anvil Design:** Anvilequip.com

→ **Dassault Systèmes:** 3DS.com

→ **DP Technology, ESPRIT:** Dptechnology.com

→ **Geometric, DFMPro:** Dfmpro.geometricglobal.com

→ **PCS Engineering Inc.:** Pcsenginc.com

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

→ **SolidCAM:** Solidcam.com

→ **Tormach:** Tormach.com

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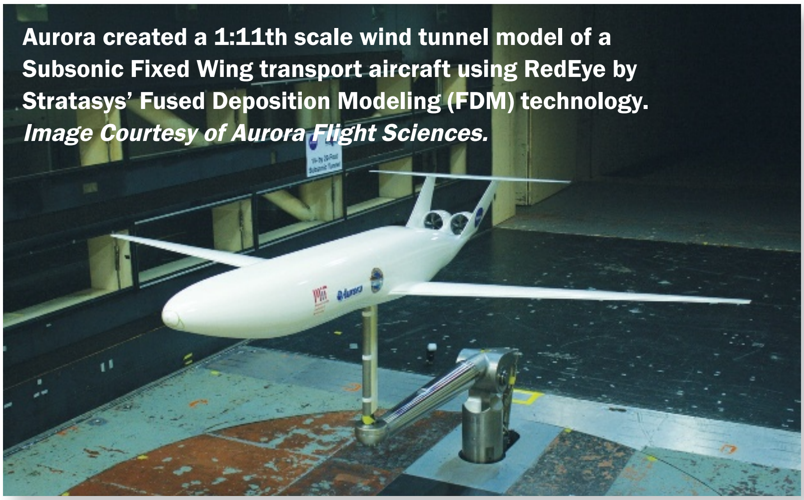
3D Printed Plane Propels Wind Tunnel Testing to New Heights

RedEye's FDM rapid prototyping services helped Aurora Flight Sciences keep wind tunnel testing on track for a next-generation NASA concept aircraft.

BY BETH STACKPOLE

Fast forward 20 years and try to picture the state of air travel. Thanks to a growing world population and maturing developing economies, air traffic is expected to double in the next 15 years. That will create new levels of congestion and raise concerns about limited runway space, rising fuel costs and a surge in noise and pollution emissions.

As part of an exercise to explore innovations that would address these challenges, NASA embarked on a multi-million dollar Aeronautics Research Mission Directorate concept study to evaluate design approaches for a next-generation aircraft, akin to today's 737-class fleet, that would go into service in the 2030 to 2035 timeframe. Central to the design study was identifying technologies that would reduce fuel consumption by as much as 70%, significantly cut back on noise and pollution emissions, and enable operation from 3,000 ft. runways that are common to secondary airports outside of major metropolitan areas.



Aurora created a 1:11th scale wind tunnel model of a Subsonic Fixed Wing transport aircraft using RedEye by Stratasys' Fused Deposition Modeling (FDM) technology. ***Image Courtesy of Aurora Flight Sciences.***

A key phase in the project was a wind tunnel modeling effort that would assess the aerodynamics, propulsion, operation and structure of the proposed concepts. Led by one of the partners on the study, Aurora Flight Science's Research & Development division, the team took off with Stratasys' Fused Deposition Modeling (FDM) additive manufacturing technology as a way to shorten its design cycles and maximize limited time slotted in NASA's wind tunnel facility.

"Typically the turnaround on projects like this is weeks, if not months," notes Roedolph Opperman, a spacecraft systems engineer at Aurora Flight Sciences. "Because we were working with NASA, we had to schedule time in their wind tunnel months ahead of time and we had to meet our deadlines. With FDM, we were able to get everything done and have an assembled tail in the tunnel in just under a month. That's unheard of in this industry."

The "Double Bubble" Design

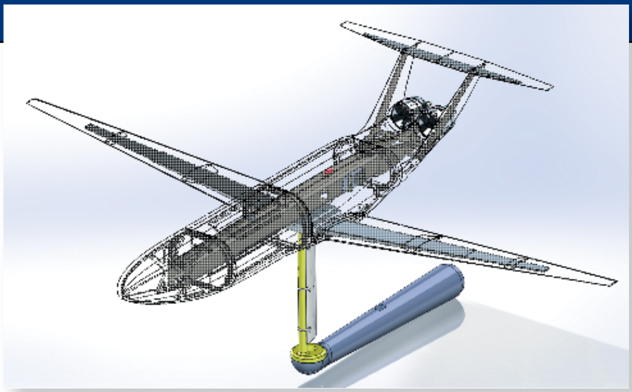
The concept study for the N+3 subsonic fixed wing transport aircraft — or a jetliner in layman's terms — called for the project partners to explore three areas of innovation: An aircraft design that could harness liquid natural gas, use a distributed, multiple-engine propulsion system, and would fly about 10% slower than current-day aircraft in order to take advantage of emerging technologies that aren't supported at current commercial flight speeds.

The team, led by MIT, which included Pratt & Whitney in addition to Aurora Flight Sciences, came up with a radically different design concept for the aircraft, intended to fill the seat of the B737/Airbus A320 class, which accommodates 180 passengers for travel ranging from 500 nautical miles to a transcontinental range trip. Referred to as the D8 series, the concept aircraft took on the shape of a "double bubble" or double-tube and wing, Opperman explains, a design intended to increase lift while allowing for more room to accommodate additional passengers.

The other big change in the design was the placement of the engines — from under the wings where they typically reside, to the back of the plane, riding on top of the aft end of the fuselage. "That was done to take advantage of boundary layer ingestion — a concept that essentially reduces the drag created by the airplane," Opperman says. "It's better for the engine."

Once the primary design concept evolved and was validated with robust simulation testing, it was time to move on to the wind tunnel stage to put the proposed "double bubble" plane model through its paces and prove out the simulation results.

Aurora's role was to develop a scaled-down model of the plane design that would attach to the wind tunnel. The bigger the model, the closer the team could get to resembling the actual aircraft for evaluating drag, the effect on engine placement as well as other capabilities. Initial testing was done at MIT with truncated wings on the 1:11th scale model in order to have it fit in the tunnel. Eventually, the project was moved to NASA's 14x22-ft. wind tunnel facility to test the full-length wings because the larger tunnel reduces the negative impact of tunnel boundary effects on the measurements, Opperman explains. The team had to schedule the testing period for the NASA facility months in advance and had only a limited amount of time to conduct its wind tunnel verification work, he adds.



In this full CAD model view of the integrated tail assembly, 3D printed parts were made transparent to show internal metal support structures.
Image Courtesy of Aurora Flight Sciences

RedEye FDM Puts Test Model in Flight

Facing those requirements, and with a heightened interest in 3D printing as the wave of the future for manufacturing, Opperman and his team decided to engage Stratasys' RedEye rapid prototyping services division to create the test model

In one test, an FDM wing with an aluminum skeleton was mounted upside down and loaded with 340 pounds to simulate a 300% loading of maximum lift force in the tunnel, resulting in a wing tip deflection of 8 inches. *Image Courtesy of Aurora Flight Sciences.*

RedEye's FDM additive manufacturing services were engaged to produce engine nacelle parts for the wind tunnel model. *Image Courtesy of Aurora Flight Sciences.*

in an effort to meet its rigorous timelines.

The typical model used in wind tunnel testing is machined out of aluminum, with foam parts used intermittently. It can take as much as a month just to get the machined part — a timeframe that would negatively impact the schedule, he explains. Using the RedEye service, the team submitted designs and received the finished 3D printed versions ready for assembly and finish work in just a few days, which enabled it to meet its aggressive deadlines.

Evaluating possible engine placement and the different variations of the engine nacelle design were also much easier with an additive manufacturing approach, Opperman says. RedEye was able to very quickly print out eight different nacelle shapes during the test period in the wind tunnel, allowing the team to switch out variations and zero in on the optimal shape, he explains. "The clock was ticking — we had six weeks to do all the testing and working with RedEye, we were able to get parts quickly," he says. "Because everything was changing so rapidly, we wouldn't have been able to do it if we went the aluminum route."

Another benefit of FDM is the flexibility in quickly manufacturing complex surfaces, especially when it comes to the aerodynamically blended shapes of the fuselage, particularly around the integrated engine nacelles of the tail as they are difficult, expensive and time-consuming to machine, Opperman says. The smaller weight also minimizes the support structure required, so it simplifies the design and handling of the model in the wind tunnel.

RedEye by Stratasys could also provide expertise surrounding additive manufacturing practices that Aurora and its team of partners lacked, Opperman says. RedEye is also the single biggest installation of consolidated FDM printers, so it can accommodate large jobs and handle the variety and size of parts and still deliver in a timely fashion, according to Jason Bassi, senior account manager at RedEye.

Because use of 3D printed parts in a wind tunnel was a relatively new application for NASA, due diligence was required in the form of a 400-page report and sample materials to prove that the materials and the process were structurally sound and wouldn't do damage to the NASA wind tunnel, Opperman says. "NASA wanted to ensure that nothing would break and that there wouldn't be pieces flying off the model and damaging the tunnel," he explains. "Because 3D printing is so new [for this application], we needed to show them the calculations and prove that it would be safe."

Aurora Flight Sciences' effort to validate the acroylonitrile butadiene styrene (ABS) materials and FDM additive manufacturing process for wind tunnel modeling will go a long way in convincing others of the merits of the approach for this and other serious simulation efforts, according to Bassi.

"The fact that Aurora took the proper steps to certify the materials and the process is crucial," Bassi says. "The more examples that are tested and validated, the more people have confidence in pushing the limits as to what additive manufacturing can do. Aurora is breaking new ground by validating that the materials work in these scenarios." **DE**

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

INFO ➜ **Aurora Flight Sciences:** Aurora.aero

➜ **RedEye:** Redeyeondemand.com

➜ **Stratasys:** Stratasys.com

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

3D Systems' New Printers

3D Systems' (3DS) ProJet 1200 is a professional desktop stereolithography 3D printer. It has a 43 x 27 x 180mm (1.69 x 1.06 x 7.08 in.) build envelope, with a vertical build speed of 14 mm/hour (0.55 in/hour).

The new system offers builds with 30 micron layers at a 585 dpi resolution. The ProJet 1200 is priced at $4,900.

3DS also announced production of the CeraJet AM system. This new product builds ceramic objects that can then be fired and glazed. Added to the ChefJet food 3D printer, the CeraJet shows 3DS' dedication to expanding the definition of 3D printing.

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3D Printed Pre-fab Housing Erected in Shanghai

With enough ingenuity, almost anything can be built using additive manufacturing (AM), including houses. Ever since 3D printing hit the consciousness of the mainstream, various inventors and organizations have been dreaming of 3D printing a house. Even NASA has investigated construction through additive manufacturing.

Now, it seems, Chinese company WinSun Decoration Design Engineering Co. has succeeded in using AM to erect pre-fab housing units in Shanghai. While this doesn't represent a true effort at printing a house in situ, it is still a leap forward. All the pieces for the pre-fab units were built off-site using 3D printing.

The result is a single room dwelling with a glass front to let in light. The building was made using recycled construction waste, industrial waste and tailings, which lowers cost significantly, with each unit priced at around $5,000.

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National Lab Develops New AM Process

The Lawrence Livermore National Laboratory (LLNL) has developed a way to use electrophoretic deposition (EPD) for additive manufacturing (AM) in a new process the lab is calling light-directed electrophoretic deposition. EPD itself has been used for almost 100 years as a way of coating materials through deposition. As an example, new cars can be primed using EPD by moving a positively charged car body into a negatively charged dunk tank.

EPD can deposit materials on a wide variety of surfaces, including ceramics, metals, polymers and even living cells, but has been limited to area dispersal patterns. LLNL's project has discovered a method to force material buildup in specific areas, turning the old technology into an AM process. Researchers used photoconductive electrodes and DC

electrical fields to direct the patterns of deposition, encouraging a layering effect in targeted areas where the light comes in contact with the photoconductor's surface.

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Staples In-Store 3D Printing Comes to U.S.

One expression of increased awareness is the push to move 3D printers from the back of the store to the front. Staples has been at the forefront of this movement, adding AM systems to store shelves, and offering AM printing services in Europe since last year. Now a new partnership with 3D Systems (3DS) will bring AM services to Staples in the U.S.

"3D printing offers enormous potential for small businesses, and by using Staples, they can print with the technology without having to invest in it," said Damien Leigh, senior VP of business services for Staples, Inc. "The test with 3D Systems will help us learn about our customers' needs for a local 3D printing service, and how Staples can help them make more happen for their business through 3D printing."

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A DLP 3D Printer on the Way from Stalactite 3D

One of the newest entries into desktop resin printing is called the Stalactite 102. It is the product of a Barcelona startup named Stalactite 3D. The new 3D printer uses digital light projection (DLP) from the side, rather than the top or bottom, to build objects. The company has also developed four different material options for its new system.

According to the company, its designers chose to place the DLP system to the side (instead of above or below the build envelope) for a number of reasons, including the size of the laser and resolution. Placing the projector on the side allowed for similar results to other stereolithography systems while using a smaller laser,

which reduced cost. Having the projector on the outside also makes changing resolution easier, according to the company, as the projector can be adjusted without having to open the AM system.

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CNC Machining on Cruise Control

From prototype to production.

The Tormach PCNC 1100.

From his Anaheim, CA, machine shop, Tormach PCNC 1100 owner and motorcycle enthusiast Brian Carmichael manufactures the OMNI-CRUISE, a universal throttle lock/cruise control that he designed to enhance the riding experience for motorcycle enthusiasts around the world.

The idea for OMNI-CRUISE came about when Carmichael was looking for a way to ease the stress on his wrist while riding. "I realized that the imported plastic cruise controls weren't of a high enough quality for me to put on my bike. So, I decided to make one out of metal," he says.

Carmichael's throttle lock design is completely universal, fitting most motorcycles and scooters on the market. It installs in seconds and at just ¼-in. wide is the thinnest on-grip product available on the market today, he says.

The OMNI-CRUISE.

When *Motorcycle Magazine* featured a review of the OMNI-CRUISE, Carmichael's business changed quite literally overnight.

"*Motorcycle Magazine* wrote an article on my product," he recalls. "The article came out on a Thursday and it was obvious I'd be sold out by the following Monday, so I turned in my resignation at my day job and got to work ramping up production in my shop."

Increased Production

Carmichael initially prototyped his invention on a small hobby mill before switching to a Tormach PCNC 1100. In doing so, he saw a significant increase in production volumes and a significant decrease in per part machining time.

"Switching to the Tormach PCNC 1100 changed my production volume from being able to make about 75 at a time to the batch I'm running right now which is 1,620 OMNI-CRUISES and is going to be a little over 5,000 individual parts," he says.

"The fixtures I had when I first started were ¼-in. thick and measured 6 in. wide by 16 in. long, which would yield 12 halves of the cruise control from each plate. If I stacked the fixture plates three tall, my machining time ended up being 4.5 minutes each," he explains. "With the Tormach PCNC 1100, my current fixture holds 18 parts and I'm able to run them four plates thick. So, every time I hit Cycle Start, essentially I'm cutting 72 parts. I've gotten my unload/load time down to about 20 minutes in an hour and a half of machining, which knocks my time per part down to about 1.6 minutes."

Production volumes aside, Carmichael said he saw the popularity of the OMNI-CRUISE coming a long way out.

"There are 9.5 million registered motorcycles in the United States of America," he says. "If I'm able to target half of 1% of the market, this will exceed my expected annual income for the rest of my life if I worked until 100 at my other job."

Happy Customers

Customer feedback on the OMNI-CRUISE has been nothing but positive. "The No. 1 thing I hear about my product is its quality," Carmichael says. "Everything they touch is molded plastic and people are not used to seeing the attention to detail in after-market parts, especially in the $50 price range."

Each OMNI-CRUISE is finished with a micro-grain textured powder coating that is both abrasion resistant and easy to grip. To protect from wear against the brake lever, Carmichael machines the bottom piece out of Delrin plastic. "There's a Delrin slide all the way around the bottom, which needs to be plastic because it comes in contact with a chrome or powder-coated brake lever — otherwise it's going to wear the brake lever before the OMNI-CRUISE," he explains.

Carmichael adds, "Honestly when I started making the OMNI-CRUISE, I figured if half the people that bought my product liked it, I'd be satisfied. But the vast majority of people who've even touched it have either bought one or plan to. The overall sales have been a lot better than I ever thought they would be, considering I haven't really even done any traditional advertising yet." **DE**

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5-axis Machining at Sea

HyperMill helped Italian company Gianoplast manufacture an intricate, one-piece yacht instrument panel.

When making molds for large-sized and high-precision parts, using CAM software is inevitable. In the case of style components, like those earmarked for the marine industry where the design of the shapes includes sophisticated geometries and high-quality surfaces, CAM is able to help the user with adequate processing and machining strategies. To make an instrument panel for an innovative yacht from the Wider shipyard, Gianoplast made full use of the powerful tools found in hyperMill, CAM software from Open Mind Technologies that can be used to program the complete process and more complex parts.

When owner Claudio Fioroni, along with his colleague Antonio Baroni, started using hyperMill they approached it carefully: "When the production period was over, we then experimented with the possibility of using the 5-axis milling machine with CAM software to make models which, up until then, had previously been made by hand out of wood," Fioroni says. "For a company like ours, which specializes in thermoforming and making parts out of fiberglass, working with complex geometries and in the most difficult positions is par for the course, therefore, we needed a form of software that could effectively support 5-axis machining. As a result of working very well with hyperMill over many years we decided set up a sort of alliance with Open Mind, which ended up with us also buying the latest hyperMaxx module for high-performance roughing. We mainly supply large-sized parts and the use of hyperMaxx prevents any downtime, considerably speeding up the production processes."

With the help of hyperMill, Gianoplast recently made an instrument panel for a yacht out of a block of stratified resin.

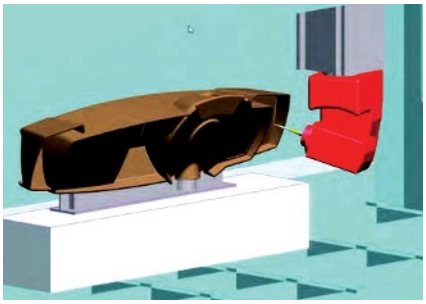
A Model 'Dashboard'

Fioroni says a lot of thought went into the instrument panel that they made for the Wider shipyard. Besides being a considerably large part, it also had to be made out of just one block of stratified resin, which was then coupled with a carbon fiber component from another company that also had a number of different openings in it to house all the yacht's control instruments.

"Therefore, the level of precision had to be spot on, an aspect that we had to take into consideration as early on as the initial mold design phase," Fioroni says. "This meant assessing any possible material shrinkage and its behavior during the production process, to ensure that the finished part had the same measurements as those specified in the customer's design and was a perfect match for all the other parts of the yacht.

Unlike many other instrument panels, the design by the Wider shipyard also included a 'visible' component both at the front and the back. So Gianoplast positioned the part in such a way so as to be able to work on it from all angles, also reaching the most hidden areas and leaving just a few support points.

"By doing so, we created an exact copy of the production components, which, in collaboration with one of our associates, GR Composites, we created a cast that was used to make the final parts," Fioroni says. "This decision was made because it involved making a limited number of parts, which, however cheap, did not justify using thermoforming. Without the help of 5-axis milling we would have had to cut the part in half to be able to work first on one side and then on the other. However, with 5-axis milling we managed to reach the entire surface of the part, once removed from the block, we created a finished part that needed no further attention."



A 360° machining process was carried out to create a 'visible' result both at the front and at the back.

A Reliable Partner

"The decision to use hyperMill provided the right strategies to solve all the processing problems," Fioroni continues. "In particular, the automatic collision check and avoidance function stops the tool or spindle affecting the parts of the component. This enables us to use 'standard' tools also for complex processes like this, without having to buy any expensive tools that are tailored to suit specific situations. Furthermore, given the high level of reliability of this collision check function, with the exception of certain processes carried out at the limit of feasibility, the milling machine can operate unmanned, a big advantage in terms of timesaving.

Before going home at night, Gianoplast employees loaded the workpiece and set the process in motion and, in the morning, when they returned to work, they found the finished product. They also noticed how hyperMill can be used to create 5-axis machined parts with minimum machining signs. "This aspect is imperative when it comes to manufacturing parts made out of fiberglass where the surface quality has to be impeccable, as in the case of the instrument panel," Fioroni says.

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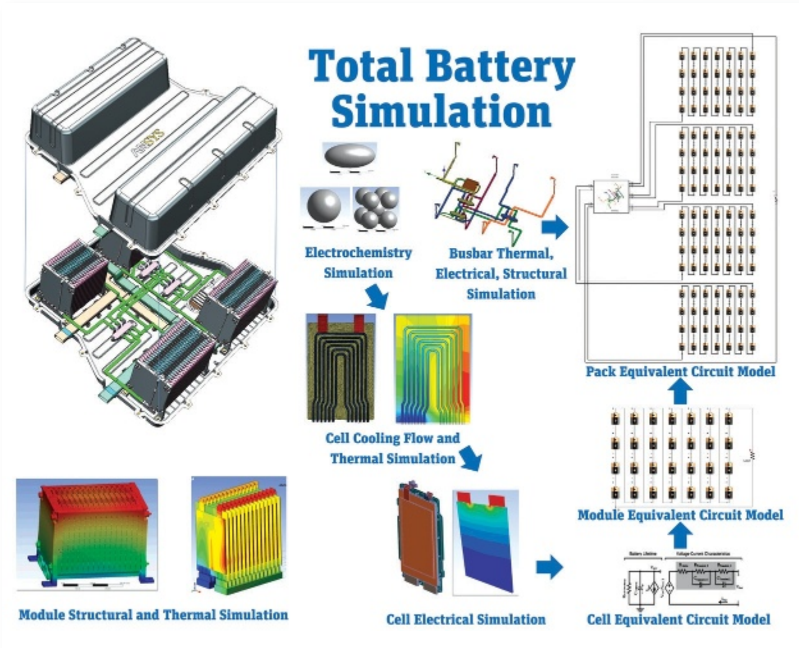
Driving Automobile Electronics

Simulation software gives insight into battery and MEMS-based device design.

BY PAMELA J. WATERMAN

Gears are a symbol of engineering, and though many projects involve more than mechanical considerations, gears offer a relevant perspective: turn one, and its neighbor, and the next one also respond. Think about automotive design in the same way, and that connectedness grows to include electrical and chemical behavior modulated by a dose of thermal response. If you don't understand how the physics of one affects the other, your design won't make it out of the garage.

Even then, great performance isn't enough. Keeping down costs while speeding up time to market — these are the kinds of challenges that lead Bernt Nilsson, COMSOL senior vice president of marketing to observe, "There's a lot of pressure to be productive with creative designs; you have to be at the front of the industry." For the automotive electronics world, that means applying multiphysics tools and really understanding the results, especially in two critical subsystems: lithium-ion batteries and micro-electro-mechanical systems (MEMS)-based sensors and actuators.



All levels — cell, module and battery-pack — and physics effects — electrochemistry, mechanical, thermal — for an automotive Li-ion battery are handled by ANSYS Multiphysics software. *Image courtesy ANSYS.*

Batteries Taking the Heat

Compared to its counterpart of 10 or 20 years ago, today's lithium-ion cell-phone battery seems a work of genius. But the challenges faced by engineers transferring this basic technology to large-scale automotive applications calls for even more creative skills backed by solid analysis tools. Nothing less will yield the details necessary to design the cathodes, anodes, electrolytes, barriers, housing and cooling systems. Software for simulation and optimization must balance often-conflicting specifications for safety, durability, charging time, output power, energy density, operating temperature and cost of materials.

As an example of the ripple effect of these characteristics, a recent webinar by Mentor Graphics on using FloEFD for Siemens NX to evaluate vehicle battery-pack cooling had a broad audience. The "who should attend list" included battery-pack design engineers, mechanical engineers, powertrain cooling engineers, hybrid vehicle propulsion engineers, battery simulation/modeling engineers, thermal systems engineers and design engineers. Each has a role to play, but how best to do it?

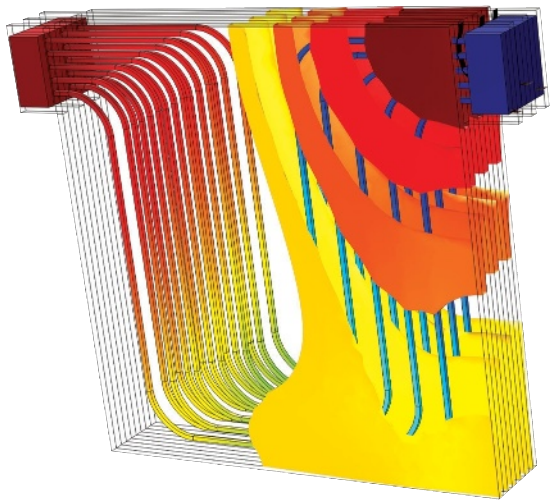
First things first. "With batteries, MEMS and really anything multiphysics, you always have to the get the single physics right before you can get the multiphysics right, and you have to have a lot of confidence in it," says Chris Wolfe, ANSYS lead product manager for multiphysics. She notes that this accuracy is one of ANSYS simulation software's strengths.

In the operation of lithium-ion batteries, multiphysics apply to several aspects. To supply the necessary power for vehicles, individual cells are connected in a series, creating modules, then modules are connected together to form a battery pack, all of which must conform to a hybrid or electric vehicle chassis. Whether a combination of consumer-type cylindrical batteries used in the Tesla (7,000 of them in the 85KWh pack), or the 288 rectangular cells of the Chevy Volt, the compact physical layout combined with the exothermic chemical reactions that generate electrical power produces heat, which can impact performance.

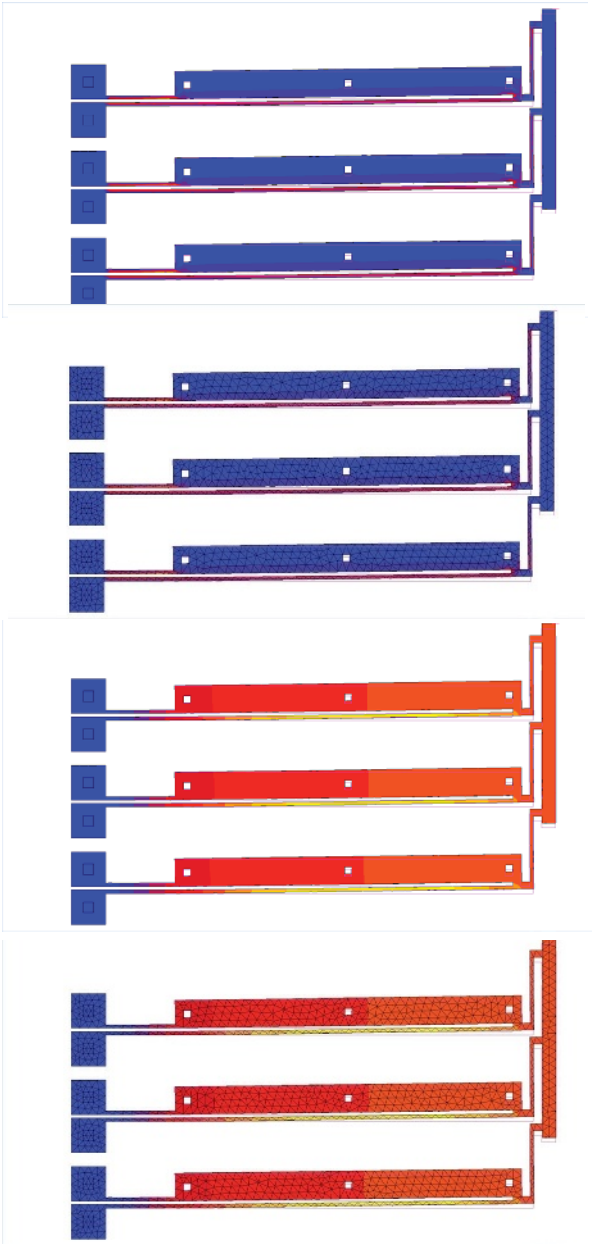
"You have to make sure the casing doesn't heat up too much and deform," Wolfe explains. To analyze this "a lot of [finite element analysis] FEA packages use models or an empirical convective heat-transfer coefficient. That's OK for a lot of things, but it doesn't take into consideration actual turbulence that's happening around the battery — it's just an estimate. If you really want to understand what's going on from a thermal perspective, you need to look at the fluid flow and how the convective cooling in addition to the conductive cooling is pulling heat away from your device. With ANSYS, you can strongly pull all the physics together to get the best possible high fidelity representation." She says that they've actually seen a 10 to 20% difference in results when comparing estimated vs. calculated coefficients.

Bob Spotnitz is a 30-year-veteran in the field of battery design. He's seen automotive applications come, go and finally gain significant market penetration with both hybrid and plug-in vehicles. As the president of Battery Design LLC, and now a consultant to computational fluid dynamic (CFD) analysis company CD-adapco, Spotnitz and CD-adapco have pushed their Battery Design Studio (BDS) software to new capabilities. "Even five years ago," he says, "accounting for non-uniform heat generation just wasn't possible. You just had to overdesign (a battery), adding a huge safety margin for long life. Now, you can design much more economically, because your confidence in the design is much higher. That's the major advance."

Battery simulation code is compiled directly in CD-adapco STAR-CCM+ software and just "turned on" with a switch upon purchase. BDS lets you define cell-level details (e.g., electrode



Temperature field in an automotive battery pack, simulated with COMSOL Multiphysics software. The model includes a high-fidelity electrochemical model of the batteries coupled to a thermal analysis for the batteries and the components in the battery pack, plus the fluid flow in the cooling channels.
Image courtesy COMSOL.



Coupled electrical-thermal-mechanical analysis of a MEMS-based microactuator (approximately 200 microns long), performed with MSC Software Marc software. Temperature-dependent material properties require nonlinear analysis to accurately model the complex behavior. As electricity passes through the actuator, the thinner beam gets hotter and expands more. It tries to bend, applying force on the other end of the actuator. When electric flow is discontinued, the actuator cools and returns to its original shape. Images show models and meshing for stress (top two) and thermal analyses. Typical automotive applications for such actuators include microvalves and dispensers in engines. *Images courtesy MSC Software.*

geometry, chemistry formulation and packaging) then calculate such characteristics as volume, weight and energy density. STAR-CCM+ also incorporates a Battery Simulation Module (BSM) that imports the cell geometry for CFD analyses, coordinating the physics of electrical, chemical and thermal aspects. Users can perform tightly coupled CFD simulations over multiple cells, evaluating different battery module/pack configurations, and even including thermal interactions with other vehicle components. Adding mechanical effects such as vibration is worked through third-party packages such as SIMULIA's Abaqus.

Once a basic design is chosen, Spotnitz says the software provides a number of routes for design-of-experiments and optimization. "With BDS," he notes, "CD-adapco has extended its functionality making it interoperable with MATLAB's Simulink to evaluate different control strategies. It has also partnered with (and last year acquired) Red Cedar HEEDS optimization software. Within STAR-CCM+, HEEDS is incorporated as an add-on product called Optimate. For example, for cooling channels, you can figure out the optimal diameter to minimize pressure drop but maximize temperature uniformity."

Another analysis source comes from COMSOL Multiphysics software. Its Batteries & Fuel Cell Module provides a detailed description of electrochemical phenomena, such as ion transport and electrokinetics, which are used for physical modeling of the governing processes in lithium ion batteries. Henrik Ekstrom, COMSOL product manager, says such models can, for instance, provide spatially resolved heat sources during power cycling of a battery. "By combining heat transfer and battery chemistry modeling," he says, "various aspects of cooling, thermal management and thermally induced battery-aging can be studied."

Alongside all the electrical, structural and thermal issues, proper mechanical sealing of battery units is critical. Srinivas Reddy, MSC Software senior product marketing manager, points out that since the components expand due to the heat generated during the chemical reaction, it is important the seals are effective over a wide temperature range. He says, "Ineffective sealing can lead to leakage of corrosive chemicals, leading to hazardous conditions and premature failure of the batteries. Using finite element solvers like Marc (MSC Software's nonlinear simulation package) users can model the complex electrical-thermal-structural coupling behavior."

Micro-sensors and micro-actuators

A different but equally active area of automotive engineering is the world of micro-electro-mechanical systems (MEMS) sensors and actuators, which convert one form of energy to another resulting in dozens of useful applications. Based on piezoelectric (strain-measuring) and capacitance-sensing technology, these millimeter- to micron-scale devices are vital components for airbag deployment, tire-pressure monitoring, stability control, active suspension and more.

Multiphysics simulations play a critical role in the effective design of these devices, which by their nature display combinations of electrical, mechanical and thermal behavior. To support this need, COMSOL Multiphysics software offers a MEMS Module that can model electromechanical actuation, piezoelectric devices, capacitive sensing and resonant devices. Accommodating the fine details is critical. For example, since electrostatic forces can deform a solid, the software accounts for nonlinear geometric effects. COMSOL product manager James Ransley says that in addition, "Damping is often critical in the design of accelerators and gyroscopes; consequently (with COMSOL) detailed modeling of thin-film damping is possible at both atmospheric pressure and at the reduced pressures applicable for vacuum packaged devices."

In support of efficient design optimization, updates to CAD drawings can be automated and controlled either by a parametric sweep or the COMSOL optimization solver. "The user can adjust all the parameters of CAD geometry from inside the COMSOL Desktop," says COMSOL Sales Manager Winfried Geis, "using either the built-in geometry capabilities of COMSOL Multiphysics or one of its LiveLink interfaces. COMSOL supports distribution on a cluster or in the cloud, and uses shared and distributed memory parallelism for each model run to squeeze out maximum hardware performance."

ESI Group is another company with deep experience in the automotive world, recently celebrating 40 years in engineering analysis, beginning with crash analysis and now including fuel-cell design as well as MEMS technology. Its ACE+ Suite of CFD and multiphysics solutions covers a broad range of physics including flow, heat transfer, stress/deformation, chemical kinetics, electrochemistry, electrostatics, electromagnetics and microelectronics, coupled in any combination, for analyzing MEMS and microfluidic devices. Applications include accelerometers, micromirrors, gyroscopes, pressure sensors and shock sensors. **DE**

Contributing Editor **Pamela Waterman**, Desktop Engineering's *simulation expert, is an electrical engineer and freelance technical writer based in Arizona. Contact her via de-editors@deskeng.com.*

INFO ➜ **ANSYS:** ANSYS.com

➜ **Battery Design LLC:** Batdesign.com

➜ **CD-adapco:** CD-adapco.com

➜ **COMSOL:** COMSOL.com

➜ **ESI Group:** Esi-Group.com

➜ **Mentor Graphics:** Mentor.com

➜ **MSC Software:** MSCsoftware.com

➜ **Siemens PLM:** Siemens.com/plm

➜ **SIMULIA:** SIMULIA.com

Using FEA for Thermal Analysis

A look at how you can incorporate heat simulation into finite element analysis.

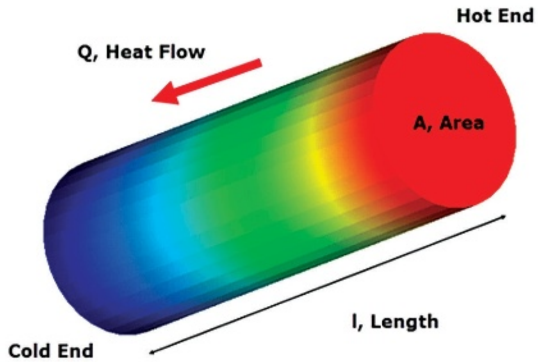
BY TONY ABBEY

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.

When figuring out thermal problems, engineers can draw from a variety of solutions. These include finite element analysis (FEA), finite different approaches, 1D thermal networks and thermal analysis within computational fluid dynamics (CFD) solutions. This article concentrates on the FEA methods with an emphasis on thermal analysis used in support of, or in conjunction with a structural FEA analysis.

The extension from a structural FEA solution to a thermal FEA solution is quite straightforward as there are direct analogies between the variable we are solving for — displacements become temperatures, and the terms in the matrices we are building — stiffness becomes thermal conductivity, and the full analogy between structural and thermal modeling is shown in Table 1.

Table 1 also shows both US and SI systems of units. SI thermal units are straightforward, US thermal units can be confusing with "hard wired" time and distance terms. It is a good idea to check in a thermal textbook for simple examples of units and to practice and double check working with them.



$$Q = kA\,(T_{upper} - T_{lower})/L$$

Q = Heat
K = Thermal Conductivity
A = cross sectional area
T_{upper} = Temperature at hot region
T_{lower} = Temperature at colder region
L = path length

FIG. 1: Conduction along a rod.

Going back to basics, we are considering three types of heat transfer: conduction, convection and radiation. The physics of each of these and implications for the FEA solution are discussed in turn. The heat transfer equations for each are shown in Figures 1, 2 and 3.

Structural	SI	US	Thermal	SI	US
Displacement	m	in	Temperature	K	F
Stress	N/m^2	Lbf/in^2	Heat Flux	W/m^2	Btu/hr.ft^2
Load	N	Lbf	Heat	W	Btu/hr
Stiffness	N/m	Lbf/in	Conductivity	W/m.K	Btu/hr.ft.F
m	meter	K	Degrees Kelvin	W	Watts
in	inch	F	Degrees Fahrenheit	Btu	British thermal unit
N	Newton	Lbf	Pound Force	hr	Hour
ft	foot				

TABLE 1: Structural and thermal equivalents in US and SI systems.

Conduction Considerations

Conduction occurs when there is a temperature differential across a component. The heat energy will flow from the hotter region to the cooler region. The heat energy depends on the temperature differential, the cross sectional area of the material in the component and the thermal conductivity of the component material — all in a direction normal to the energy path. It is inversely proportional to the path length.

If we think of a round bar, say 1 m in length, it is intuitive that we will be transferring more energy if the temperature differential is 200°C rather than 100°C. Similarly if the bar is of radius .025 it will transform less energy than a bar of radius .05 m. Thermal conductivity is a material property. Highly conductive materials include copper, while low conductivity materials include ceramics. The bar in our example if made of copper, will transmit much more thermal energy than a ceramic bar. Table 2 shows typical values of thermal conductivity. Finally, consider the bar shortened to 0.5 m. With the same temperature differential the heat flow will be doubled.

Material US Units	(Btu/hr.ft.F)	SI Units (W/m.K)
Air	0.0153	0.026
Glass	0.50	0.865
Nylon	0.14	0.242
Styrofoam	0.02	0.035
Al 2024 T4	70	121.1
Titanium	9	15.6
Pure Copper	230	398.0
Steel SAE 1010	34	58.8

TABLE 2: Conduction coefficient for various materials (US and SI units). Do not use as definitive – check sources.

Forms of Convection

Convective heat transfer from a surface occurs by movement of the adjacent gas or fluid, such as air. Convection

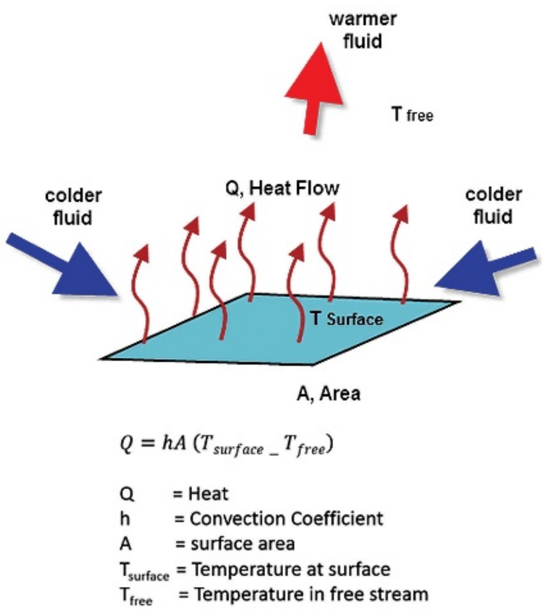


FIG. 2: Natural Convection from a surface.

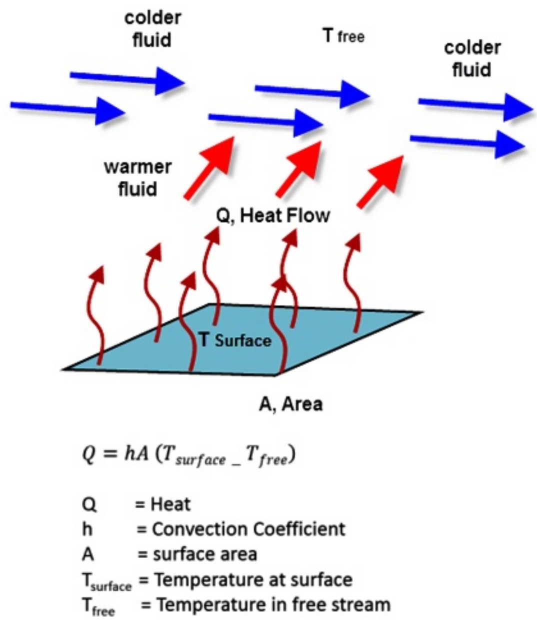


FIG. 3: Forced convection from a plate surface.

typically transports warmer fluid away from the surface and replaces it with cooler fluid. The actual mechanism of the fluid movement is quite complicated and involves a boundary layer at the surface that permits local thermal transfer by conduction. This thin layer then circulates away from the surface and is replaced by a fresh layer of cooler air. The micro level of transportation is simplified into an effective macro representation, which is assumed dependent on the temperature difference between the surface and the free fluid, the surface area and the convective heat transfer coefficient.

Because convective heat transfer relies on fluid motion, there are two basic forms. The first is called free convection in which the fluid is initially stationary and then is assumed to circulate because of the local heating. The orientation of the surface with respect to gravity is important here; if the surface is vertical then gravity is assisting in the motion of the fluid. If the surface is horizontal then gravity will not initially assist the circulation. Figure 2 shows a schematic.

There are many standard methods for estimating the free convection heat transfer coefficient.

An alternative form of convective heat transfer occurs when the fluid is being entrained to move by some external driving force. For example, a fan blowing across a surface as shown in Figure 3 will provide a more energetic medium for the fluid to move away from the heated surface. Calculating the actual heat transfer under forced conditions can be very complicated and for accurate solutions may require a coupled CFD analysis. There is some variability also as to where the surface temperature and the free strain temperature are measured. However, luckily for us for many empirical calculations are available to estimate the convective heat transfer.

Radiation Calculations

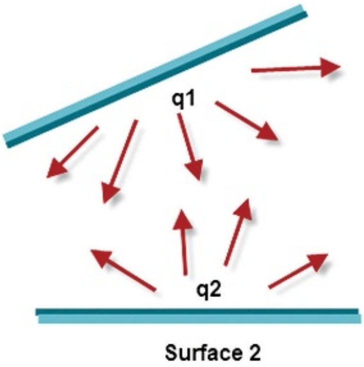
Any surface which has a temperature above 0° Absolute is theoretically emitting heat energy by radiation. The transport mechanism in this case is by electromagnetic waves or photons emanating from the surface. This mechanism does not need a medium to pass through, so radiation can occur in a vacuum. As well as emitting radiation a typical surface will also be absorbing radiation from adjacent surfaces or sources. Emissivity and absorptivity are properties of the surface. The relative temperatures of each surface, absorptivity, emissivity and the angles at which the photons track between them will govern whether an individual surface is cooling or heating.

There are several difficulties associated with radiation calculations, the first is that the view that panel A has of panel B controls the tracks the photons can follow between the two panels. This parameter is called the view factor and can be very difficult to calculate for arbitrary surfaces, without some kind of ray tracing solution. Luckily for us, many common surface shapes and orientations have empirical solutions. A further very important aspect of radiation is that the heat transfer is dependent on a fourth order temperature term as seen in Figure 4. This means that any heat transfer analysis including radiation effects becomes a nonlinear solution.

Four Types of Analysis Solutions

1. Linear solutions. In a linear solution the material thermal properties do not change with time or temperature and there is no radiation. It can be confusing in some solvers to define a linear solution, as the default solution strategy is nonlinear, and will only revert to a linear solution in the absence of radiation and other nonlinear effects.

2. Nonlinear solutions. In a nonlinear solution the material thermal properties can vary with temperature. Thermal



$$q = \varepsilon\sigma(T^4{}_{surface})$$

q = Heat Flux
ε = Emissivity
σ = Stefan-Boltzmann constant
$T_{surface}$ = Temperature at surface

FIG. 4: Radiation between two surfaces.

boundary conditions and loading can also vary with temperature. As mentioned, the presence of radiation will force a nonlinear solution. Examples of nonlinearity include thermal conductivity, convective heat transfer coefficient and applied heat flux from the source as a function of temperature. Nonlinear analysis requires a load incrementing strategy with the total thermal loading broken down into successive steps. This is exactly analogous to structural nonlinearity.

3. Steady-state analysis. The steady-state in a thermal event occurs when the temperature distribution and all thermal flows stabilize and remain constant through time. The steady-state can be calculated directly by performing an energy balance assuming this stabilized condition. Steady-state conditions are often of interest to derive a temperature distribution over component, which is then used in a subsequent structural analysis.

4. Transient analysis. In this type of analysis the initial conditions are defined and then time stepping solutions carried out in response to the thermal loading and boundary conditions. The calculation can be carried out through to a steady-state condition, or to evaluate initial thermal shock loadings, for example where the steady state condition is not important. One of the considerations in the transient thermal analysis, somewhat analogous to a transient dynamic analysis, is an accurate calculation of the time step required. In the thermal case there is a stability criteria that is often used to establish what this should be. It may be that the solver uses this time step automatically, or the user has control to set up

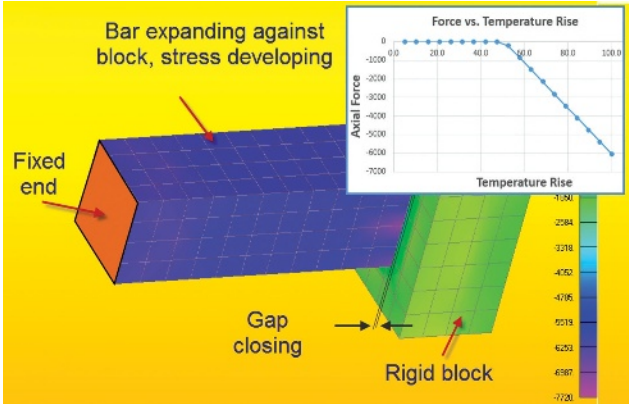


FIG. 5: A nonlinear structural analysis with direct thermal loading.

one's own time step. Time steps coarser than the stability limit are not advised. In some analyses the rate of change of thermal effects is dominant in the beginning of the analysis, so time steps here will be critical. In other analyses a nonlinear effect may occur well into the time history and require fine attend steps. Many solvers have adaptive time stepping that can, to some extent, deal with this variation in optimum time step.

Thermal Strain Loading in a Stress Analysis

As mentioned, in many cases, the thermal analysis objective is to provide the temperature distribution for subsequent stress analysis. In a typical uncoupled thermal and structural solution, a steady-state temperature distribution is mapped from the thermal model to the structural model. Mapping can be direct within the same physical mesh, or interpolated between dissimilar mesh models. Either approach will result in thermal strains throughout the structure. The thermal strain is proportional to the temperature change from initial conditions and the coefficient of thermal expansion. If a component such as a bar is allowed to freely expand under a uniform soak of temperature change then it will have a constant thermal strain throughout and there will be no stresses induced. However, if both ends of the bar are held, then the thermal strains are opposed by induced mechanical strains — the bar is not free to expand naturally. In practice components will have a more complex temperature distribution and distribution of thermal properties as well as mechanical boundary conditions and will develop thermal stresses throughout, even if nominally free to expand. A simple example of this is a bimetallic strip.

Figure 5 shows a bar that is free to expand in a stress free manner until a small gap is taken up with an adjacent block. At this point the stresses will increase from zero. An initial thermal analysis is not needed in this case as the temperature field is just a constant elevated temperature which is defined as a thermal loading in a structural sense directly into the stress analysis. However as the gap is closing a nonlinear static solution is required.

Material structural properties can be temperature dependent, but still allow a linear static solution and steady state. The temperature dependency is essentially a lookup table for each material structural property at a specific temperature. It does not matter if the actual temperature dependency is linear or nonlinear.

A nonlinear static solution may be required if the thermal loading means that linear structural responses are exceeded. This could include regions of plasticity or material nonlinearity, or geometric effects such as large displacement, buckling or contacts (as seen in Figure 5). A judgment is needed here to decide whether a fully coupled solution should be attempted — where both thermal nonlinearity and structural nonlinearity are updated throughout the analysis. A simple example would be opening or closing of contacts changing the thermal load distribution.

Solution Accuracy and Applicability

Just as in structural analysis using the FEA method, thermal solutions can also suffer from various inaccuracies. The FEA solution is always a discretization of a continuous response. In structural analysis the response is the displacement field, and a thermal analysis it is the temperature field. We usually assess the accuracy of structural analysis by looking at stress jumps between adjacent elements and attempt to achieve a convergence. When considering thermal analysis, the temperature distribution is the most commonly presented form of thermal response, typically as a contour plot. However, to obtain a better feeling for how accurate the solution is, we should really be looking at the heat flux passing through each element — this is analogous to the stress in the structural solution and hence is a good indicator of convergence and accuracy. A classic example is the simple structure shown in Figure 6. The sharp corner is in fact a singularity both in the thermal and structural sense. This is not so obvious when looking at temperature distributions, but does become obvious when looking at heat flux distributions as shown in the top right inset. Heat flux distributions are not so intuitive as the stress distributions so they tend to be ignored other than at boundaries. The figure also shows a mesh refinement study — the singularity does not go away, but its effect is reduced, and the overall accuracy of the heat flux distribution, is vastly improved.

Comparison with structural analysis is useful when thinking about other sources of inaccuracy. We know that constraining the structure is a harsher boundary condition than applying an equivalent pressure loading when trying to simulate connection to an adjacent component. A judgment has to be made as to which method is more appropriate or whether we should be thinking about using boundary stiffnesses or contact surfaces. The same applies to a prescribed temperature on a boundary as opposed to a heat flux passing through

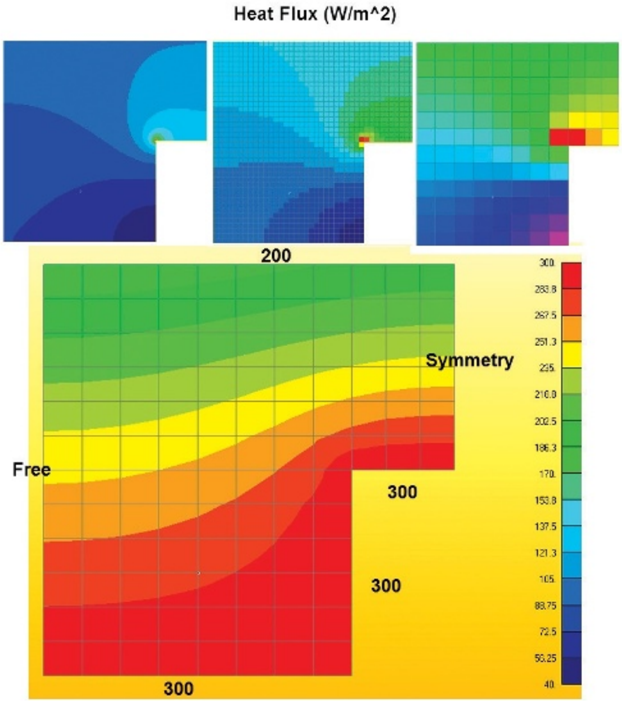


FIG. 6: Thermal singularity in sharp corner shown by Heat Flux contours.

boundary. They may both develop the same effective thermal loading but one will be harsher than the other.

If the objective of thermal analysis is to provide temperature distribution for subsequent structural analysis, then it is worthwhile to investigate the sensitivity of that structural analysis to errors in the thermal distribution. That is the ultimate measure of required accuracy.

Challenging Analysis

Thermal FEA solutions are relatively straightforward to set up, however obtaining the required accuracy, idealization methods and mesh discretization can be challenging. A smooth temperature contour plot is not a very good indicator; instead the heat flux convergence is a better guide and is analogous to the stress convergence in a structural solution. If the ultimate goal is a structural analysis with thermal strain loading then the accuracy and sensitivity of this analysis with respect to the thermal modeling is the criterion to judge the analysis by. **DE**

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

V-Ray 3.0 for 3ds Max *Speeds Rendering*

V-Ray 3.0 is the latest version of the Chaos Group's popular and widely respected ray tracing application.

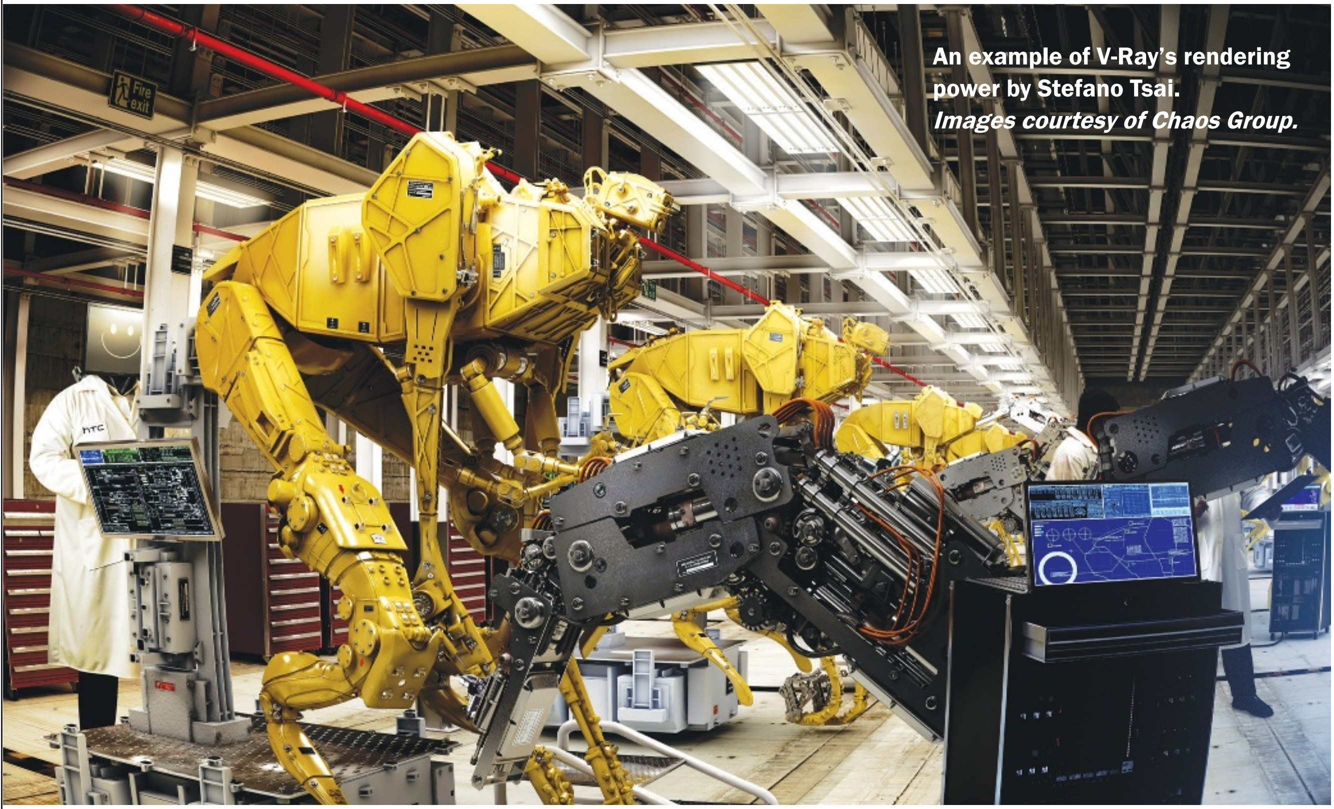
BY MARK CLARKSON

Chaos Group's V-Ray ray tracing software is available for a number of applications including 3ds Max, Maya, Rhino, Sketch-up and Blender, in addition to a stand-alone form. I tried out the recently released 3ds Max version.

I wasn't using the previous version of V-Ray with Max, so I can't personally compare its render speed to 3.0's, but anecdotal reports from forums as well as Chaos Group's literature, indicate that the new version of V-Ray is significantly faster than its predecessor — by anywhere from 10 to several hundred percent.

Simplified User Interface

So what's new with this version of V-Ray? First and foremost, there's a somewhat simplified user interface. I admit that I only use 3ds Max periodically and usually find myself more than a little overwhelmed by the interface. Thankfully, the V-Ray part, at least, has



An example of V-Ray's rendering power by Stefano Tsai.
Images courtesy of Chaos Group.

V-Ray's new tool bar gives you handy access to options, lights, cameras, hair, materials and more.

gotten a bit easier to decipher and use.

For starters, there's a new toolbar that gives you handy access to V-Ray's options, lights, cameras, hair, materials and more.

The toolbar's Quick Setup button provides one-click setup for Architectural exterior and interior scenes, VFX scenes and studio scenes, automatically setting the Global Illumination (GI), Shadow, and Anti-aliasing type and quality. The Studio setup, for example, selects for brute force plus light cached GI; architectural interior visualization selects for irradiance mapping plus light caching; architectural exteriors go for straight brute force. If you're not sure what those mean, or why you would chose one over the other, then these quick settings are definitely for you.

You can further adjust the quality of the GI, shading and anti-aliasing from within the Quick Settings dialog with simple sliders.

If you go a little deeper into V-Ray's setup, 3.0 still simplifies things for you a bit with Basic, Advanced and Expert modes. Basic and Advanced modes essentially hide varying numbers of settings from you in an effort to keep you from being overwhelmed by details.

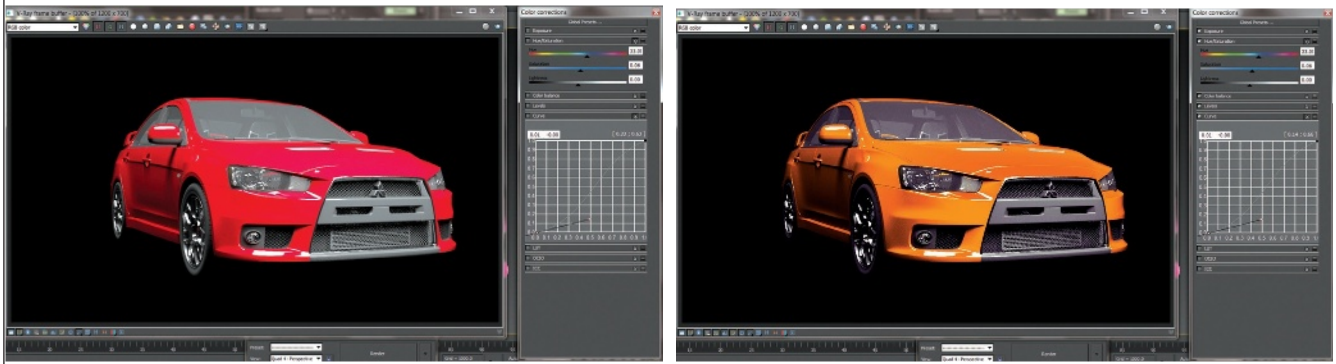
Where the simplified user interface falls apart a little bit is in V-Ray's documentation. The only documentation I can find is on Chaos Group's website. And while it seems relatively complete, it's basically non-searchable. Let's say you read somewhere that V-Ray 3.0 supports Embree (a collection of ray tracing kernels developed by Intel and supported by many Intel processors.) How do you enable it? Searching on 'Embree' turns up nothing. To find the help, you have to first click on Plug-ins, then Renderer, then System. By the time you've made it that far, the documentation itself — which tells you that checking the Use Embree box enables the Intel Embree raycaster — is pretty pointless. It's faster to just click on every single dialog and scan them for a "Use Embree" checkbox.

Progressive Rendering

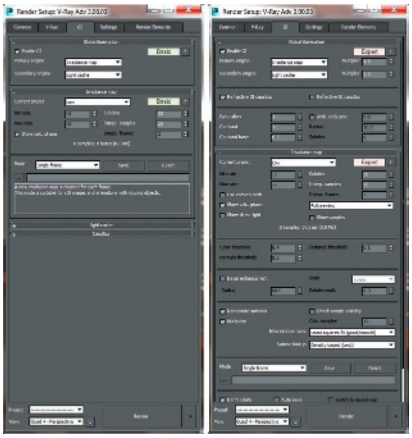
The most outstanding toy in V-Ray 3.0 is its new progressive rendering engine. In the older, bucket-based rendering methods — which are still available — the image is divided up into chunks called "buckets" which are distributed to your various processor cores. Each bucket is rendered completely before that core moves on to the next one.

In a progressive render, it's more like seeing the entire image rendered at once, but at very low resolution. The renderer then goes back over the scene, again and again, refining the render further with each subsequent pass. The effect is a bit like a fuzzy image slowly coming into focus.

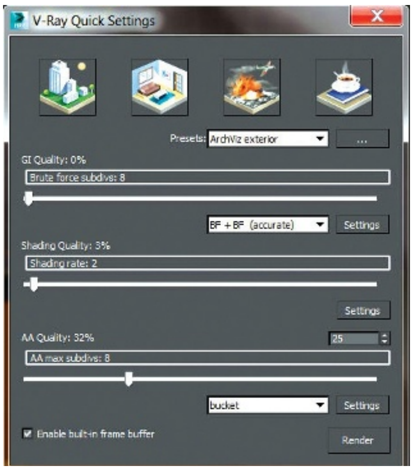
You can set a maximum render time



V-Ray's color corrections allow you to adjust the exposure, color balance and contrast of your renders without leaving the 3ds Max environment. The red car is the original render; the other car is the same render after adjustment in V-Ray's Color Corrections dialog.



V-Ray simplifies things for you a bit with Basic (left), Advanced and Expert (right) modes, which hide or reveal settings to keep you from being overwhelmed by details.



The tool bar's Quick Setup button provides one-click setup for a variety of different scene types.

(or 'quality'), and then interrupt at any point if the render looks adequate to you before that time expires.

Last Bucket Syndrome

Another nifty feature is 3.0's Dynamic Bucket Splitting. This addresses a problem known as "Last Bucket Syndrome." Oftentimes, at the very end of the render, you'll be stuck waiting for one last bucket to render. In a beauty shot of a car, for example, it might be part of the headlight that, with all its varying transparencies, reflections and refractions, can bring the ray tracing process to its knees. So the entire render has finished … except for one corner of the headlight assembly, leaving all of your cores idle except the one working on that last, especially taxing section.

Dynamic Bucket Splitting breaks that last bucket down into two smaller buckets, or four, or eight, keeping all of your CPU cores busy and potentially significantly speeding up the render significantly.

The Masked Render

My personal favorite new feature is the Render Mask. You can now render selected parts of your scene based on object selection, layer, an include/exclude list, or a texture map. Why would you want to do that? Maybe you're working on a render of a 1,000-part assembly and it's looking pretty good … except for the aluminum texture on your bolts, which is still a bit off. So you tweak and re-render. Tweak and re-render. Tweak and re-render. It's a familiar story to anyone who works with 3D design. There's no reason, however, to re-render the entire scene — you really only want to check the texture on the bolts themselves.

The traditional way to handle this task is by defining a small rectangular region that includes a bolt or two and re-rendering only that chunk of the final image. That speeds things up a bit, and it's still an option in V-Ray 3.0. But the easy to use new render mask is a much better option. Now, I can select a bolt (or several bolts, or everything with the bolt material) and tell V-Ray to use that selection as a mask. When I re-render, V-Ray only renders those bolts. The old render is intact (unless you've cleared the buffer) so you don't wind up with a bunch of bolts floating in the ether, but rather a complete new render with newly textured bolts.

But Wait — There's More!

V-Ray 3.0 has added what it calls comprehensive color corrections to the frame buffer, allowing you to adjust the exposure, color balance and contrast of your renders without leaving the 3ds Max environment. You can also assign a color profile such as ICC (International Color Consortium) and OpenColorIO.

V-Ray has improved the way it renders with many, or very bright, light sources. Max Ray Intensity clamps secondary rays to eliminate noise and artifacts caused by


A V-Ray render of a watch's inner workings by Real FX.

very bright light sources. Probabilistic lights increase the render speed of scenes with large numbers of lights.

V-Ray's improved subsurface scattering, used for rendering translucent materials, may be useful to some engineers. The improved skin material and faster hair and fur rendering … probably less so.

Check It Out

Despite welcome changes to simplify its interface, and the addition of progressive rendering, V-Ray is not as simple to use as programs such as Bunkspeed and Keyshot. If you're not comfortable moving around within 3ds Max (or Maya, for which V-Ray 3.0 is also available) then you're not going to be immediately comfortable rendering scenes with V-Ray.

Is V-Ray right for you? 3ds Max comes with several perfectly fine rendering engines right out of the box, including mental ray, iray, and Max's default scanline renderer, but V-Ray's combination of speed and sophisticated, realistic lighting and textures have won it a widespread community of ardent fans. If you're curious to see why, you can download a free trial, here: chaosgroup.com/en/2/vray.html. **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 ➜ **Chaos Group:** Chaosgroup.com

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

HPC Options, Part 1

Choose the Right Hardware for Maximum Performance and Value

Engineers need to choose the right computing hardware to do the job or risk harming productivity and increasing costs.

BY FRANK J. OHLHORST

The HP Z1 was billed as the first all-in-one workstation when it was released in 2012. It features a custom line of NVIDIA Quadro GPUs designed especially for all-in-one workstations.

Fighter pilots have a saying, "Speed is Life," yet there is a lot more to speed than just going fast, something that engineers have found out when it comes to the design process. Today's engineers are realizing that a whole host of technologies must be integrated to deliver productivity and are quickly discovering that effectively performing CAD/CAM and simulation work takes more than just clock cycles on a workstation. In other words, it takes more than just raw speed to maximize performance.

However, many engineers are still following the pied piper of advertising and selecting their workstations based upon marketing speeds and feeds, and not the actual components. While some of that ignorance can be attributed to vendors and manufacturers not providing enough actionable information about their technologies, most of the blame lies squarely with the individuals specifying systems and ultimately purchasing the wrong tool for the job.

Luckily, this issue can be solved by replacing ignorance with knowledge about workstation hardware and then performing the appropriate due diligence necessary, before signing off on a purchase order; a process that usually begins with the engineers seeking the best tools for the tasks at hand. Those "best tools" come in a variety of configurations, and selecting the appropriate configuration takes knowledge, research and validation. After all, the ideal solution should add up to more than just the sum of its parts and should deliver the desired performance level, but not forsake economy.

Workstations vs. High-Performance PCs

In the past, it was pretty easy to distinguish a workstation from a PC. Workstations tended to be power hungry processing appliances that delivered the raw power needed to do complex mathematical tasks and deliver engineering insight into complex problems. Those workstations often ran specialized operating systems, leveraged specialized hardware subsystems and proved to be very costly to own and operate.

On the other hand, PCs were thought of as business machines, used for more simplistic tasks, including data entry, word processing and perhaps even some mathematical analysis using software such as MS Excel or a desktop database. However, Moore's law came into play and PCs become powerful tools in their own right, sporting high-performance CPUs, top notch graphics cards, high-speed storage devices and oodles of fast memory — seeming to make a high-performance PC a poor man's workstation, blurring the lines between what constitutes a dedicated workstation or a power user's PC.

"With processor technology and storage capacity on the rise, many of today's high end PCs are able to effectively process the work loads of previous generation workstations," says NVIDIA's Senior Technical Marketing Manager, Sean Kilbride. "However, workstations tend to have several design advantages over high-powered PCs, the primary elements being reliability and expandability."

Kilbride is referring to the fact that most workstations are designed to run 24/7 under heavy loads and incorporate higher quality hardware to increase reliability. Donald Maynard, senior product manager at Dell explains how enhanced reliability differs on workstations, "Dell's Precision Workstations incorporate Reliable Memory Technology, which automatically detects failures in DIMMs [dual in-line memory modules] and removes that section of memory from use, allowing engineers to continue to use the workstation in the event of a partial memory failure, where PCs would probably just become inoperative."

Maynard adds "Many of Dell's Precision Workstations also support ease of expansion. For example, our dual socket machines can be shipped as single socket units, and later upgraded with an additional CPU. Dell's design attaches memory to the CPU, so adding a second CPU also increases system memory."

Maynard and Kilbride point out that while high-end PCs can do many of the routine chores engineers have come to expect from a workstation — workstations still offer advantages when it comes to working with engineering problems.

CPUs, GPUs and APUs

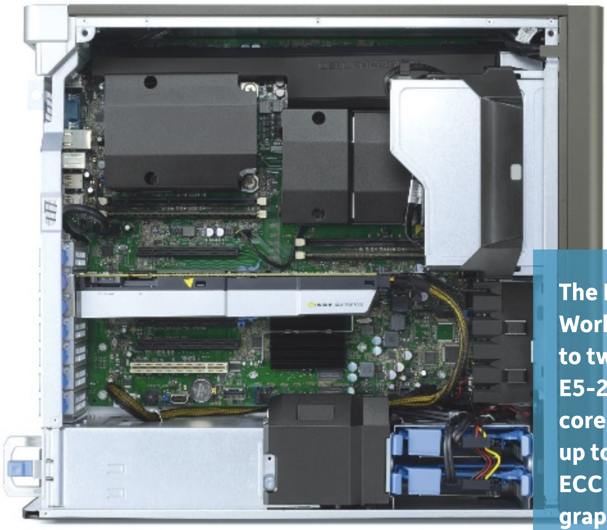
Just a short time ago, the CPU was considered to be the primary component for judging performance. However, CPUs have evolved and other technologies have come into play, such as, multiple cores, GPUs, APUs, cache sizes and more that help to make CPUs more efficient and even shift much of the processing load away from the traditional CPU.

However, CPUs, GPUs and APUs come from chip manufacturers, such as Intel, AMD and NVIDIA and each company offers what they feel is the ideal technology for maximum processing power. Choosing a CPU is an important consideration, and determining how that CPU directly benefits the task at hand has become trickier, shifting the focus to selecting the proper workstation for a dedicated task, as opposed to selecting processors that may offer the most versatility across multiple types of projects.

Intel's Segment Manager for Workstations, Wes Shimanek says "having a workstation with a lot of processing cores and memory is critical for simulation work; however you must make sure that you have the bandwidth to feed the processors."

Shimanek adds "The Intel Xeon processor is designed to move data around and when it comes to high end processes, such as ray tracing and data visualization, those processes and their related algorithms are best run on a CPU based system, as opposed to GPU systems."

Kilbride offers a different take on performance, "Our Maximus technology combines NVIDIA's Quadro GPU technology with NVIDIA's Tesla companion processor — a combination that allows engineers to perform graphics and compute intensive processing at the same time on their workstations."



The Dell Precision T7610 Workstation can house up to two Intel Xeon Processor E5-2600 v2s with up to 24 cores (12 per processor), up to 512GB of 1866MHz ECC RAM and up to three graphic cards.

Kilbride added "Maximus frees the system CPU to carry out all the functions that it needs to do, while Maximus accelerates rendering and other processes using GPU technology. The end result proves to be significant time savings and the ability to work with ever more complex engineering problems."

NVIDIA claims that Maximus offers significant processing gains for applications that use the technology. For example, NVIDIA claims a 21x performance increase for Adobe Premiere and 39x increase for Adobe After Effects.

However, Intel and NVIDIA are not the only companies paving the path to high performance —AMD offers its APU (Accelerated Processing Units) under its FirePro brand. AMD's Demir Ali, senior field application Engineer, says "The AMD FirePro brand graphics cards are optimized and tuned to work with high end design applications and offer innovations such as the ability to work with six displays concurrently."

Matthias Willecke, AMD senior business development manager adds "the FirePro GPUs can send data in both directions at full PCI Express 3.0 speed. Furthermore, the memory bandwidth of the AMD FirePro has increased 64GB/s to 103GB/s, which allows large CAD models to be loaded faster, also the architecture supports performing computational tasks in parallel for graphics operations, which delivers significant advantages for simulations."

Obviously, these different takes from primary vendors in the CPU/GPU/APU market space can create uncertainty as to which technology to choose. That said, decisions can be simplified by thoroughly researching what software works with what hardware and choosing appropriately. After all, you can purchase the fastest technology available, yet that technology becomes worthless if it is incompatible or not supported by the primary engineering applications you use.

Storage and Memory

There is more to workstation selection than just processing power, GPU performance and software vendor recommendations — there are a whole host of other components that can add to or detract from the efficiency of processing complex computational tasks on workstations. Take for example the role system memory plays in computational operations — where not only the quantity of RAM makes a difference, but also the quality of RAM as well.

"A workstation is much more than the sum of its parts, important configuration concerns should be addressed when selecting a Workstation, such as the usage of ECC (Error Correction Code) RAM," says Brett Newman, who is in HPC sales and marketing at Microway. "ECC RAM can detect and correct single bit errors, which prevents memory corruption and possible system failures."

Because professionals use their computers more, they are more likely to be affected by RAM errors. Simply put, technologies such as ECC RAM improve reliability and can prevent computational errors. Many consumer-level computers don't support ECC RAM, but professional workstation do.

But how much RAM to specify? Here, the age-old axiom of "more is better" is not always true — especially when there are budget considerations. For most engineers, following the recommendation guidelines set forth by software manufacturers proves to be one of the best places to start.

For example, SolidWorks specifies a minimum of 1GB RAM, but suggests 6GB — yet, 6GB may not be the best choice, especially if other applications are going to be run. Considering how inexpensive memory has become as of late — perhaps the best guideline is to buy a bit beyond the recommended amount to help future proof the workstation.

However, one should always leave room for expansion — in other words, if a workstation comes with 32GB RAM, check to see that it can be upgraded to more at a later date. When adding additional fuel to the RAM purchasing fire, you need to consider how an application is being used. There are many factors that can create the need for additional RAM and even more graphics processing horsepower. Considerations such as working with large assemblies and complex parts (such as plant and routing design), rendering and running first-pass finite-element and kinematic analyses can all have an impact on the amount of RAM or processing power needed.

Those considerations aside, there is still one more important configuration element to consider when selecting a workstation for advanced design work — and that comes in the form of storage. Until recently, solid state drives were thought of as too expensive and too low of a capacity to be useful for professional workstations, where very large capacity high speed SA-SCSI HDDs ruled the day. However SSDs have fallen in price and risen in capacity while achieving high factors of reliability. Engineers should not just rush out and buy any old SSD — there are significant differences between consumer level and enterprise level SSDs, namely performance and endurance.

Naturally, performance is important, but it is not just a single measurement of throughput — one has to take into account both sustained and random read/write speeds, which may differ across brands and models. However, there are limits to overall performance, as seen in the bottleneck presented by the PCI Express 3.0 Interface, which tops out at 6Gbit/s (600MB/s).

The importance of performance can be quickly overshadowed by the importance of reliability — where endurance is becoming exceedingly important for advanced computational workloads. One should expect the same level of reliable performance throughout the full life of the SSD and be confident that all the data is safe. Unfortunately, endurance is very hard to quantify, made harder by the fact that there is no industry measurement standard.

Drives are often rated in terms of Terabyte Written (TBW) or Program and Erase cycles. The two can be linked by the Write Amplication Factor (WAF). Both of which prove to be almost meaningless in determining the true, expected lifespan of an SSD. However, engineers should find some comfort in the five-year warranty offered on most professional SSDs — while the majority of mainstream consumer SSDs only offers a single year of protection.

What's more, there are additional benefits that SSDs offer over mechanical drives beyond raw read/write performance gains. The biggest performance advantage over an HDD comes in the form of heat output — SSDs generate very little heat and consume significantly less power, thanks to a design that has no moving parts.

SSDs are also exceptionally quiet and can significantly help in keeping work areas quieter and potentially more productive. Noisy traditional HDDs have other disadvantages, and drives running full time in a RAID array, adds to the overall noise of the workstation and while increasing the heat loads on CPU, GPU and other cooling fans.

More Than its Parts

The plethora of technologies, applications and choices has made it difficult to pick what one would consider to be the best workstation for their purposes. However, by focusing on the critical elements and observing how a workstation performs as a whole should help to narrow down the selection process. For engineers, it all comes down to using the right tool for the job and avoiding the economic pressures to buy inferior tools to just save a few dollars upfront. **DE**

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

INFO ➜ **AMD:** AMD.com

➜ **Dell:** Dell.com

➜ **Intel:** Intel.com

➜ **Microway:** Microway.com

➜ **NVIDIA:** NVIDIA.com

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Dell Precision M3800: A Perfect Portable?

This remarkably thin, lightweight system proves that you can be slim, fast and powerful.

BY DAVID COHN

INFO ➜ Dell: Dell.com

Dell Precision M3800

- **Price:** $2,887 as tested ($1,799 base price)
- **Size:** 14.56"x10.0"x0.71" (WxDxH) notebook
- **Weight:** 4.35 lbs. plus 0.9 lb. power supply
- **CPU:** 2.20GHz Intel Core i7-4702HQ w/6MB Smart Cache
- **Memory:** 16GB (16GB max)
- **Graphics:** NVIDIA Quadro K1100M w/2GB GDDR5 memory
- **LCD:** 15.6" QHD+ Ultrasharp 3200x1800 wide view backlit touchscreen LED
- **Hard Disk:** 512GB SSD
- **Floppy:** none
- **Optical:** none
- **Audio:** built-in speakers, headphone/microphone jack, noise-canceling digital array microphones
- **Network:** Network: USB to Ethernet adapter, Intel Dual Band Wireless-AC 7260 Plus Bluetooth 4.0
- **Modem:** none
- **Other:** Three USB 3.0, one USB 2.0, HDMI, mini DisplayPort, 3-in-1 media card reader, integrated light-sensitive HD video webcam
- **Keyboard:** integrated 80-key full-size backlit keyboard
- **Pointing device:** gesture-enabled multi-touch touchpad with 2 buttons

It has been nearly four years since we last reviewed a Dell mobile workstation. Undoubtedly, a lot has changed in the interim, but the Dell Precision M3800 mobile workstation that recently arrived at our labs ranks as one of the most dramatic shifts we've ever seen.

The Dell Precision M3800 is one of three new Dell Precision mobile workstations. But while its M4800 and M6800 siblings still look like typical notebook PCs and weigh more than 7 lbs., the Precision M3800 bears a striking resemblance to Apple's 15-inch MacBook Pro. The Dell M3800 is sleek, light and weighs just over 5 lbs. including its external power supply. In fact, from the minute I opened the box, I had to keep telling myself that this wasn't a Mac. Even the minimalist packaging seemed to borrow a page from the Apple playbook.

Housed in a gorgeous aluminum and carbon fiber chassis, the Dell Prevision M3800 measures just 14.56 x 10.0 x 0.71 in. and weighs a mere 4.35 lbs. as tested. The base configuration weighs 4.15 lbs. The equally sleek 130 watt AC adapter adds 0.9 lbs., bringing the total weight to 5.25 lbs. Compare that to 11 lbs. or more for most mobile workstations.

Gorgeous Inside and Out

Raising the lid reveals a 15.6-in. display and a full-size 80-key backlit keyboard. The only thing lacking is a separate numeric keypad. A gesture-enabled multi-touch touchpad with two buttons is centered below the keyboard and a round power button is located to the upper-left. The caps lock button includes a small LED that indicates when caps lock is enabled.

The wide view LED backlit display extends practically to the lid's edges. Above it is a noise-canceling microphone array, are an ambient-light sensor, HD video webcam and camera-status light. But it was the display that caught my eye and then blew me away.

The base model M3800 comes with a 1920x1080 display with 10-finger multi-touch, but our evaluation unit was equipped with the optional QHD+ 3200x1800 touch-screen panel (a $70 option). The images on this panel were nothing short of amazing. Even with Windows 7, I found myself using the touchscreen capabilities more and more as I evaluated the system. Dell configures the M3800 with either Windows 7 or 8.

Unlike many other mobile workstations, Dell does not offer a choice of processors. The Precision M3800 is built around an Intel Core i7-4702HQ quad-core processor and a Mobile Intel HM87 Express chipset. The Haswell CPU runs at 2.20GHz while accelerating to a maximum turbo speed of 3.2GHz. The processor includes a 6MB Smart Cache and its 37 watt thermal design power (TDP) rating helps extend battery life.

Although the CPU includes integrated Intel HD Graphics 4600, Dell also equips the Precision M3800 with an NVIDIA Quadro K1100M discrete graphics card with 2GB of GDDR5 dedicated memory. This powerful GPU, with 384 CUDA parallel processing cores, has a 128-bit interface and a bandwidth of 44.8GB/sec., helping deliver exceptional graphics performance. Here again, Dell chose wisely. With a maximum power consumption of 45 watts, the K1100M helps deliver great performance while conserving battery power.

Drive Options

Dell also does not skimp on memory, providing 8GB of memory in the M3800 base configuration. Our evaluation unit came with 16GB of RAM, installed as two 8GB 1.6GHz SODIMM modules, an option that added $112 to the price.

The base configuration also comes with a 500GB hybrid 2.5-inch hard drive, but Dell again raised the ante on our configuration by replacing it with a 512GB Samsung solid state hard drive, an option that added $749 to the total cost. Considering the performance and additional power savings of the SSD drive, the cost is definitely justified.

The M3800 can even accommodate a second hard drive, and choices include a 500GB hybrid drive, 1TB 5400rpm standard drive, or a second SSD with either 250GB or 512GB capacity. What this Dell Precision system does not offer, however, is an optical drive. While that is becoming less of an issue for many users, we had to first copy several programs onto an external USB hard drive before we could install them on the M3800. At just $80, Dell's optional external DVD-RW drive is worth considering.

The system provides just the right selection of expansion options. The right side of the case provides a 3-in-1 memory card reader, USB 3.0 and 2.0 ports, (both with PowerShare) and a security slot. The left side houses the power connector, HDMI port, a mini DisplayPort, two more USB 3.0 ports with PowerShare, an audio jack, a battery-status button and display. Dell also includes a USB-to-Ethernet adapter and the M3800 comes with Intel Dual Band Wireless-AC 7260 plus Bluetooth 4.0.

Although the base M3800 system includes a 6-cell 61-watt-hour 12.2 volt battery, our evaluation unit came with a 91WHr battery, a $42 option. Thanks to that battery and the system's energy conserving components, our M3800 ran for an impressive 6 hours and 12 minutes before saving all data and shutting down. Once we restored AC power, this entirely solid state system went right back to work.

Performance not Compromised

We were very impressed with its light weight and battery life, but what would be compromised? As our benchmark results began to flow in, we quickly answered that question.

On the version 11 of the SPEC Viewperf tests, the Dell Precision M3800 out-performed many of last year's larger, more expensive mobile workstations, although it lagged behind the desktop replacement systems we've recently reviewed. SPEC has recently released Viewperf v12 and the M3800 is the first system on which we've run the new benchmark. We are including its results on this new test and will eventually switch over to reporting just the Viewperf v12 results once we have enough systems to compare.

The results on the SPECapc SolidWorks 2013 test were also quite good, better or on par with last year's mobile workstations but again behind the desktop replacements.

On the AutoCAD rendering test, a multi-threaded test on which faster systems with more CPU cores have a distinct advantage, the Dell Precision M3800 held its own, completing the rendering in just over 71 seconds, faster than some of those desktop replacements.

We also ran the brand new SPECwpc workstation performance benchmark. Because we have no other results yet

Mobile Workstations Compared Numbers in blue indicate best recorded results. Numbers in red indicate worst recorded results.		Dell Precision M3800 (2.2GHz Intel Core i7-4702HQ quad-core CPU, NVIDIA Quadro K1100M, 16GB RAM)	MSI GT70-20LWS (2.4GHz Intel Core i7-4700MQ quad-core CPU, NVIDIA Quadro K4100M, 16GB RAM)	Eurocom Racer 3W 2.4GHz Intel Core i7-4700MQ quad-core CPU, NVIDIA Quadro K1100M, 16GB RAM)	BOXX GOBOXX G2720 3.6GHz Intel Core i7-3820 quad-core CPU, NVIDIA Quadro K5000M, 16GB RAM)	Eurocom Panther 4.0 (3.1GHz Intel Xeon E5-2867W 8-core CPU, NVIDIA Quadro K5000M, 16GB RAM)	Lenovo ThinkPad W530 (2.90GHz Intel Core i7-3920XM quad-core CPU, NVIDIA Quadro K2000M, 16GB RAM)
Price as tested		$2,887	$3,200	$2,172	$5,895	$6,800	$2,592
Date tested		3/13/14	11/25/13	11/10/13	5/28/13	4/20/13	12/29/12
Operating System		Windows 7	Windows 7	Windows 7	Windows 7	Windows 7	Windows 7
SPECviewperf 12 (new)	higher						
catia-04		14.74	n/a	n/a	n/a	n/a	n/a
creo-01		13.37	n/a	n/a	n/a	n/a	n/a
energy-01		0.28	n/a	n/a	n/a	n/a	n/a
maya-04		12.79	n/a	n/a	n/a	n/a	n/a
medical-01		3.72	n/a	n/a	n/a	n/a	n/a
showcase-01		8.50	n/a	n/a	n/a	n/a	n/a
snx-03		14.74	n/a	n/a	n/a	n/a	n/a
sw-03		19.43	n/a	n/a	n/a	n/a	n/a
SPECviewperf 11							
catia-03		33.56	72.47	28.97	73.23	65.87	34.82
ensight-04		17.50	50.62	17.38	61.24	61.01	18.40
lightwave-01		58.84	64.39	31.53	78.03	65.85	62.75
maya-03		61.83	112.33	51.20	111.58	102.18	62.04
proe-5		15.37	18.38	9.43	16.06	13.82	15.58
sw-02		39.48	55.00	24.95	63.26	55.06	39.48
tcvis-02		28.69	60.63	27.70	60.91	59.28	30.63
snx-01		23.76	59.76	23.17	63.57	64.62	25.14
SPECapc SolidWorks 2013	higher						
Graphics Composite		2.41	5.72	3.63	2.72	2.26	2.06
RealView Graphics Composite		2.71	6.27	3.97	2.93	2.42	2.18
Shadows Composite		2.34	6.26	3.95	2.93	2.42	2.18
Ambient Occlusion Composite		2.20	13.00	5.35	6.09	5.14	3.76
Shaded Mode Composite		2.31	5.78	3.83	2.66	2.41	2.13
Shaded with Edges Mode Composite		2.51	4.80	3.44	2.78	2.12	2.00
RealView Disabled Composite		2.40	2.62	2.55	2.02	1.72	1.65
CPU Composite	ratio	2.41	3.74	3.99	3.61	3.72	3.59
Autodesk Render Test	lower						
Time	seconds	71.42	60.33	55.83	79.20	57.33	62.00
Battery Test	higher						
Time	hours:min	6:12	4:34	3:47	1:15	1:14	6:09

for you to compare, we are publishing the M3800's results in the online version of this review and will continue to use this new benchmark on all future reviews.

Dude. It's Just About Perfect

Throughout our tests, the M3800 ran cool and silent. Dell backs the system with a 1-year ProSupport plan plus one year of next business day limited on-site service after remote diagnosis. That plan can be extended to up to five years for an additional fee. The company also offers accidental damage protection for one to five years and up to two years of extended battery service as well as hard drive recovery services. The battery service may be something to consider. Although we downloaded a product manual that shows how to open the system and change components, it is a complicated process. Like the Apple MacBook Pro, the Dell M3800 is a closed system (the M3800 chassis can be opened after removing a dozen tiny screws). We think most customers will elect to have Dell service the system should it ever require a new battery.

Dell also sells a Dual Video Docking Station. This $170 add-on lets you connect up to two external monitors with up to 2048x1152 resolution as well as providing four USB 2.0 ports, two USB 3.0 ports, an RJ-45 network port, DVI-D, HDMI, headphone, microphone and PS/2 keyboard/mouse port. But this is a generic type of device that connects to any computer via USB 3.0, not something specific to the M3800. We had no trouble connecting an external monitor to the mini DisplayPort and then duplicating or extending our desktop.

At its base configuration price of $1,799, the Dell Precision M3800 is already an excellent system. As configured, our evaluation unit priced out at $4,128. But Dell is currently offering discounts of 35%, reducing our price as-tested to $2,887. At that price, the Dell Precision M3800 may be the perfect system for any engineer on the go. It offers light weight design and style without sacrificing performance at a very affordable price. **DE**

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

Instrumentation for Generation Y

Generation Y's obsession with technology will drive the next generation of benchtop instrumentation.

BY CHRIS DELVIZIS

Each generation of engineer has seen new iterations of instrumentation. Baby Boomers (born in the 1940s to 1960s) used cathode-ray oscilloscopes and multimeters with needle displays, now commonly referred to as "analog" instruments. Generation X (born in the 1960s to 1980s) ushered in a new generation of "digital" instruments that used analog-to-digital converters and graphical displays. Generation Y (born in the 1980s to 2000s) is now entering the workforce with a new mindset that will drive the next generation of instrumentation.

Generation Y has grown up in a world surrounded by technology. From computers, to Internet and now mobile devices, this technology has evolved at a faster rate than ever before. A recent report from Cisco delved into the nature of Generation Y and their relationship with technology:

- Smart phones rated twice as popular as desktop PCs.
- A third of respondents check their smart phones at least once every 30 minutes.
- Eighty percent use at least one app regularly.
- Two out of three spend equal or more time online with friends than in person.

Generation Y is obsessed with technology. They embrace change and quickly adopt new technologies because they understand the benefits that it provides. The innovation in consumer electronics, which Generation Y engineers use in their daily lives, has outpaced the instruments they use in the professional setting. In fact, the form factor of benchtop instruments has remained mostly unchanged over the years. All components — display, processor, memory, measurement system and knobs/buttons — are integrated into a single, stand-alone device.

With the current era of instrumentation reaching maturity, Generation Y engineers will demand that modern technologies be incorporated with instruments. Instrumentation in the era of Generation Y will incorporate touchscreens, mobile devices, cloud connectivity, and predictive intelligence to provide significant advantages over previous generations.

Touchscreen-Based Tools

According to Frost & Sullivan, "engineers will increasingly associate the concept of a user interface with the one they use on their consumer electronics devices." The touchscreen-based user interfaces found in today's mobile devices provide a different experience compared to the physical knobs and buttons on today's instruments, which will be unsatisfactory for Generation Y.

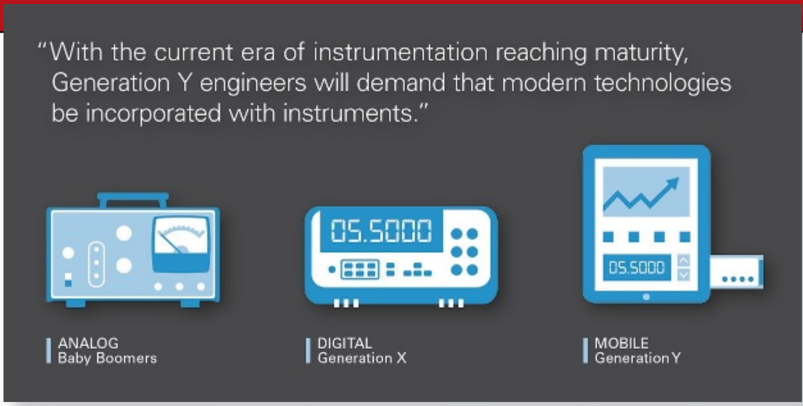
As instruments have added new features, they've also added new knobs and buttons to support them. However, this approach is not scalable. At some point, the number of knobs and buttons becomes inefficient and overwhelming. Some instruments have resorted to multi-layered menu systems and "soft buttons" that correspond to variable actions, but the complexity of these systems have created other usability issues. Most Generation Y engineers would describe today's instruments as cumbersome.

An instrument that completely ditches physical knobs and buttons, and instead uses a touchscreen as the user interface, could solve these challenges. Rather than presenting all of the controls at once, the touchscreen could simplify the interface by dynamically delivering only the content and controls that are relevant to the current task. Users could also interact directly with the data on the screen rather than with a disjointed knob or button. They could use gesture-based interactions such as performing a pinch directly on the oscilloscope graph to change the time/div or volts/div. Touchscreen-based interfaces provide a more efficient and intuitive replacement for physical knobs and buttons.

Mobile-Powered Approach

By leveraging the hardware resources provided by mobile devices, instruments can take advantage of better components and newer technology.

This approach would look very different from today's instruments. The processing and user interface would be handled by an app that runs on the mobile device. Since no physical knobs, buttons or display would be required,



the instrument hardware would be reduced to only the measurement and timing systems, resulting in a smaller size and lower cost. Users would not be limited by the tiny built-in displays, small onboard storage and slow operation. They could instead take advantage of large, crisp displays, gigabytes of data storage and multi-core processors. Built-in cameras, microphones, and accelerometers could also facilitate new possibilities such as capturing a picture of a test setup or recording audio annotations for inclusion with data. Users could even develop custom apps to meet specialized needs.

While it's entirely possible for traditional instruments to integrate better components, the pace at which this can happen will lag mobile devices. Consumer electronics have faster innovation cycles and economies of scale, and instruments that leverage them will always have better technology and lower costs.

Cloud-Connected Access

Engineers commonly transfer data between their instruments and computers with USB thumb drives or with software for downloading data over an Ethernet or USB cable. While this process is fairly trivial, Generation Y has come to expect instantaneous access to data with cloud technologies. Services like Dropbox and iCloud store documents in the cloud and automatically synchronize them across devices. Combined with Wi-Fi and cellular networks that keep users continuously connected, they can access and edit their documents from anywhere at any time. In addition to just storing files in the cloud, some services host full applications in the cloud. With services like Google Drive, users can remotely collaborate and simultaneously edit documents from anywhere.

Instrumentation that incorporates network and cloud connectivity could provide these same benefits to engineers. Both the data and user interface could be accessed by multiple engineers from anywhere in the world. When debugging an issue with a colleague who is off site, rather than only sharing a static screenshot, engineers could interact with the instrument in real time to better understand the issue. Cloud technologies could greatly improve an engineering team's efficiency and productivity.

"Intelligent" Features

Context-aware computing is beginning to emerge and could fundamentally change how we interact with devices. This technology uses situational and environmental information to anticipate users' needs and deliver situation-aware content, features and experiences.

A popular example of this is Siri, a feature in recent Apple iOS devices. Users speak commands or ask questions to Siri, and it responds by performing actions or giving recommendations. The Google Now effort provides functionality similar to Siri, but also passively delivers information that it thinks the user will want based on geolocation and search data: weather information and traffic recommendations appear in the mornings; meeting reminders are displayed with estimated time to arrive at the location; and flight information and boarding passes are surfaced automatically.

Similar intelligence combined with instrumentation could be game changing. A common challenge engineers face is attempting to make configuration changes to an instrument at the same time that their hands are tied up with probes. Voice-control could not only provide hands-free interaction, but also easier interaction with features. In addition, predictive intelligence could be used to highlight relevant or interesting data. An oscilloscope could automatically zoom and configure based on an interesting part of a signal or it could add relevant measurements based on signal shape. An instrument that leverages mobile devices could integrate and take advantage of context-aware computing as the technology is developed.

The Generation Y Edge

Technology in consumer electronic devices is evolving rapidly and influencing the expectations of Generation Y. As more and more Generation Y engineers enter the workforce, it is only a matter of time before their expectations are applied to the instrumentation they use for their jobs. Not only will this evolving technology provide significant benefits to instrumentation, the technically savvy Generation Y engineer will leverage it to solve engineering challenges faster than previous generations ever thought possible. **DE**

Chris Delvizis *is a product manager at National Instruments. Contact him via de-editors@deskeng.com*

INFO → **Cisco:** Cisco.com

→ **Frost & Sullivan:** Frost.com

→ **National Instruments:** NI.com

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Collaborative Culture and System Modeling Go **Hand in Hand**

Whirlpool learned how to combine social media-style collaboration with multi-disciplinary simulation.

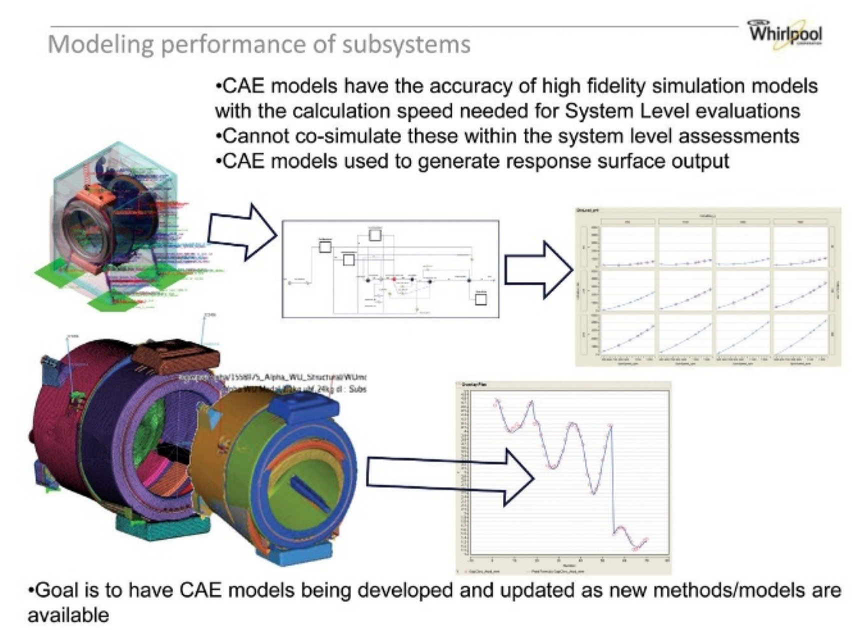
BY KENNETH WONG

As he watched his daughter getting ready for her summer trip to India, John Mannisto, Whirlpool's director of engineering, Simulation Based Design, reminded her, "Call me." True to the spirit of the social media generation, she promptly replied, "Follow me."

She meant, instead of sitting by the phone for weekly updates from her, Mannisto should just "follow" her on Twitter — that is, to subscribe to her Twitter feed. That incident, along with a Skype video chat with his grandkids and a Facebook page shared by the company-sponsored FIRST Robotics team, alerted him of something many business executives might find difficult to accept: Social media has outpaced corporate collaboration.

Today, Mannisto's team uses Whirlpool Commons, incorporating many of the features of Twitter and Facebook. Team members subscribe to — or "follow," in the jargon of Mannisto's daughter — and receive project updates. They post questions and ideas to the Commons, as the platform has come to be known internally, and watch them go viral. Sometimes they discover colleagues several continents away that have the expertise they need to finish a job.

Often, when Mannisto talks about the Commons at business seminars and data management conferences, people want to know who the vendor is. He takes great pleasure in informing them that the Commons was the brainchild of Alex Otten, a 17-year-old intern he hired from a FIRST Robotics team.



Whirlpool relies on ESTECO's modeFRONTIER software as a dashboard to coordinate different simulation tasks. It's part of the company's system-level design philosophy, as reflected in this presentation slide.

Built in Open-source Code

Traditionally, a corporation like Whirlpool — with $18 billion in revenue and 68,000 employees, selling its products in more than 130 countries — turns to one of a handful of enterprise software vendors when it needs something. But Mannisto realized a new type of tool was needed to facilitate the new behaviors he'd observed among consumers and software users. He looked beyond the commercial software choices, and decided instead to outline his team's needs and let his intern custom-develop something.

The first incarnation of the Commons was more than what Mannisto bargained for, because Otten had created a platform that showed off everything he knew about web design. "It was something that would have given my engineers seizure," Mannisto recalls with a chuckle. He asked for a revised version that would be easily adopted by "the 50-something guys on my team who learned to use the Internet six or seven years ago." That eventually put the Commons on the right track.

Whirlpool Commons was designed mostly in open source software: Drupal for content management, SilverStripe for web development, and Apache Solr for enterprise search. It began as a local implementation for Mannisto's engineering group, but quickly spread to other divisions because of its ease of use.

Structured and Unstructured Data

At first glance, Whirlpool engineers seem to straddle two separate worlds: the unstructured knowledge shared in the Commons; and the structured data managed in PTC Windchill, a product lifecycle management (PLM) system, and ESTECO's modeFRONTIER, an optimization integration platform. But the two worlds are inseparably linked. What happens in the Commons produce ripple effects in the revision controls in Windchill and the system modeling tasks in modeFRONTIER.

"System modeling requires a high degree of collaboration. It is, by nature, a group project, with lots of team input," observes Mannisto, noting that in the Commons, he has witnessed unlikely collaborations spring up among employees in Rio Claro, Brazil; Poprad, Slovakia; and St. Joseph, MI. "modeFRONTIER gets hungry for input, so having a tool like Whirlpool Commons gives us the ability to feed it. The source of input comes from many unexpected places. One director of testing posted a question [to the Commons] about testing air flow to his team around the globe. He hadn't anticipated that one of the responses would be from a simulation team member who sits 15 ft. from his desk."

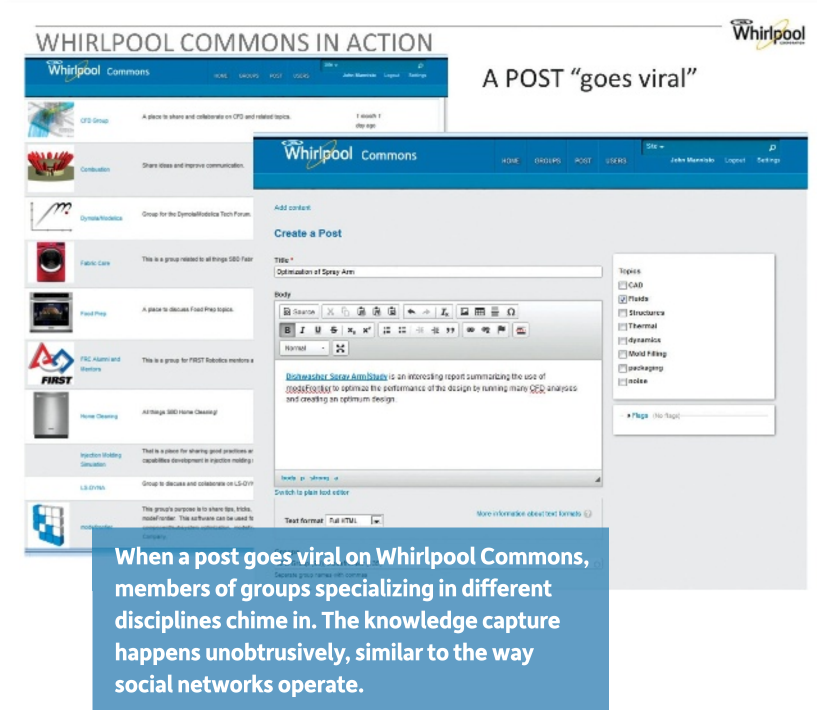
Using modeFRONTIER as the multidisciplinary project dashboard, Whirlpool can study and analyze the interrelated electromechanical simulation inputs and outputs — for example, how changing the foam thickness of the refrigerator cabinet and the type of compressor used might affect the overall experience of the consumer. But such initiatives and discussions can only occur within an environment that fosters cross-disciplinary dialogues and knowledge sharing. Though inputs and outputs in Whirlpool Commons and modeFRONTIER are not formally linked, the Commons promotes the culture needed for system modeling in modeFRONTIER.

Benefit to the Consumer

For Whirlpool, system modeling — the coordinated simulation and analysis of the subcomponents in a product — is not an abstract engineering objective. It goes to the heart of the consumer experience.

"The consumer wants spotless dishes, a short cycle time, and low water and energy consumption," Mannisto notes. "They want an experience. They don't think about motor torque; they think about wash quality, noise, reliability, etc."

To deliver that ideal consumer experience, Whirlpool engineers perform computational fluid dynamics (CFD) studies of the airflow inside refrigerators, ovens and dryers; simulate two-phase dispensing and spraying operations in washers and dishwashers; model combustion activities; and analyze thermal management inside subsystems and systems. They're supplemented by structural simulations to understand drive systems and vibrations in products. To see how the products will stand up to real-world usage, the engineers also simulate the clean-



When a post goes viral on Whirlpool Commons, members of groups specializing in different disciplines chime in. The knowledge capture happens unobtrusively, similar to the way social networks operate.

ing process itself — complete with chemistry, mechanical action and heat generation.

The engineers employ a correlation and calibration document, described by Mannisto as “a tool to measure our confidence in a particular simulation, and to also understand the variations in our processes.

“We are constantly asking ‘How well did we predict?’ by looking at product-approval testing, and building this into our database for the next project,” he adds. “The system model is where modeFRONTIER really shines. It helps us [perform] like a symphony conductor, pulling together the individual subsystem outputs to understand the interplay among them. This lets us explore and discover possibilities we never considered.”

A Brainstorming Session that Lasts Weeks

When Mannisto recently logged into the Commons, he noticed no fewer than 50 comments and responses to a post about ideas for compressing cycle time — the time it takes to design and bring a product to the market. For an internal corporate discussion, that’s robust activity, a sign that the post has gone “viral” on the Commons.

“Suppose you want to have a formal meeting about this topic,” Mannisto offers as a comparison. “You invite three or four people to bring their best ideas into the boardroom at 10:30 a.m. on Tuesday. So they come, they talk, they have about 15 seconds to react to ideas proposed. You get the ideas that come out of their heads in that moment.”

If he proposes a weeklong brainstorming session, it’s doubtful any of his colleagues will take him up on it. Yet, that’s exactly what’s happening in the Commons.

“[Cycle time reduction discussion] is an online conversation that happens over the course of three weeks,” he points out. “It’s still ongoing. People will read the thread, think about it, and contribute. There are about 50 people in this [virtual meeting] room.”

Suddenly, calling for a meeting at 10:30 a.m. on Tuesday seems drastically less efficient.

A Higher Standard Set for Commercial PDM/PLM

The development and evolution of the Commons taught Mannisto and his team one crucial lesson: Don’t settle for a whizbang, out-of-the-box solution. “Use a solution provider if you need to, but get involved,” Mannisto advises. “It’s a journey. We learned most by piloting, playing around, and modifying things organically as we develop — and it works.”

With a tinge of sadness in his voice, Mannisto revealed that Whirlpool Commons’ days may be numbered. While it has served the engineers well up to this point, and many users have grown accustomed to it, the next phase of integration will require something else from a commercial vendor for the long haul.

“What Whirlpool Commons has shown us is how we should work,” he says. “We’ve had that theory that we needed a social layer to our collaboration for a long time. We didn’t know how to do it.”

They didn’t until they developed it with the help of a 17-year-old intern, who, being an outsider, was able to bring fresh outlooks from the social media universe. “Alex’s best asset is his inexperience [with standard collaboration systems],” Mannisto concludes. “He thinks differently.”

At press time, Whirlpool Commons users have formed a committee to identify the system attributes they now know they’ll need to effectively collaborate. In the not-so-distant future, when the company goes shopping for an enterprise collaboration platform, they’ll presumably invest in something that costs significantly more than the Commons. But they also know they don’t have to settle for anything less than what Alex Otten was able to come up with in his summer project. **DE**

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

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→ **PTC:** PTC.com/product/windchill

→ **Whirlpool:** Whirlpool.com

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A Portable Printer for Your Pocket

How's this for a Kickstarter pitch: it's like the Roomba, but it's a printer. That's the concept behind Zuta Labs' Pocket Printer, a tiny device that runs across any size paper and prints grayscale images and documents from a mobile phone, tablet or laptop.

The device helps solve the challenge created by ubiquitous mobile computing devices that generally have nowhere to send a required print job. The inkjet lasts for 1,000 printed pages, and the battery (which recharges via USB) is good for an hour.

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Wal-Mart Shows off the Truck of the Future

Wal-Mart has developed a next-generation big rig to help reduce the carbon footprint of its massive truck fleet. The Wal-Mart Advanced Vehicle Experience (WAVE) is a concept tractor/trailer combo designed by the retailer, Peterbilt, Roush Engineering, Great Dane Trailers and Capstone Turbine. The cab is 20% more aerodynamic than a traditional truck, and is powered by a Capstone micro-turbine hybrid electric drivetrain that can run on diesel, biodiesel and compressed natural gas. In urban areas, the trucks can run on electric power alone.

According to the company, designers used computational fluid dynamics (CFD) analysis to optimize the cab, which sits over the engine. The wheelbase has been shortened, which reduces weight and improves maneuverability. It also has a 53-ft. carbon fiber trailer that has shaved nearly 4,000 lbs. of weight from it.

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Convertible Cargo Vehicle/Helicopter Makes First Flight

Advanced Tactics has completed the first flight test of the Black Knight Transformer, a vertical takeoff and landing (VTOL) aircraft that operates as both a truck and a helicopter.

According to the company, the Black Knight is the world's largest multicopter that is controlled and stabilized with propeller speed. It has a maximum takeoff weight of 4,400 lbs. On the ground, the independent engine and transaxle can reach speeds up to 70mph. It is stabilized and controlled using differential thrust between opposing sets of prop-rotors. It can also be remotely controlled.

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Electric VTO Plane

Joby Aviation is developing an electric-powered vertical takeoff plane called the S2. Joby has built several dozen 10-lb. models. The plane would use one dozen electric motors, and includes retractable arms to reposition the motors for takeoff, forward flight and landing.

NASA is funding a 55-lb. unmanned aerial version. Based on supercomputer simulations, a full-scale S2 could fly two people 200 miles in an hour using 50 kilowatt hours of electricity, which would make it roughly five times more efficient than a typical two-seater airplane.

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Commentary

by Nicholas M. Veikos

The Importance of Engineering Simulation for Innovation

Innovation. We hear the word with increasing frequency in today's business environment. In the April 2014 issue of the *Harvard Business Review* (*HBR* Vol. 92, No. 4), the editors used Google's Ngram Viewer to track the frequency of a variety of familiar business terms used in books over the past century. Their premise was that language is a reflection of our culture, and the phrases used reflect our shifting priorities. In this study, the word "innovation" showed more than a five-fold increase in frequency of use over this period; much larger than either "management" or "leadership."

In the same issue of *HBR*, "innovation in response to customer requirements" was highlighted as one key way in which manufacturers in developed countries are competing successfully with those in emerging economies with much lower labor costs.

The ability to quickly test new ideas is critical to innovation.

The U.S patent office received over 575,000 patent applications in 2012, more than six times the number received in 1962, and 60% more than in 2002. So, innovation is not only increasing, it is accelerating rapidly.

Enabling Innovation

There are many factors that enable innovation. A culture of creativity and flexibility is key, but so is the ability to quickly test new ideas and identify those that merit further development.

With the use of computer aided engineering (CAE) simulation, today's trials can be virtual. This approach can be orders of magnitude faster and cheaper than innovation by building one physical prototype after another. In our rapidly moving and competitive world, vetting new ideas and processes in a virtual environment provides significant advantages compared with traditional physical experiments. An engineer can dream up a new concept during a morning shower, flesh it out a bit more during the drive to work, simulate it by lunchtime to prove feasibility, and have a solid, defensible proposal on the manager's desk by 3 o'clock. With sufficient computer hardware, a hundred different variations of the original concept will be ready to review by morning. Someone taking the traditional physical testing approach would be lucky to have the paperwork requesting lab resources completed in this same timeframe.

Savings in time and cost are not the only advantages that simulation has to offer. Sometimes, innovation happens by accident. For example, making minor modifications during product testing or changing materials may yield huge performance benefits. The reasons for the improvement may not always be understood; testing is great for answering what happened, but not always so good for answering why it happened. You need a lot more testing for that — or you can simulate.

Because simulation can help engineers visualize the relevant parameters, it can provide insight and understanding not easily achievable by testing. New products that rely on multiple physics working together are the most complex to test and are those where simulation brings the most benefits. Simulation answers the "why" question, which is critical when filing for a patent or when deciding whether to further pursue a concept.

Simulate Early and Often

The pace of change is fast and getting faster with breakthrough technologies like additive manufacturing. Traditional manufacturing constraints will soon disappear, opening a new universe of potential designs for even everyday items.

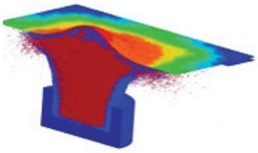
With this increased pace comes increased risk. A company may be looking at dozens of innovative ideas. How does it decide which ones to proceed with? While the basis of this decision is multi-faceted, simulation can certainly help. One obvious way is to model the innovation to ensure that it can achieve the performance and benefits required for success. In addition, CAE simulation can help determine the manufacturing methods, tolerances and material requirements for a successful implementation, thereby helping to put a number on production cost and timeframe. Without simulating early on, it is difficult to rationally draw these conclusions before committing significant time and resources.

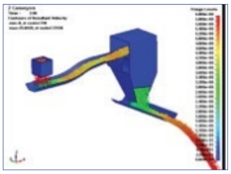
Like most things that have increased risk, there is also potential for increased reward. Businesses at the forefront of innovation who embrace simulation level the playing field as they compete with more established and conservative rivals. DE

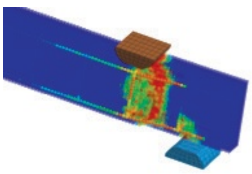
Nicholas M. Veikos, *Eng.Sc.D., is president of CAE Associates Inc. He has more than 30 years of experience in engineering analysis. Contact him via caeai.com or de-editors@deskeng.com.*

13th LS-DYNA® U.S. & International Users Conference

Four New Solvers for Multiphysics Purposes





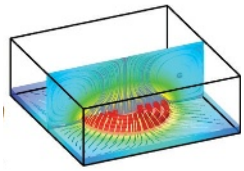


Discrete Element Sphere (DES)

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.

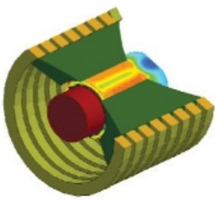
A bond model has been developed to bond particles and form "continuum" materials. The behavior and stiffness of these bonded particles match the same material behavior in solid mechanics, such as the bulk and shear moduli and deformation energy. The fractural energy is captured over all broken bonds for crack initialization, propagation, and fragmentation during dynamic and impact analysis. This bond model bridges the continuum mechanics and the DEM, and enables seamless transition crossing multiphysics analyses. 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.



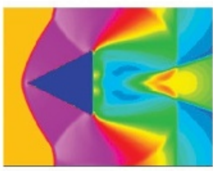
Incompressible CFD

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.

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