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FOCUS ON: Energy Storage

Simulation for All

Democratize simulation via fast hardware and easy-to-use software. P.14

Degrees of Freedom

by Jamie J. Gooch

Managing Simulation Democratization

As the walls separating design engineers and analysts continue to crumble, workflows are evolving to take advantage of new technologies that help make the design process more efficient. However, there's a perennial problem slowing that evolution to a crawl.

The fact that there are more design engineers than analysts is nothing new. What's exasperating this bottleneck in the design cycle is widespread access to more advanced computing hardware and software that allows design engineers to consider more "what-if" iterations. All of those promising potential designs from all of those engineers need to be simulated and analyzed — often by a very small team of analysts.

The app model has the potential to alter the design workflow.

Simulation for All?

The obvious solution would be to provide simulation and analysis tools to more design engineers. What's not so obvious is how to best do that. Simulation and analysis requires specialized skills not all design engineers have. For example, here are the requirements from a recent job post for a modeling, simulation and analyst intern:

- Knowledge of programming languages: FORTRAN, C/C++
- Good verbal and written communication skills
- Knowledge of basic physics and its application to modeling and analysis
- Knowledge of physics, random variables and its application to modeling and analysis
- Familiarity and knowledge of system engineering and analysis
- Experience in software development processes, object oriented design, and real-time applications
- Debugging/Analysis methodologies in optimizing application performance
- Understanding of computer architecture and design and digital system modeling and simulation experience
- Ability to troubleshoot simulations problems and write post processing scripts.
- Shell/Perl/Python scripting

If that's what's expected of an intern, you can imagine what is required of a full-time simulation and analysis expert. Even if a design engineer has some analysis skills, he/she has plenty to do in the design process without taking on more. The key is to find that sweet spot where design engineers can quickly get answers that will help them refine designs without waiting in a queue for analysis, which frees up the analyst to work on the most promising and refined product iterations or the most complicated simulations.

There are a number of approaches being applied, from simulation tools that are integrated in popular CAD packages to software that focuses on particular industries or engineering problems, to user interfaces and templates that can guide design engineers through some common simulation tasks. The problem with many of these approaches is that they're either too specific to be applied to other designs and industries or too general to be really useful in analyzing specific problems. The ultimate solution — in addition to training more analysts — is to combine all of these approaches into a custom solution for each customer. That's where apps come in.

Analysts as Developers, Managers

MathWorks, the developer of MATLAB and Simulink, provided a path to specialized application development and deployment. Its MATLAB Central File Exchange allows the company and customers to share custom applications, classes, code examples, drivers, functions, Simulink models, scripts, and videos. A community of users has developed around File Exchange, sharing apps and expertise.

COMSOL is taking a similar tack with its Application Builder, which allows experts to create specialized multiphysics apps that non-experts can use to simulate changes they make to variables defined by the expert analyst. (For more examples of the democratization of simulation, see page 14.)

The app model has the potential to alter the design workflow. It provides analysts with the tools they need to become software developers, albeit on a small scale. Those apps will no doubt need updated as design engineers request more features. The designs informed by those apps will still need a final analysis, but the potential is there for the analyst to become the management hub of design activity, rather than a bottleneck in the process. **DE**

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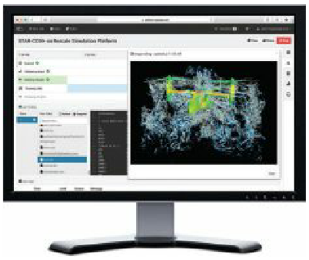
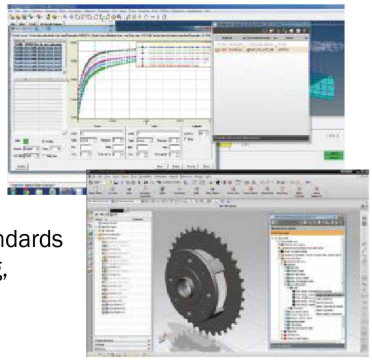
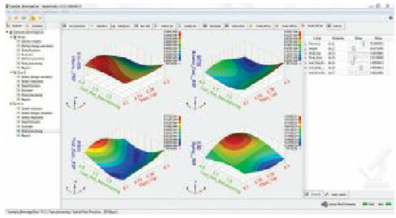
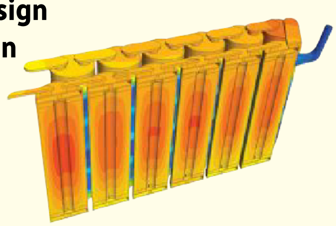
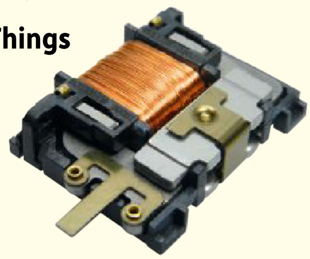


ON THE COVER: Apps democratize simulation.
Images courtesy of COMSOL.









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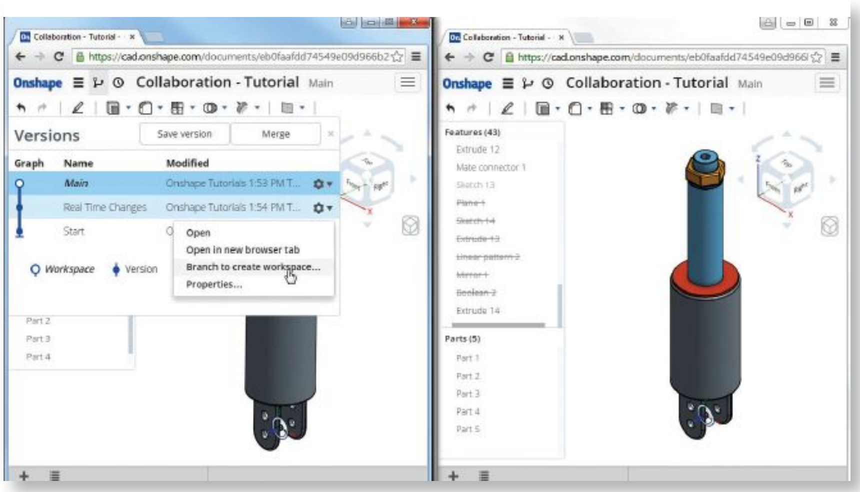
by Kenneth Wong & Beth Stackpole

Onshape Beta Goes Live

In early March, the beta version of Onshape, developed by SolidWorks cofounder and former CEO Jon Hirschtick, came online. In this case, "online" is the appropriate phrase, as the program runs in a browser. No installation, no client app — just a standard browser. Your login and password gives you a personal workspace with tutorials and sample parts, your private library and your shared documents.



The new mechanical CAD software Onshape, developed by former SolidWorks talents, offers Google doc-style collaboration.

Primarily Parametric

Onshape is a parametric CAD program with a sketching environment, part creation tools and assembly functions. Some creative tweaks to the usual sketching workflow add a level of ease, like the software's ability to collectively select entities based on a succession of clicks (without resorting to the Ctrl+click or Shift+click) and the Offset tool that uses an arrow you can drag.

The software has some direct-editing tools, but they're limited — that is, in comparison to software like SpaceClaim, Solid Edge with Synchronous Technology or Autodesk Fusion 360 that operates primarily as a direct-editing program. That's a reasonable compromise, since a parametric program's purpose is usually not quick concept exploration but detailed mechanical design.

The direct-editing features available in Onshape, such as Move Face or Rotate Face, work well in reconciling the new geometry with previously established parametric constraints. But Onshape won't let you push and pull geometry, points and vertices freely the way a program that's designed from the ground up as a direct editor would. It requires a more disciplined workflow.

Concurrent Collaboration

Another noteworthy feature of Onshape is the Google doc-style collaboration function, where multiple editors can be working on the same 3D model simultaneously. Individual changes are instantaneously visible to the rest. It's a workflow made possible by Onshape's cloud architecture, making an argument to move CAD collaboration from desktop to the cloud or the browser.

Along with its simultaneous-editing interface, Onshape gives you the ability to create what's called Branch designs — multiple iterations of the main design. The idea is to let a number of engineers work on different areas of the main design (for example, one person adding brackets and ribs in a region) or explore variations with slightly different geometry. At some point, a project manager can then merge the details or the differences found in the Branch designs with the main design, thus incorporating all the work (or rejecting a few, as the case may be).

Onshape follows the a standard SaaS (Software-as-a-Service) pricing structure, offering a free version along with paid subscriptions beginning at $100 per user per month. The free version made available to "Students & Makers, View & Markup, Light-Duty Pros" limits you to five active private documents.

Even in its beta phase, Onshape appears to be a stable parametric CAD program, a new mechanical design package that also takes on the challenge to prove CAD in cloud is not experimental but pragmatic.

Editor's Note: *Autodesk CEO Carl Bass penned a blog post titled "Setting the Record Straight" in response to the launch of Onshape, pointing out that Autodesk Fusion 360 went to the cloud much earlier than Onshape. Fusion 360 evolved from what was previously Autodesk Inventor Fusion, Autodesk's direct-editing CAD software. It is by comparison a more mature code than Onshape, with rendering, simulation and CAM features integrated into the main CAD environment. The software runs from a client program that straddles both your local machine and the cloud. Autodesk is also championing lower-cost subscription licensing instead of traditional perpetual licensing for desktops.*

—K. Wong

by Kenneth Wong & Beth Stackpole

Ford Kicks Up Enterprise MDO Strategy

As multidisciplinary optimization spreads throughout all corners of its design process, Ford Motor Co. has adopted a new platform aimed at streamlining optimization collaboration across a global design team while making multidisciplinary design optimization (MDO) processes an enterprise best practice.

Building on its decades-long MDO work with ESTECO's modeFRONTIER, the auto giant is now implementing SOMO, an enterprise collaboration and distributed execution framework born from the pair's partnership and now a commercial piece of software. SOMO delivers the enterprise foundation that extends Ford's MDO efforts from its roots as a desktop focused-task to a Web-enabled solution, according to Yan Fu, Ford's technical leader of business strategy and engineering optimization.

"SOMO's mobile and Web interfaces simplify access for non-MDO experts, helping provide visibility to all optimization processes and results," says Matteo Nicolich, product manager for Enterprise Solutions at ESTECO. "SOMO provides the enterprise piece, extending MDO knowledge to others within the organization."

modeFRONTIER has been widely deployed within Ford for years, helping cross-functional engineering teams make informed design tradeoffs. During early efforts, Ford initially coordinated the MDO work through a manual process heavily reliant on meetings. Eventually, that effort evolved into a more structured approach that tasked a formal MDO group with collecting models and requirements of multiple attribute design teams into a single environment, that being modeFRONTIER, Fu says.

While having a team of MDO experts was beneficial, there was still a lot of manual effort required to coordinate efficient MDO processes, not to mention the fact that the key domain-specific knowledge stayed with the appointed MDO experts. "This can lead to bottlenecks in the process," she says. "Just imagine what happens when an expert leaves the company or is absent from work — the entire project can suffer from huge delays. If you don't have the appropriate technological tools to handle this kind of information flow, the global product development time milestone might be missed."

Ford's Yan Fu explains the auto maker's vision for an Enterprise Multidisciplinary Design Optimization (EMDO) system built around ESTECO's modeFRONTIER and SOMO platforms. *Image courtesy of ESTECO.*

Sharing Knowledge

Enterprise MDO built around SOMO automates the process and prevents human error. Moreover, MDO knowledge is captured through standardized templates, which helps get new employees up to speed and enables Ford to pool its best resources from around the world, funneling their knowledge throughout all facets of the design process, says Fu.

"MDO processes become institutionalized and transparent, with engineers truly able to focus on their work without depending on the schedules of other department experts," she says. "Actual models and data become centralized — the so-called, 'single source of truth.'"

A recent pilot project illustrates how the process delivers benefits to Ford engineers. Used in the design of a bigger model pickup truck, the optimization analysis comprised three different truck sizes with the aim of minimizing the weight while meeting all constraints relating to safety, NVH and durability. The final optimization workflow included seven models, 113 variables and 34 responses — a workload that would have taken at least a month to complete with traditional MDO processes.

With SOMO integrated into the Ford private cloud, engineers do their own work and publish their latest models to the shared platform so the entire team can build the top-level MDO process right away. Now, running a single model simulation for one safety mode takes about three hours using 32 CPUs while execution of the entire multidisciplinary optimization takes about eight days. "This is something new that has revolutionized our way of working," Fu says.

—B. Stackpole

Charting the Orion's Flight to Mars

In 1981, Jon Friedman watched the first Columbia space shuttle's launch from a black-and-white TV screen. Friedman, now the aerospace manager at MathWorks, was watching the first test flight of NASA Orion from an iPad alongside his kids last December. Time passes and children grow up, but the passion for space exploration remains the same in the Friedman household.

Friedman has another reason to care about the Orion's journey. When the Orion sets its course for Mars, it will rely on the guidance, navigation and control (GN&C) software developed in partnership with MathWorks to get there.

"I want to congratulate the engineers at NASA, Lockheed Martin and Draper Laboratory who made it work," says Friedman. "[MathWorks] has always been about accelerating the pace of discovery in engineering and science."

The Orion in the water, awaiting recovery. *Image courtesy of NASA.*

Acceleration via Automation

The Orion project is also an exercise in software development acceleration, made possible by MathWorks' MATLAB and SimuLink. Roughly 40,000 lines of code were automatically generated by the process, bypassing the need to schedule manual coding time.

"Guiding the Orion craft to a splashdown point within a half mile of its chute deploy target required the strengths of the entire team," says Mark Jackson, Draper Laboratory's GN&C integration lead for the NASA team. "By combining Draper's entry guidance algorithm with the auto-generated code capability of MATLAB and Simulink, the team met NASA's objectives for landing guidance, navigation, and control."

"With this approach, you don't have to wait for the best software coders in the team to hand-code the software. The code-generator can easily reproduce code, so when you have a design configuration you like, you can automatically generate the code," says Friedman.

The GN&C software is critical in the closed-loop simulation of the Orion's flight. NASA uses the C++ flight code in its flight simulation conducted in Trick, a software-based simulation environment. This approach, MathWorks revealed, allows the apace agency to simulate a full 10-day Orion mission in just one day.

MBD ABCs

Committing to the model-based design (MBD) approach meant a steep learning curve for some engineers unaccustomed to the method. "We've seen that the return-on-investment for model-based design could be in the range of 100-200% over the lifespan of a program," says Friedman, "because you discover errors earlier, can identify problems with requirements much earlier."

In software development, the "model" is not a detailed 3D CAD assembly (as the case would be with MBD in manufacturing) but a graphical representation of the dynamic system of the spacecraft. "Simulink Advisor can essentially interrogate the model to make sure it meets your standards, that it doesn't include certain constructs you don't want," Friedman says. "For example, if you decide to permit only linear models of actuators, Simulink can catch the nonlinear models that might have snuck in."

In mechanical system modeling, engineers may try to push the limits of the design to find its breaking point. In software simulation, Friedman says, "It's important to verify the model's coverage, meaning, you make sure you have explored all the different paths the software can take, that you have fully exercised everything." That task was largely automated in the Orion project using MathWorks' Simulink Verification and Validation.

Developing the algorithms for the Orion GN&C software involves more than 100 engineers. The MBD approach ensures all the works were done in synchronicity. According to MathWorks, "Simulink models serve as an executable specification from which flight software is automatically generated. As a result, the domain experts — the GN&C analysts — work directly with the executable algorithm models rather than with documents that must then be interpreted by software developers."

Friedman quipped that his son is also learning the art of MBD in a class exercise where he and his classmates must model a city block together in Minecraft — without accidentally building high rises on top of one another.

The NASA Orion leadership team is currently on the road in California, with stops planned at the NASA's Jet Propulsion Laboratory in Pasadena, Aerojet Rocketdyne in Sacramento and Lockheed Martin's Sunnyvale facility.

—K. Wong

Monash University 3D Prints Complete Jet Engine

Many companies are investigating in methods of using additive manufacturing to replace complex parts in a single build, rather than requiring multiple production methods and additional assembly. Australia's Monash University (MU), along with its spinoff AMAERO Engineering, have gone further and produced a jet engine with 3D printing.

"It was our chance to prove what we could do," says Professor Xinhua Wu, the director of the Monash Centre for Additive Manufacturing. "But when we reviewed the plans we realized that the engine had evolved over years of manufacture. So we took the engine to pieces and scanned the components. Then we printed two copies."

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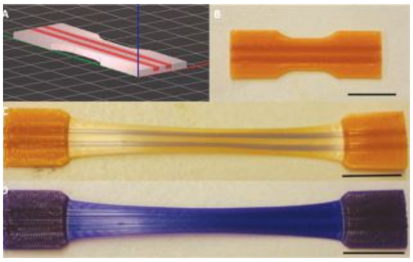
3D Printed Materials Reveal Stress

Researchers at the University of Washington are combining functional polymers with 3D printing. Functional polymers react to outside influences such as heat, light or stress in a number of different ways, including changing shape or color.



The changes in the material act as a passive mechanical sensor that is capable of alerting onlookers to changes in material stress. It can be challenging to integrate functional polymers into objects produced through traditional manufacturing because the heat and pressure typical for many processes would cause the functional polymer to indicate prematurely.

Additive manufacturing (AM) works at much lower temperatures than other manufacturing processes, making it a likely candidate for generating functional polymer objects.

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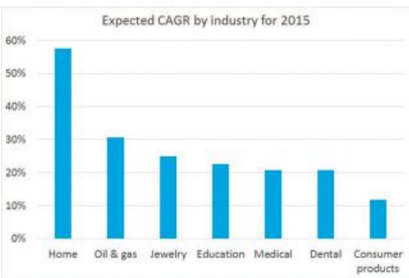
3D Printing Market: $20 Billion by 2025

The 3D printing market could reach $20 billion in the next decade, according to a report from IDTechEx. The company forecasts that the $1 billion in revenues the market generated in 2012 will reach $20 billion by 2025, a CAGR of 22%.



The report, "3D Printing 2015-2025: Technologies, Markets, Players," also evaluates fast-growing sectors.

According to the report, more than 60% of 3D printing revenues come from mid-range printers in the $30,000 to $300,000 range, which are used primarily for prototyping. That segment of the market, however, is experiencing the slowest growth due to application maturity.

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America Makes Awards $3M in Funding

Leading 3D printing companies and universities will share in more than $3 million in research funding via America Makes and the Air Force Research Laboratory.

America Makes

In December, America Makes announced the awardees of the three AFRL-funded Special Topic Project Calls. Along with the National Center for Defense Manufacturing and Machining, the organization will award more than $2.12 million in funding to the projects, with $998,000 in matching funds from the project teams.

The three special topic project calls focus on closed-loop process control, open source protocols and non-destructive evaluation of complex structures.

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Autodesk's Ember Explorer Edition Goes on Sale

Autodesk has been a big player in the CAD market for nearly as long as such a market has existed. The advent of AM created additional market space for the company, and resulted in new products designed specifically for AM. The one area of the 3D printer market Autodesk had previously left to other companies was hardware.

News that the company had plans to build its own AM system first broke last year. Autodesk showed off a prototype design, and announced plans to operate on open source footing, labeling its forthcoming Ember as a development tool, rather than a dedicated manufacturing platform. Now, the Ember Explorer Edition package has arrived and is available for sale.

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HPC Cluster Help is at Hand

High-performance computer clusters have proven to be a perfect solution for many design engineering teams tasked with running more advanced computer-aided engineering (CAE) simulations in less time. As products increase in complexity, simulations are following suit. The large model sizes and multi-disciplinary workloads can be too demanding for existing hardware, including those high-performance workstations specifically calibrated for engineering software.

Clusters are well positioned to drive HPC horsepower downstream, but there are still deployment challenges that the average small- to mid-size shop can't handle without assistance. For example, proper configuration of an HPC cluster entails far more than choosing the right processor and core count or specifying enough memory. On the hardware front alone, there are many decisions to be made, from weighing the benefits of a CPU-centric architecture to building out a system that has a greater reliance on GPU technology and memory, just to name a few.

2X

The amount that product complexity doubled between 1997 and 2012 across all industries. More complex products require more advanced simulations, which in turn require the scalable processing power of high-performance computing clusters.†

24%

The percentage the average product lifecycle was shortened by between 1997 and 2012.†

Beyond the hardware, there are considerations around network computing and storage resources in addition to what kind of communications bus can best support the target CAE applications and workloads. Additionally, there are requirements specific to HPC environments—for example, the proper configuration and on-going management of the job scheduling software along with workload management applications that ensure the environment runs at peak performance.

HPC clusters provide an obvious path to more powerful simulation studies, but not every company has the internal know-how to benefit from that journey without an expert guide. Specially trained value-added resellers, working in partnership with key HPC providers like HP and CAE software specialists, can deliver a fully integrated solution in conjunction with support services that reduce HPC complexity and allow engineers to focus on what they do best: innovating great products.

80%

The percentage of product design decisions that small- and medium-sized businesses are responsible for in their role as suppliers to larger corporations, according to some industry accounts.

Professional Process

HP value-added reseller partners like Nor-Tech and Dasher Technologies follow a formal set of processes through each stage of deployment.

1. Following the customer assessment, the VAR will make a recommendation for a specific HP HPC cluster design.

2. That cluster design will then be put through its paces in a modified test environment to determine if it's the optimal configuration for that particular environment.

3. From there, the integration process kicks off to ensure all the pieces are working seamlessly before shipping the turnkey HP HPC cluster out to the customer site.

Get the Full Story

Download the complimentary report, "Partnerships Remove Complexity from Clusters," sponsored by HP and produced by *Desktop Engineering*, at deskeng.com/de/vars for more information on how value-added resellers can help you deploy high-performance computing clusters.

† Source: "Mastering Product Complexity," Roland Berger strategy consultants.

The "Appification" of Simulation

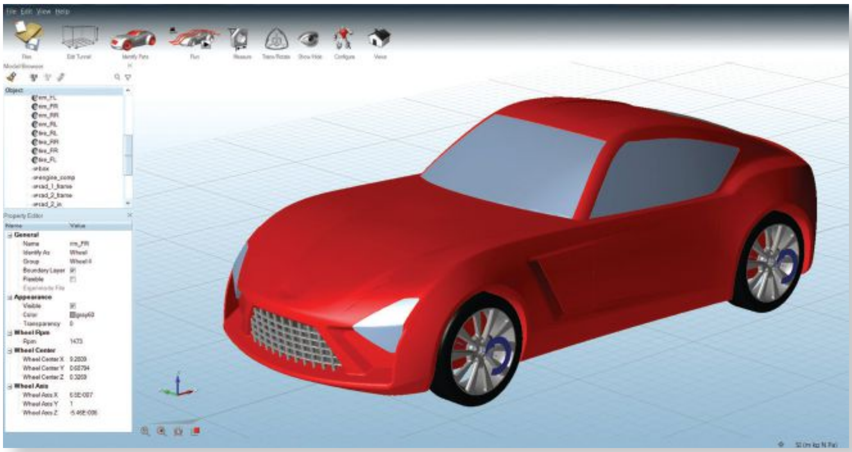
Mimicking the ease of use and specialization of popular mobile apps may help expand the reach of simulation.

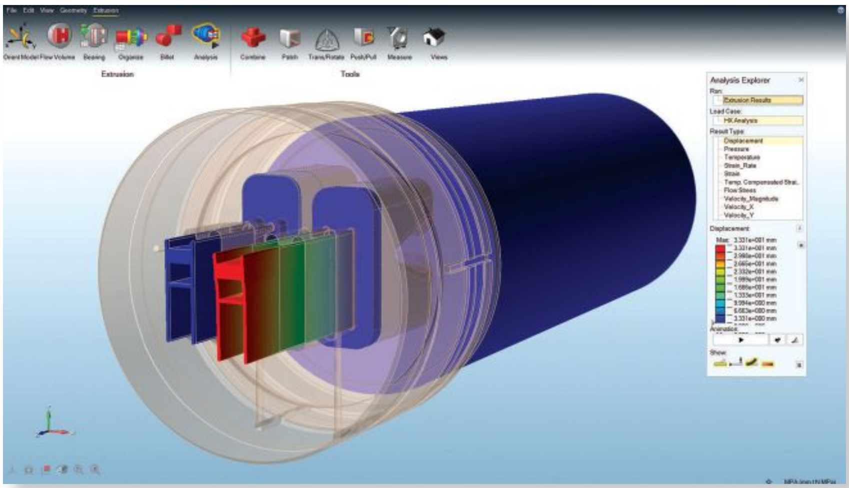
BY KENNETH WONG

Most of my digital photos end up in one of two programs: Adobe Photoshop or Instagram (now part of Facebook). I've had Photoshop for five to six years. I began using Instagram about a year and a half ago. But these days I found myself using Instagram 80% of the time to process my photos, and Photoshop the other 20%.

Whether it's a dramatic increase in contrast, a highly saturated look or a sepia-tone flush, I can get that in Instagram with just a few touches. Sure, I can get the same look in Photoshop, but it means going step by step, experimenting with the contrast and color sliders one at a time until I arrive at the desired effect. This offers a clue to how some companies are planning to broaden the reach of software-based simulation, currently the domain of experts.

On Apple's App Store and Google Play, you'll find Autodesk ForceEffect. ForceEffect Flow and ForceEffect Motion, three mobile apps that let you calculate stress, visualize fluid and airflow, and examine movements in mechanical structures without the burden and the learning curve of a general purpose simulation program. In late 2013, Altair Engineering launched HyperWorks Virtual Wind Tunnel and, more recently, HyperXtrude in 2015, special programs built to simulate external aerodynamics and metal extrusion. In October 2014, COMSOL





Altair's HyperWorks Virtual Wind Tunnel (top) and HyperXtrude are two examples of simulation that is being customized as specialized applications. ***Images courtesy of Altair.***

released a new version of its multiphysics simulation software with the Application Builder, which let users publish and share simulation apps.

Over the last two years, Comet Solutions has been developing a broad catalog of simulation apps, dubbed SimApps, many of which are deployed via Web interfaces. These may be harbingers of simulation marketplaces, populated with simplified, template-driven simulation applets that let you bypass or augment general-purpose simulation programs.

The Origin of Templates

In the past decade, CAE software developers experimented with various methods to broaden their market. Some introduced CAD plug-ins. Others repackaged their products in industry-specific configurations. For example, Dassault's SIMULIA brand products exist in different flavors for biomedical, life sciences, consumer goods, and other industries. They all succeeded in demystifying the black art once confined to the realm of PhDs. But one fundamental challenge still remains. Whether it's a car crash, the airflow around a plane, or the kinematics of a crankshaft, recreating a complex physical event inside a general-purpose simulation program is inherently complicated. That hurdle prompted many to resort to templates.

"Templates are a trend mostly among large companies that have method groups or have established best practices," says Gilles Eggenspieler, CFD (computational fluid dynamics) product line manager at ANSYS. Such time-tested workflows can be encapsulated in expert-built templates so non-experts can perform simulation at their own convenience with little or no expert intervention.

"[Templates and apps] give the amateur or introductory level user the ability to be productive without learning the simulation software," says Derrek Cooper, lead for CAE and HPC (high-performance computing) product lines at Autodesk. But to build a template, you still need an expert who knows the software inside-out — something not every business possesses. Currently, some consultants and freelancers fill that void for companies without in-house talent.

Some of ANSYS' customers, for instance, hire ANSYS to build simulation templates for them. "If you are GM or GE, for example, you may have resources to build a template on your own. Other organizations without resources may subcontract the template building to outside sources," says Bruno Reymond, general manager of ANSYS France. In time, the practice caught the attention of software developers, who woke up to the need to include robust workflow automation or template-building functions.

Automation Features

There is now an additional burden on CAE vendors. They're expected to deliver not only general-purpose programs that can solve a range of structural and fluid dynamics scenarios but also include tools that make template-publishing or workflow automation possible.

"Many of our products in the HyperWorks suite, for example SimLab, have template systems built right into their tools. This is especially attractive for larger companies with significant numbers of users, or companies that work with multiple vendors to complete their CAE process," says Christopher Peterson, director of User Experience at Altair.

Peterson also pointed out the difficulty of inventing targeted templates and apps. "Even within the same industry, modeling and analysis standards vary from company to company. Bottom line, the applications we deliver are customizable, a goal which is uniquely supported by Altair's open architecture," he says.

ANSYS 16.0 comes preloaded with ACT templates, covering a wide range of wizards. "They are made in a way that's easy to develop (in XML and Python languages) and to deploy without the need for additional licenses. They enable organizations to easily repeat simulations, capture product and process knowledge, and reduce training and implementation barriers for non-expert simulation users," ANSYS' Reymond says.

The sole purpose of Comet Workspace from Comet Solutions is to rapidly and easily create automation templates, according to Malcolm Panthaki, founder and CTO of Comet Solutions. "While templates have been around for a while, they required a lot of scripting and programming, making them expensive to create and maintain," he says. "The Comet Workspace is designed to create templates graphically, with a minimal amount of scripting."

San Francisco-based Rescale has built a business by offering on-demand HPC infrastructure to companies that want to pursue large-scale simulation. But part of its value may be coming from the software layer that allows automation.

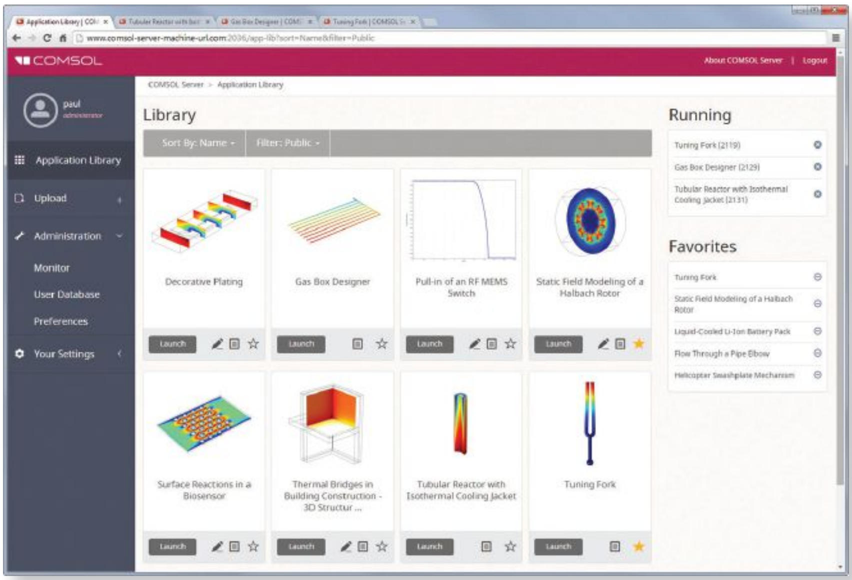
"As part of the Rescale toolset, we offer templates that let you set up a combination of software and algorithmic applications, so you can run design of experiments, Monte Carlo algorithms, or optimization sessions. Once you set up that workflow, it can be cloned so that you can change just a few parameters and rerun this job. The other popular feature of ours is the ability to share the workflow that you have set up with other people," says Joris Poort, CEO of Rescale.

Design Automation Associates (DAA), an engineering consultant, has made process automation its specialty. According to John Lambert, DAA's president and CEO, "Iterative problems occur in all areas of engineering design and analysis, but they especially occur in companies with engineered-to-order and configured-to-order products," says John Lambert, president and CEO of DAA.

Finite element analysis (FEA) of a printed circuit board (PCB) destined for use in an aerospace application, for example, provides the ideal conditions for automation.

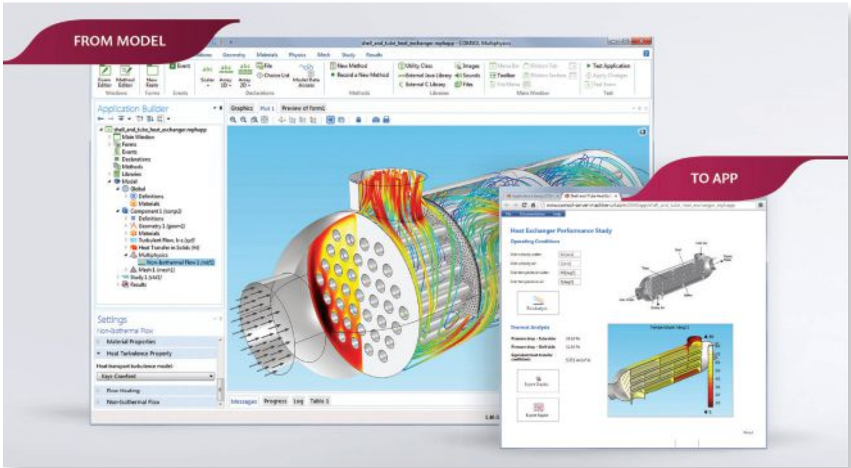
DAA's PCB analysis automation framework was built on Siemens PLM (product lifecycle management) Software's NX. DAA automated the mesh generation and iterative frequency extraction using NX's common application programming interface that supports a number of popular programming languages. Lambert estimated that the automation cut down the analysis that previously required 40 hours to a mere 15 minutes. The efforts required to set up the automation, however, is considerable. "It takes approximately 10 times as long to create a somewhat robust automation routine as it does to run a single iteration, so not everything is appropriate for automation," he says.

In most cases, such process automations are nested inside a simulation program; therefore, they require the non-experts to have some rudimentary knowledge of FEA software. Comet's Panthaki doesn't think that goes far enough. "Our experience clearly tells us, however easy you make those general purpose tools, the non-experts will still find it extremely



COMSOL's Application Builder lets COMSOL Multiphysics software users turn their simulation models into apps, in a simpler interface suitable for use by non-experts. ***Image courtesy of COMSOL.***

difficult to use, because setting up models for simulation is difficult," Panthaki says. He thinks the secret to mass-adoption of simulation is to "bypass the general-purpose simulation software interface altogether and create Web-deployable apps that have simple interfaces that speak the language of the engineer."



With the introduction of COMSOL Server, COMSOL is laying the groundwork for housing a collection of simulation apps. *Image courtesy of COMSOL.*

FEA App Store, CFD Marketplace

The idea of an online marketplace populated with thermal, structural, airflow and fluid flow simulation apps for specific tasks is not as farfetched as you might think. Some versions of this are already in incubation.

In the ANSYS Customer Portal, there are extension libraries under the Download section, where you'll find apps and templates built by third parties or ANSYS.

After releasing COMSOL Multiphysics 5.0 with Application Builder, COMSOL is now laying the groundwork for an app universe with its COMSOL Server, described as "the engine for running simulation apps and the platform for controlling their deployment and distribution."

"The future of simulation app stores isn't far off at all. In fact, we have made considerable progress in this direction with the Altair Partner Alliance, which opened our platform to third party applications that take advantage of our on-demand software licensing system," says Altair's Peterson.

This is not about delivering a general-purpose simulation program from the cloud (for that topic, read "A Map to Simulation on the Cloud," July 2014). Rather, this is about delivering small, purpose-built apps that let you perform simulation with little to no knowledge of simulation software.

Comet's library of SimApps range from simple to highly-complex models. For example, a Driveline SimApp is described as, "A single environment for axle system design that allows quick and easy evaluation of any axle geometry, without the manual effort." Its Electro-Optical Sensor SimApp lets you conduct integrated structural, thermal and optical performance analysis on space-borne EO sensors. Its Socket Stack Assembly SimApp is used by Intel to perform complex socket chip stack analysis using Abaqus.

"Vendors and customers have been creating these vertical apps for a long time, but they often only work across a small range of the design space. Using abstract modeling, Comet's templates can work across geometry and topology changes, across an entire family of products that shares a common functional architecture. This is important — if the range of utility of a template is narrow, as is often the case today, then the template is not very useful," Panthaki says.

Autodesk's Cooper thinks the online marketplace idea is spot on, but the challenge is to identify certain simulation tasks that make sense economically for the provider. "To be successful, you have to look for a problem that's pervasive enough to affect a lot of people, something sufficiently time-consuming but simple in nature," he says.

"I don't want to discount the possibility of a simulation app marketplace. That's certainly is a possibility, but it will be very challenging to do it for complex workflows," says S. Ravi Shankar, director of Simulation Product Marketing at Siemens PLM Software.

If software vendors do start adding more robust app-publishing functions in the software, consultants and CAE software users with sufficient knowledge in their own fields will likely become app developers. That means simulation analysts and researchers may very well be the ones who come up with the simulation equivalent of Instagram. **DE**

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

INFO → Altair: Altair.com

→ **ANSYS:** ANSYS.com

→ **Autodesk:** Autodesk.com

→ **Comet:** CometSolutions.com

→ **Rescale:** Rescale.com

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

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The RISE of the Simulation Stack

New alternatives in high-performance computing are rewriting the CAE playbook.

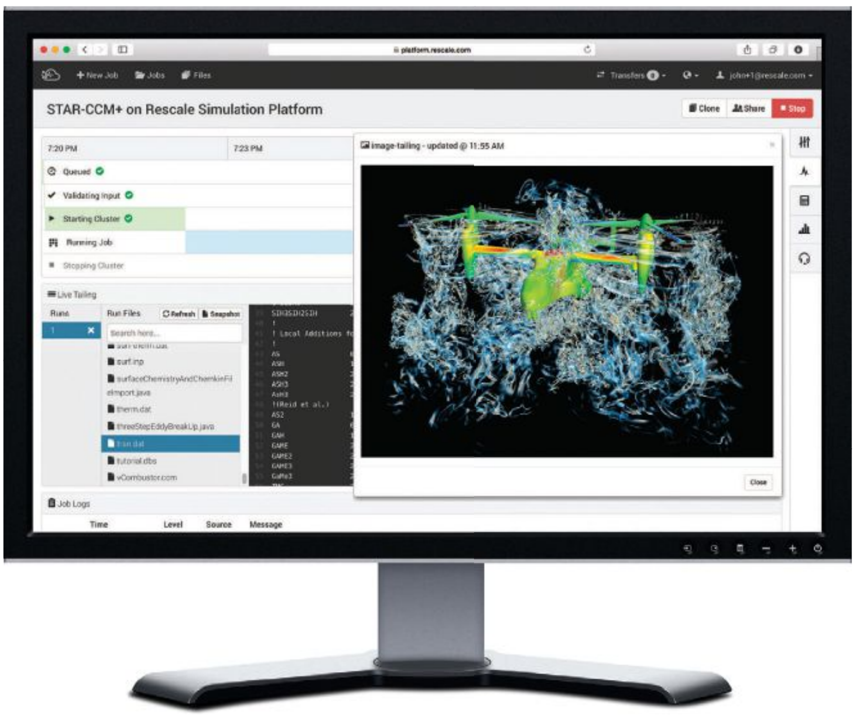
BY RANDALL S. NEWTON

Innovations in the design and deployment of high-performance computing (HPC) hardware and supporting middleware are paving the way to new services and opportunities to improve engineering simulation and analysis. Vendors and customers alike are finding ways to increase the number of simulations, spend less money and still get results faster than with traditional methods.

At the heart of this revolution is not one innovation but several, creating what could be called a simulation stack. You may be familiar with the software term "stack" popularized by the rise of open source software solutions that have become foundational in computing today. The best-known stack is LAMP (Linux, Apache, MySQL, PHP): four separate technologies that when used in tandem become a synergistic force that make today's connected world possible.

The emerging simulation stack is a trifecta of faster/cheaper/better, moving simulation further upfront into the design cycle and bringing to reality the often-prophesied "democratization of simulation."

The simulation stack is still a fluid concept. The software and hardware varies from vendor to vendor. Elements include cloud storage and computation, HPC clusters, virtualization technology and the use of GPUs (graphics processing units), either specifically for graphics computation or for general-purpose computation.



Rescale is a cloud simulation platform designed to make simulation easy through an integrated, optimized, workflow-driven solution. Shown on the screen is a CD-adapco STAR-CCM+ simulation of an Osprey tilt-rotor aircraft running on Rescale's simulation platform. *Image courtesy of Rescale and CD-adapco.*

Eating the Dog Food

There is a saying in the software industry: "eating our own dog food." It started at Microsoft in the 1980s, when a manager told employees they needed to be using Microsoft products whenever possible.

Altair is no stranger to using its own engineering simulation solutions, having launched as a software developer in 1985. But Altair also offers consulting services, taking on complex CAE projects for customers in a variety of industries. "We produce software, but we are also a big consumer of it," says Ravi Kunju, head of strategy and marketing for Altair's enterprise business unit. Over the years Altair has built several HPC data centers strategically placed around the globe. Creating each data center was a six-to-eight month process, Kunju says, of specifying hardware components, choosing vendors, selecting CAE applications (its own or from competitors) and modifying software for cluster management and scheduling, and much more. In software industry terms, Altair was eating its own dog food.

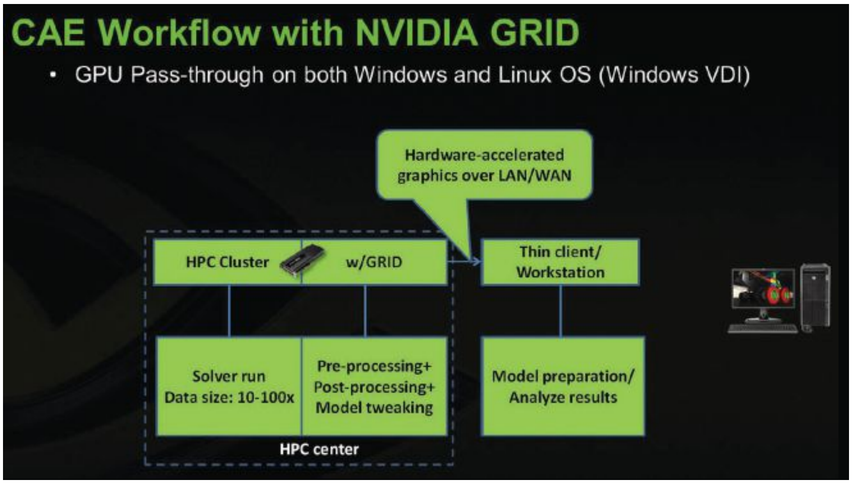
As computer technology advanced, Altair realized it could replace all the work of creating each custom installation with a simulation appliance. Now known as HyperWorks Unlimited, the appliance puts in all the required software and hardware in one physical unit. Altair built the appliance for its own use, but also produced a commercial model. "It gives the customer a Web portal, not a Linux command line," says Kunju. "Our customers could connect, power up and run their first project in one hour."

The HyperWorks Unlimited appliance eliminated the need for individually sourcing every part of a HPC cluster and its associated storage and software. Altair leases HyperWorks Unlimited, turning a capital expense into a recurring operational expense item. Today each appliance is custom built in a six-to-eight week process of determining customer need and building it to match.

Kunju say the 5,000+ customers of HyperWorks Unlimited include boutique consulting firms, Fortune 100 manufacturers and everyone in-between. But there were still customers for whom the appliance was too expensive or more powerful than required. When cloud computing and virtualization arrived on the scene, Altair realized they could be used to take the appliance concept to another level. "We have replicated the physical appliance as a virtual product," says Kunju. "It offers all the access, all the applications, and the same portal, but we don't move a physical appliance to the premises; they get it on the cloud." Kunju says Altair can spec and deliver a physical copy of HyperWorks Unlimited in six to eight weeks, but it can deliver a virtualized cloud version "in minutes."

A virtual HyperWorks Unlimited brings high-performance simulation to a larger customer base, but there is still a problem: bandwidth. A single simulation from a 1MB input file can generate 10GB of data. If a customer is connecting on a 10 Mbps connection, it takes hours longer to download the results than to generate the data. Altair solves the problem with another part of the emerging simulation stack, remote graphics virtualization support. "One customer calls it the best thing they've introduced into HPC," says Kunju. Customers can run their simulation jobs and immediately process the data where it is, viewing and working with the graphical results as if they were being generated on a local computer.

NVIDIA's GRID is installed as an add-in board to servers or workstations. *Image courtesy of NVIDIA.*



GRID technology can eliminate the bottlenecks by taking over the solver and post-processing stage, NVIDIA states. *Image courtesy of NVIDIA.*

Changing the Workflow

Access to high-performance simulation on-demand turns the traditional system of running CAE jobs on its head. When all simulation and analysis work had to be submitted to an in-house computing center, jobs were prepared then handed off to specialists. All workflow was based on the capabilities of the data center. An engineer might say "I can only run my job on 20 cores, because if I do more people will be standing in line." To run a simulation every day, engineers had to optimize models to complete a run in eight to 10 hours. Now engineers are adapting to a new reality of unlimited cores available on-demand without scheduling issues. To get a faster result, it is now possible to throw more cores at the problem instead of reducing the complexity. "Use the cloud for dynamic provisioning of resources," says Altair's Kunju. "No more worries about fixed resources and budget and time constraints." Altair refers to this process as design exploration; others call it the democratization of simulation.

Rescale is an engineering simulation service provider with a different approach. It does not write CAE software but offers products from all vendors as a cloud-based service. Rescale CEO Joris Poort says the on-demand access to as many as 10,000 HPC computing cores beats on-premise HPC in two key ways that radically change engineering workflow.

First is the accessibility of services. "Our customers upload a model and kick off the job in a few clicks," says Poort. "It does not require knowledge of how to access the hardware. Many who are traditionally trained as designers are now doing simulations, and others are running more simulations because of the ease." Barriers to entry are removed, Poort says, and feedback comes more quickly, creating a virtuous cycle of more information to move to the next design iteration faster.

The second big workflow change is related to cost. The cost of running a purchased copy of NX Nastran for a year might work out to between $10 and $20 per hour. One hour of using Rescale might cost double on an hourly basis, but only be used a few hours a year. And that's just for the one software product; there must also (generally) be a dedicated workstation or HPC cluster running the software, and at least one person dedicated to its use. The savings add up rapidly, and as the cost advantages sink in, Rescale users generally run more simulations and run them more often.

Rescale provides common-use clusters and custom clusters. "We tailor the hardware to the simulation," says Poort. An acoustics simulation may require terabytes of processing RAM and storage, but such a hardware investment is out of reach for all but the largest users. Part of the Rescale offering is matching the customer and the service. Rescale works with the leading cloud vendors, including Microsoft Azure and Amazon Web Services. Customers do not have to modify their IT stack for a particular cloud service; Rescale acts as the middleman.

Visual computing hardware specialist NVIDIA is also a player in the new simulation stack. Baskar Rajagopalan, senior marketing and alliances manager at NVIDIA, sees big changes coming to the traditional three-step CAE workflow. The three steps — pre-processing, solving, and post-processing — have been done on three different computers or a mix of workstations and HPC clusters for years.

Pre-processing prepares a simulation model from the original CAD design, usually on a local workstation. The results are then passed along to a HPC cluster or single high-performance computer. The results then move to post-processing (generally a single workstation) for design review and possible submission of another simulation run. Typically, if the data is 1x at pre-processing, solving generates from 10x to 100x of data. Moving this data back to another computer for post-processing can become a significant bottleneck; it might take longer to move the solution set data than to generate it.

NVIDIA says its GRID technology — GPU technology as a cloud-based service — can eliminate the bottlenecks by taking over the solver and post-processing stage. "Move the model tweaking back to the cluster and save all the transfer time," says Rajagopalan. This "GPU pass-through" saves all the transfer time while offering a state-of-the art computing environment for the solving stage. "Any engineer can now use the data set when the system is idle," he says. NVIDIA's GRID service is available both as a dedicated cloud device and as a virtual appliance.

Because Rescale's simulation platform is cloud-based, it can be accessed via lightweight computing devices, such as a tablet. ***Image courtesy of Rescale.***

Rajagopalan agrees this new technology is giving engineers reason to change their workflows. But he notes such change is not coming at break-neck speed. "CAE users are conservative; adoption is just the start." Few engineering companies use the latest versions of their CAE products. The current version of ANSYS Workbench, for example, is certified for use on the NVIDIA GRID, but most ANSYS customers are two or three releases behind. "We foresee more use [of this technology] as customers upgrade their software, then they will also do a hardware refresh" and consider new options. **DE**

Randall S. Newton is Principal Analyst at Consilia Vektor, and a contributing analyst for Jon Peddie Research. He has been part of the computer graphics industry, in a variety of roles, since 1985.

INFO ➜ **Altair:** Altair.com

➜ **NVIDIA:** NVDIA.com

➜ **Rescale:** Rescale.com

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Computer Cluster Considerations

BY JESS LULKA

When it comes to selecting a high-performance computing (HPC) cluster, how can you ensure you're picking the right system for your needs? *Desktop Engineering* chatted with experts to find out the most important aspects engineers should consider.

Q: What are the most common HPC cluster misconceptions you see?

A. Dominic Daninger, vice president of Engineering, Nor-Tech: Many potential HPC users view clusters as difficult to setup and maintain. We also commonly see users who are moving from the workstation CAE environment to an HPC cluster environment who view and attempt to use the cluster as just a bunch of workstations. They don't understand the intelligent job schedulers and resource managers that a cluster can add to the engineer's toolkit. They miss the fact that a cluster can be used as a powerful shared resource and can run multiple different CAE applications at the same time for different users.

A. Rod Mach, principal at TotalCAE: A common misconception is that cluster systems are too expensive. The increase in the amount of engineering work that can be done per month, when compared to the monthly cost to obtain that capability, makes the ROI a no brainer. Another misconception is focusing on hardware as the only enabler, instead of the entire engineering workflow required to make engineers more productive.

Q: What are the top cluster considerations for design engineering teams?

A. Daninger: Some users don't understand what applications can be run on a distributed parallel computing machine, which a cluster is. They don't understand which CAE applications they need for their work. Many of our customers come to us after they have lost projects to their competition on a time-to-market basis. They may not be using design simulation or if they are, they may be doing it on workstations and waiting 72 hours for each solver simulation solution.

A. Mach: The first consideration is the impact to their product if they were able to do more analysis per day. If each engineer can go from one simulation today to three or four in a single workday, that makes the justification an easier sell to management. Another consideration is to validate that your models and solver will obtain speedup. Have your cluster vendor benchmark your model, and see the real-world impact. Finally, teams should consider working with a vendor who understands their solver applications, and can deliver a complete turnkey solution.

Q: How should engineers determine cluster size?

A. Daninger: Available budgets for CAE simulation are an important consideration when determining cluster size. The software licensing can often be 60-70% or more of the cost for purchasing a CAE cluster. It is important to understand how the customer models scale.

A. Mach: Typically, common models engineers would run are benchmarked on the proposed system to determine the optimal number of CPUs to run based on a price/performance curve. Then we determine the mix of jobs they need to run, and the target amount of work per day, to determine the optimal size.

Q: Why would engineers choose an in-house private cluster vs. a cloud computing solution?

A. Daninger: Intellectual property protection is one of the key reasons that customers choose to go with an in-house private cluster vs. a cloud solution. Another reason is very few cloud HPC offerings have InfiniBand fabric. Cloud solutions typically will offer 10G Ethernet, which has much longer latency times than current InfiniBand fabric.

A. Mach: Private clusters have the following advantages over public cloud computing solutions: There is no change to the engineering workflow. There are no extra CAE licensing complexities, all work can be done on the same central system. An on-premise professionally managed cluster is much cheaper for your baseline constant engineering computation needs. A private system is completely inside the corporate firewall, which for some organizations can address data governance and security concerns. A private cluster is highly reliable. CAE software implicitly is designed with the assumption the underlying hardware, software and interconnects are highly reliable. DE

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Make Time

Top 5 ways desktop 3D printers speed the engineering design cycle, resulting in a rapid return on investment.

THE LATEST GENERATION: Includes the MakerBot® Replicator® Desktop 3D Printer and the MakerBot Replicator Z18 3D Printer. (left-right).

1 Reduce prototyping time and expenses. Instead of outsourcing every prototype, a desktop 3D printer can democratize design by allowing more engineers to test proof of concept, especially in the early stages of development.

2 Create better designs. The ability for design engineers to 3D print at their desks allows them to try new ideas and make mistakes. Without real-time prototyping, the most innovative design may never be discovered.

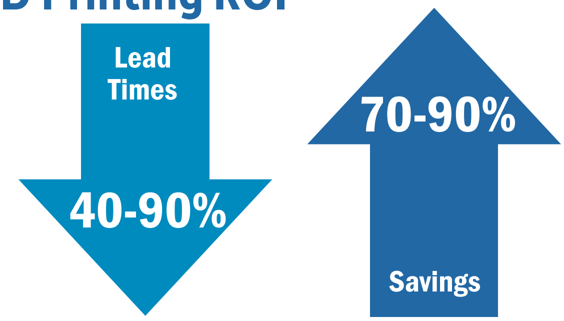
3 Speed approvals. Hand a client or upper-level management a physical model to transform the design cycle. 3D printing speeds the design process by ending arguments and avoiding long meetings, leaving more time to focus on the best ideas.

4 Ease of use increases productivity. Using the latest generation of MakerBot® Replicator® Desktop 3D Printers allows design engineers to choose settings that range from fast drafts to finer resolutions that don't need postproduction. The printers' large build volume, on-board camera and diagnostics, and assisted build plate leveling accelerate prototyping. The printers' Wi-Fi, USB and Ethernet connectivity ensures a seamless production workflow that can be remotely monitored.

5 Competitive advantage. Be faster out of the gate with a design that has been prototyped and improved multiple times by incorporating desktop 3D printing into your design engineering workflow.

> "The idea is **speed**. We build a concept, test it, try it out, make mistakes, do corrections, and are always pushing to go even **faster**. We try to go to 3D printers as soon as we can."
>
> *— Rick DeVos, senior consulting engineer, GE FirstBuild*

3D Printing ROI



MakerBot and Stratasys estimate that 3D printing can realize a 40-90% reduction in lead times and a 70-90% cost savings when used in the creation of jigs and fixtures.

For more information, download the free white paper, Economics 101 for Desktop 3D Printing *at deskeng.com/de/3Dprinting101, produced by* Desktop Engineering *and sponsored by MakerBot.*

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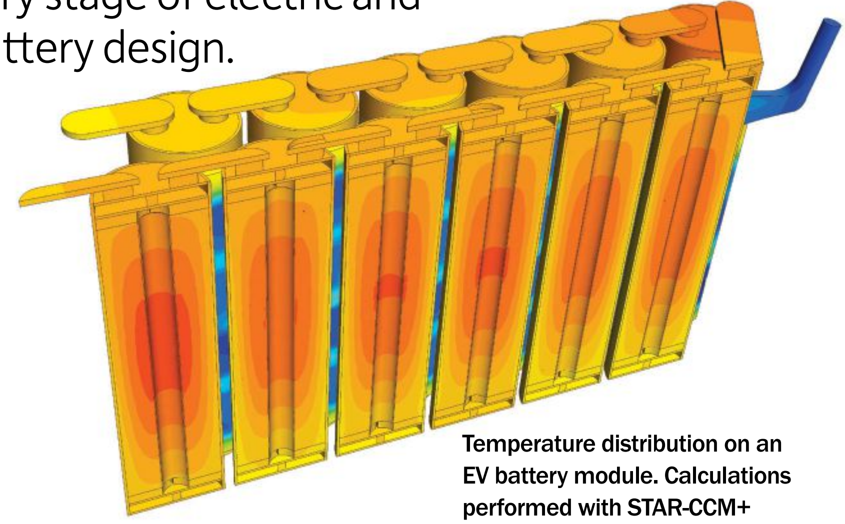
Powering Up Battery Design with Multiphysics Simulation

There is software for every stage of electric and hybrid electric vehicle battery design.

BY PAMELA J. WATERMAN



Temperature distribution on an EV battery module. Calculations performed with STAR-CCM+ multiphysics Battery System Module. ***Image courtesy of CD-adapco.***

In the world of battery design for electric and hybrid electric vehicles (EV/HEVs), temperature is everything. Electrochemical reactions create heat. Radiation and conduction distribute that heat, components expand and change contact, and hotspots trigger more electrochemical reactions. This interwoven behavior of chemical, electrical, mechanical and fluid properties means that designers must address thermal considerations with multiphysics simulation software. Fortunately, such tools are more capable and connected than ever.

At the Heart is the Cell

EV/HEV batteries are complex systems comprising multi-element cells, multi-cell modules and multi-module packs, best analyzed with computer simulations. Some software focuses on the details of cathode/electrolyte/anode design in cells, some packages offer bi-directional multiphysics analysis across system components and still others take a mathematical, equivalent-circuit approach to both hardware and control-system design.

Thermal management is crucial for the capacity of the battery, as well as for safety.

"Temperature gradients can develop in a battery pack, where one cell is hotter than another," says Sandeep Sovani, director, Global Automotive Safety at ANSYS. "Internal currents develop; one cell starts to charge another rather than sending the current to drive the vehicle. The car drives less [efficiently] because the cells are just charging each other. Thermal management ensures that cells are evenly cooled."

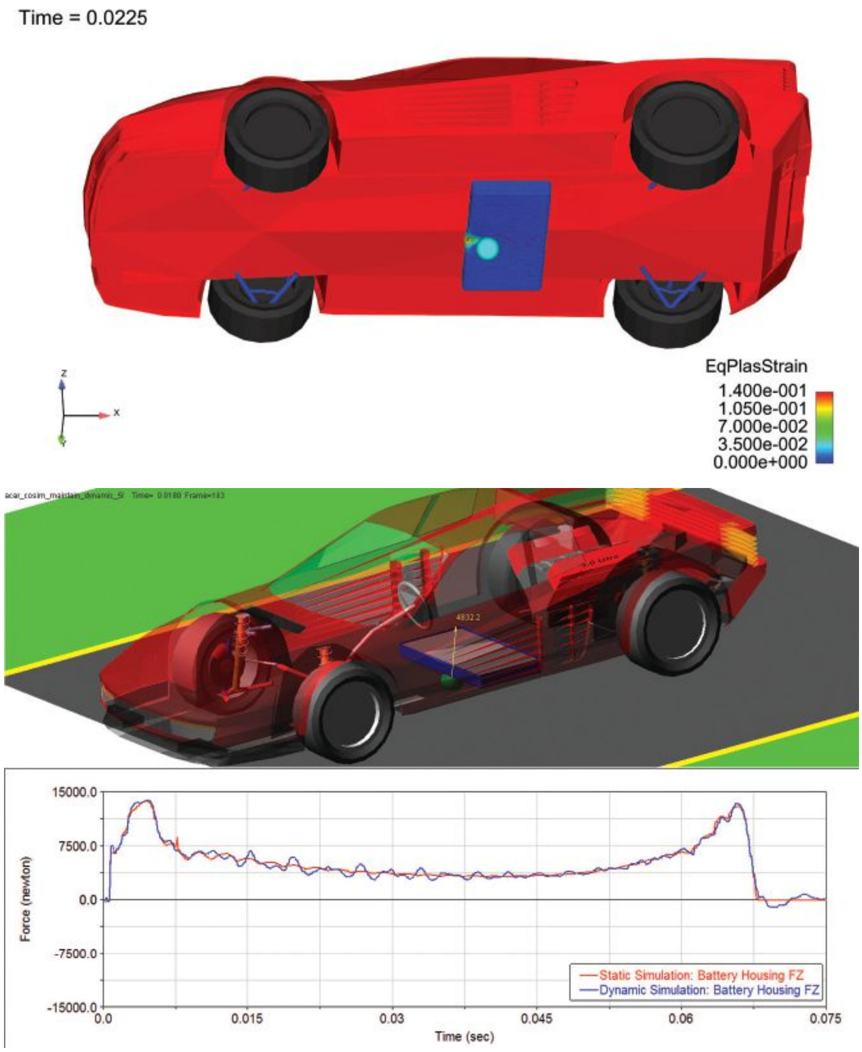
Sovani notes that thermal management is complicated because it is multi-scaled, with the microscopic electrochemical phenomenon affecting the cooling strategy at the meter scale and vice versa. From a simulation perspective, coupling the models across the scales is a challenge; since users would like to run cycles that simulate, say, an hour of vehicle operation, standard CFD (computation fluid dynamics) analysis runs would take far too long.

The ANSYS solution uses a reduced-order model (ROM) method to do a detailed analysis at the smallest scale. Translating these results into operational characteristics of the electrodes (values which are almost as accurate), the larger-scale cooling channel model can be simulated in much faster runs. The results are verified by comparing one instance of the ROM model to a full CFD run as well as to data from lab experiments.

CD-adapco offers three approaches to battery challenges. First, microscopic-length-scale simulation is standard within the company's STAR-CCM+ license as the 3D-MSE feature. Second, the company provides Battery Design Studio (BDS), supporting simulation of Lithium-ion cells and cell-pack arrangements. This package lets battery developers assess materials (additives, electrolytes, separators) and components (cans, seals, headers, spacers) for predicting current, voltage and temperature. Users can fit simulated results to experimental data.

Third, the STAR-CCM+ Battery System Module (BSM), which combines the electrochemical solver of BDS with the flow and thermal solver of STAR-CCM+, calculates the 3D thermal, fluid and electrochemical cell-to-pack properties. It can model standard layered cells or those with a spiral geometry pattern, predicting performance-using models defined as physics-based or equivalent-circuit.

Throughout the design process, what's key is the ability to account for non-constant heat generation during actual vehicle operation. "When you drive an EV/HEV vehicle, you accelerate, so



Stress and reaction force analysis of EV battery housing, due to impact from a foreign object (represented by a sphere in the top image). Analysis performed with Marc FEA software from MSC Software, with results passed to the company's Adams software; the full vehicle is modeled in Adams, which calls Marc at every time increment and imports the results. *Images courtesy of MSC Software.*

you have a power demand that's generating heat. But, you'll be braking as well, so you generate some heat in recharging the battery," says Gaetan Damblanc, battery application specialist at CD-adapco. In the past, he says, with a constant-heat model, this evolution pattern was not respected; now with BSM it is.

During the drive cycle, the battery's external climate also changes, so it is critical to have BSM's coupled solutions account for all influences to better optimize the cooling system. "The way you can arrange the battery cells, how big the space between cells should be to ensure the most optimum cooling efficiency, what kind of cooling you should do – passive or active, air or water cooling – you can do all of these strategies," Damblanc says. He adds that the BDS can even simulate the resistive lithium build-up over time on the electrodes' solid-electric interface (SEI), accounting for another aging factor.

ESI Group has a strong history in the development of complex fuel cells and EV batteries. Its ACE+ Suite is a modular, customizable analysis package that offers solvers for a broad range of physics, from flow and heat transfer to electrochemistry and stress-deformation, covering all stages in the value-chain of battery design. The software offers strong multiphysics coupling, which Kunal Jain, product manager at ESI Group, says allows designers to analyze battery performance at the component, cell, module and pack levels without compromising on any one physics type.

"Most companies want to reduce the cost, increase the life span, improve safety and increase the charge and power (of EV batteries)," says Jain. "They also want to reduce weight, size and charging time," a tough challenge to achieve simultaneously. However, Jain adds that the workflow automation in ACE+ Suite enables a quick design of experiments (DOE) of different thermal management configurations, which helps cater to the needs of the battery industry.

Batteries of all types, and at all levels of operation, can be analyzed within the Batteries & Fuel Cells module of COMSOL multiphysics software. From the transport of dissolved gases in pore electrolytes, to the inclusion of structural stresses on electrodes during charge and discharge cycles, this module gives users flexibility to define behavioral equations and have them depend on desired variables.

COMSOL offers a number of tools beyond the necessary coupled multiphysics for improving battery design, including it's new Application Builder software package, says Ed Fontes, chief technical officer, COMSOL. It can be used by modeling specialists to create dedicated user interfaces for specific purposes.

"The principle is quite simple and is nothing new for experimentalists. However, it is pretty new in multiphysics modeling software," says Fontes.

One such application is a customized tool that lets users study how design parameters impact electrochemical impedance. Incorporating fully coupled multiphysics, instead of equivalent circuits, improves the accuracy of the study.

Simple is Powerful

Many battery suppliers use Siemens' LMS Imagine.Lab Amesim simulation tool as a first step, putting together a

1D multiphysics model of a battery pack instead of jumping right away into a 3D CAD environment. "They say, 'I don't yet have a CAD model,'" says Hari Vijayakumar, director of business development, MBSE Solutions, Siemens PLM (product lifecycle management), "'but I know I need to generate this amount of voltage, this should be the peak current and I have a space constraint. Let's try to build a 1D multiphysical model of a battery pack with all my assumptions, and see if my assumptions make sense.'"

Cells are modeled in Amesim mostly by equivalent circuits; users then add mechanical, fluid and thermal aspects plus a battery control system. The result is a fast-running 1D model of a battery operating inside a vehicle, seamlessly integrated with simulated controls. Thousands of such multiphysics models can run in an hour, letting everyone quickly evaluate the quality of the proposed design.

Once Amesim identifies a good design direction, users move to detailed 3D analysis. "Now you can run a co-simulation, where the physics justifies determining 3D fields like distribution of temperature in an enclosure," says Sairam Prabhakar, thermal products manager for MAYA. "You can't have one tool that does it all, so this is an open platform for multiphysics."

Newcomer EC Power stepped into this field in 2011 with a fresh look at speeding up battery simulation. Its AutoLion thermal coupled battery (TCB) modeling and virtual testing software captures all aspects of Li-ion batteries, from performance to safety to system integration. The AutoLion suite targets three user groups: AutoLion-1D is for material developers and cell manufacturers, AutoLion-3D supports cell and battery-pack designers and AutoLion-ST supports the model-in-the-loop level needed for vehicle integration and control systems.

Real-World Battery Use

As with so many other kinds of product design, at some point engineers are

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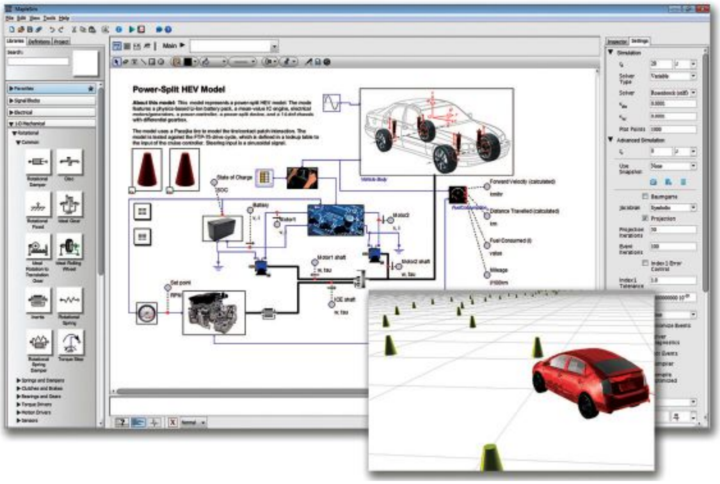
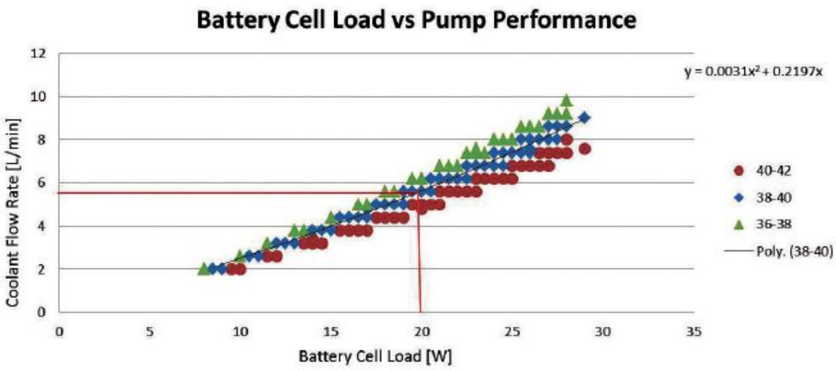
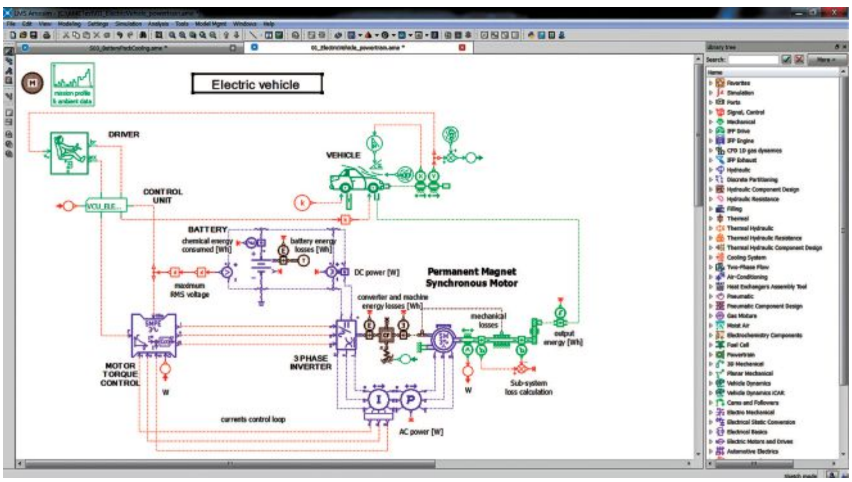
- "Why Batteries Perform Poorly in Cold Weather": COMSOL.com/blogs/
- "Driving the Future of Advanced Automotive Batteries": CD-adapco *Dynamics* magazine, March 2015
- "What to Consider Before Deciding on the Right Li-ion Battery Software for Your Application": ECPowerGroup.com/blog/



The MapleSim application and the MapleSim Battery Library allow you to incorporate physics-based predictive models of battery cells into your system-level HEV/EV vehicle models. *Image courtesy of Maplesoft.*



Trendline for a sustained battery cell load vs. coolant flow rate, performed with Mentor Graphics FloEFD software is pictured. A thermal engineer could use this as a starting point for fine-tuning of pump control algorithms. *Image courtesy of Mentor Graphics.*



Electric vehicle model for range and state of charge, done with Siemens LMS Imagine.Lab Amesim 1D multi-domain simulation platform. *Image courtesy of Siemens PLM Software.*

handed a spec sheet of battery characteristics and told to just make it work in the vehicle environment. Mentor Graphics, which specializes in automotive technologies simulation, knows this well. "As the phrase 'operational behavior' says, the OEM (original equipment manufacturer) and Tier 1 supplier can only try to manage any misuse of the battery [using] the battery controls electronics, or improve the thermal management to limit its influence on the battery and its life," says Boris Marovic, product manager for Mechanical Analysis/Simulation at Mentor Graphics.

Mentor Graphics continues to improve its FloEFD 3D CFD solution, either stand-alone or embedded with many MCAD packages for concurrent design simulations. "In our latest version, we improved our transient solver, which in one of our test cases gave around 25 times faster results compared to the old solver. Larger time-steps can be considered but with the same accuracy as before," says Marovic. The company also offers Flowmaster, a 1D thermo-fluid solution

Battery system designers are always trying to reduce the weight of their products while maintaining sufficient cooling and safety. People generally consider electrochemistry aspects first, but mechanical seals also play a critical role. MSC Software's products help analyze such details.

"You don't want the electrolytes leaking," says Srinivas Reddy, senior product marketing manager, Global Products, MSC Software. "Whether over time, or if there is a crash or if a stone is impacting from the bottom." Manufacturers can design a stiff housing but that affects the weight. To quickly identify yield or breakage, MSC Software has incorporated non-linear finite element analysis (FEA) of parts as a co-simulation of the entire vehicle multi-body dynamics (MBD) done with MSC Adams. At each time increment, Adams passes loads to Marc, which does the FEA on the fly then passes the results back to Adams, saving computation time and giving more accurate feedback on seal behavior.

Another company addressing aspects of battery simulation is SIMULIA. "I think [analysis] is one of those areas more than anything else in automotive that is fundamentally fragmented," says Brad Heers, engagement manager, Transportation and Mobility, SIMULIA. "So many pieces are moving at the same time, and each one uses a simplification to look at the other."

SIMULIA is open to supporting other software within the Abaqus co-simulation framework. "It's important for customers to use what they see as 'best in class' at each stage, such as BDS software to give the charge and load," says Heers. "Classic Abaqus users then do the electro/thermal/structural analyses, using the electrical charge to derive Joule heating, which results in thermal strain, which can cause changes in contact." Results can also be input to a CFD code to investigate venting, with subroutines linking results.

For a Different Point of View

Maplesoft recently announced its MapleSim Battery Library, an add-on component library that enables engineers to incorporate physics-based predictive models of battery cells into multidomain models. What's important about these models is that they're not just about the batteries but how they behave when deployed in the vehicle when it is running.

"We have equivalent-circuit-based models as well as models based on physical and chemical reactions," says Laurent Bernardin, executive vice president and chief scientist, Maplesoft. "Both are able to run in real time. You can hook them up to a driving simulator, to a steering wheel and a gas pedal, and it will show how the battery will respond in real time." Input parameters can come from FEA calculations (such as output from ANSYS or Abaqus) or from experimental measurements; results include what kind of energy the battery will draw, what kind of heat flow to expect, and how long the cells will last. "These days, too many different parts interact – it's really critical to test how the battery system behaves in the entire (vehicle) system," says Bernardin. **DE**

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POWERING the Internet of Things

How do engineers figure out a way to run a massive network of wireless sensors?

BY MARK CLARKSON

The Internet of Things (IoT) will be millions or billions of wireless sensors, monitoring everything from doors and windows to air quality and soil pH. It won't all plug into the wall, so how will we power it?

We've been conditioned to think of computing progress in terms of ever greater horsepower – megabytes moved, or millions of triangles drawn and shaded – but that's not the only path we can go down.

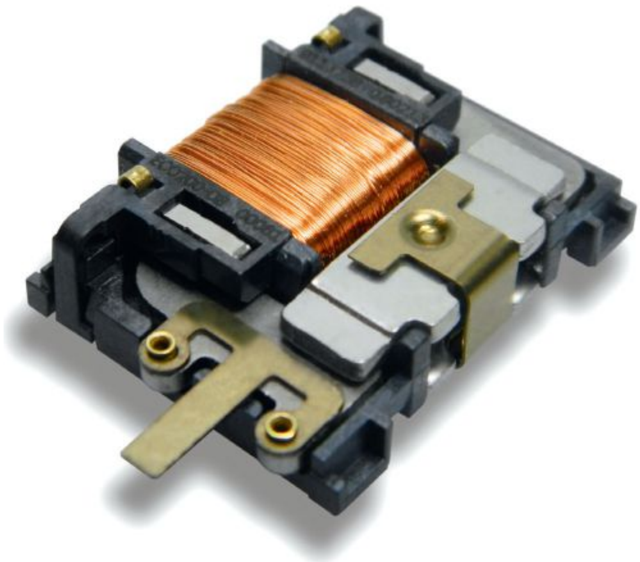
"The good news," says Brendan Richardson, CEO, PsiKick, "is we're moving away from dependence on Moore's law." PsiKick is creating a full system on chip: MCU, analog front end, power management, radio and memory on a single piece of silicon.

"Most of these embedded sensors and nodes won't need a 7nm system with a billion gates," says Richardson. "Performance is not the driver anymore. The sharp end of the stick is going to be power efficiency. The next big volume driver for the IC (integrated circuit) industry will be achieving the lowest joule per operation on your silicon. That's the lens we look at the world through."

300 Million Batteries a Day

Sure, you can slap in some batteries to power some Internet of Things devices, but batteries have a limited lifespan. Even sitting on a shelf, they'll lose charge over a few weeks, months or years. I if they're rechargeable, you can only recharge them a limited number of times. They're big. They're heavy. And they have a disproportionate effect on the final form factor of any product that includes them. But it's worse than that.

The next few decades will see deployment of hundreds of billions – maybe trillions – of independent, wirelessly connected devices. "If you had a trillion sensors," says Richardson, "and each sensor had a 10-year battery attached to it […] you would still need to change nearly



An electromechanical harvester for kinetic power. *Image courtesy of EnOcean.*

300 million batteries every day of every year."

Clearly that won't work. Can we build a sensor platform that doesn't depend on a battery? Yes, says Richardson, "but to get there we have to look at a power budget that can live on ambient harvested energy – somewhere in the tens of microwatts."

Harvesting Power

How about generating your operating power onboard the sensor itself? EnOcean specializes in switch and sensor networks that are wireless and self-powered. No wires, no batteries. "As the [volume of sensors] increases, many people foresee the issues associated with accessing and changing batteries as quite an impediment to the rapid adoption of this Internet of Things," says Jim O'Callaghan, president, EnOcean. "So EnOcean specializes in generating the energy for powering a switch or sensor right at the switch or sensor. For instance, we have a little inductive harvester that, when you press a switch that couple of millimeters, snaps a magnet through a coil and generates a pulse of energy sufficient to send a radio signal a hundred feet, through a few walls." Simple electronics, maybe, but it still wows at trade shows, he says.

EnOcean devices also harvest energy from light and even temperature differentials. "If we can get about 3° C differential from one surface to another, we can generate electricity," says O'Callaghan. Think of a radiator valve, he says, powered by the temperature difference between hot water inside and cooler air outside, controlled by a wall thermostat, linked to a building automation system. "You can do all of that without wires or batteries."

Solid-State Sensing

The building control market is extremely interested in this kind of capability, to save energy – and money – by intelligently controlling temperature and ventilation. "The problem designers have is finding the transducers that measure temperature or whatever, that are low enough power for the amount of energy that you can create," says Bob Smith, technical director of Pressac Sensing. Case in point: carbon dioxide (CO_2).

"The building control industry has [wanted] to deploy CO_2 sensors with wireless communication systems that could transmit data from buildings to control ventilation. The problem was that CO_2 sensors were too power hungry," says Alan Henderson, managing director of Gas Sensing Solutions (GSS).

GSS came up with a unique, solid-state solution using LED emitters shining on photodiode receivers. "The magic recipe for this," says Henderson, "is that we tune both the LEDs and the photodiodes to the absorption waveband of CO_2. That means there are no filters, and you're using solid state technology which is very robust, has a very long life, and runs at very, very low power."

GSS's technique isn't limited fundamentally to CO_2. The company runs its own facility to grow LEDs and photodiodes, and can tweak the process to create detectors tuned for, say, carbon monoxide or methane, if the market is there. "It's not a trivial exercise," says Henderson. "There has got to be a business case behind it."

GSS's CO_2 detector is mainly used in building automation, but can also found in shipping containers, greenhouses and incubators. "It's very simple to use," says Henderson. "You just plug it into any wireless system."

Subthreshold Operations

Another opportunity to save power lies in the arcane realm of "subthreshold" circuit operation.

A transistor is like a switch. When you apply a voltage to the input gate, the transistor turns on, allowing current to flow from the source to the drain. Reduce the input voltage below a certain threshold and the transistor turns off, stopping the flow of current.

In reality, the operation of transistors isn't quite so binary. If the input voltage is slightly below the cutoff threshold, there is still some current leaking through the transistor. And that leakage is correlated to the input voltage; that is, you can modulate it. You can still do useful work with that transistor, even though you're working at voltages where it's nominally turned off.

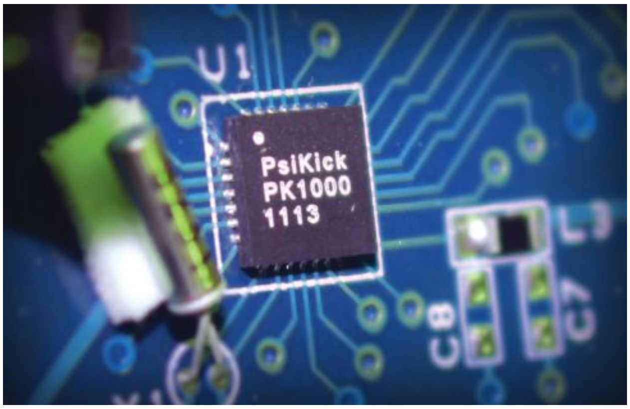
Miniaturized solar cells for light power.
Image courtesy of EnOcean.

The subthreshold region is noisy and finicky and not especially well understood. So why bother? "When you operate a circuit in the subthreshold region, the [power consumption] is reduced and the circuit slows down," says David Wentzloff, vice president of Engineering, PsiKick. "If you run a processor in the subthreshold region, you're not going to clock it at 3GHz like the processor in your laptop or your phone, but at 3MHz or maybe 300KHz. We're going to slow it down by a thousand times or 10 thousand times. But the energy that it consumes decreases quadratically – with the voltage squared." Reduce your voltage from, say 1.8v to 0.6v, and your overall energy consumption drops by a factor of 9.

"Provided I can still complete my task in the given time," says Wentzloff, "operating subthreshold is the most energy-efficient thing to do, in terms of how many joules [it takes] to complete a given task."

Subthreshold operation is transparent above the circuit level. "At the logic level and above," says Wentzloff, "the software is unaffected by subthreshold operation. Meaning you could run, for example, Linux on a subthreshold processor, just more slowly than at typical voltages."

Sadly, you can't take an off-the-shelf microcontroller and reduce its operating voltage to achieve spectacular power savings; it will just fail. A working subthreshold circuit must be designed and built, from the ground up, specifically to operate at subthreshold voltages. Not many people understand how to do it. Not everyone is convinced the technology is ready for production.



A prototype chip developed by PsiKick.

A DC/DC converter for thermal power.
Image courtesy of EnOcean.

A miniature, solar-powered temperature and humidity sensor from Pressac Sensing.

Compatibility is Key

"We've proven that you can build subthreshold in production," says Mark Foley, CEO of Ambiq Micro. "We've shipped well over a million parts now of our subthreshold real time clock." Their new ARM-compatible subthreshold microcontroller is eminent.

"We've gone into the underlying circuit technology," says Foley, "built our own models, and then run the ARM IP core on top. To the outside world – to an end user – it looks like any other MCU. If a customer is already using an ARM core and they've already written software, we can come in and say, 'Ours is lower power and you can run the same software.' Of course, they love that."

Using less energy means that your power lasts longer or, alternatively, that you can do more with it. "We have some customers who will swap out the [microcontroller] they're using for ours, so that the product battery will last a month or two instead of a week. But most people are actually saying it's more important that I add another sensor or two. Or three." Other customers are happy to keep battery life the same while reducing the battery's physical size.

Growing Confidence

"There's been some nervousness in the [building management] industry about wireless products, because of past performance," says Pressac's Smith. "Five years ago, if you put a battery in a sensor, you accepted that you're going to have to put a new battery in it in a year's time. But the reliability and the lifetime of wireless products is superb now. The energy harvesting and battery technology is so good, and power consumption so low, through technical innovation by people like Gas Sensing and EnOcean, that manufacturers like Pressac can make complete sensing solutions that are, in effect, maintenance-free." **DE**

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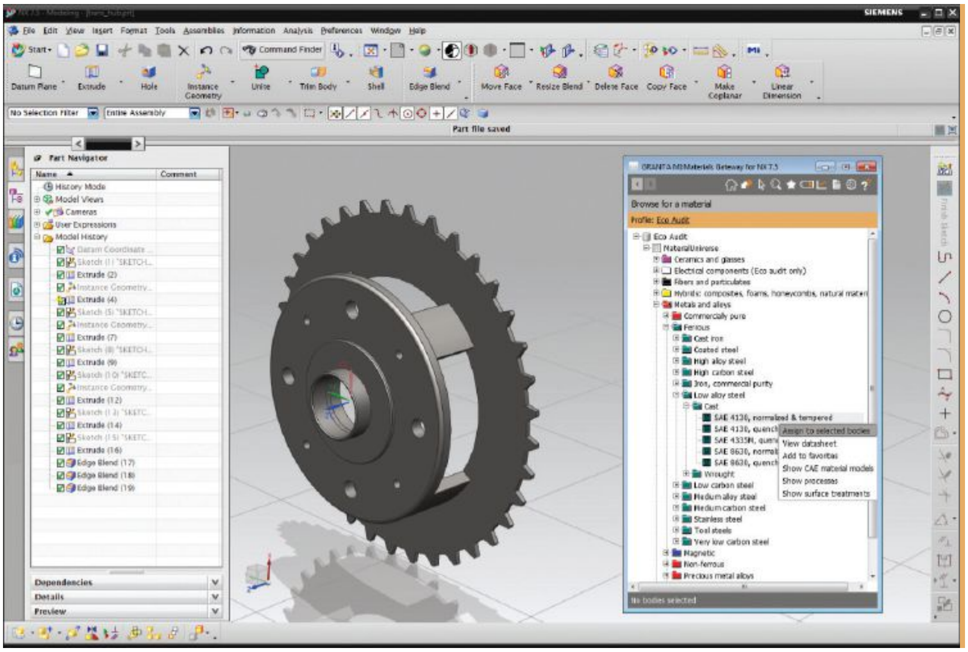
Consortium Tackles Materials Data Challenge

AutoMatIC aims to develop automotive industry-specific standards and best practices for organizing, managing and sharing critical materials data.

BY BETH STACKPOLE

The steel and auto industries have long been inextricably tied. Pittsburgh counts Detroit among its most prolific customers. But with regulators calling for higher emissions standards in the coming years, car makers have been steadily adding alternative materials like carbon fiber composites and aluminum to the mix, loosening their ties to steel and ramping up materials programs as part of competitive business strategy.

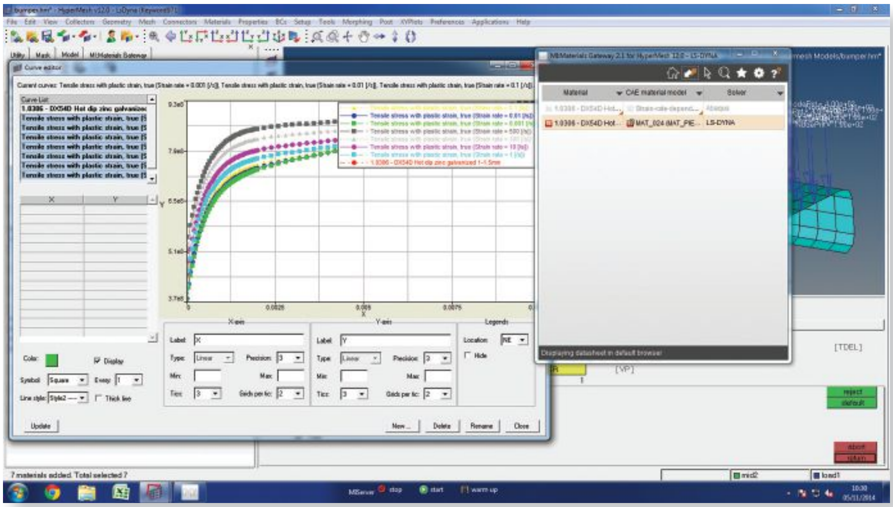
The heightened focus on materials has opened the door to the Automotive Material Intelligence Consortium (AutoMatIC), a new collaborative effort tasked with helping auto OEMs (original equipment manufacturers) and suppliers make the most out of materials information and develop best practices. Spearheaded by materials information expert Granta Design, along with five automotive industry founding members, the AutoMatIC takes a page from similar efforts in the aerospace sector to improve how materials data is organized and managed. By creating standard methods of storing and sharing materials-related data, the goal is to open up new avenues for automotive design engineers who have limited experience with the properties and behaviors of non-traditional materials.



A key AutoMatIC goal is to provide a standard view of materials across all stages of design and engineering. This screenshot showcases Granta's MI:Materials Gateway for Siemens NX — a window into a company's materials specifications directly within CAD. ***Images courtesy of Granta Design.***

"The auto industry has been using different materials for a long time, but they've never really had the strategic importance that they've gotten over the past few years," says Dan Williams, product management and marketing manager at Granta Design, which markets Granta MI, a materials information management system.

A look at some of the industry's marquee projects illustrates how far car companies have come melding alternative materials into next-generation vehicles. Ford Motor Co., for example, made headlines with the redesign of its best-selling F150 pick-up truck, which features an all-aluminum body to achieve a weight savings of 700 pounds over its all-steel predecessor. Still in the experimental stages is the multi-material lightweight vehicle (MMLV), a project between Ford and Magna International Inc. to create a concept vehicle that employs advanced materials in different areas of the car to achieve a nearly 25% weight reduction compared to the 2013 Ford Fusion, the production vehicle upon which it is based. There's also BMW, which has made significant investments in



Providing materials information to support virtual product development is a major AutoMatIC initiative. This image shows a three-way interaction between the materials database (GRANTA MI), the pre-processor (HyperMesh) and the solver (LS-DYNA).

carbon fiber materials that will be used to produce its i3 and i8 boutique electric vehicles.

"CEOs of auto companies are now talking about materials strategies and what the plan is for the right materials mix," Williams says. "With materials programs now taken so seriously, the time is right for a consortium that can help simplify and standardize best practices."

Taking a Page from Aerospace

AutoMatIC, announced last April, aims to do just that. In addition to Granta, founding members include such heavyweights as General Motors, Honeywell Turbo Technology, Jaguar Land Rover, KSPG AG and PSA Peugeot Citroën. The consortium was modeled after the Material Data Management Consortium (MDMC), a similar Granta-led effort to develop and apply software to manage mission-critical materials data for the aerospace, defense and energy sectors.

Since its inception in 2002, the MDMC has helped member organizations improve productivity in materials engineering, avoid data loss and duplication of tests and reduce risk in the engineering and design process, Williams says. The ability to routinely control, analyze and apply materials data has helped companies like NASA, Boeing, and Rolls-Royce save time throughout their complex design cycles while improving compliance with critical regulations. With AutoMatIC, Granta hopes to repeat those benefits in the automotive space, which have translated into millions in savings as well as milestones for participating MDMC companies.

"We have a phenomenally successful model in the aerospace industry and it's helping us define how this should be done," Williams says. "What we're doing with [AutoMatIC] is tailoring the technology to the needs of the automotive industry. Different industries rely on different kinds of simulation and do things in a different way."

Similar to aerospace, the automotive industry relies on a range of exhaustive simulation studies as part of the development effort to explore how vehicle designs hold up under various conditions, including crash tests, reliability and the impact of noise, vibration and harshness on the overall ride. The simulation's complexity calls for a keen understanding of materials' characteristics and behavior. Without best practices for sharing and storing materials-related data, there are little guarantees that engineers will have ready access to that data to make informed design decisions, Williams says.

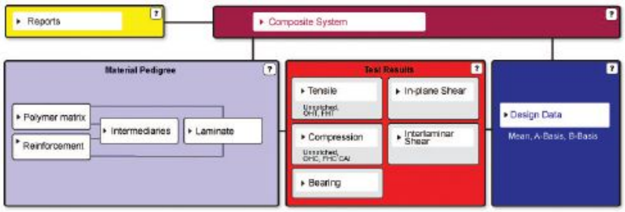
"It's more than just a few numbers about how strong and stiff a material is, there needs to be lots of data to understand how a particular material behaves when crashed at high speed or when it's vibrating next to an engine," says Williams. "This is complicated information, and the data becomes very valuable because there is an awful lot of money being invested in simulation. If the data you put into the simulation is bad, what you get out becomes bad as well."

While this information has been available in organizations, to some degree, it's been scattered and ad hoc. Williams says this is the data tucked away in a siloed crash test database or in a banned substance list that only the procurement department can access. Oftentimes, he said, the information isn't even in a formal database — it could be in spreadsheets or filing cabinets or even in the head of some guy who's retiring next month. "The data is scattered and tends to be in pockets," he says. "We are trying to create standards to join up all these communities."

The AutoMatIC Agenda

While it's only hosted one meeting (with another slated for later this month) AutoMatIC has a few key objectives. The first is to create templates for how composite data is stored and managed, which would facilitate the exchange of key design information and be much easier for automotive industry players than designing a schema on their own, Williams says. From there, the consortium is tasked with sharing expertise and best practices.

One thing Williams is quick to point out is that the consortium members do not share their materials data — only the schema, templates and best practices related to storing such data so intellectual property remains their own. "What we're doing is



This high-level schematic of a composites' "schema," developed by the aerospace industry-focused Materials Data Management Consortium (MDMC), is akin to what AutoMatIC will develop to meet the materials data management priorities of the automotive industry.

agreeing to how this data should be shared, we're not encouraging them to share competitive or sensitive data," he says.

The data sharing standards and best practices would transcend multiple layers, from the data security and collaboration best practices related to IT infrastructure, all the way through how to store and specify materials information related to composites, fabrics, lightweight alloys, and welding and joints. Standardizing how this information is managed and stored facilitates integration with other core design software like simulation, PLM (product lifecycle management), CAD, etc., Williams says.

Linking materials data to core CAD and CAE tools and gaining input to accelerate its own materials data management efforts are the primary reasons Jaguar Land Rover (JLR) is onboard with AutoMatIC, says Dr. Mark Blagdon, materials characterization technical specialist for the firm, which is a user of Granta's MI materials information management platform.

"We need quicker and more robust distribution of the design data via tighter integration between Granta MI and our PLM system and CAE pre-processor," Blagdon says. "This will be a common issue for other automotive OEMs so I hope we can use our collective voice to aid in prioritizing the development of these tools."

While JLR has invested a lot of time and money into developing a materials management strategy around Granta MI, there is a sharp learning curve in understanding how to store data, Blagdon says. The hope is the consortium's efforts can accelerate the process — for example, using the output from the "joining schema" workgroup to use as a base point for JLR's own joint properties database.

"By sharing knowledge and collaborating on common database schema and tools with other members will assist in our return on that investment," he says. "I have seen some excellent presentations by other members that has widened my understanding of how we could use the Granta MI tool to assist with JLR's wider data management needs."

AutoMatIC members don't have to be Granta MI users, although currently all founding members do have materials management efforts underway using the software. Williams says automakers can still benefit from exposure to best practices for sharing materials data so they can reduce risk, streamline costs and make the smartest decisions possible about materials.

According to JLR's Blagdon, there is too much at stake for automakers if they don't address materials data management best practices. "The cost of us not using this data or using poor quality data in the design phase due to either poor distribution or poor translation of data from one format to another is a threat to the robust delivery of the vehicle programs," he explains. "We need to develop 'more great products faster,' and a company wide materials database is key to supporting this aim." **DE**

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

INFO → AutoMatIC: GrantaDesign.com/automotive/consortium.htm

→ **Ford:** Ford.com

→ **Granta Design:** GrantaDesign.com

→ **Jaguar Land Rover:** JaguarLandRover.com

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Peak Performer

The new over-clocked workstation from BOXX delivers high-end results.

BY DAVID COHN

The BOXX APEXX 2 workstation features plenty of ports and a hinged power supply that provides access to the CPU and RAM. *Images courtesy of BOXX Technologies*

It is always exciting to receive a new workstation from BOXX Technologies. The Austin, Texas-based company has been building computers since 1996 and its systems have consistently delivered peak performance. The APEXX 2 2401 is the first new BOXX workstation we've tested since we reviewed the 3DBOXX 4150 XTREME (deskeng.com/de/?p=1551).

Like its predecessor, the BOXX APEXX 2 came housed in a custom-designed aluminum chassis measuring a compact 6.85 x 16.6 x 14.6 in. (W x D x H) and weighed just 18.75 lbs. The case is all black except for a brushed aluminum BOXX logo on the removable front panel and matching logo cutout on the top of the case. As in previous BOXX workstations, the front grille conceals a pair of 4 in. diameter cooling fans and holds a filter to trap dust before it can enter the interior of the case. On the APEXX 2, one of those fans is actually part of the CPU water cooling system.

Like the 3DBOXX 4150 XTREME, a single 5.25-in. drive bay above the front grille housed a 20X dual-layer DVD+/-RW optical drive as well as a panel containing two USB 3.0 ports, two USB 2.0 ports, audio jacks for headphone and microphone, a round power button with bright-white LED power indicator, a blue hard drive activity light and a small reset button. A Blu-Ray RW drive is a $212 option.

The rear panel was also identical to the previous BOXX workstation, providing four additional USB 2.0 ports, four more USB 3.0 ports (including one that allows for updating the system BIOS), an RJ45 network connection for the integrated Intel 1218V Gigabit LAN and both DVI and HDMI ports for the Intel CPU's integrated graphics. There were also six audio connectors (microphone, line-in, line-out, side, rear and center/subwoofer) as well as an optical S/PDIR Out port.

Improved Interior

Loosening a pair of captive screws and removing the right side panel revealed a compact but well-organized interior. In addition to the single drive bay with front panel access, there are also four internal drive bays — two 3.5-in. bays with quick-release drive mounts and two 2.5-in. bays. In our evaluation unit, one of those 2.5-in. bays contained an Intel 240GB SSD (solid state drive), an option that added just $47 over the 180GB SSD drive standard in the base configuration. BOXX offers other drive options, including SSDs up to 800GB and standard drives up to 4TB. The system's integrated drive controller supports RAID 0, 1, 5 and 10 configurations.

An air-cooled 550 watt 80 Plus Gold power supply tucked into the bottom rear of the case provides ample power for any expansion needs. Although the power supply covers more than half

Single-Socket Workstations Compared

		BOXX APEXX 2 2401 One 4.0GHz Intel Core i7-4790K 4-core CPU over-clocked to 4.5GHz, NVIDIA Quadro K5200, 16GB RAM	Xi MTower PCIe One 3.7GHz Intel Core i7-5930K 6-core CPU over-clocked to 4.32GHz, NVIDIA Quadro K5200, 16GB RAM	Lenovo P300 One 3.6GHz Intel Xeon E3-1276 v3 quad-core CPU, NVIDIA Quadro K4000, 8GB RAM	Digital Storm Slade PRO One 3.4GHz Intel Xeon E3-2687W v2 eight-core CPU, NVIDIA Quadro K4000, 32GB RAM	HP Z1 G2 One 3.6GHz Intel Xeon E3-1280 v3 quad-core CPU, NVIDIA Quadro K4100M, 16GB RAM	HP Z230 One 3.4GHz Intel Xeon E3-1245 v3 quad-core CPU, NVIDIA Quadro K2000, 8GB RAM
Price as tested		$5,111	$4,985	$2,072	$5,804	$5,918	$2,706
Date tested		2/4/15	12/13/14	11/9/14	5/10/14	5/3/14	11/24/13
Operating System		Windows 7	Windows 8.1	Windows 7	Windows 7	Windows 7	Windows 7
SPECviewperf 12	higher						
catia-04		100.40	98.53	38.19	34.81	42.23	n/a
creo-01		77.69	86.66	34.31	33.15	30.82	n/a
energy-01		3.61	3.49	0.65	0.60	1.74	n/a
maya-04		74.68	72.18	32.31	31.28	33.79	n/a
medical-01		30.01	28.84	12.38	10.75	10.34	n/a
showcase-01		49.76	48.98	22.64	20.65	21.12	n/a
snx-02		83.03	150.42	36.79	34.12	40.37	n/a
sw-03		130.28	126.08	69.37	50.78	38.66	n/a
SPECviewperf 11	higher						
catia-03		131.40	99.71	67.84	69.41	63.80	46.17
ensight-04		152.22	148.83	48.80	47.76	61.56	29.32
lightwave-01		107.01	100.99	88.54	76.90	82.76	87.98
maya-03		245.35	99.44	132.59	101.12	128.09	92.05
pro-5		27.19	18.19	21.34	16.29	17.18	20.25
sw-02		96.35	88.89	72.05	63.66	67.75	57.31
tcvis-02		106.96	78.64	55.66	54.26	58.99	38.78
snx-01		137.53	134.51	53.24	52.98	65.58	34.09
SPECapc SolidWorks 2013	higher						
Graphics Composite		10.27	8.82	6.29	5.37	5.67	4.38
RealView Graphics Composite		12.08	10.03	6.88	5.90	6.16	4.69
Shadows Composite		12.12	10.05	6.89	5.85	6.13	4.68
Ambient Occlusion Composite		24.55	17.58	9.65	9.46	8.48	5.81
Shaded Mode Composite		10.25	8.95	6.17	5.30	5.55	4.75
Shaded with Edges Mode Composite		10.30	8.69	6.41	5.45	5.79	4.04
RealView Disabled Composite		5.37	5.28	4.39	3.70	4.08	3.35
CPU Composite		4.87	4.50	4.18	3.70	3.12	4.15
Autodesk Render Test	lower						
Time	seconds	41.88	42.33	64.08	38.25	45.00	49.00

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

of the ASUS Gryphon Z97 motherboard, it swings clear after removing a pair of screws. The motherboard supports Intel 4th and 5th generation CPUs and is based on an Intel Z97 Express chipset. Our evaluation unit came with an Intel Core i7-4790K CPU, a 4th generation processor previously codenamed "Devil's Canyon." This quad-core CPU has a thermal design power (TDP) rating of 88 watts and features an 8MB Smart Cache. Although the processor has a base frequency of 4.0GHz and a maximum turbo frequency of 4.4GHz, BOXX boosts the base frequency to 4.5GHz. It then cools the CPU with an advanced liquid cooling system to ensure that the system runs cool and quiet.

The ASUS motherboard provides four memory sockets supporting 240-pin DDR3 DIMMs and accommodates up to 32GB of RAM. The base configuration comes with 8GB. Our evaluation unit came with 16GB, installed as a pair of 8GB 1600MHz DIMMs and adding $212 to the base price. The black rubber hoses extending from the CPU's heat sink to the radiator on the front panel make it a bit more difficult to access the memory sockets, but users should have no difficulty installing additional RAM.

The motherboard provides four expansion slots — two PCIe 3.0/2.0 x16 slots, a PCIe 2.0 x16 slot, and a PCIe 2.0 x1 slot — and supports both NVIDIA SLI and AMD CrossFireX technologies. Although the Intel Core i7-4790K CPU includes Intel HD Graphics 4600, the base BOXX APEXX 2 configuration includes an NVIDIA Quadro K620 discreet GPU (graphics processing unit). BOXX also offers other graphics options from both NVIDIA and AMD, as well as NVIDIA Tesla boards. Our system came with an NVIDIA Quadro K5200 graphics accelerator. This high-end GPU, which includes 2304 CUDA parallel processor cores, added $1,866 to the overall system price. However, the thickness of the K5200 blocks access to the adjacent expansion slot, leaving just two of the other slots accessible.

Peak Performance

We have come to expect great performance from every BOXX workstation and once again the BOXX APEXX 2 2401 lived up to our expectations. On the SPECviewperf tests, which focus solely on graphics performance, the APEXX 2 surpassed the performance of every other single-socket workstation we have ever tested on all but two of the Viewperf 12 datasets.

On the SPECapc SolidWorks benchmark, which actually runs SolidWorks 2013 and provides results more representative of actual CAD performance, the BOXX APEXX 2 out-performed all other systems equipped with a single CPU on all of the tests with the exception of the CPU composite.

On the AutoCAD rendering test, which clearly shows the advantages of fast CPUs with multiple cores, the BOXX APEXX 2 completed the test rendering in an average of 41.88 seconds, just 3.63 seconds slower than the current single-socket record holder, a system with the equivalent of 16 CPU cores compared to just eight in the BOXX workstation.

We also ran the SPECwpc workstation performance benchmark. Having now run this analysis on a total of eight systems, we are beginning to make more sense of the results obtained from this extensive assessment. The BOXX APEXX 2 scored at or near the top in most of the tests.

BOXX rounded out the system with a Logitech K120 104-key USB keyboard and a Logitech M500 USB laser mouse. Windows 7 Professional 64-bit came preloaded. Windows 8.1 is also available. BOXX Technologies backs the system with a three-year warranty featuring premium next business day on-site service with 24/7 phone support during the first year and depot repair service with weekday daytime phone support during the second and third years. Premium support during years two and three is available for an additional charge.

Like other BOXX workstations we've reviewed in the past, not only does the APEXX 2 deliver excellent performance, it does so at a very reasonable price. The BOXX APEXX 2 has a starting price of $2,937, which gets you the overclocked Intel Core i7-4790K CPU, 8GB of RAM, NVIDIA Quadro K620 graphics, a 180GB SSD drive, 20X DVD+/-RW drive and Windows 7. As configured, our evaluation unit priced out at $5,111. While that is much more than an entry-level workstation, the BOXX APEXX 2 delivers incredible performance, making it perfect for CAD and 3D modeling applications. 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.*

INFO → BOXX Technologies: boxxtech.com

BOXX APEXX 2 2401

- **Price:** $5,111 as tested ($2,937 base price)
- **Size:** 6.85 x 16.6 x 14.6 in. (W x D x H) tower
- **Weight:** 18.75 lbs
- **CPU:** One Intel Core i7-4790K (quad-core) 4.0GHz (over-clocked to 4.5GHz)
- **Memory:** 16GB DDR3 at 1600MHz (up to 32GB supported)
- **Graphics:** NVIDIA Quadro K5200
- **Hard Disk:** Intel 240GB SSD (four internal drive bays)
- **Floppy** None
- **Optical:** 20X dual-layer DVD+/-RW
- **Audio:** Onboard integrated high-definition audio (microphone and headphone on front panel; microphone, line-in, line-out, side, rear and center/subwoofer and S/PDIF out on rear panel)
- **Network:** Integrated 10/100/1000 LAN with one RJ45 socket
- **Modem:** None
- **Other:** Two USB 2.0 and two USB 3.0 on front panel; four USB 2.0 and four USB 3.0 on rear panel; integrated DVI and HDMI video ports
- **Keyboard:** 104-key Logitech K120 USB keyboard
- **Pointing device:** Logitiech USB Laser Mouse

Exploration, Optimization and Iterative Design

The industry is seeing new breakthroughs in software platforms to help teams generate more ideas in early-stage design.

BY BRIAN ALBRIGHT

Image courtesy of Altair.

The beginning of the design process can involve as much as art as science, and a lot of trial and error. In the past, the ability of engineers to explore the design space and come up with optimal solutions has been limited by time, computing resources and even the experience of the design team.

Technology is changing that. Specifically, design exploration and optimization strategies, combined with high-performance computing (HPC), can help engineers make faster decisions about key design criteria, run through and eliminate more iterations faster, and reduce the amount of manual labor required during all phases of design.

"Traditional product development and conceptual design is very frequently based on engineering intuition, which is great if you have a well-understood problem that has been more or less solved," says Bruce Jenkins, president of Ora Research. "But if you require fundamental innovation in the conceptual engineering phase, these tools can be of great value. These are situations in which the best solutions may lie far outside of the experience envelope of the engineers."

Exploration vs. Optimization

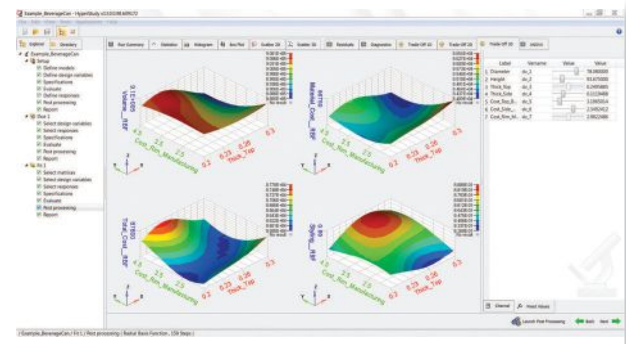
Design exploration and optimization are two parts of the design process that have benefited greatly from automation and HPC capabilities, although not all engineering teams and managers understand the difference between the two concepts.

Exploration takes place early in the process, as engineers grapple with defining the functional parameters of a product. "Design exploration is used to understand the relationships between inputs to design systems and outputs, and to understand the physics of the problem you are trying to solve," says Fatma Kocer, business development director at Altair. "It can be used to sample the design space to create analytical functions and do faster trade-off studies."

The term "optimization" can refer to numerical optimization that takes place at the beginnning of a design to help lead engineers down the correct path, topology/structural optimization that focuses on specific elements of a model — often to balance material placement vs. loads, for example, and even software that streamlines multi-disciplinary design workflows.

Adding to the confusion is that the various optimization technologies are sometimes referred to as design exploration, though they are actually a subset of that process.

"Design exploration is an umbrella," says Bob Ryan, president of Red Cedar Technology, "and you can think of optimization as being underneath it."



Design exploration tools enable engineers to quickly and easily perform trade-off studies throughout the design process, and help identify the best design. *Image courtesy of Altair.*

Thousands of Options

While most engineering departments are pretty familiar with existing structural optimization tools, new exploration solutions are emerging that could provide drastic improvements in efficiency. Autodesk's Project Dreamcatcher, for example, is a goal-directed design system that could allow designers to input design objectives, and then generate tens or thousands of different options that meet those goals. It does so by evaluating design trade offs rapidly (in the cloud) and then providing results that allow designers to sidestep repetitive computing tasks and concentrate on creative design.

Using this concept of computational or generative design, Autodesk already helped create a carbon fiber swingarm for the LS-218 electric motorcycle from Lightning Motorcycles in California. Bentley Systems' GenerativeComponents (GC) solution, which is primarily aimed at the architectural market, is a similar solution.

There is no shortage of other design exploration tools that include some level of optimization functionality: Altair's HyperStudy, Red Cedar's HEEDS MDO, ESTECO's modeFRONTIER, Noesis Solutions' Optimus, PTC's Creo BMX and Siemens PLM Software's LMS Virtual.Lab Optimization among them. CD-adapco, which acquired Red Cedar in 2013, announced earlier this year that STAR-CCM+ v10.02 would focus on Multidisciplinary Design Exploration (MDX) and improving productivity.

Exploration also helps reveal design possibilities that might never have emerged using traditional methods. "You get better designs faster," Ryan says. "Rarely are you trying to find the optimal design, just to get a better design quickly. Software might tell you that one design is better than three others, but those others might have characteristics you didn't build into the problem statement."

Once that better design is identified, optimization tools can be used to further refine specific elements within known parameters.

Simpler User Interfaces Aid Adoption

These exploration and optimization techniques aren't so much replacing a human activity as engaging in a process engineers couldn't perform manually: running through thousands of design possibilities in a very short period of time. A major change in design exploration has been the way that new software tools have made it possible for more engineers to use these complex techniques for exploring the design space.

"What the technology does is enable engineers to quantitatively rather than intuitively evaluate large numbers of design alternatives," Ora's Jenkins says. "And to evaluate multiple performance criteria simultaneously and in interaction with one another in a way that older processes really didn't accommodate."

Typically, exploration includes design of experiments, multi-disciplinary optimization, multi-objective or Pareto optimization, process automation and stochastic simulations. Engineers can use these tools to examine the relationships among different variables without the need to perform more CAE evaluations or experiments.

Most of these capabilities were commercially available decades ago, but were difficult to learn, use and integrate with complementary tools like simulation solvers. Now, CAE models can rebuild across a wider part of the design space, engineers have access to more compute resources to run iterations in parallel, and design exploration strategies are much less cumbersome.

"The technology, both the software and hardware, has matured to the point now that it is much more economical and efficient to employ optimization algorithms to high-fidelity simulations," says David Vaughn, vice president of marketing at CD-adapco. "The cloud has also changed things. You can get much more high-performance computing power per dollar."

In the past, companies would develop simulation models and then hand them to optimization groups. "Nobody learned anything, and it was laborious," Red Cedar's Ryan says. "You would turn the model over to someone who was interested in math, not the product. The engineer is the one who should be learning about sensitivities and finding things in the study that are interesting and help build insight."

And many engineers are still doing much of this work manually. Improving the user interface so that engineers can quickly and easily run through iterations and learn from them is a key advancement.

"We've focused on simplifying the use of these products," Altair's Kocer says. "The products have traditionally been targeted at experts rather than practitioners. Now you can use these tools without having to spend too much time learning how to apply the technology."

A Cultural Shift

Leveraging both exploration and optimization technologies requires more than just installing some software or accessing HPC resources. Engineering departments may need significant re-training to get the most out of these tools, which automate processes that in many companies relied on highly manual trial and error.

Vaughn says that CD-adpaco's customers have taken a variety of approaches. Some have actually created design exploration departments, or multi-disciplinary teams to work on specific projects. "The unmanned aerial vehicle (UAV) industry is a good example," Vaughn says. "Many of these companies started in a garage, and they had small groups of engineers taking a product from start to finish in a multi-disciplinary way. They could readily employ design exploration techniques because the organization itself was structured to take advantage of that."

ESTECO often initially helps companies automate existing processes to help the engineers make the transition. "For newcomers we replicate a process that they are comfortable with," says Carlo Poloni, president at ESTECO. "If the engineer trusts the manual simulation, he will also trust hundreds of simulations done in the same way."

The idea of throwing designs back and forth "over the wall," has become outdated. The gulf between CAD and CAE has to be bridged in a more intelligent way.

"Leading companies are changing the way CAD is done first," Ryan says. "It has to be robust, and should be able to be rebuilt automatically across a whole range of potential design changes. Then you give a real live dynamic model to the CAE engineers. That's huge in terms of its importance to doing design exploration."

"The mindset of the engineer has to move from trial and error to process driven, and from single simulations to multi-simulation," Kocer says. "If [design teams are] using multi-disciplinary optimization, then departments in each discipline have to get together and discuss fair trade offs and compromises, and formulate the problem they need to solve."

Speaking the Engineer's Language

Many of these tools still require a certain amount of expertise and understanding to set up a problem and execute it, according to Jenkins. Further innovations will center on making the tools even easier to use. "There are a number of different quantitative and statistical methods used, and some of the solutions still require parameter tuning," Jenkins says. "The engineers need to know something about which of the algorithms is being used."

The interface will be presented in the language of the engineer. "We have to look at the software interface, and find ways to make sure the practitioner can use this, and use terminology that is meaningful to the engineer," Kocer says.

ESTECO's Poloni agrees that ease of use will be a major focus in the industry. "We are moving into a world that is more collaborative thanks to Web technologies," Poloni says. "This will allow users to build even more sophisticated models during design exploration."

With a simplified interface, the exploration tools can do a better job of helping engineers more efficiently improve designs. "Good exploration software will allow what I call collaborative exploration," Ryan says. "The engineer is participating and injecting designs in the process. You can change the geometry, have it updated, and see what happens. Then these intelligent strategies will start to help you find things you never would have thought of before." **DE**

Brian Albright *is a freelance journalist based in Columbus, OH. He is the former managing editor of* Frontline Solutions *magazine, and has been writing about technology topics since the mid-1990s. Send e-mail about this article to DE-Editors@deskeng.com.*

INFO → **Altair:** Altair.com

→ **Autodesk:** Autodesk.com

→ **CD-adapco:** CD-adapco.com

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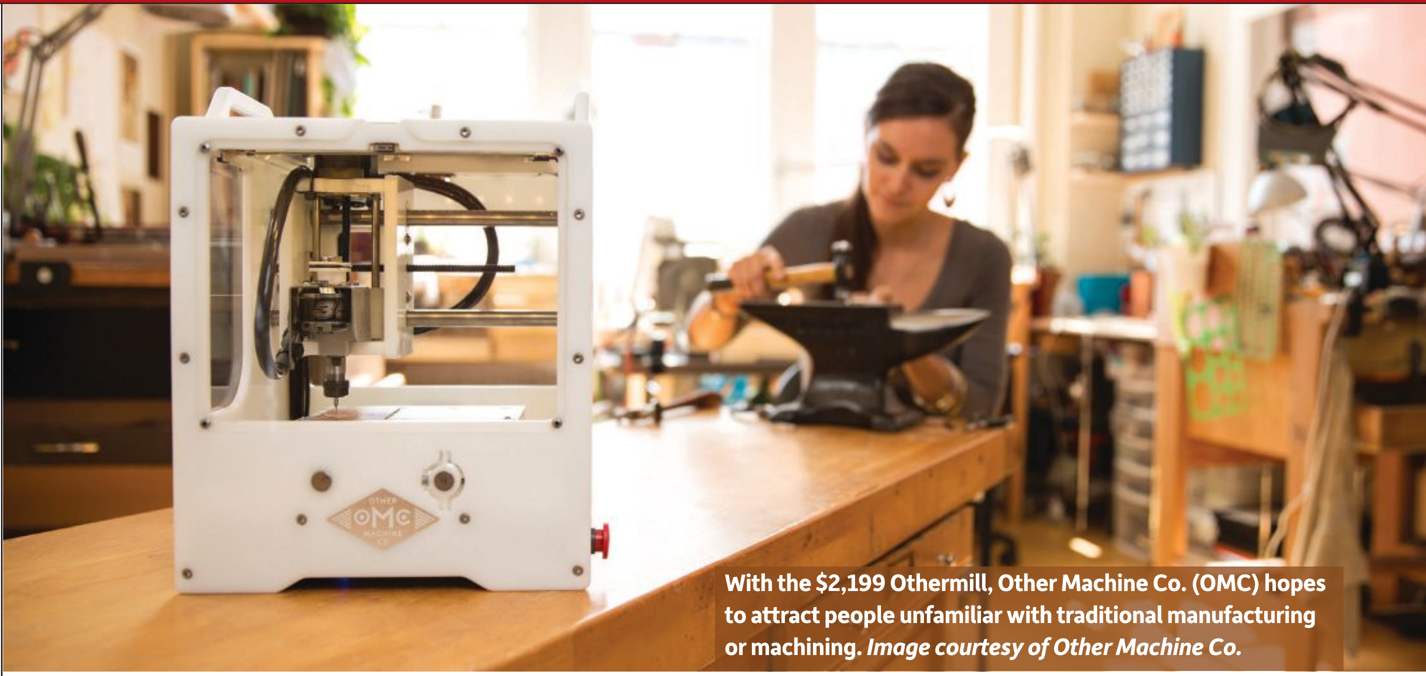


With the $2,199 Othermill, Other Machine Co. (OMC) hopes to attract people unfamiliar with traditional manufacturing or machining. ***Image courtesy of Other Machine Co.***

Ease of Use is the New Mission in CAM

An overture to makers adds new players, challenges existing CAM software developers to improve ease of use.

BY KENNETH WONG

The sun was streaming into the Herbst Pavilion at San Francisco Fort Mason, the site of Autodesk REAL 2015 Conference (February 25-26). Ezra J. Spier and his colleagues from Other Machine Co. (OMC) set up their booth by a window looking out to the Golden Gate Bridge. The machine on display was a portable desktop CNC (computer numerically controlled) machine, roughly the size of a beer cooler. It's called the Othermill, priced at $2,199.

Holding an exquisite piece of wood with mother of pearl inlay, Spier explained, "Our machine works with wax, plastic, rubber, wood, aluminum, brass, copper — anything softer than steel," says Spier, OMC wants to bring CNC to people who don't have training in manufacturing or machining. "To make that happen, we built our own software," he says. In line with the company's brand, the software is dubbed Otherplan.

Joseph Coffland is someone else who hopes to bring CAM to a new community. By his own admission, Coffland had little to no experience with commercial CAM programs. He felt that made him the ideal person to develop a program for the underserved segment frustrated with over-complicated software packages. He's going after the makers, hobbyists, tinkerers and DIYers — the uninitiated who are just like him.

Coffland came up with OpenSCAM, which stands for Open-Source Simulation and CAM. The name was originally an off-the-cuff joke to the hacker community; but now that it has become a more serious piece of software, he plans to change it. In the process of developing his 3-axis CNC program, he also learned a lot about the commercial CAM titles available in the market.

These new players' outreach efforts are indicative of the coming of a different breed of CAM software, characterized by a simpler interface and a smaller set of functions. Established CAM vendors who target a different market feel the pressure to make CAM easier, more accessible and more affordable.

Milling for the Other People

OMC manufactures its milling machine domestically in the U.S. It's headquartered in San Francisco's Mission District, a café-dotted hub for tech workers. 3D printing may be hip, but OMC's Spier points out CNC has certain advantages. One is the ability to cut into materials that come from life, like wood and mother of pearl.

OMC's software Otherplan is currently available only for Mac OS. "Historically, there have been very few options for CAD/CAM/CNC on the Mac, but in the design world it's the dominant platform. With Otherplan on Mac OS, we've been able to quickly bring CNC to an entirely new group of people," says Spier.

Traditional CNC focuses on producing complex mechanical shapes, but Spier believes robust 2D pattern cutting is important, especially in prototyping printed circuit boards (PCBs). He said, "With our software, it's very easy to do 2D cuts or build PCBs. Typically, you need to do complicated things to get your toolpaths for PCB. With our software, all you have to do is load your design file," he says.

Spier doesn't see a distinction between professional and maker markets. OMC wants to cater to both. The more important trend to note is the changing definition of manufacturing itself. "We see the future of manufacturing not as bigger factories but as smaller ones and neighborhood operations. So we want to build a machine that cuts with factory-level precision, but runs on a much smaller scale," he says.

Open-Source CAM

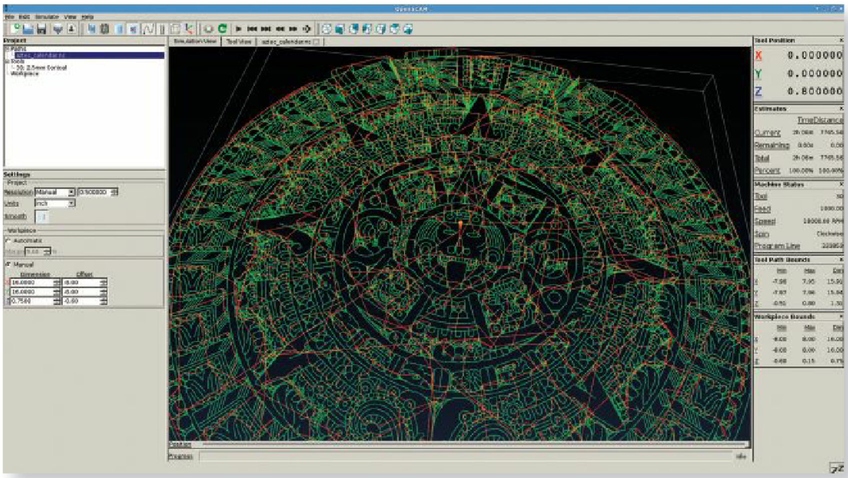
Coffland may be new to CAM, but not to software development. He operates Cauldron Development LLC, a software engineering business.

"I'm not trying to compete with the existing CAM packages," he says. "My software focuses more on accomplishing basic tasks, without burdening it with the advanced features experts might want." For example, cutting text into solids — one of the often-requested functions among the maker community — is often not supported or is overly complicated in professional CAM programs.

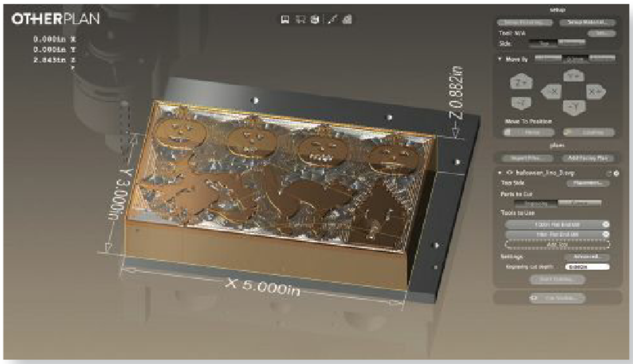
Coffland acknowledges the current open-source CAM software choices — including his — cannot compete with commercial packages when it comes to supporting the needs of traditional manufacturers. "Most commercial operations are running on commercial software," he said. "But it's not out of the question. The key is figuring out a way to fund the open-source movement. It takes a lot of time and effort to develop quality software. That takes money."

Precedence of open-source solutions supporting commercial enterprises may be rare in CAD and CAM, but it exists in other areas of manufacturing. For example, Aras, an open-source product lifecycle management (PLM) program, competes on equal footings with other paid solutions.

"Commercial vendors tend to offer a dumbed down version to beginners, in the hope that they can ask you to pay more for the professional version. That tends to turn off the makers," Coffland says. He hopes his OpenSCAM will mature



Preview of the toolpath for an Aztec calendar, shown in open-source CAM program OpenSCAM. *Image courtesy of OpenSCAM.*



Otherplan, the CAM software from Other Machine Co., shows a toolpath preview for an intricate Halloween stamp. *Image courtesy of Other Machine Co.*

over time through user input and labor, giving the community a sense of ownership and loyalty.

"In the last 12 months, I have seen about 15,000 downloads of OpenSCAM, mostly from the U.S., but spread out across the world," Coffland says. "Our web traffic is about 500 unique visits a day, and that's with little or no advertising or marketing efforts."

Coffland is gearing up for the next phase of the software, to be accompanied by an awareness-building campaign. Blender CAM, another open-source CAM program, targets artistic users, focusing more on cutting patterns and shapes favored by illustrators, jewelry designers and toy makers.

CAM with the Look and Feel of CAD

Commercial vendors like Autodesk are eying the maker movement with interest. In 2011, the design software titan acquired Instructables, a popular destination for DIY-ers to learn how to do everything, from making cupcakes to building aerial drones. Autodesk offers Inventor HSM Express, a 2.5-axis milling and drilling program, for free. Even if it's not originally targeted at consumers or prosumers, such free and low-cost offers from well-funded commercial vendors represent stiff competition for Open-Source CAM, still in its nascent stage.

For Autodesk, the key to ease of use rests with a CAM environment that's virtually indistinguishable from the CAD program. "The first step is to make the CAM system looks, acts, and feels like what the designers are used to," says Al Whatmough, product line manager for Autodesk CAM.

Autodesk's CAM product line came via its acquisition of HSMWorks, a company with a well-known plug-in for SolidWorks users. After the purchase, Autodesk added Inventor HSM for Autodesk Inventor users. Both SolidWorks and Inventor users have the option to test the waters first with free versions of HSMXpress for SolidWorks and Inventor HSM Express.

Freeware is often associated with low-quality of buggy versions, but "[Autodesk] actually waited until our software was robust enough before we started giving it away. If users are frustrated with our free product, they would never look at our paid version," says Whatmough.

The tightest integration between CAD and CAM came in the form of Autodesk Inventor Fusion 360, a CAD-CAM combo that includes cloud-hosted project management and collaboration tools. The move to integrate cloud-hosted features and a subscription-based model — both part of Autodesk's long-term strategy — are calculated to make installing, managing and using the software easier.

"Shops that make and produce their own designs love [the cloud-hosted features], but when they're producing someone else's design, they might hesitate a bit, because they can't make that decision [to trust the cloud] for their client," says Whatmough.

But Whatmough gets a chuckle when the same people who express concerns for cloud security don't have any qualms about emailing him design files — a less secure form of file transfer, in his assessment.

Balancing Automation, Ease of Use and Power

Can you simplify CAM enough for a beginner without reducing the software's capacity? That's a question that CAM software vendors have wrestled with for years, but the emergence of 3D printing increases the pressure. With 3D printing, the STL file exported from the CAD program can go directly to a printer. Sometimes the file requires cleanup or fixes, but the skills required for this step is minimal. Often printing service bureaus are happy to offer such services for a nominal fee or consider it part of the printing job's cost. A CAM package typically demands some time and effort in training to be proficient.

"We have templates that let you pick a machining strategy and apply it to your model, so we let you go quickly from digital art to physical part in CAM," says Whatmough. "But the value that individual machine shops offer is their expertise in refining the program for efficiency."

The balancing job for CAM vendors is to offer automated toolpath verification and machining functions for beginners while leaving enough room for skilled programmers to customize the jobs for best speed and output.

"Otherplan has a variety of features to help ensure that your geometry is milled in the way you want. For example, if you load a file that will cut into hardware you have installed on the mill, or if your geometry is too big for your material, you'll see a warning. Otherplan also gives you a full toolpath preview, which shows you the areas that will, or will not cut, given the tools you've selected," OMC's Spier says.

"Our software has lots of complexity and nuances to allow you to do pretty much anything you want, but because of that it may be overwhelming for beginners. We're looking at simplifying the user interface," says Greg Olsen, president of SmartCAM.

Olsen envisions the emergence of on-demand CAM, delivered from the cloud. "The idea is to let people pay for it in smaller amount, like a day's worth or a week's worth of CAM in the cloud," he says. Such a licensing model, he pointed out, would be attractive to businesses that must deal with complex surfaces for, say, three or four times a year, but not in all projects.

For CAM software developers primarily targeting the consumers and maker market, the balancing act is easier. A majority of the projects in this space doesn't require complicated machining strategies. With most users attempting to cut 2D patterns onto plates, pendants and personalized objects, the software proves easier to automate and simplify. The job is more challenging for CAM vendors attempting to cater to both power users and newcomers. **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 → **Autodesk:** Autodesk.com

→ **OpenSCAM:** OpenSCAM.com

→ **Other Machine Co.:** OtherMachine.co

→ **SmartCAM:** SmartCamCNC.com

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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.

Eurocom Ships Neptune 4W Mobile Workstation

The system is equipped with NVIDIA graphics and an Intel CPU.

The Neptune 4W starts with a 17.3 in. display that offers you 1920 x 1080 resolution, so you can see a rendered design, model or video clearly and without scrolling or zooming excessively.

The system offers VGA graphics upgradeability through its Mobile PCI Express Module (MXM) 3.0b interconnect standard for GPUs (graphics processing units).

Other interesting details about the Neptune 4W: It has three security layers, including the Kensington Lock Slot and a Trusted Platform Module (TPM). You can run 64-bit Windows 7 and 8.1 or Linux.

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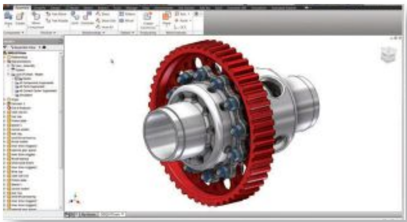

Autodesk Inventor Adds Embedded Nastran Capabilities

The integration provides a host of analysis functions.

Autodesk Nastran In-CAD for Inventor is a fully embedded, general-purpose set of FEA (finite element analysis) tools that's powered by the Autodesk Nastran solver. It provides you a palette of simulation tools for basic analyses such as exploring the viability of design alternatives and concept validation from inside of Inventor. Among its stress analysis functionalities are static fatigue, linear buckling, heat transfer and stress, strain and deformation.

The platform also includes a materials library plus automatic surface meshing and tetrahedral meshing capabilties.

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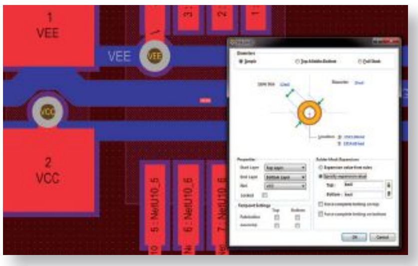

Altium Designer 15 Launches

Platform now has expanded support for data transfer standards.

This Windows-based software offers you a common interface for schematic and PCB (printed circuit board) CAD functions.

Interdisciplinary communications is a significant part of version 15. Altium Ltd. added support for Ucamco's latest Gerber X2 CAD-to-CAM data transfer standard as well as support for the new IPC-2581 vendor-neutral format for PCB design data transfer developed by the IPC-2581 Consortium.

Another key new capability is a Pin Pairs feature for high-speed signal pin pairs that should help you plan and route groups of high-speed nets faster.

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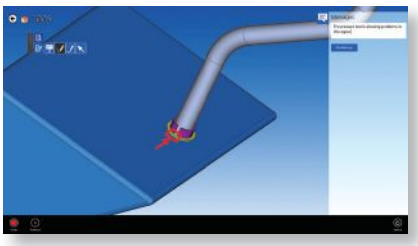

Aras Innovator 11 Extends Collaboration

New Visual Collaboration feature integrates social technology into PLM.

Version 11 of Aras Innovator offers an interesting assortment of new capabilities for program management, file handling and the like. But the key enrichment is known as Visual Collaboration.

This functionality provides you with a secure social technology within the context of your PLM (product lifecycle managmeent) items. That means you can view content, add markups and apply annotations in your product structures and processes like BOMs, parts, models, drawings, documents and change workflows. You can do this to your 2D and 3D files, schematics and more.

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Accelerated System Analysis

Co-simulation between Adams and Marc platforms helps automotive group run simulations 15 times faster.

Litens Automotive Group's patented TorqFiltr torque modulator uses an arc spring isolator mechanism to decouple the accessory drive system inertia from the engine torsional vibrations. The Litens torque modulator controls the system resonant frequency by tuning the spring stiffness to the system inertia. Because the spring stiffness is softer than traditional rubber isolators, vibrations from the engine are mostly absorbed before being transmitted to the accessory drive belt. This results in isolation of all components in the accessory drive, and any accessory drive resonance has very small peak amplitudes, since there is little excitation.

"This device provides an enormous design challenge," said Steve Jia, chief engineer for Litens Automotive Group. "We need to fully understand the behavior of the design under dynamic loading conditions. The product must be customized to deliver optimal performance for many different automotive engines.

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Creating the Perfect Part

Seco Tools uses Vero Edgecam to make a gearbox shifter for the Oxford Brookes racing team.

Oxford Brookes Racing (OBR) is a dedicated project run by Oxford Brookes University to guide young engineers through the challenge of designing, building, developing, marketing and competing as a team using their own single-seater racing car.

It was entered in the international Formula Student competition, which judges cars on design, cost, presentation, technical and safety aspects, tilt test, brake and noise test, skid pan, 1km sprint, 75m acceleration, 22km endurance and fuel economy.

Since 1999, OBR has scored more points and returned faster laps than any other U.K. Formula Student team, and has been top U.K. team five times. The current team comprises students from all over the world, researching, designing, building and testing the car. Past members of the team have gone on to work for some of the most prestigious and respected engineering names such as Red Bull Racing, Renault F1, Virgin Racing, Force India, Lotus F1, Cosworth and Audi Motorsport.

This year, the team turned to Seco Tools U.K. to help them develop a complex sequential gearbox shifter barrel. Seco worked in partnership with Edgecam, from Vero Software, to create the toolpaths and manufacture the part.

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High-Speed Electrical Analysis

Optimation uses NI hardware and software to develop a data acquisition and monitoring system for the National Renewable Energy Laboratory.

Optimation provides engineering, automation, construction and maintenance services. As a Gold National Instruments (NI) Alliance Partner with more than 27 years of experience, Optimation was invited to propose a solution to the National Renewable Energy Laboratory (NREL) for distributed power monitoring within the Energy Systems Integration Facility (ESIF). Optimation gave NREL access to qualified resources for the project.

NREL scientists and engineers research renewable energy and energy-efficient technologies. They designed the ESIF to facilitate groundbreaking research in areas such as solar and wind, grid planning and operations, energy storage, building technologies, fuel cells and advanced vehicles. Each lab at the 182,500 sq. ft. facility is designed and instrumented to foster research on all aspects of energy systems integration.

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Commentary  by Danny Shapiro

Deep Learning Will Accelerate Self-Driving Cars

Punch Buggy. Slug Bug. The names differ, but we've all played this game. See a Volkswagen Beetle, punch your sibling. Deep learning works the same way. Just with more math — and fewer bruises.

Deep learning refers to algorithms — step-by-step data-crunching recipes — for teaching machines to understand "unstructured data." That's another way of saying information that lives outside of spreadsheets and databases. For example: images, speech and video.

So, how does deep learning work? A great way to understand it is to look at NVIDIA DRIVE, a new autopilot car computer. When paired with computer vision technology — powered by NVIDIA Tegra processors — DRIVE gives vehicles a level of self-awareness. To show what DRIVE can do, NVIDIA engineers stuck video cameras onto their cars to capture 40 hours of video. They then used Amazon Mechanical Turk to have frames manually tagged by people to categorize about 68,000 objects in the footage.

Artificial neural networks learn many levels of abstraction.

Training Artificial Brains

Our engineers then fed these images to servers equipped with GPUs (graphics processing units) that form an artificial neural network. It's a process computer scientists call "training." It lets a neural network learn to see patterns and recognize objects.

Training artificial neural networks is a little like how children learn. Parents, friends and punch-happy older siblings identify objects in the world for the child. The child's brain then learns how to identify these objects in a broad array of situations.

This is where the "deep" in deep learning comes in. With deep learning, a neural network learns many levels of abstraction. They range from simple concepts to complex ones. Each layer categorizes some kind of information. The neural network then refines it and passes it along to the next.

Deep learning stacks these layers. This lets a machine learn what computer scientists call a "hierarchical representation." So, the first layer might look for edges. The next layer looks for collections of edges that form angles. The next might look for patterns of edges. After many layers the neural network learns the concept of, say, a pedestrian crossing the street.

GPUs are great for neural nets, which sort unstructured data like images. Once a system is "trained," that learning can be used in applications like self-driving cars.

Precision Vision

Deep learning is a technology that's arriving just in time to advance computer vision. Low-cost cameras and sensors are giving cars the ability to suck in huge amounts of information. Computer vision technology turns that data into 3D maps that vehicles can use to navigate the world around them.

Deep learning takes those automated navigation capabilities to another level. The NVIDIA DRIVE system takes advantage of the models that neural networks create. It lets the car understand the world the way human drivers do.

As a result of this understanding, DRIVE can tease out important driving information fast. It can pick out different kinds of vehicles. It can discern a police car from a taxi; an ambulance from a delivery truck; or a parked car from a car that is about to pull out into traffic. That capability isn't limited to vehicles. NVIDIA DRIVE can identify everything from cyclists on the sidewalk to absent-minded pedestrians.

Deep learning can even categorize images that challenge human eyes. Even in bad weather, DRIVE can read flickering electronic signs, or spot brake lights … or recognize a Volkswagen Beetle.

Trust us: Never play Punch Buggy with a GPU. DE

Danny Shapiro *is NVIDIA's senior director of automotive, focusing on solutions that enable faster and better design of automobiles, as well as in-vehicle solutions for infotainment, navigation and driver assistance. A version of this article originally appeared on blogs.nvidia.com.*

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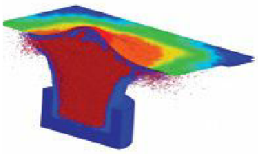
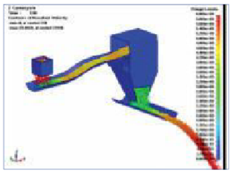
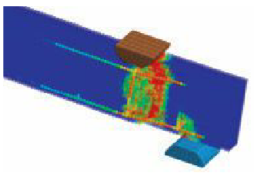


Four New Solvers for Multiphysics Purposes



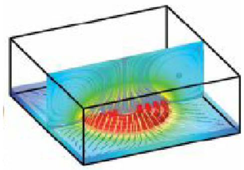
Discrete Element Sphere (DES)

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



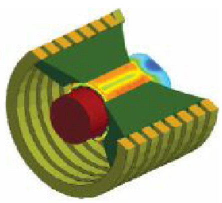
Here are some distinct features of the bond model:

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



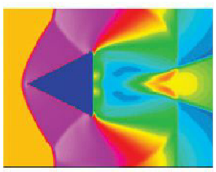
Incompressible CFD

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



Electromagnetics

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



CESE/Compressible CFD

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

Upcoming Classes in Michigan

- **April 9-10** Intro to LS-OPT
- **April 21-22** Advanced Impact Options in LS-DYNA
- **April 23-24** Composite LS-DYNA
- **April 29-30** Advanced ALE Applications
- **June 30** Advanced FEM/Meshfree Methods
- **June 22** Intro to LS-PrePost
- **June 23-26** Intro to LS-DYNA

Upcoming Classes in California

- **April 27** Intro to LS-PrePost
- **April 28-May 1** Intro to LS-DYNA

LSTC Livermore Software Technology Corp.

For more information email: sales@lstc.com or visit www.lstc.com

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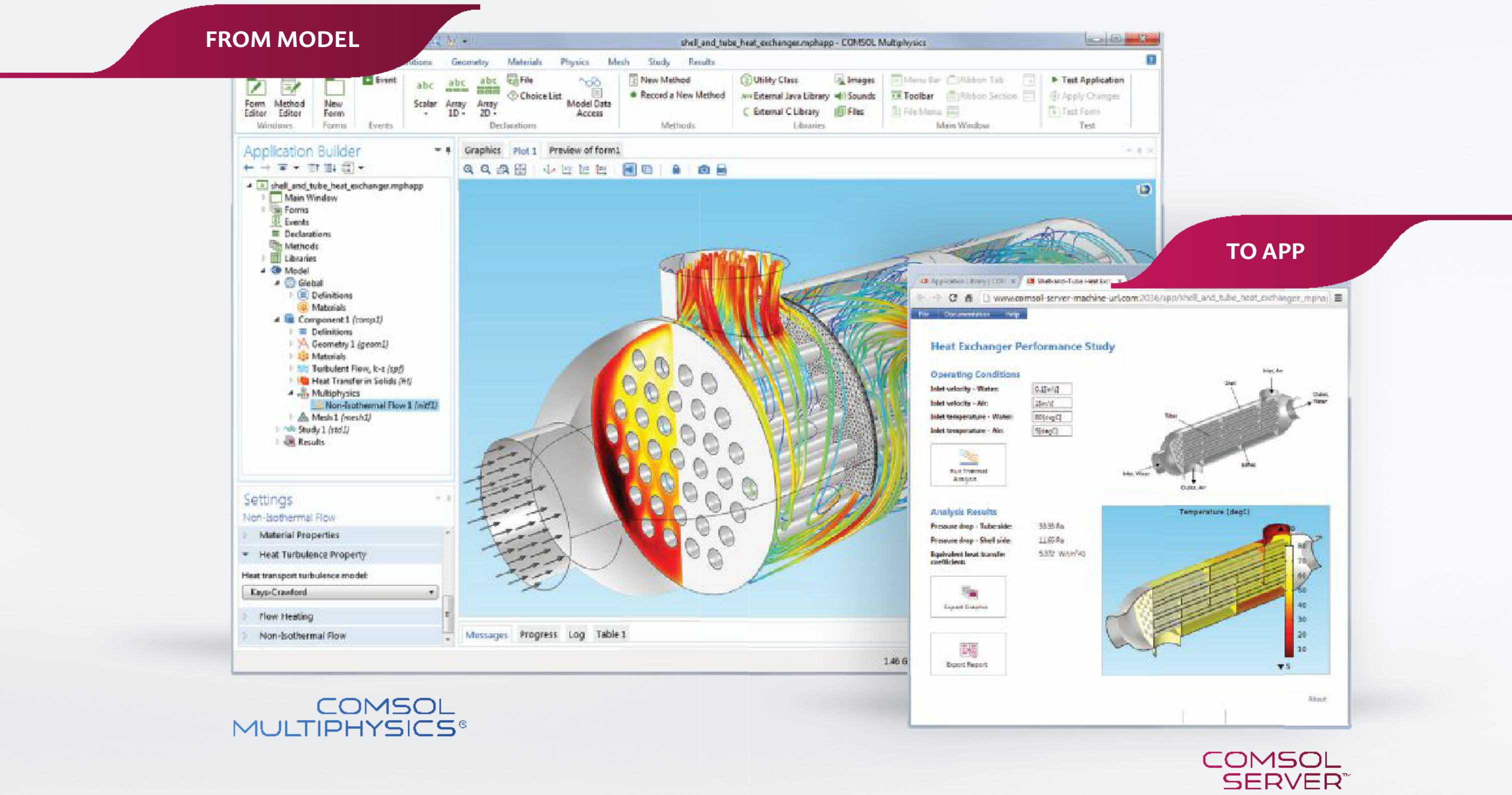

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