DE's Digital Edition

by Steve Robbins

You Can Take it With You

Welcome to the latest digital edition of *Desktop Engineering*. We hope you you enjoy having access to this issue, as well as archived issues, anywhere you have an Internet connection. But many of you have contacted us to ask if there's a way to read the digital edition while offline. The answer is: Yes, you can!

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Thank you for your comments. Please let us know if there is anything we can do to improve your experience with the digital edition. You can reach us at de-editors@deskeng.com. **DE**

Sincerely,

Steve Robbins, Executive Editor

Desktop Engineering

DE

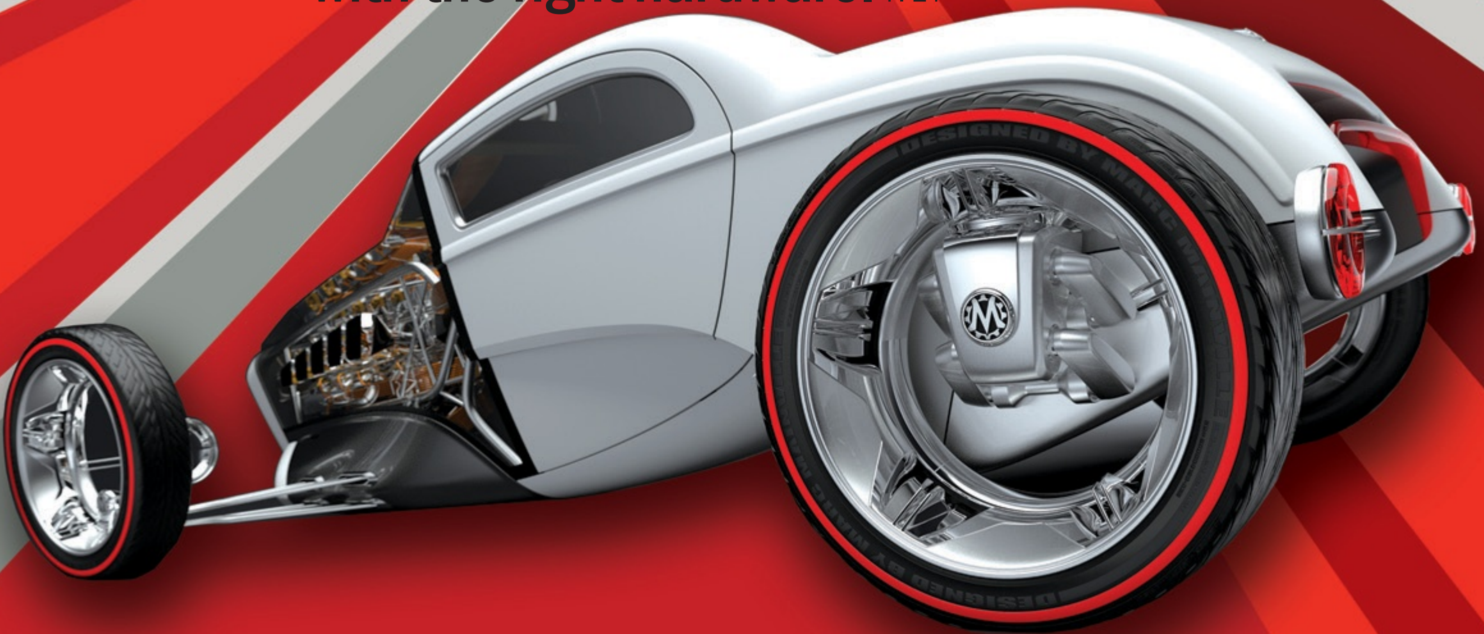
Desktop Engineering®

TECHNOLOGY FOR DESIGN ENGINEERING

April 2014 / deskeng.com

FOCUS ON: Test & Measurement

Rendering on the Road



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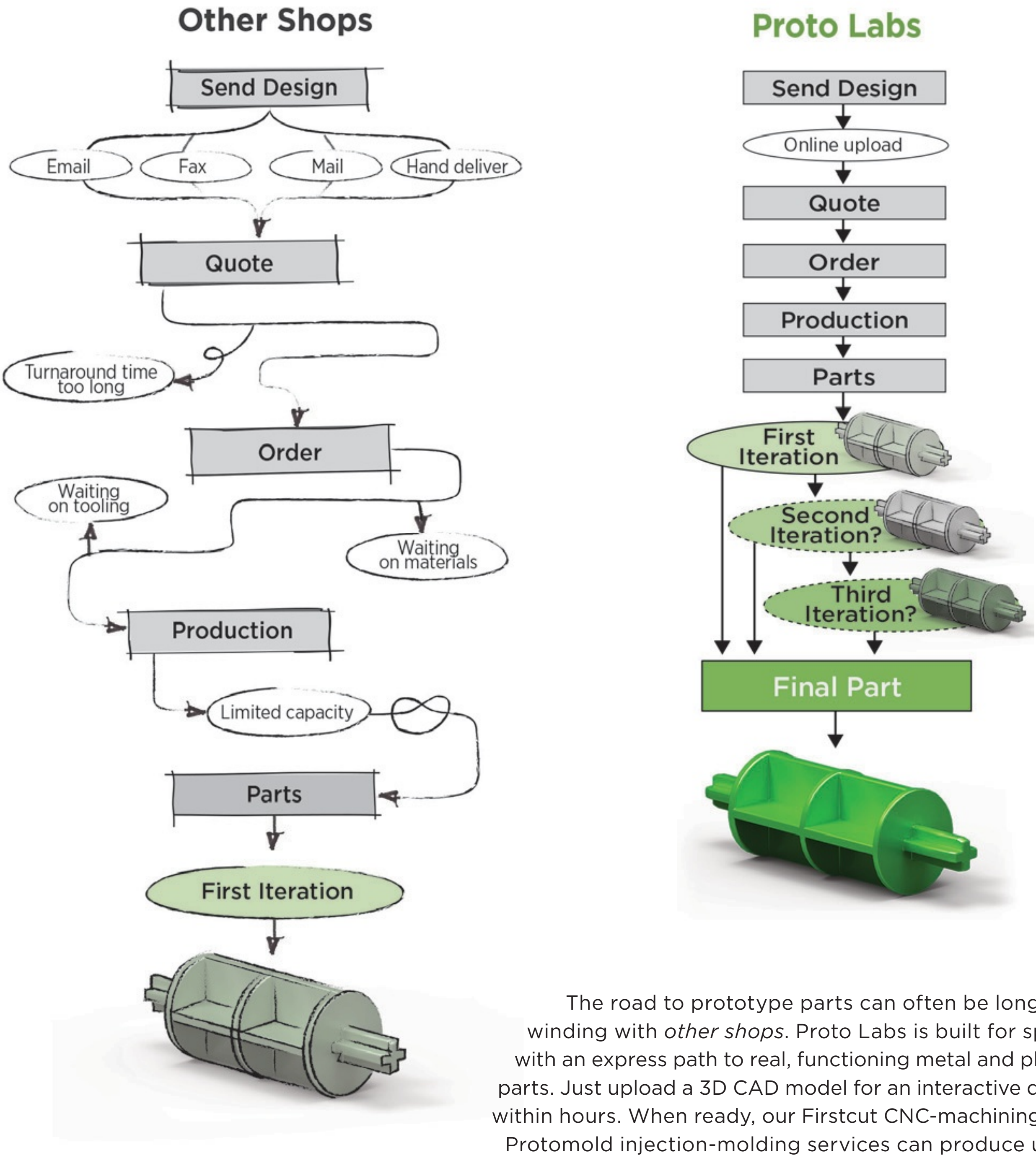

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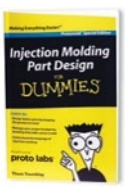

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Real Parts. Really Fast.™

by Jamie J. Gooch

Human Wit vs. Artificial Intelligence

Long ago, while working as an editor of a business-to-business agricultural magazine, I helped create its 100th anniversary issue. After leafing through issues dating back to the late 1800s, I gained a better appreciation of the huge technological changes that had transformed daily life.

Alongside articles extolling the efficiencies of steam-powered tractors were ads for everyday consumer goods — from soap to canning jars. Consumer ads were in the agricultural trade magazine because in the late 1800s, more than 70% of the U.S. population was employed in agriculture. That number has dropped to less than 2% as industrialization and mechanization increased agricultural labor efficiency 27-fold.

Many farm workers became factory workers, but now a similar shift is taking place. The percentage of U.S. manufacturing workers has fallen from its 30% high in 1950 to about 10%, and is projected to keep falling.

Now, of course, the hot crop is knowledge.

Knowledge is your best defense against obsolescence.

Keep Learning

The shift from farm to city was accompanied by states making it compulsory for children to go to school and the founding of the first research institutions. The educational hurdle from farmer to factory worker was not as high as the one factory workers have leapt to take advantage of the Information Age, and that hurdle is only getting higher.

As technology changes, education becomes increasingly important to keep up with those changes. Design engineers are well positioned to take advantage of the economic trend toward information and applied services, but they are not immune to its challenges. Simulation, rapid prototyping and high-performance computing have disrupted the traditional way things have been designed. At the same time, converging engineering disciplines require many of today's design engineers to understand mechanical, electrical and software engineering, as well as user interface design and product lifecycle management.

Today's proponents of higher education no longer talk about degrees as a precursor to employment, they talk about lifelong learning. While continual learning no doubt would be a good thing for the bottom line of any college or university, higher education leaders are also in a good position to read the writing on the wall when it comes to the future job market.

The writing on noted inventor and futurist Ray Kurzweil's website late in 2012 announced he had been hired as Google's director of engineering. Kurzweil is known for inventing the CCD flatbed scanner, omni-font optical character recognition, print-to-speech reading machines, and advancements in music synthesizers. But, he is perhaps best known for his 2005 book "The Singularity Is Near: When Humans Transcend Biology," in which he predicts how artificial intelligence will exceed human intelligence.

"In 1999, I said that in about a decade we would see technologies such as self-driving cars and mobile phones that could answer your questions, and people criticized these predictions as unrealistic," his website announcement of the new Google position read. "Fast forward a decade — Google has demonstrated self-driving cars, and people are indeed asking questions of their Android phones ...

"I'm thrilled to be teaming up with Google to work on some of the hardest problems in computer science so we can turn the next decade's 'unrealistic' visions into reality."

More Changes to Come

The world's second-largest company by market value has been making a number of interesting acquisitions since hiring Kurzweil. In January, Google reportedly acquired DeepMind Technologies for $400 million. The small startup focused on artificial intelligence research that could make machines more capable of recognizing faces or spoken words.

Such an acquisition illustrates the value of knowledge in the economy. It also leads to rampant speculation on what is to come, especially when you consider that Google has also acquired eight robotics companies recently, including the well-known Boston Dynamics.

Will your job one day be done by computer-based artificial intelligence? Maybe. Will you one day be asked to design a machine that is capable of using artificial intelligence to perform a task? Probably, if you aren't already doing so. Are you ready for those days? That's the question to ask yourself right now.

If you aren't continually learning something new, you can rest assured there's a machine out there that is — from IBM's Watson supercomputer turned Jeopardy! champion to Google's self-driving cars, even Facebook and Amazon's algorythms that determine what you want to see and when. Knowledge isn't just power. Knowledge is your best defense against obsolescence . DE

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

Smarter Embedded Designs,
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The combination of NI LabVIEW system design software and reconfigurable I/O (RIO) hardware helps small design teams with varied expertise develop demanding embedded applications in less time. Using this graphical system design approach, you can take advantage of the same integrated platform to program embedded processors and FPGAs for faster application development in industries ranging from energy to transportation, manufacturing, and life sciences.

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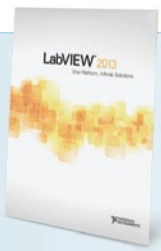

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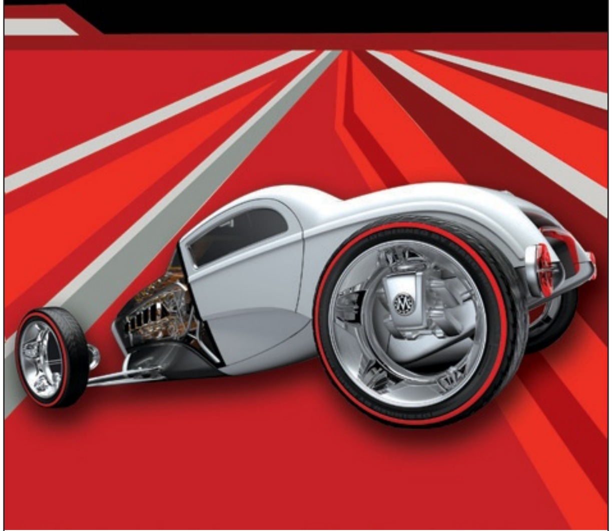
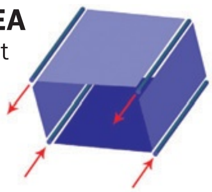
NATIONAL INSTRUMENTS

DE April 2014 VOLUME 19/ISSUE 8

Return to Render

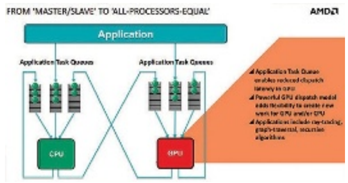


SIMULATE



ON THE COVER: "Hyper Rod" created by Marc Mainville in Autodesk Alias. Rendered by James Cronin in VRED.

ENGINEERING COMPUTING



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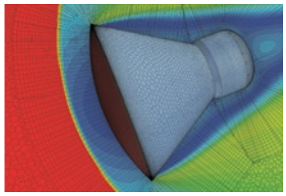

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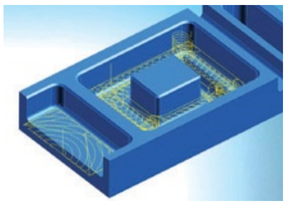
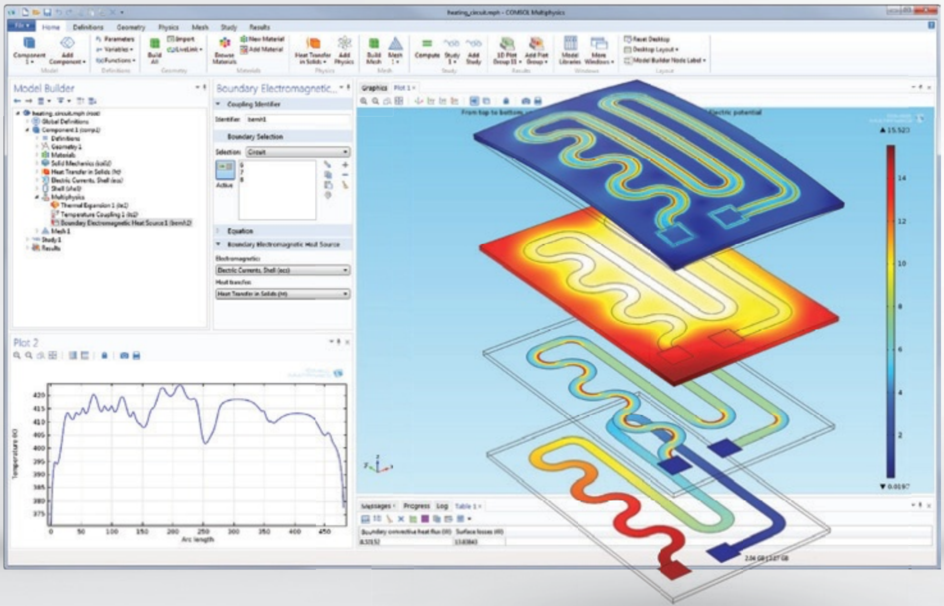


FOCUS ON TEST & MEASUREMENT

HEATING CIRCUIT: Multiphysics simulation of a heating circuit including DC-induced Joule heating, heat transfer and structural mechanics analysis of the thin resistive layer covered on a solid glass plate.



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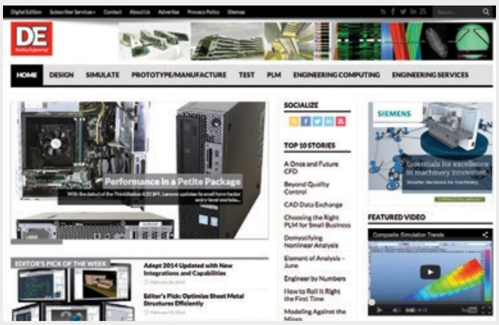

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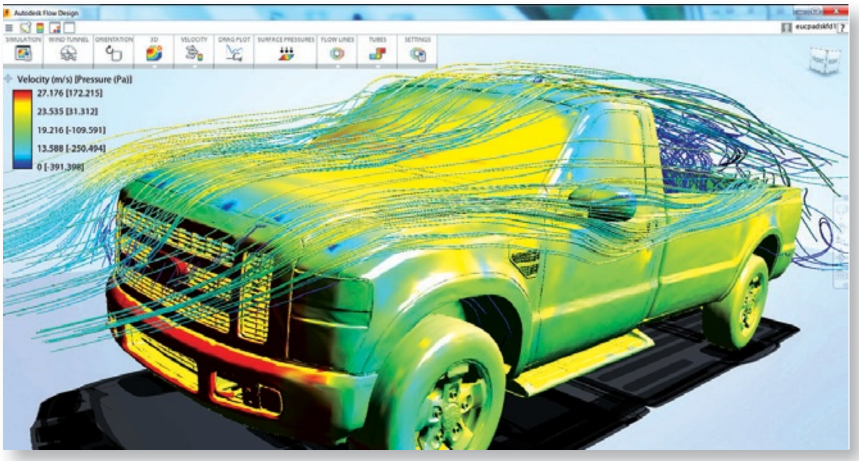
by Kenneth Wong & Beth Stackpole

Autodesk Simulation Nabs MVP Role at Super Bowl XLVIII

Thankfully, the Polar Vortex made an exit prior to February's Super Bowl XLVIII kickoff. But that doesn't mean the New Jersey Meadowlands was free and clear of winter winds. For the teams that would face off one another at the MetLife Stadium in East Rutherford, NJ, the weather — especially the wind — was a cause for concern.

To help football fans get a better understanding of what's happening with the winds, FOX Sports teamed up with Autodesk to adapt the company's Flow Design, a cloud-hosted computational fluid dynamics (CFD) simulation technology, to chart the anticipated wind patterns and study their possible impact on the big game.



FOX Weather TRAX leverages Flow Design, Autodesk's cloud-based CFD simulation offering. *Image courtesy of Autodesk.*

"Wind behavior has long been a mystery at many outdoor NFL stadiums," says Jon den Hartog, Autodesk's product line manager, Simulation. "What is reported is often completely different from what is really happening on the playing field. In fact, it isn't uncommon for wind to be blowing at different directions at all corners of the field. And yet wind can also be a critical factor affecting field goals, punts and the passing game. What we're trying to do is help people understand how the conditions are really playing a role at key moments like long kicks, punts, passes, etc."

The project with FOX Sports, dubbed FOX Weather TRAX, was meant to illustrate dynamic in-stadium airflow patterns by superimposing visual representations of wind direction directly over the game play. Typically, coaches, players, commentators and fans have pretty much taken part in a guessing game, relying on the field goal flags to determine how a gust of wind might influence a pass or field goal.

FOX Weather TRAX is similar to a project Autodesk undertook last year as part of Flow Design's early testing before it was a formal product. With an assist from a Penn State University student, Autodesk leveraged its simulation suite, including the ForceEffect Flow 2D app and Design Flow (previously known as Project Falcon), to help understand wind patterns at the Pittsburgh Steelers' Heinz Field. FOX Weather TRAX goes a few steps further by delivering data in real-time and employing some unique visualization tools for merging the simulation data with the live feed, den Hartog explains.

"Our CFD tools have been used in the past to study wind effects around large buildings, facilities, and even NFL stadiums, but mainly as part of the design process," he explains. "For this application, the main challenge was being able to take the simulation results and putting them into a format that could be used for the live TV broadcast. You can get the same insight and understanding using Flow Design alone, but it doesn't currently include everything you need to link up with a live TV feed."

First, the partners created a digital model of the MetLife stadium using 3D modeling software like Inventor. Flow Design then interacts with the digital stadium model while wind speed and direction flows are altered to suit the game day conditions. It's a step that's critical to illustrate how the airflow patterns inside the stadium are affected. The simulation graphics will then be played out over a live camera periodically to show Super Bowl viewers the wind path in relation to the field.

— *B. Stackpole*

National Engineers Week Shines a Spotlight on STEM

National Engineers Week, held this year from Feb. 16-22, was a weeklong celebration to focus attention on the role of engineers in society. Started by the National Society of Professional Engineers in 1951, the event is observed by more than 70 engineering, education and cultural societies — with participation from more than 50 corporations and government agencies.

In fact, it's grown into a nationwide outreach program that encourages corporations, academia and professional engineering societies to emphasize the importance of learning science, technology, engineering and math (STEM) to students from K-12 and beyond.

All of this focus on STEM is critically important. According to 2012 data from the Organisation for Economic Co-operation and Development, the United States ranks 26th in the world in math competency and 21st in the world for science competency among high-school students. Those are figures academia, business and even President Obama want to see rise exponentially.

"There is a widening gap between the demand for skilled, knowledgeable workers in science and engineering and the number of students pursuing degrees in these fields," notes Dave Wilson, director, academic programs at National Instruments (NI). "Furthermore, students who do obtain engineering degrees often experience a major disconnect between the concepts they have learned in their studies and the practical applications to real-world problems they will see later in their careers. To address these concerns, NI strongly believes in providing engaging hands-on learning experiences for students of all ages."

Getting students to see the value in what engineering brings to the workforce is a key piece of the National Engineers Week story. Recent studies have found that only 4% of the nation's workforce is composed of scientists and engineers, but this group disproportionally creates jobs for the other 96%.

— B. Stackpole

Autodesk Nudges Customers toward Subscription with Upgrade Deadline

The warning shot was fired last November. It came in the form of a notice to Autodesk customers. This was perhaps the portion that deserves to be in red letters: *As of February 1, 2015, Autodesk will no longer offer the option to purchase upgrades for all non-current product versions.*

In other words, if you're using older versions of the company's software — say, AutoCAD 2008 or Inventor 2010 — you have until February 2015 to pay a fee to upgrade to the latest version. If you decide to get the latest version after the February 2015 deadline, you'll have to pay full price for the new version.

The move is Autodesk's nudge to get its customers onto the subscription model and the rental model, introduced in September 2013.

"Upgrades are a small part of our business, and we want customers to get the latest technology and updates from us," Andrew Anagnost, Autodesk's senior VP of industry strategy and marketing, told investors in a conference call. "And the best vehicle for customers that own perpetual license to do that is Maintenance Subscription."

The policy change does not spell the end of perpetual licenses from Autodesk, but it's a clear sign that Autodesk wants to sell not just the license — but a subscription along with it. The company's FAQ states, "At this time, Autodesk has no plans to change the licensing model across the board for all products. Perpetual licenses with Subscription continue to be a very important part of our portfolio."

Ryan McVay, a CAD/PLM system administrator and analyst, imagined a scenario where this upgrade policy could become a dilemma for a user: "If the company doesn't have such a good year and decides they can't pay maintenance and they miss a year of subscription, they would then need to repurchase to get the latest version (one version back). That is a steep price to pay for missing one year."

Edward Lopategui, a technology evangelist and entrepreneur, says he believes the policy brings the company "one step closer toward Adobe's philosophy … to kill the perpetual license entirely."

Last May, Adobe announced it would no longer offer its most popular product, Creative Suites, under perpetual licensing, but would only offer it under subscription as Adobe Cloud. At least for now, Autodesk isn't suggesting that's what it plans to do.

— K. Wong

by Kenneth Wong & Beth Stackpole

Interactive Training for the Video Game Generation

Joshua Lewis can teach how to you to use the complex machinery and equipment in offshore oil platforms and underground mines. With his method, you don't necessarily need to be on an oil rig or in a mineshaft — you can do it from a computer.

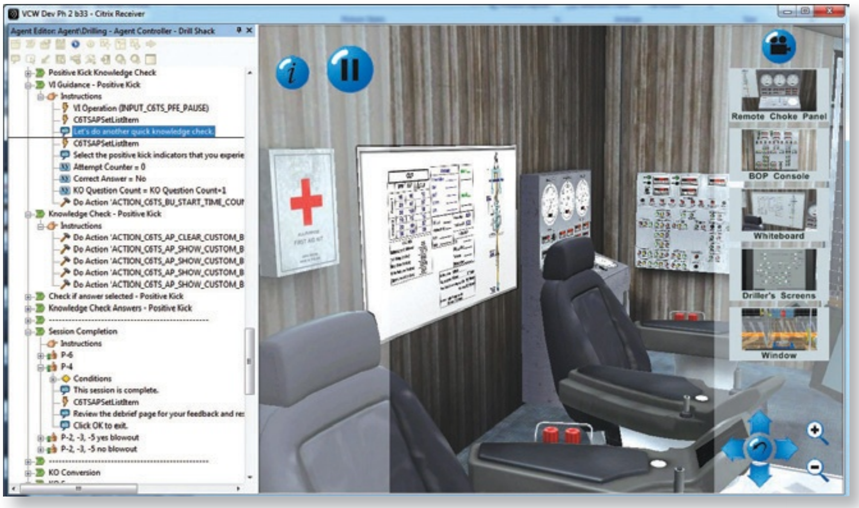
As the CTO of the Training Systems division of Check-6, Lewis is responsible for developing the company's PC-based training program Competency Assurance Training System (CATS). Check-6 customers use it to train their new hires and to test the skill level of their employees.

The system was designed by "commercial and combat aviators" for "the Game Boy generation," in Check-6's own words. The experience is much like being in Microsoft Flight Simulator, a highly popular video game that lets you take control of a realistic airplane cockpit. Lewis and his team put in a lot of efforts to make CATS' virtual environment feel real. If a trainee makes a catastrophic operational error, he or she will witness an explosion, complete with flames and smokes (thankfully, also virtual).

"In fact, our customers ask for the explosion," said Lewis. "They want to make it apparent when you make a mistake."

CATS relies on the graphics processing unit (GPU) — in this case, NVIDIA GPUs — to render and constantly refresh its interactive world. Check-6 developers use NVIDIA's Enterprise GRID to develop and test CATS before deployment at customer sites.

In addition to the developers responsible for 3D content (like the replica of an oil rig's console and the surroundings), Check-6 also employs courseware developers to create the training materials. These include questions to pose to the trainee during the session, imaginary scenarios to test the trainee's skills, etc. Courseware developers are located all over the U.S., but are remotely connected to CATS.



Simulation-based training provider Check-6 uses NVIDIA GRID hardware to design and deliver virtual training courses for oil rig operators. *Image courtesy of Check-6.*

When the courseware designers are working, they're operating Windows 7 virtual machines, using Citrix's Virtual Desktop Agent, called XenDesktop, Lewis says, noting that they run on the NVIDIA GRID appliance. "The program has a relatively large installation footprint [4GB]," he adds. "These courseware developers are essentially working from their homes without an IT department. So to have them install and run a very complex application on their own is not practical."

With NVIDIA GRID and Citrix, Check-6 can keep CATS in its own IT-controlled environment and give developers access to it via virtual machines. "We also want all the developers to be on the same configuration," says Lewis. CATS is constantly updated by content developers; therefore, delivering these updates to courseware developers' virtual machines by updating the central server ensures consistency.

When something goes awry with the program, whether it's a data corruption or a crash, the centralized approach makes it easy to restore the virtual machine to its prior state remotely from backup data. "In just a couple of minutes, we can resurrect the failed machine," says Lewis. "That's important, especially when they're facing a delivery deadline."

Currently, Check-6 customers keep CATS on their own networks. Check-6 is exploring the prospects of hosting training and testing sessions on the NVIDIA GRID, thereby extending the way the courseware developers currently use the system to the trainees at the clients' sites.

"On-demand training, Software-as-a-Service (SaaS), subscription, pay by the hour, pay by number of users, pay by number of courses — we're heading that direction. That's the vision," Lewis says. He delivered a session on this topic at the NVIDIA GPU Technology Conference, which took place March 24-27 in San Jose, CA.

— K. Wong

Can **Your** Three-Year-Old Workstation Handle Today's Analysis-Led Design?

Just because a workstation doesn't grind to a halt when manipulating large CAD files or can run a finite element analysis (FEA) simulation doesn't mean it's optimized to help engineering organizations test the limits of design.

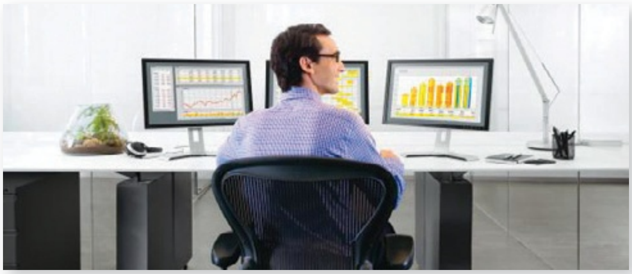
Today's complex products demand a development process that pushes the boundaries of what's possible via simulation-based workflows that let engineering teams explore a greater number of design alternatives. Need convincing of the merits of analysis-led design? Consider research from Aberdeen Group, which found that the top 20% best-in-class companies (those pursuing a robust design approach that includes widespread use of simulation) were more likely to meet product launch dates, hit product revenue, cost, and quality targets, and reduce overall development cycle times.

Yet if a workstation is three years old or more, it's likely not equipped to handle analysis-led design workflows in any kind of high performance or efficient manner. A three-year old workstation doesn't have sufficient speed and number of cores to adequately support such complex simulations. Moreover, processor architectures are routinely updated with new instruction sets that streamline how data is handled—a huge factor in boosting overall performance, particularly for data-intensive CAD and simulation tasks. Factor in the concept of a properly balanced workstation with the optimal combination of processor, memory, and hard drive configuration, and an upgrade investment goes a long way in upping performance for design-oriented applications.

It's not just hardware advances that point to the need for a system refresh. Design software, including CAD and CAE offerings, is periodically modified to exploit the new instruction sets, optimizing how complex routines like meshing or large assembly modifications will run in a workstation environment.

Next Steps

- Develop new workflows that make simulation an integral part of the concept design process.
- Encourage engineers to explore up to five ideas a day instead of one.
- Provide plenty of training to acclimate engineers to simulation-based design.
- Consider a refresh if your hardware and simulation software is more than three years old.
- Check out the easy to use system configuration tool created by SolidWorks and Intel: goo.gl/6lhmGJ.



Upgrade Economics

Making the case for a system refresh is pretty straightforward. Upgrading an entry-level Xeon E3-1280 v3 workstation to a state-of-the-art system based on a 2S Intel Xeon E5-2687W v2 will deliver a 3.5X performance boost running ANSYS Mechanical v14 for structural linear or nonlinear analysis, and up to a 4.6X lift with ANSYS FLUENT v14 for computational fluid dynamics (CFD) analysis. There are similar gains running other CAE and CAD programs, including SIMULIA Abaqus, and Autodesk Showcase and Simulation.

Testing performed by SolidWorks and Intel reveals how SolidWorks Simulation 2014 benefits by running on an updated workstation with multiple cores. Multicore support delivers a 2X speed boost to FFEPlus operations, and because the Large Problem Direct Sparse Solver is much faster than the Direct Sparse Solver for problems with millions of degrees of freedom (DOF), solution time for a chassis simulation with 3,360,485 DOF will operate in minutes as opposed to hours.

Despite the potential gains, the decision to upgrade always comes down to a matter of cost. Yet achieving such high levels of productivity is surprisingly affordable. A workstation tuned for running simulation software costs in the neighborhood of $10,000 and the average engineer makes around $100,000 annually or approximately $1,900 a week. Given the typical three-year lifespan of a workstation, a system refresh will cost a company between $40 and $60 per week, accounting for a mere 3% of an engineer's annual salary.

Call to Action

It's time to transform your development processes around simulation-based design workflows using powerful design suites like those from SolidWorks and Dassault Systèmes. A simple upgrade to a new workstation with the latest ISV design software will deliver big by helping engineering teams achieve more in less time.

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Engineer Contributes to Team USA Medals

Thanks in part to Hans deBot, the USA Bobsled and Skeleton teams earned six total medals in Sochi, Russia. DeBot is an engineer and president of deBotech Inc.

According to a company press release, deBot helped the United States Bobsled and Skeleton Federation develop carbon fiber technology that was used in the sleds. These stronger, lighter carbon fiber parts helped Team USA to win two silver and four bronze medals in its respective events.

"It was exciting to watch Team USA take the medal podium and make history," said deBot. "Knowing that our carbon fiber parts and composites likely played a role in the outcome of events where speed is the name of the game is amazing."

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Microdesk and Panzura Partner to Deliver Advanced Cloud Storage

Microdesk has partnered with cloud storage solutions provider Panzura to address the need for high performing data storage and management systems in the architecture, engineering, construction and operating industries.

According to a company press release, the issues the companies will be focusing on include reducing file opening time, centralizing storage, delivering a consistent user experience and improving existing workflows.

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Medical Device Manufacturer Turner MedTech Debuts

Utah-based Turner MedTech officially debuted at the MD&M Conference in Anaheim, CA. The company plans to provide medical device product developers with highly-specialized alternatives for rapid prototyping and short-run outsourced manufacturing.

Within its facilities, Turner MedTech will provide a variety of services, including rapid prototyping, CNC machining, injection molding, low to medium electromechanical assembly, process validation and component traceability. It will also offer product design, engineering, verification and validation to its clients.

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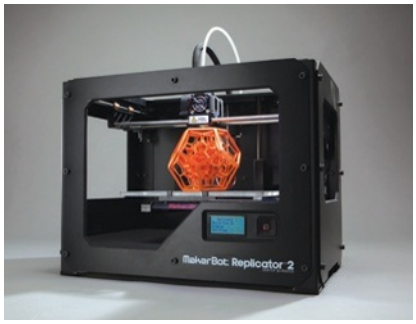
MakerBot Opens Innovation Centers

MakerBot has announced the opening of two Innovation Centers located at the State University of New York at New Paltz and College of the Ouachitas in Malvern, AR.



These centers are filled with more than 30 MakerBot desktop 3D printers and scanners to help train the next generation of engineers, architects, industrial designers and artists.

Not only will these centers be available to university students, but also to businesses that can use the 3D printing and scanning technologies for design, product development and rapid prototyping.

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ScaleMP Partners with Boston Ltd

ScaleMP, a provider of virtualization solutions, announced a partnership with Boston Limited, a manufacturer of high performance, low-power server, storage and clustered solutions.

According to a company press release, the Boston xScaler-vSMP products can deliver up to 8.5TB RAM. This is the largest memory footprint for an AMD Opteron computing solution.

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Find Help Fast

Desktop Engineering has created the Engineering Services Directory — a compilation of companies that can help you throughout engineering process, from concept design to testing, and everything in-between.

Available online at deskeng.com/services and in an annual print edition in May, our directory gives you access to more than 130 companies and counting that specialize in CAD modeling, design analysis, industrial design services, IT, product testing, rapid prototyping/reverse engineering and educational services.

The directory gives you the opportunity to contact companies that will be available to support your day-to-day or long-term engineering needs, allowing you to optimize cost and time in all stages of design.

The directory comes at no cost to you, and doesn't require an additional subscription.

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➜ For a directory of engineering service providers, visit deskeng.com/services

NAMII Announces Second Project Call Winners

The National Additive Manufacturing Innovation Institute (NAMII), which was recently branded “America Makes” is handing out nearly $30 million in funding meant to advance AM in the US.

America Makes
National Additive Manufacturing Innovation Institute

Launched in August 2013, the second call for projects focused on five areas of AM: design, materials, process and equipment, qualification and certification, and knowledgebase development. The project call winners will share $19.3 million in new funding.

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A License to Print Money

The continued growth of additive manufacturing (AM) relies on innovation as much as consumer appeal and, in a capitalist world economy, the monetary forces that drive innovation generally come from outside investments. Alan Meckler has launched the first 3D printing mutual fund, the “3D Printing and Technology Fund,” to bring more money to the global business of 3D printing.

Note the use of the word “global.” While U.S. companies like 3D Systems and Stratasys are part of the fund, the mutual fund is meant to drive 3D printing around the world. That includes the growing European and Asian markets.

The fund will also be investing in other companies that have a serious interest in additive manufacturing, such as GE, which has invested heavily in AM, and even rapid prototyping and 3D printing service bureaus, such as Materialise.

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3D Printing Sweet Music

Artiphon is using additive manufacturing (AM) to help create and share music with the introduction of the INSTRUMENT 1, a music machine that has carved out a new product category the company has dubbed the multi-instrument. With assistance from an iPhone or iPod, the INSTRUMENT 1 can be strummed like a guitar or banjo, placed on a musician’s shoulder like a violin, or placed flat across the lap to produce steel drum and drum pad sounds.

The INSTRUMENT 1 has gone through five iterations of prototypes. The introduction of 3D printing and rapid prototyping, with help from RedEye, has sped up the design process — and offered a sense of flexibility that wouldn’t have been possible using traditional manufacturing methods. The six-string, six-fret virtual fingerboard, pressure-sensitive strum section and the iPhone/iPod housing were all built on a Fortus 400mc with ABS-M30, a production-grade thermoplastic.

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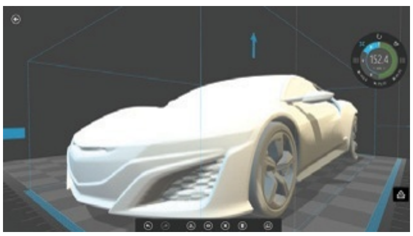
Honda Embraces Consumer 3D Printing

The latest company to draw a connection between its car designs and 3D printing is Honda Motor Co. Ltd., which recently released 3D data for the exterior designs of several previously released concept models as part of its “Honda 3D Design Archives” campaign. The 3D-printable STL models, based on version 4.0 of Creative Commons licenses, can be downloaded online — allowing interested parties to use their personal 3D printers to create their own novelty version of Honda’s concept cars.



According to Motor Authority, Honda has uploaded five concepts spanning about 20 years. Honda is encouraging them to customize the cars and even improve upon the designs prior to printing.

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3D Printing Brings Prosthetics to Africa

Additive manufacturing (AM) not only makes building prosthetics less expensive, it allows them to be put together wherever AM can be set up. Charitable organizations have begun setting up 3D printing workshops in rural Africa.

Not Impossible Labs (NiL) and Project Daniel were founded by Mick Ebeling and Elliot Kotek after hearing about a Sudanese boy named Daniel who lost both his arms to bombs. Daniel was unable to feed himself, and said he felt like a burden to his family before NiL visited him and set up a digital manufacturing lab. Daniel’s measurements were scanned, and a low-cost arm and hand prosthetic design was altered to fit him.

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Return to Render

Autodesk's James Cronin takes VRED on the road with the help of BOXX Technologies' renderPRO.

BY MARK CLARKSON

"Hyper Rod" created by Marc Mainville in Autodesk Alias. *Rendered by James Cronin in VRED.*

James Cronin originally learned Alias at Detroit's College For Creative Studies, way back when it was still "Alias Wavefront." He's worked for General Motors, Alias and Nissan Design America (where he was a concept modeler and visualization lead).

After more than a decade on the West Coast, Cronin decided it was time to return to Michigan. Friends told him of an opening for a "Subject Matter Expert in Automotive Design" at Autodesk, and it was a perfect fit.

"There's a big auto design presence here, and they need someone local," says Cronin. "I go around to customers and show them Autodesk's automotive design tools."

Those tools were mainly Alias, Sketchbook and Showcase until Autodesk acquired PI-VR, makers of the VRED ray-tracing software. Cronin promptly added VRED to his arsenal. In fact, with the exception of some "what's new" demos when a new version of Alias ships, VRED is just about all Cronin's using these days.

Auto Visualization

Autodesk bills VRED as "visualization software," but it's what we used to call a ray tracing application. VRED is similar in concept to products like Bunkspeed and Keyshot, in that it produces very high quality renders, quickly and with a minimum of fuss. VRED doesn't create geometry; all your models come in from other software.

It doesn't do complex animations, physics or particle effects, although you can import animations from other applications, such as Maya. Controls and options are relatively simple. As a result, says Cronin, "VRED training is usually just two days. That's it, and people are up to speed. It's a pretty straightforward, easy-to-use piece of software."

That's good, because more and more designers are finding that visualization is becoming a part of their job.

"You're seeing visualization entering every single aspect of automotive manufacturing and design," says Cronin. "That's part of the reason that Autodesk acquired VRED. VRED is very horizontally positioned. It can be in lots of groups, and those groups can share assets instead of re-inventing your rendering for every stage. You can get your data in here quickly and make a nice rendering; you can bring in full production data sets and do analysis of gaps; and then you can do your marketing level imagery, all in one tool."

VRED does come in several flavors — Standard, Design, Professional and Presenter — depending on your particular needs. Do you need to analyze surface shape and continuity? Or just render simple objects with realistic materials?

Signature Lighting

One of the advantages of ray tracing in general is the ability to do accurate simulations of light as it bends and bounces off of, between and through materials. VRED can do advanced, accurate light visualization, which is crucial to an increasingly important area of automotive design: signature lighting.

"These days," says Cronin, "when cars are coming toward you, it's not just the headlights you see, it's the signature lighting elements. When you're behind a Volvo at night, you know it's a Volvo. BMW has those 'angel eyes.' Even the new Ford F150 truck has signature lighting.

"A lot of design studios are taking traditional designers and saying, 'You're going to be our specialist in automotive lighting design,'" he continues. "That's where VRED and its ability to do high-end lighting simulation is becoming important for the standard designer."

Traditionally, the way to visualize a headlight is to build a physical prototype. But those prototypes — typically 3D printed via stereolithography (SLA), then sanded, chrome plated and capped with a nice vacuum-formed lens — can cost a design studio up to $40,000 per part. Add in a prototype taillight, revise a time or two, and multiply by however many designs a company might do every year — and it adds up rather quickly.

"If you can do some digital prototyping inside of VRED," says Cronin, "you're going to pay for the software in one project. The cost of the software and hardware is minor compared to spending $40,000 per light. It's cheap to do these things upstream."

Thanks to constantly increasing computer power, more and more "upstream" designers have access to powerful visualization tools. "My laptop's more powerful than my workstation was 3 years ago," Cronin points out. And speaking of laptops …

Laptops vs. Workstations

Cronin notes that everyone in his role — Autodesk Technical Account Managers or Subject Matter Experts — has a laptop. Portable by design, they're the perfect machines to take to clients for software demos. Cronin can still recall a time when demoing Alias software involved hauling an entire workstation and its accompanying fat CRT monitor around from client to client.

But laptops also have a key problem: While today's models may be as powerful as yesterday's workstation, they are in not as powerful as today's workstations, and a high-end ray-tracing program like VRED wants all the fast RAM and CPU cycles it can get. That's especially true if you're visualizing the fiddly bits inside a car's headlight assembly, for example.

Yet workstations, with their giant power supplies and multiple graphics cards, are just as heavy as ever — and

The BOXX Technologies renderPRO, packed in its case and ready for air travel. *Image courtesy of James Cronin.*

The BOXX Technologies renderPRO. *Image courtesy of BOXX Technologies.*

renderPRO Fast Stats

- **Processor Type:** Intel Xeon E5-2600v2
- **Processor Cores:** up to 24
- **Overclocked:** No
- **Cooling:** Air Cooling
- **Maximum Configurable Memory:** 128GB
- **Total GPUs:** 1
- **Maximum Number of Hard Drives:** 2
- **Total USB Ports:** 3
- **Thunderbolt Enabled:** No
- **Optical Drive:** None
- **Power Supply:** 350W
- **Chassis:** 6.75 in. W x 3.8 on. H x 20 on. D
- **Price:** $3,128 for the base model, which includes dual Xeon (2.1 GHz) 6 Core processor, 16GB of DDR3-1866 ECC Memory, 120GB solid-state drive, Microsoft Windows Professional 7

just as impractical to lug around. Enter the BOXX Technologies renderPRO into Cronin's life.

Packs a Punch

As a minimalist box designed to sit nicely atop your desktop workstation — 6.75x20x3.8 in. — the renderPRO packs a choice of dual Xeon processors, a solid-state drive (SSD) and up to 128GB of DDR3 RAM. Depending on your loadout, it will run you from $3,200 for the basic configuration to $13,000 and change for a high-end package. Use an Ethernet cable to plug it into a PC or laptop running a cluster-capable application such as VRED, and it's like having a miniature render farm in an oversized shoebox.

"That is why I got it," says Cronin. "When I'm in front of a customer and I'm tumbling the model, that little bitty renderPRO is doing all the work. I'm demoing on my laptop, but I've got the power of a workstation."

Need more power? Add another renderPRO. "I could have five renderPROs, and VRED would use all of them," says Cronin. "That's one reason that I demo VRED's clustering. A lot of our customers already have a large render farm available. It sparks ideas."

Our expectations evolve concurrently with software and hardware. "Ten years ago," says Cronin, "they were happy if you had something that looked like a video game. Now they want something that looks like a photograph. And when you rotate it, they don't want to sit and watch the ray tracing happen. They want it to be instant.

"[The renderPRO] alleviates those long dramatic pauses in demos when you're waiting for your little laptop to do a bunch of work, wishing you'd brought your workstation," he adds.

VRED plus the renderPRO yields near real-time performance, even with very demanding renders. "That's important when you're demoing headlights," says Cronin. "People get bored very quickly. You don't want them looking at a view that's gritty and noisy and slowwwwly calculating those bounces."

Travel Companion

As important as its speed, says Cronin, is the renderPRO's petite size: "The renderPRO is the perfect size for travel." He packs both his laptop and the renderPRO in a rolling hard case, which fits nicely into the overhead bins on airplanes. More than convenient, this is absolutely crucial, he says.

"I can't have something that goes under the plane," he explains. "I'm sure the luggage handlers are all very careful with everything, but the expense and the importance of the hardware I'm taking on demos, or to trade shows, means that I need something I can carry on."

In fact, Cronin doesn't bother with small test renders these days. He renders everything at 4000x2000 — print resolution — right from the start. He trusts the renderPRO and VRED to produce a final render on his laptop before he gets bored.

Cronin has a conventional, desktop workstation, but says he rarely uses it. "Last night, I did a render on [my laptop and renderPRO] that was 34,000 by 18,000 pixels. They want to make a wall poster of one of my renderings, so I needed a render that was a gigantic resolution, but I didn't need a gigantic workstation.

"The renderPRO is like my own little one-machine render farm," he concludes "I can add my laptop into the processing power if I want those eight extra virtual cores. But if I just render on the renderPRO, then I can keep working, answering emails and surfing the web on my laptop, while the renderPRO is doing all the work." **DE**

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

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Flying with Structural FEA

A look at some of the finite element analysis technologies used in the aerospace industry — and the simulation methods involved.

BY TONY ABBEY

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

The aerospace industry is one of the originators of finite element analysis (FEA). The company division I worked for in the UK in the 1970s was typical of that time, with roots as an independent aircraft manufacturing company. Our homegrown FEA solution was used on all our aircraft projects. The FEA solver was sophisticated, and met our specific needs. There were six to eight independent FEA solvers in the UK aircraft industry alone; the same pattern was repeated worldwide.

Subsequently, the limitations of an independent FEA solver became apparent. Maintenance, documentation and support were a burden on the engineers who originated the system. Similar problems were found worldwide, with a need for rationalization and compatibility between contractors on many major projects.

For us, the spur to abandon our own FEA solver was the Multi-role Combat Aircraft (MRCA) international project. In the U.S., one of the main drivers for compatibility was the Apollo moon project. Contractors were responsible for building and testing analysis models of their components, which were then combined into a single project model. NASA defined a common specification for FEA data and solution structure, which became NASTRAN. Later, NASA outsourced the development. Commercial FEA solvers are now almost universal.

Idealization Methods

At that time, aircraft and spacecraft FEA models were very simplified representations of the real structure. This was achieved by high level idealization: Fig. 1 shows a typical part mesh. A mix of pure shear panels and end-load carrying rods provide the only load transfer path. However, bending, torsion and axial loads can be carried effectively by this scheme.

A modern-day complaint is that we can't develop any realistic stresses directly from the FEA model. In fact, the purpose of such a model is not to develop local stresses, but to develop load paths through the structure. Even today, many aerospace FEA models — although they use more sophisticated elements — actually function as load path models, as shown in Fig. 2. The detail stresses are developed from the internal loads found in such a model downstream of the FEA analysis.

There are two main drivers toward this mixed FEA and conventional stressing approach:

- **Approximation:** The FEA method is a displacement-based solution, and struggles to find an adequately converged stress solution in many cases — particularly when a coarse mesh is used.
- **Certification:** All primary structures require detailed strength assessment calculations. It was not practical to model large amounts of detail structure using FEA. (Even now, it is problematic to attempt to model a complete structure in detail via FEA.)

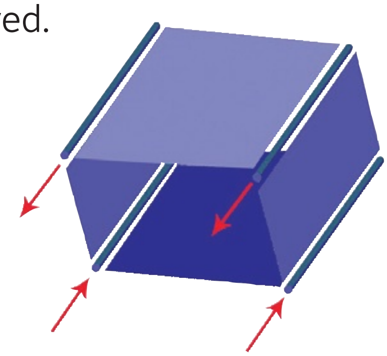

Fig. 1: Early shear panel and rod element idealization.

Global Modeling Strategy

As noted, many large projects required contractors to combine models in the buildup of the complete aircraft or spacecraft structural model. The super-element technique was developed early on to facilitate this approach. There are two major advantages for this method:

1. Each component can be modeled independently by individual subcontractors. All that needs to be shared in the full system model are the mass and stiffness matrix representation and boundary nodal points. This means that each subcontractor can check out his or her own model and share this when ready. The cost of running the final super-element assembly analysis is far cheaper than attempting to run a single standalone model.

2. A subcontractor wanting to keep a component confidential only supplies the mass and stiffness terms to the prime contractor assembling the model. The boundary results are passed back to the subcontractor, who solves for the component structural solution locally, but within the context of the overall structural response.

This methodology has become common within the aerospace and other industries for dealing with large structural models, particularly where component confidentiality or autonomy of design is required. However, it does require disciplined analysis setup, which can become quite complex. Most large aerospace companies have evolved this as a "black box" internal process.

An alternative to super-elements is local global modeling. This

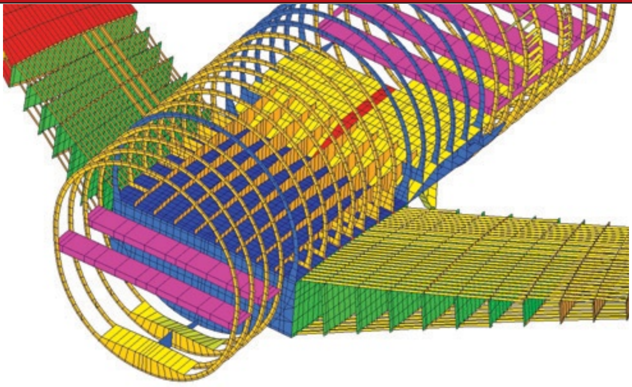

Fig. 2: Model of an aircraft fuselage. *Image courtesy of Altair.*

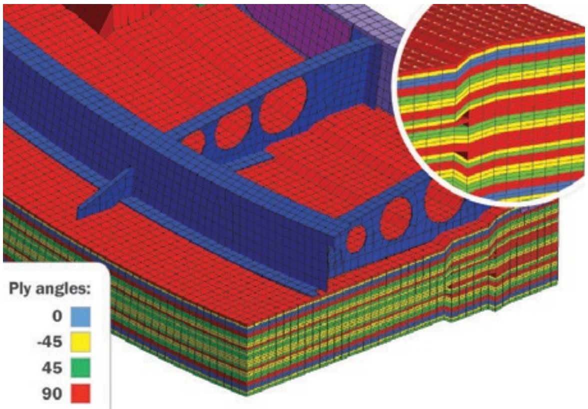

Fig. 3: A 3D solid composite. *Image courtesy of Altair.*

can provide a bridge between the loads model and a local detail FEA stress model. Forces or displacements from the boundaries of the global model are applied to the corresponding positions in a more highly refined local model. Although this method also has limitations, it is a powerful technique.

At some point in the future, aircraft stress models will presumably use solid element meshing directly of the CAD components. The main attraction will be to eliminate the notoriously complex and time-consuming process of idealization and meshing from solid geometry to shell and beam elements. The downside to this is that models of the order of Giga (10^9) degrees of freedom (DOF) or even Tera (10^12) DOF would be required. This far exceeds the current practical limit for model size.

Fatigue and Damage Tolerance

Fatigue failure is a result of repeated stress application under cyclic loading — often way below yield stress levels. Conventional fatigue analysis identifies stress concentration sites throughout the aircraft using linear static FEA analysis. This can be done with detail models or downstream assessment of a loads model.

The loading mechanism and history applied at the sites are critical, and require careful identification of how compressive, tensile or shear stress states combine. Vibration fatigue analysis may be required on components that see significant dynamic response, such as engine pylons and skins near jet efflux.

Fatigue analysis identifies sites in a structure where crack initiation is likely to occur. The estimate of the fatigue life is based on empirical methods fitted to test data. Fatigue analysis does not, by itself, predict any form of crack growth.

Damage tolerance assessment, on the other hand, can predict crack growth. Potential crack initiation sites are identified, and various crack shapes and sizes are assumed. Linear elastic fracture mechanics coupled with FEA solutions are used to estimate crack growth. The principle is straightforward; however, the challenge is in meshing a crack in a 2D shell or 3D solid model and then allowing automatic re-meshing of the growing crack.

Damage tolerance assessment requires a high level of mesh refinement in a local detail model. Specific sites of interest have to be selected — there is no overall process to sweep through a complete aerospace model.

Loads Derivation

Loading environments vary considerably across aerospace applications. Military aircraft sustain high G maneuvers across all corners of the flight envelope. Also, there may be many variations in external payload and fuel state that have to be assessed, with particular dynamic environments from gunfire or store ejection.

The critical cases for civil aircraft include gust response and dynamic landing. Variations of payload and fuel state must be accounted for — and each possible phasing and positioning of the aircraft in the gust and landing conditions has to be assessed. There may be hundreds of thousands of load cases to be used in assessment of the structural integrity of all components of aircraft. The sheer quantity of load cases demands specific processes to handle this volume of data and stress analysis.

Launcher and satellite structures see high inertial loading during the launch. This occurs together with a harsh dynamic environment, with random vibration loading forces being transmitted from the rocket motors up through the structure. A great deal of effort is spent on ensuring strength and fatigue life.

Aerospace vehicles are subject to aerodynamic loading. Until fairly recently, most of the loading data was calculated from wind tunnel results or well proven classical solutions. As structural configurations have become more complex and performance requirements more demanding, however, a need for greater fidelity in aerodynamic calculations has evolved: Computational fluid dynamics (CFD) now plays a vital role in modern aerodynamic simulation and loads derivation.

For initial calculations, a wing or control surface is assumed to be rigid under aerodynamic loading. However, the wing is flexible and will change its configuration with resultant perturbation of aerodynamic loading until a balanced state is reached. Steady aeroelastic FEA calculates this interaction, and allows a modified aerodynamic loading distribution to be used.

Unsteady aeroelastic analysis calculates the dynamic interaction between an oscillating airflow and a vibrating control surface. A search is carried out for critical flutter modes across the aircraft flight envelope. (Flutter is an extremely dangerous phenomenon, and is usually catastrophic.)

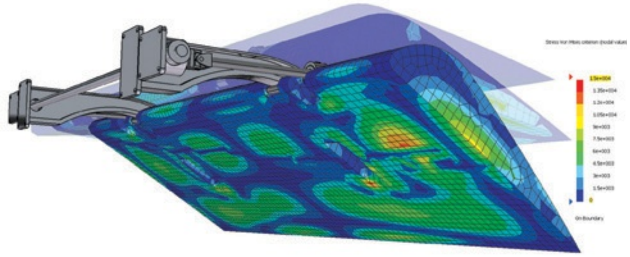

Fig. 4: Management-based Design for Environment (MbDfE) co-simulation of a wing flap mechanism. *Image courtesy of MSC Software.*

Both steady and unsteady aeroelastic analysis traditionally used linear structural analysis, basic aerodynamic panel methods and simple load models to develop the required dynamic interaction. However, these methods cannot deal well with structural non-linearity, complex 3D vehicle shapes, transonic flow or highly localized flow.

There is now a move to couple more accurate CFD calculations with structural calculations using fluid structure interaction (FSI) methods. UAVs can have highly flexible wings and FSI permits coupling non-linear structural analysis with CFD. The main issue here, however, is that the CFD calculations are expensive compared to structural calculations.

Thermal loading and analysis are required for structures near engines, rocket motors, etc., as well as kinetic heating of the airframe from high-speed flight. This may be done fully within an FEA solution, or an independent thermal solution may be mapped or coupled to the structural FEA.

Composites

The biggest change in aircraft design over the past 20 years has been the dramatic increase in the use of composites for primary structures. Test programs and techniques have developed to provide the supporting evidence for strength and stiffness assessment. Similarly, simulation methods have evolved to handle a new type of structure (see Fig. 3). This has been a steady evolution from classical laminate theory mapped into thin shell applications.

This works well for continuous structures such as wing and fuselage skins. However, for joints and more complex (and typically, heavier) fittings, local effects become important in a composite layup. In this case, 3D solid elements are used that allow full interlaminar and through-thickness effects to be simulated. Failure modes such as delamination and interlaminar shear would otherwise be missed.

The actual failure mode of a composite structure can be a challenge to assess. Even a simple coupon test, subject to compression and shear, results in complex microlevel failure that is not well represented by traditional failure theories. If the real structure is a skin-to-stringer joint at the edge of a panel, it can be difficult to predict failure. FEA techniques are evolving along several fronts to try and deal with these situations.

Phenomenological failure criteria attempt to predict distinct failure modes that are strongly dependent on loading action. These replace the more traditional failure criteria. For example:

- **Progressive ply failure** degrades the stiffness properties of plies within a layup to allow a more gradual loss of strength as load is increased.
- **Cohesive zone elements** attempt to model the bond line failure between plies, using local bond separation forces and displacements.
- **Virtual crack closure technique** (VCCT) methods model bond line and possibly ply matrix failure using a fracture mechanics approach, to assess crack propagation under loading history.

Micromechanics analysis of failure modes in localized regions is mapped to the global FEA model to improve the fidelity of the failure modeling.

New Analysis Areas

In addition, there are structural analysis techniques becoming increasingly important within the aerospace industry, including:

- **Multi-body dynamics analysis (MBDA)** deals with mechanisms made up of rigid components. The technology has been extended so that flexible bodies created from FEA can be coupled into the MBDA. In the past, structures such as flaps (see Fig. 4) were analyzed in separate configurations. With MBDA, multiple configurations can be introduced — as well as the dynamic interaction with the surrounding structure. Whole vehicle applications in gust or dynamic landing scenarios look promising.
- **Non-linear analysis** has not traditionally been used, as structures are expected to show adequate margin over limit conditions. However, in the drive for ever-lighter structures combined with the strength-to-weight ratio of composites, post-buckling analysis of structures that are allowed to develop wrinkles or moderate buckling below limit load is being explored. Some radical designs of UAV, space sails, etc., require large deformation analysis, for example.

The biggest changes in aerospace analysis are linked to the growth of composites. However, the tremendous growth in computing speed and power is allowing a steady increase in the number of highly detailed local models of aircraft structures.

One of the biggest challenges is to be able to harness this level of model fidelity, and use it effectively within the traditional strength assessment requirement for the whole vehicle structure. At some point in the future, there will be a migration to solid-element, full-vehicle modeling that will require a rethink of the whole process. DE

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GoBOXX 2725 Marries Desktop Power with Laptop Convenience

GoBOXX 2725 makes the work-anywhere workstation a reality.

As high-powered mobile devices take the business world by storm, it's no longer a stretch for professionals to work from wherever they are, using their laptop or tablet to access a core set of productivity tools. That same kind of work-anywhere flexibility has eluded many engineers, however, because most 3D design tools demand the power and performance traditionally reserved for desktop workstations.

Portable Xeon Power

The scenario has changed with the advent of BOXX Technologies' GoBOXX 2725 mobile workstation. The GoBOXX 2725 is the first mobile platform to feature a true workstation-class Intel Xeon processor with up to 12 cores (not available from other workstation manufacturers), marrying the full power of a desktop workstation with the convenience of a laptop.

As a result, engineers can now take advantage of the full functionality of a traditional system wherever they choose to work, without sacrificing performance and without placing limitations on what they can accomplish. In fact, the addition of the desktop-level Intel Xeon E5-2600v2 Series processor means that the GoBOXX 2725 is very likely faster than a user's current, highest-end Dell or Hewlett-Packard desktop workstation.

Unlike previous models in BOXX's mobile workstation line that were best suited for lightweight design work or collaborative design reviews, the GoBOXX 2725 is powered to run the most demanding engineering and design applications like SolidWorks with PhotoView rendering or Autodesk REVIT with mental ray rendering. Ideal for light rendering workflows, design, compositing, and video editing, the GoBOXX 2725 doesn't put limits on where or how an engineer can work, enabling them to finally break free of the constraints of the desktop and work effectively on the road.

Professional-Grade GPUs

In addition to the workstation-level Intel Xeon processors with up to 12 cores, the GoBOXX 2725 can be configured with a choice of professional-grade GPUs: Either an NVIDIA Quadro K5100m or NVIDIA GeForce 780M. The GPU horsepower, coupled with up to 32GB of 1866

MHz memory, ensures the system has the power to run graphics-intensive design applications with top-notch performance—again, no trade off in speed just because of the laptop form factor.

Expansion Opportunities

Unlike other mobile workstations that might feature limited screen size, the GoBOXX 2725 is equipped with a 17.3-inch, high-definition screen with a resolution of 1920x1080, making it a match for graphics-intensive 3D CAD, animation, and CAE applications. For engineers looking to employ a larger size monitor for presentations or large-scale design reviews, the GoBOXX 2725 has two USB 3.0 ports in addition to other expansion capabilities. There are also three 2.5 SATA hard drives on board.

While powerful enough to support high-performance rendering on its own, the GoBOXX 2725 can also be paired with BOXX Technologies' renderPRO, a purpose-built, personal render farm. renderPRO delivers added processing muscle, allowing design engineers to offload rendering tasks to the dedicated device, freeing up the GoBOXX 2725 for use on hands-on modeling or other design operations.

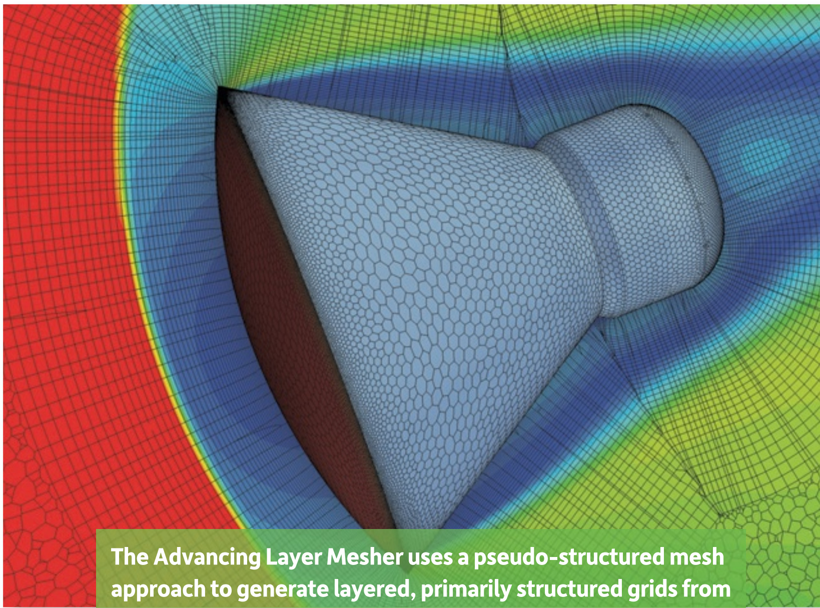
Finally, engineers have the flexibility to work anywhere without taking a hit in performance. The GoBOXX 2725 gives engineers an on-the-go workstation for their office, for the studio, for a client site or wherever else their business takes them.

To learn more, see a video, and configure your own GoBOXX 2725, visit www.boxx-tech.com/products/mobile-workstations/goboxx-g2725 or call 1-877-877-BOXX.

Meshed up or **Messed up?**

Automatic meshing saves time; expert meshing ensures accuracy. Which is right for you?

BY KENNETH WONG



The Advancing Layer Mesher uses a pseudo-structured mesh approach to generate layered, primarily structured grids from wall boundaries beyond the boundary layer. This meshing approach is suitable for computations involving bow shocks, as depicted in this simulation of the re-entry of the Crew Exploration Vehicle. *Image courtesy of CD-adapco.*

It's easy to spot a bad mesh model, but a lot harder to know if a mesh model is good enough for what you need. That's how John Chawner, president of simulation software developer Pointwise, sums up the dilemma of meshing.

Meshing — subdividing a 3D CAD model into tiny geometric elements — is largely automated these days, usually as a standard feature in preprocessing simulation programs. The software uses built-in algorithms to scan the imported CAD geometry, decide on the appropriate mesh to use, and create the mesh model. When something goes awry in the process, the signs are unmistakable. Instead of producing a mesh model, the software issues a failure alert. Or it produces a disfigured, twisted mesh model dramatically different from the original.

But in many cases, the software may just make educated guesses to resolve the conflicts and produce a mesh model. Based on experience, a simulation expert may be able to decide whether the software-produced mesh model is acceptable for the job at hand, be it flow simulation inside a pump or mechanical simulation of a landing gear. A non-expert unschooled in meshing principles, however, has few other choices but to trust the software-produced mesh model.

How can novice users determine whether the mesh model is good enough? Industry insiders point to a template-driven approach as the way of the future. They also say that, even if you end up taking a leap of faith in the software's automatic meshing, it's not exactly blind faith: Modern simulation software has built-in safeguards to prevent you from walking off the cliff.

Root Causes of Meshing Problems

Pierre Thieffry, ANSYS' product manager for structural mechanics solutions, points to "dirty geometries that exhibit slivers, overlapping surfaces and holes" as a source of mesh failures. "Overly detailed geometry [or] models that contain too many details, some of which are not relevant to the model's behavior" can also stump the automatic mesher, he adds.

Gilles Eggenspieler, senior fluid product line manager at ANSYS, notes that many simulation groups deal with CAD geometries with imperfections, such as gaps between surfaces, holes, etc. This is especially problematic for computational fluid dynamics (CFD) simulation, he adds, "because the first operation in every CFD simulation is to extract the fluid volume inside (internal flows) or outside (external flows) a given geometry."

Design and simulation departments, although interdependent, treat geometry differently. As Eggenspieler points out, "A CAD file can incorporate bolt nuts, company logo, etc. Those details are important from a manufacturing point of view, but do not influence the flow behavior."

The reality is, CAD-exported geometry is bound contain errors and flaws. "We made the decision that some user geometry is bound to be sloppily built or messy," reports Pointwise's Chawner. Accordingly, Pointwise's products — and many others — shoulder the cleanup burden in the preprocessing phase of simulation.

Where Automation May Not be Ideal

Simulation products targeting nonexperts avoid overwhelming users by keeping required inputs to a minimum. Presenting the user with a long menu of mesh types to choose from, for example, could be a stumbling block. To bypass this, sometimes the automatic meshing feature might use a default mesh type that's easier to automate, but may not be suitable for a particular problem.

"In the CFD community, we typically automate the meshing process by using unstructured meshes," says Dave Corson, program manager for Altair Engineering's AcuSolve. "Usually, that's tetrahedral elements. This approach provides the most flexible and robust technique for handling arbitrarily complex geometry."

But when the geometry is anisotropic — like the flow inside a long, skinny pipe — Corson says the mesh elements "should be stretched out in the direction of the liquid flow. Filling that type of volume with tetrahedral mesh is not such a good idea, because it uses far more elements than needed to be accurate."

On the other hand, in a scenario like the leading edge of an airplane wing plowing into a high-gradient velocity field, the affected region requires special handling in the meshing process. To be able to detect such an exceptional case and create the appropriate mesh is "a tall order" for any software, Corson says.

The Healing Touches

ANSYS's Thieffry notes that "for problematic geometry, we offer tools to clean it, both automated and manual. Our meshing tools also allow you to automatically or manually defeature a model."

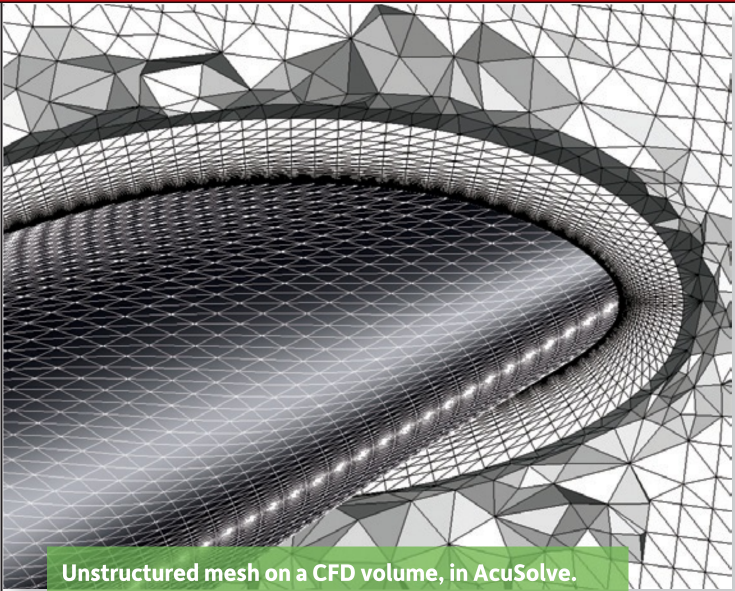
Automated defeaturing, Thieffry continues, takes into account the size of geometric elements such as edges or holes. "It can also detect proximity between similar entities — two close-enough edges that need to be pinched into one for the mesh, for example," he says. "Manual defeaturing usually involves the use of what is called 'virtual topologies,' where users can group features or entities (edges, faces)."

Pointwise software uses two approaches to dealing with imperfections. According to the company, "The first approach is fault-tolerant meshing, in which we mesh the geometry as-is and then heal any problems on the mesh level. The second, newer approach is Solid Meshing. While importing CAD data into Pointwise, this technique creates *models* and *quilts*. Models are topological CAD entities that allow for watertight meshing over gaps and cracks in the underlying geometry. In addition to models, Pointwise includes the concept of meshing regions defined on the CAD level, also known as quilts. While a model is a watertight representation of the geometry, quilts are the regions within this model that hide unnecessary complex topology in the underlying geometry by identifying meshing region boundaries."

In simulation software like Patran from MSC Software, users can rely on the free boundary check and free face check tools to identify geometry that needs to be patched before meshing.

"We have automatic healing, so [the software] looks at the flawed geometry and uses what it thinks is the best approach to clean it up," explains Tim Kuhlmann, a product manager for MSC Software. Products that target more sophisticated users, he adds, are "less automatic" by design: With them, "you can drag and drop the edge lines to clean up the geometry."

For simulating scenarios involving dense mesh in one


Unstructured mesh on a CFD volume, in AcuSolve. *Image courtesy of Altair Engineering.*

area and coarse mesh in another area, Patran offers tools for mesh ceding and mesh zooming, Kuhlmann says.

The Penalty for Improper Meshing

Improper mesh — whether it results from automation or the user's inexperience — affects the size of the model, and thus the time required to solve it. In quantitative terms, you pay for the wrong choices in higher CPU/GPU cycles and delays.

"In a massive 3D model, the use of tetrahedral elements has become prominent, even if hexahedral elements are necessary in some cases," says ANSYS' Theiffry, referring to elements such as crash analysis and some specific nonlinear models. "For thinner parts such as surface body, shell elements are usually preferred. And for truss-like structures, beam elements are preferred."

ANSYS' Eggenspieler points out that "A CFD tetrahedral or polyhedral mesh of a turbomachinery blade system is known not to be as accurate as a hexahedral mesh. In many cases, the mesh type is not critical, but the quality of the mesh is. CFD simulations require high quality meshes. If this is not the case, the simulation will either not be accurate or it will take a long time to converge — or both."

Some software developers intend to circumvent the mesh-quality problem by making the solver technology insensitive to the mesh quality. "AcuSolve has made great strides in this area," Altair's Corson says. "Having a robust solver capable of handling badly distorted elements with high aspect ratios is one way to overcome the problems associated with automatic meshing."

Bridging through CAD

If many imperfections are the outcome of CAD geometry export, then why not stop the problem right at the gate? That thinking, along with the vendors' desire to make their tools more CAD-friendly for broader appeal, has led to the development of CAD-embedded simulation plug-ins.

"Our CAD client is a tool that embeds STAR CCM+ functionalities in popular CAD programs," notes Joel Davison, a product manager from CD-adapco. "It offers a simplified front end for designers and nonexperts. It requires from you only a limited number of choices."

Delphine Genouvrier, senior product portfolio manager for SolidWorks Simulation, observes that, with the tight integration of finite element analysis (FEA) and CFD tools inside CAD systems, "one of the values is geometry recognition and an intelligent-meshing methods. With SolidWorks Simulation, an automatic transitional mesher will refine mesh size for small entities and ensure proper mesh distribution between the refined areas and the rest of the model with transitional mesh.

"Moreover, the CAD integration offers tools to easily simplify and clean the CAD model for simulation purpose, such as the defeaturing for small fillets," Genouvrier continues. "It enables as well to directly use the CAD boundary for automatic fluid domain creation for CFD analysis in SolidWorks Flow Simulation."

Expert-built Templates

Some envision that, in the future, automatic meshing may behave more like artificial intelligence (AI): It would learn from past simulations performed, and apply the same approach in the future. Until that happens, however, it may be up to the users to feed that knowledge to nonexperts, in the form of templates.

"We have very good template-building tools," said CD-adapco's Davison. "An expert user can make a template file, so the nonexpert user can simply drop the geometry into the simulation tree and hit 'Go.' The advantage of that approach is, you are capturing your best practices. It's a guided workflow, so the nonexpert only has to execute a string of commands."

With this approach, simulation experts can develop templates for the most commonly executed jobs (for example, simulating wind tunnel tests for vehicles or turbo-machinery blade rows). For the type of geometry anticipated, the experts can specify in the template the recommended meshing procedures. This removes the burden from the nonexpert user. **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 Engineering: Altair.com

→ **ANSYS:** ANSYS.com

→ **CD-adapco:** CD-adapco.com

→ **MSC Software:** MSCSoftware.com

→ **Pointwise:** Pointwise.com

→ **SolidWorks Simulation:** SolidWorks.com/simulation.htm

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

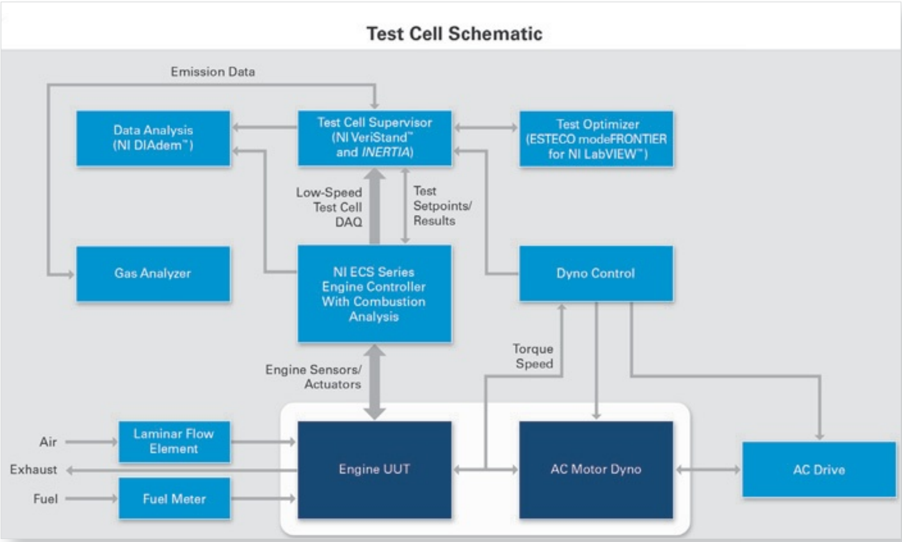
Optimization Steers ECU Testing into the Fast Lane

Alma Automotive is piloting mF4LV as part of a strategy to leverage optimization and automation — with the goal of reducing engine control unit test cycles.

BY BETH STACKPOLE

In light of the next generation of more rigorous emissions standards, the automotive supply chain is facing a tricky dilemma: How to throttle up complex testing on powertrain and engine control units, without casting undue drag on test cycles or performance.

It's been quite a balancing act for Alma Automotive, whose core business is providing hardware and software-based custom solutions dedicated to engine control, diagnosis and testing for such high-profile customers like Ferrari, Ducati and Lamborghini. Founded in 2003 by researchers from the Department of Mechanical and Energetic Engineering at the University of Bologna, the company focuses its testing services in three areas: real-time combustion analysis, hardware-in-the-loop (HIL) systems and rapid control prototyping.

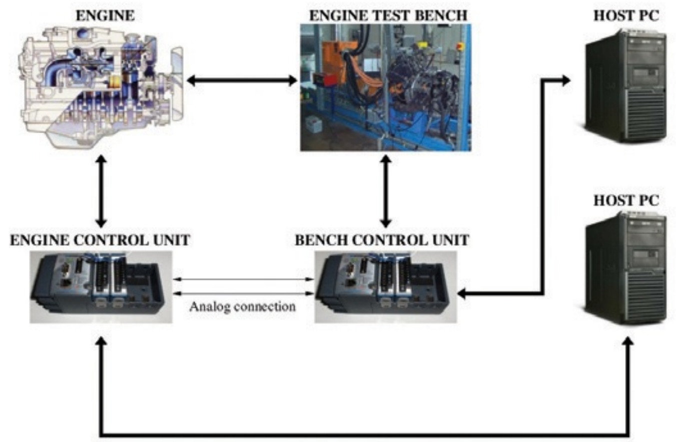


Schematic shows where modeFRONTIER for LabVIEW fits in as part of an automotive test cell. *Image Courtesy of National Instruments.*

Given its customers' penchant for speed for both engine performance and steering high-octane sports car and motorcycles to market, Alma Automotive was in search of new practices that could turbocharge its engine control unit (ECU) test bed, specifically as it relates to calibration. Its typical process was slow and cumbersome, requiring test engineers to painstakingly make manual adjustments to parameters using the engine test bench, which was instrumented with hardware and software from National Instruments (NI). The primary challenge was to achieve optimum parameter results as quickly as possible while maximizing system accuracy — a scenario that was increasingly difficult to achieve with the manual test process.

A solution came via a collaborative effort among Alma Automotive, NI and ESTECO, a maker of the modeFRONTIER multi-disciplinary and -objective optimization platform. The trio partnered to create a direct integration between LabVIEW, NI's graphical system design software used by Alma Automotive to design its ECU test bench, and modeFRONTIER. The result enables modeFRONTIER's process integration and optimization capabilities to be deployed on the ECU's HIL testing, automating the search for optimum parameter results — and in the end, driving significant efficiencies throughout the test process.

"Our customers' target is to optimize engine performance. They need to change the control parameters in order to achieve something that could be the optimal power or minimum fuel consumption," explains Enrico Corti, one of the founders of Alma Automotive. "But they need a guide for which direction to move the control parameters in to minimize or maximize their cause. We wanted to add real-time optimization to our systems; that's why we thought of using modeFRONTIER and integrating it with LabVIEW."



Alma Automotive set up a test environment for the automatic calibration system, consisting of engine and test bench controllers based on NI CompactRIO devices. *Image courtesy of ESTECO.*

Complex DOE

The trio embarked on a project to demonstrate the value of combining the NI test and measurement devices with a modeFRONTIER framework, leveraging specific applications developed by Alma Automotive for the engine setup. The result of their efforts is modeFRONTIER for LabVIEW (mF4LV), a light, add-on version of the process automation and optimization platform. It's specifically integrated with LabVIEW with the goal of helping engineers and scientists quickly reach a sought-after response from the hardware or control systems they have under test.

By exploiting modeFRONTIER's advanced optimization algorithms, mF4LV significantly speeds up HIL testing by automatically modifying the values assigned to control parameters. This helps to achieve optimal hardware behavior in lieu of relying on humans to manually make the adjustments.

Dr. Matt Viele, principal architect for NI's Powertrain Controls Group, says modeFRONTIER's process automation and optimization capabilities are a key asset in helping automotive powertrain groups accelerate the increasingly complex design of experiment required to accommodate modern engine design for current and future fuel emissions standards.

"The modern engine now has between six and seven actuators, and maybe 12 degrees of freedom in the system, which means it would take decades to run through calibrations with a brute force method," Viele explains. "That just isn't practical. Something like modeFRONTIER is required to choose battles when going through this kind of optimization."

Viele says that when setting up ECU design of experiments (DOE), it isn't possible to cover all corners of the test matrix with manual processes. That's where an optimizer like modeFRONTIER comes in. "You need a more advanced algorithm and an iterative approach, like what can be delivered by an optimization tool," he adds. "The hope is that in the course of a few hundred or thousand test points, you can get the map 99% of the way there — as opposed to the billion test points that you would have to create manually without the help of automation or optimization."

NI opted to partner with ESTECO on the project rather than try to build its own test optimizer technology because the area isn't the company's strong suit. mF4LV is sold on NI's LabVIEW Tools Network.

"We know how to build a great test system and great test hardware, but we are not great DOE people. ESTECO is," Viele says.

mF4LV's direct integration with LabVIEW makes it easier for LabVIEW users to take advantage of modeFRONTIER's optimization capabilities. While the two could be used together previously as part of modeFRONTIER's node architecture, mF4LV has a customized graphical user interface (GUI) that makes it look and feel like LabVIEW. This way, users are neither required to learn a new environment nor encumbered with modeFRONTIER capabilities that aren't specific to the testing process.

"The integration simplifies set-up," explains Dr. Livio Tenze, ESTECO's head of IT. "They can set up constraints, generate random starting points, and select the optimization they'd like to use. The process is simplified, and they don't have to learn new software."

Alma's Test Bench

Having optimization capabilities as part of a LabVIEW user experience is one of the primary appeals of mF4LV for Alma Automation, which is piloting the package as a way to help its customers achieve a shorter calibration period for optimal engine-under-test management. Alma Automotive set up a test environment for the automatic calibration system, consisting of engine and test bench controllers based on NI CompactRIO devices, which are programmed and equipped with field-programmable gate array (FPGA) boards. The test bench controllers are connected to the engine, as well as to the bench transducers and actuators.

The CompactRIO devices send signals through an Ethernet connection to two host PCs running Windows 7, which store the data and set up the operating parameters. The interfaces developed by Alma Automotive provide easy interaction with the ECU system, allowing the test-bed sensors to route signals to mF4LV, running on the host PCs, as optimization targets. From there, the optimization algorithm, in a range specified by the user, automatically chooses the parameter values and drives the transducers toward the optimal solution.

To test the ECU test bed optimization workflow, the partners set up two tests. The first was a simple test that involved finding the optimal calibration for the spark advance on a real engine, which was mounted on the test bench, to optimize the maximum brake torque.

"This is one of the most important aspects that need to be optimized," explains Alma Automotive's Corti. "Our objective was to maximize this parameter while maintaining the engine in safe operating conditions."

Before the test, the team set the range of spark advance degrees on modeFRONTIER, choosing the simplex (Nelder-Mead) algorithm for maximum torque; the team reached the goal in approximately 10 optimization steps.

After successfully completing the first test, the team moved on to a more complex experiment to prove the effectiveness of the system for optimizing fuel-film automatic compensation. Typically, some of the gasoline injected into an intake manifold of a spark ignition engine collects at the bottom of the intake runner wall. After a while, depending on the temperature, the wall film evaporates and goes into the cylinder, which can cause delays in engine reaction.

The test involved using mF4LV algorithms to identify the value of the X and tau constants in real time to compensate for this fuel-film dynamics, thus preventing any engine delays. mF4LV's automation capabilities let X and tau values be mapped and the optimal compensation strategy established, Corti says.

"To predict such a dynamic, two parameters have to be calibrated so the optimization problem has different objectives that need to be coupled in a multi-objective optimization," he adds. "In this case, the classic approach based on measurements on a test bench, and offline analysis would be quite demanding and not always achievable. But this is modeFRONTIER's sweet spot."

While Alma Automotive is not yet committed to offering mF4LV as part of its ECU test bench solution, it does see a clear role for automating the optimization process around testing, depending on the specific problem. modeFRONTIER, in particular, offers some real benefits when it comes to the need to reduce test cycles.

"If you use an optimizer requiring 1,000 tests, it means you have to stay at the test bench for 20 hours," explains Giorgio Mancini, a Ph.D. student at the University of Bologna working with Alma Automotive on this project. "The good thing with modeFRONTIER and its optimizers is they get you to close to the optimal solutions in just a few steps, reducing the time you have to stay on the bench." **DE**

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

INFO → **Alma Automotive:** Alma-Automotive.it

→ **ESTECO:** ESTECO.com

→ **National Instruments:** NI.com

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

Coordinate Metrology Society Turns 30

Its annual gathering July 21-25 will showcase 3D measurement technology and offer new certification opportunities for metrology professionals.

BY LYNNE BRAKEMAN

If it's been a while since you've been acquainted with the term metrology, you may recall it is the science of measuring objects. Applied industrial metrology focuses on measuring instruments, their calibration and quality control measurements for purposes of designing, testing and manufacturing objects.

This summer, the Coordinate Metrology Society (CMS) will celebrate its 30th anniversary at its annual conference. Taking place July 21-25 in North Charleston, SC, conference organizers expect to welcome an international audience of around 500 metrologists, manufacturing executives, quality managers, scientists, students, educators and other industry professionals.

"I've only missed about five of these conferences in the last 30 years," says Ron Hicks, Chairman of the CMS Conference Committee and president of API Services. In fact, six years ago, Hicks found his latest job through networking events offered at the CMS Conference.

At the 2014 CMSC Measurement Zone, attendees will be able to take part in a just-for-fun hands-on Laser Tracker Competition to see who can measure a part and complete a design model most accurately and efficiently Other interactive activities in the Measurement Zone will include training in Portable Arm measurement applications, and access to the National Physical Laboratory's coordinate measurement courses on e-learning workstations.

Ron Hicks

During the conference, CMS will also conduct its Fifth Annual CMS Measurement Study, which is still under development.

Quick Conference Details

The 2014 CMS Conference will showcase state-of-the-art portable 3D metrology technology, including articulated arm coordinated measurement machines (CMMs), laser trackers, laser radar, photogrammetry/videogrammetry systems, scanners, indoor GPS and laser projection systems.

Besides access to more than 40 exhibitors at the trade show, attendees can choose from a wide variety of events, including technical paper presentations, metrology solutions and services, industry updates, user group meetings and educational workshops.

The CMS Conference's educational program includes dozens of technical papers and presentations covering successful applications, best practices and research and development in the field of metrology.

—LB

Evolution of the Industry

Hicks says the enormous changes in portable measuring technology over the last 30 years are largely because of the advances in both the measuring instruments themselves and in computer technology.

"Thirty years ago, design engineers had limited options," Hicks recalls. Back then, engineers used manual measurements, or an optical alignment instrument like a theodolite or precision piano wire to establish the exact location of a point on an object. Hicks adds that turning obtained data into something useful was quite the time-intensive process.

"Today, we have very accurate portable scanning systems that can quickly take millions of 3D points from all around an object, and create an accurate CAD file that can interact with another object's CAD file," he says.

Hicks says there will be new technological advances introduced at the CMS Conference, but companies who attend the trade show typically wait until the conference to unveil their latest improvements.

"Any portable measurement system on display will probably be even more rock-solid and have an even better software user interface than last year," he predicts. "In addition, advances are being made on equipment that can actually probe inside an object to measure interiors and hidden points."

3D Metrology Certification Program

At its 2013 conference, the CMS launched the Level-One Certification Program for Portable 3D Metrology. This proctored, online assessment covers foundational theory and practice common to most portable 3D metrology devices. The CMS Certification credential aids in quantifying knowledge of metrology.

At this year's conference, CMS will also offer a Level II Certification, which will involve hands-on use of a portable CMM measurement arm under a proctor's supervision. Hicks says the rigorous practical test will ensure the individual can produce accurate results.

"We've been working on this certification program for the last five or six years," he explains, noting that it came about because often it is shop-floor employees, rather than engineers, who need to operate the equipment and help interpret the results. Both the equipment and the software are very technical.

"Over the years, representatives from many different industries have asked CMS to develop this certification system, which will allow them to be confident an employee can successfully perform the required tasks," Hicks says. Now employers can actually search for CMS-certified metrologists on the organization's website. DE

Lynne Brakeman *is a contributing editor based in Northeast Ohio. Contact her via de-editors@deskeng.com.*

The CMS Measurement Study

The 2013 Measurement Study evaluates how decisions made during and after measurement affect the final result. Download a summary of the report, "Non-Contact Scanning: How Data is Affected by the Decisions We Make" here: cmsc.org/2013measurementstudysummary.

INFO → Coordinate Metrology Society Conference: CMSC.org

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

Put Success to the Test

Streamline the materials testing process to save time and money.

BY LYNNE BRAKEMAN

Product and materials testing services provide the final stamp of approval, allowing new or improved products to graduate from detailed CAD designs into the marketplace. Because of the time and cost involved, however, designers and developers need to understand how to partner effectively with their materials testing facility. The kind of product, the materials used, the product's intended end use, industry standards and government regulations all affect what kind of testing facility to choose and when to get the facility involved.

Two materials testing experts share their advice with DE on how new product developers can get the best value for their testing dollar: Gary Delserro, specializing in automotive, defense and aerospace product testing; and Dawn Lissy, whose lab focuses exclusively on medical device testing.

Dawn Lissy inspects the results of a medical device test.

Automotive and Aerospace Testing

With more than 20 years experience as an aerospace reliability engineer for the Naval Air Warfare Center, Gary Delserro, president of Delserro Engineering Solutions in Easton, PA, performs vibration and shock testing for aerospace, automotive, medical, telecom and military industries. His lab specializes in testing to specifications such as MIL-STD-167, MIL-STD-202, MIL-STD-810, RTCA/DO-160, General Motors, SAE, ISTA and IEC for companies all over the country.

"When we're doing final testing to meet one of these specifications, it's important that all the dimensions and shapes of a product are very near the final stage," says Delserro. "From a test-house point of view, when we have to fabricate complicated fixtures, it creates problems if a product's dimensions keep changing."

Delserro explains that designing a new test fixture starts with receiving a CAD file of the product to be tested. This lets his team check dimensions on the computer and make sure everything needed for the test will fit the test fixture. For example, his facility recently built a new test fixture to provide both vibration and temperature testing on proposed new sensors for car engines.

"The fixture design for this test was very complicated," he recalls. "We had almost 50 sensors that had to be powered on during the test, and monitored for severe extremes of vibration and temperature over a long duration."

Delserro says the complicated fixture took months to design and build, thanks to the amount of cabling, wiring and harness work needed. The final test was successful, but if there had been last-minute changes to the physical configuration of the sensors being tested, they would have had to rebuild the test fixture. That would have cost the designers significant money and time.

On the other hand, Delserro says testing for new product reliability and manufacturability should happen near the beginning of the product design cycle.

"Sometimes reliability test results can change the final design, which would also cause tooling changes," he adds. "So from a reliability and manufacturability point of view, it's better to test a new product as early as possible."

Medical Device Testing Challenges

"Testing must be a fundamental part of the medical design process," says Dawn Lissy, co-owner of Empirical Testing Corp. (ETC), Colorado Springs, CO.

Lissy holds a master's degree in biomedical engineering and has extensive post-graduate experience in new product design and development. Early in her career, she managed maintenance, manufacturing, testing and quality for AcroMed Corp. (now DePuy Spine). As the market for orthopedic and other medical devices grew over the last few decades, however, Lissy founded ETC, which is now an A2LA ISO/IEC 17025:2005 accredited mechanical testing laboratory solely specializing in medical device testing. Her lab tests products from all over the world to meet global regulatory requirements, including U.S. Food & Drug Administration (FDA) and CE marking approval.

Lissy emphasizes the importance of early involvement of the medical device testing facility in the product development lifecycle. She recommends holding a strategy meeting with all stakeholders early in the cycle.

"A good test service should be able to provide developers a number of possible strategies, and be able to explain what differences there might be in the timeline and the results," she adds. "We always tell our partners there's the cowboy approach, the conservative approach — which takes the most time but has the least risk — and the middle-of-the-road approach."

Design engineers need to factor the time needed for testing into their product development lifecycle plans, because each of these test methods will take a specific amount of time, Lissy says.

"Mechanical testing is usually the last step you take before submission to the FDA. And if it takes four to six weeks, it can't be compressed to two weeks," she point out. "So early on, you need to plan time in your product development cycle in case you get data you weren't expecting."

Facility Considerations

Both Lissy and Delserro agree that product developers need to pick a testing facility that can help them not only run the tests, but also interpret the results.

"We are product reliability engineers who can help our clients develop a test plan, build a custom test setup, and help the designers interpret the results," says Delserro. "Some labs just run the standard tests to the specs, and don't provide much help with how to use the data to predict field life."

Lissy stresses the importance of institutional knowledge: "Designers of medical devices need to be sure that the testing facility they choose has actual experience and is ISO-accredited with the required methodology. At ETC, we often find ourselves testing medical devices that have evolved beyond the existing standards. In medical device testing, everything is custom. There are no across-the-board rules."

For example, says Lissy, the FDA standard for pedicle screws used in spine fusion and other orthopedic uses lags sig-

Testing Companies Say Product Designers Should…

- Choose a product testing facility that is properly accredited and experienced with the appropriate type of product and pertinent industry standards.
- Check to see whether the testing facility also provides assistance with interpreting data results.
- For fast-changing industries like medical devices, choose a facility that stays abreast of potential changes to pertinent industry standards and specifications, and incorporates these into the test design.
- Include all stakeholders, including the test facility, at a meeting early in the product development planning life cycle, especially for brand-new products or medical devices.
- Provide clear instructions on the product setup and the tests required.
- Provide all the parts and fixtures (if required) at the same time.
- Provide extra parts, especially for medical device testing.
- On complicated tests, come to the testing facility during setup to troubleshoot and answer questions.
- On standard tests, make sure cables for test chambers are long enough — and are the right dimension for the facility's standard test fixtures.
- Be considerate of the lab's schedule; understand that a miscommunication or missing part might cause the lab significant scheduling hardship and delay your test.
- Try to plan for the unknown; consider in advance what components might be an issue and how to mitigate that risk.

— LB

nificantly behind current developments.

"When that standard was developed five to 10 years ago, it only accounted for monolithic screws where the head did not move," Lissy explains. "Now engineers have developed polyaxial screws that give surgeons more options. If you choose a lab that is not familiar with testing polyaxial screws, they may not adapt the existing standard appropriately."

Lissy adds that medical device standards are in constant evolution, and keeping up with actual industry-wide standards that are in use, but not yet officially published, is essential for a medical device testing facility.

"As new technologies evolve, the published standards lag behind," she says. "There are many standards under discussion in ASTM committees that have not yet been officially published. So a lab that is not familiar with these may test inappropriately on a whole slew of variables, which would waste time and money."

Because ETC is constantly testing new devices, the company is an active member of the relevant ASTM standards committees that are writing standards for new technology.

Avoiding Stumbling Blocks

According to both Lissy and Delserro, good communication is the single most important factor in ensuring the success and cost-effectiveness of a test.

"We recently had a customer submit their own test plan for us to follow," recalls Delserro. "It was not very comprehensive, and lacked information on how to set up the product. Then, we got some of the parts one day, some special cables that were needed on another day, and a little later we received the test fixtures. But there were no instructions on how to set everything up."

Just as they were ready to start the test, Delserro's team discovered they were missing a bolt. Luckily, his facility had enough in stock to complete the setup.

"If we had not had that specific piece of hardware, the test would have been delayed," he says. "Last-minute changes cause us great hardships, especially if we have to tear down a fixture, because other companies are already in line to use the equipment."

Gary Delserro sits at his lab's Highly Accelerated Life Test (HALT) Chamber, which performs combined temperature and vibration loads simultaneously.

Lissy says her firm tries to mitigate problems early in the development process by holding a strategy meeting with all the stakeholders. "Once you determine your strategy, you can determine up front your timeline and how many specimens to manufacture," she continues. "The worst thing you can have happen is when someone only sends us 26 parts and we actually need 36 parts. Then it takes time to get the rest of them."

Regular communication with your materials testing facility will save your firm time and money in the long run. **DE**

Lynne Brakeman *is a Cleveland-based writer. Send e-mail about this article to DE-Editors@deskeng.com.*

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CPUs, GPUs, APUs and You

APUs, CPUs and GPUs are driving the next generation of simulation software, 3D modeling solutions and advanced design systems.

BY FRANK J. OHLHORST

The marketing war going on between the purveyors of high-performance computing (HPC) hardware may seem to be much like the cola wars of the 1980s, where selecting a flavored, carbonated, sugar-infused can of water became a matter of marketing prowess over substance.

However, choosing the proper processor for advanced simulations, 3D modeling and complex designs should not be based upon vendor's marketing budget. There must be substance behind the manufacturing claims, which can be translated into a price vs. performance argument. It must ensure that a CPU, GPU or APU can deliver both productivity and value.

With that in mind, understanding how today's HPC solutions operate and how they differ have become the primary prerequisites for selecting the appropriate high-performance processor, especially when thousands of dollars are on the line and failure is not an option.

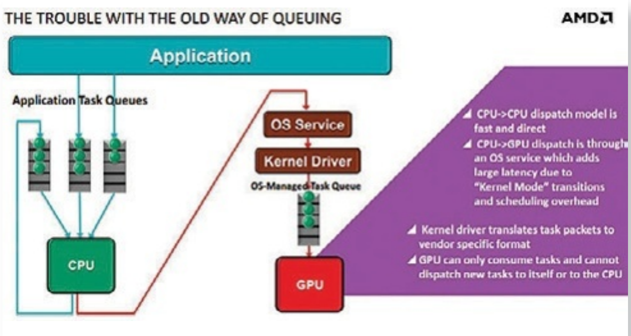
CAD, CAM, Design and Simulation Today

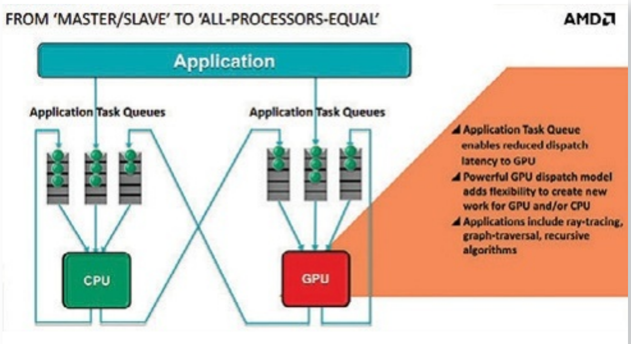
For the most part, engineers, scientists and designers have come to rely on the tried-and-true workstation to process their workloads, and a multitude of vendors have met the call to supply those pricey and powerful machines. Vendors such as HP, Dell, BOXX, Xi, Thinkmate and Lenovo have strived to build the most powerful workstations, consistently outpacing one or another to claim the gold crown of performance.

However, *performance* is a relative term. Engineers today have to decide what level of performance they need to guarantee positive results in a timely and cost-effective fashion. Some engineers focus on simulation; others on animation, and the rest focus on something that is critical to their operation, be it 3D modeling, CAD, CAM or big-data analytics.

Yet those performance identifiers all have something in common: They rely on the throughput of a processing unit, which has to crunch the numbers, run the algorithms, and digest the data into usable output — and that processing hardware is not created by the workstation vendors. Simply put, CPUs, GPUs and APUs come from chip manufacturers, such as Intel, AMD and NVIDIA. Each company focuses on what they define as the ultimate in performance, either by incorporating multiple cores or parallel processing, or even becoming the primary engines of compute farms.

In the past, choosing a processing platform was mostly driven by the software in use, with software vendors such as Autodesk. Dassault Svstèmes. Siemens PLM Software and PTC calling the shots. However, things are starting to change. As hardware platforms evolve, software vendors are playing a strategic game of catch-up to make sure their products perform across multiple choices — and are not tied to any one specific chip manufacturer. For example, the latest version of SolidWorks from Dassault Systèmes works with both Intel and AMD CPUs, yet can leverage the additional processing power offered by NVIDIA Quadro FX GPUs.





AMD's take on how its processor reduces latency.

While that may sound like it covers the gambit of chip manufacturers, there is another factor to consider: How efficiently are those processing components being used?

For Dassault and the majority of software vendors, designing software to fully leverage the processing power available has become a challenge, simply because of the architectures involved. Take, for example, today's architectures that require the copying of data from a CPU to a GPU to allow the GPU to contribute to processing. Applications today will copy data from system RAM to the GPU memory over the PCIe bus to do some computational work, and then send the results back over the PCIe bus when the computation is complete. That process adds significant overhead to the parallel processing chores to the otherwise-efficient GPUs.

Major software vendors can attempt to "code" around those limitations, but that requires subverting the initial hardware architecture and accessing the hardware directly — which may not even be possible based upon the design. In other words, eliminating those engineered "waits" may be all but impossible, unless something changes with architecture design.

Are HSA, hUMA and hQ the Future?

It has become obvious that maximizing performance on workstations is going to require some sort of architectural design change. Software alone is not going to overcome the architectural handicaps placed on CPU-to-GPU communications.

However, there are some new acronyms on the horizon that may spell relief for software vendors looking to maximize performance: Heterogeneous System Architecture (HSA), Heterogeneous Unified Memory Architecture (hUMA) and Heterogeneous Queuing (hQ) are technologies that are coming together to remove processing bottlenecks and move simulation, design and modeling into the future. While HSA, hUMA and hQ are associated with chipmaker AMD, the ideology behind what the technologies have to offer can be found on the drawing boards of other chip manufacturers.

AMD is hoping that HSA takes hold, and has made the industry take notice by forming the HSA Foundation. At press time, the foundation has garnered the backing of chip and system makers — save for the company's main rivals NVIDIA and Intel, who apparently are taking a wait-and-see approach as to what the organization is looking to accomplish.

AMD claims HSA means faster and more power-efficient personal computers, tablets, smartphones and cloud servers. What's more HSA, works with hUMA, which is the latest way for processors to access the memory inside an APU. HSA allows developers to take control of the GPU and make it an equal partner with the CPU, as well as other processors. It does this by incorporating hQ, which allows software to communicate with the GPU; this eliminates the need for software to wait for the CPU to orchestrate communications to the GPU.

Vendor partners include Imagination Technologies, ARM, Samsung, MediaTek, Qualcomm and Texas Instruments.

Nevertheless, AMD's move to HSA lacks one significant element: mainstream simulation, modeling and CAD/CAM software designed to leverage the company's APU architecture. That said, there is still growing interest in the HSA Foundation, with national laboratories (Lawrence Livermore, Oak Ridge, Argonne) and tech industry giants (Oracle, Huawei, Broadcom, Canonical) joining the organization last fall. That is sure to lend credibility to HSA, and it may not be long before CAD/CAM software joins the development fray.

Intel's Dash to the Future

While much of the industry is taking note of what may come of HSA, Intel is not one to sit on its haunches. It has long been a favorite among workstation manufacturers with its continually evolving Xeon processor, and the company promises to move ahead with innovations that will keep the Xeon at the top of the heap of high-performance CPUs.

Case in point is the company's plan to bring to market a standalone Xeon Phi CPU that can replace the combination of Xeon CPU and Xeon Phi coprocessor widely used in HPC systems today. The company did not say when to expect the product, which will be built using a 14nm process technology. Raj Hazra, VP of Intel's data center group and general manager of its technical computing group, offered some info at the SC13 Supercomputing Conference in Denver. Hazra

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said the concept of making Phi a host processor will do away with the notion of having to off-load code across a PCIe or some other limited-capacity connection. He added that one of the CPU's most important features will be in-package memory, which means memory will be part of the CPU package, as opposed to a separate card on the motherboard.

Applications will be able to use the memory resource as part of the overall memory space, as cache or as a hybrid of the two, Hazra explained. It will use a familiar programming model for using processor cores and the memory, which will be connected with a high-bandwidth link. "This is a fundamental advancement on the path to many-core and exascale," he said.

The Xeon Phi CPU is not the only thing on Intel's road map. The company just introduced the Xeon E7 v2 processors. According to the company, the E7 v2 family has triple the memory capacity of the previous generation processor family. That capacity enables in-memory analytics, which places and analyzes an entire data set in the system memory rather than on traditional disk drives. The E7 v2 family is built for up to 32-socket servers, with configurations supporting up to 15 processing cores and up to 1.5TB of memory per socket. Intel says it achieves twice the average performance of the previous generation.

The company also expects to release the Xeon E5-4600 v2 series processors later this year. Last, but not least, Intel also plans to announce a 15-core Xeon processor, at 2.8 GHz and at 155W, which should help to give Intel the HPC crown with existing software for some time.

NVIDIA Not to be Left Out

Arguably, NVIDIA rules supreme in the GPU market. The company offers many different solutions for those looking to improve workstation performance — mostly in the form of a graphics card. However, as software developers discovered the power of the GPU for more than just processing graphics, software evolved to take advantage of what GPUs bring to the table, such as parallel processing and low power consumption.

With the company's Tesla GPUs and compute unified device architecture (CUDA) parallel computing platform, NVIDIA has made GPU HPC available to almost anyone. It aims to increase market share with its Tesla GPU Accelerators, which enable the use of GPUs and CPUs together.

However, NVIDIA's future lies with its Kepler architecture, which the company claims is the world's fastest and most efficient for HPC. For the workstation market, it has recently launched the Tesla K40 GPU Accelerator, which brings cluster level performance to workstations and is based upon the NVIDIA Kepler architecture.

"GPU accelerators have gone mainstream in the HPC and supercomputing industries, enabling engineers and researchers to consistently drive innovation and scientific discovery," says Sumit Gupta, general manager of Tesla Accelerated Computing products at NVIDIA. "With the breakthrough performance and higher memory capacity of the Tesla K40 GPU, enterprise customers can quickly crunch through massive volumes of data generated by their big-data analytics applications."

Even more performance is expected to arrive when NVIDIA moves forward with its Maxwell GPU architecture that will replace Kepler sometime in 2014, according to the company's GPU road map. The Volta architecture will follow Maxwell sometime beyond 2014, bringing even more HPC capabilities to workstations.

What Does It All Mean?

Engineers working with simulation, modeling, CAD/CAM and other design tools are going to have to keep a close eye on the HPC/workstation battles that occur in 2014. From a value standpoint, AMD seems to show the a lot of promise, if — and only if — major software vendors fully support HSA. However, both Intel and NVIDIA's viability in the workstation market seems to be assured, remaining safe choices for the masses looking for speed, reliability and productivity.

Ultimately, choosing a platform still comes down to what software is being used and hardware is optimized for the primary tasks faced by each engineer. **DE**

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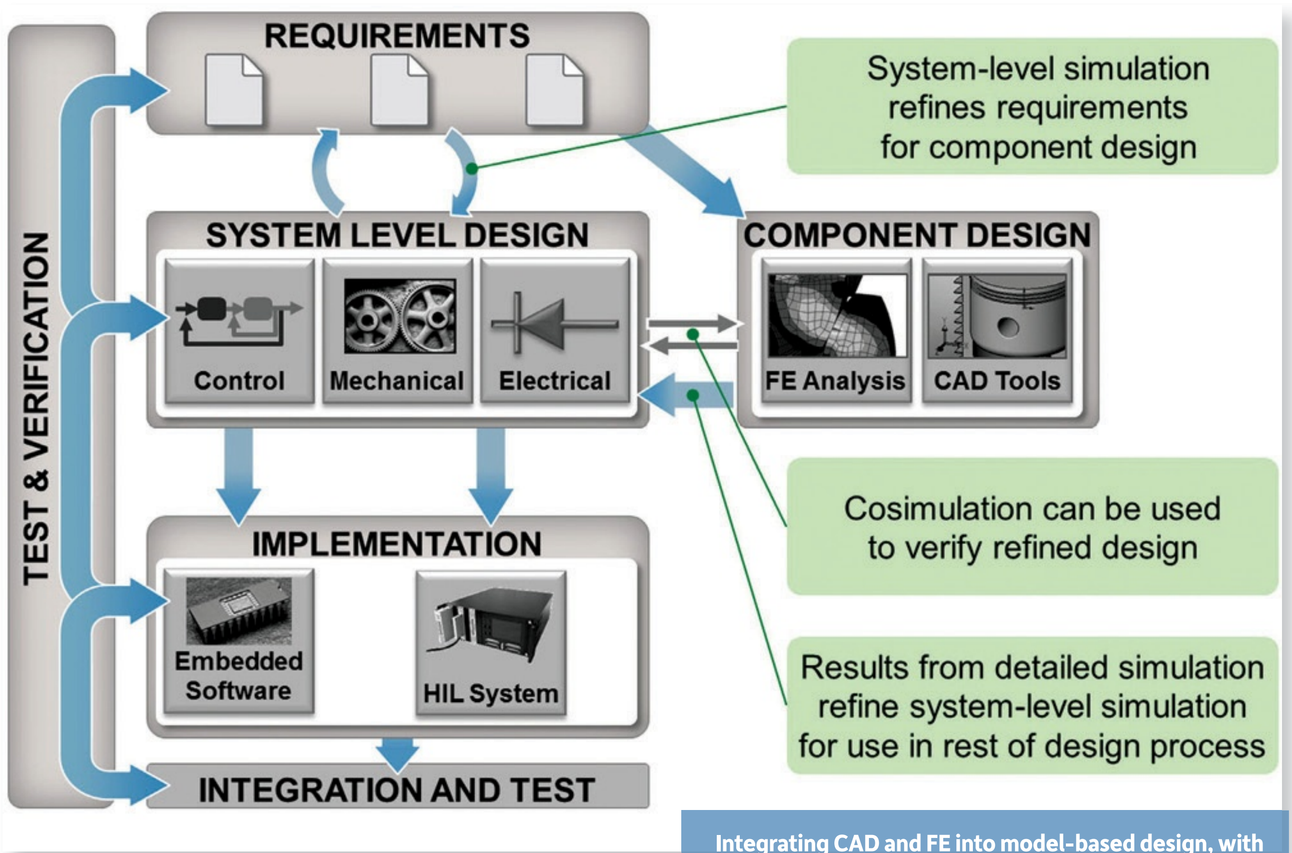
Better Simulations: Are You Missing Math Tools?

Fine-tuning your pre- and post-processing tasks can rock your design cycle.

BY PAMELA J. WATERMAN



Integrating CAD and FE into model-based design, with the assistance of MATLAB and Simulink products from MathWorks. *Image courtesy of MathWorks.*

If you already own and use both a 3D CAD program and a finite element analysis (FEA) or computational fluid dynamics (CFD) analysis package, are there good reasons to also spend another thousand or two on mathematical software such as PTC's Mathcad Prime 3.0, MathWorks' MATLAB and Maplesoft's Maple? The answer from Alan Abul-Haj, principal scientist at ARA Engineering, is a resounding yes. And many other consulting engineers would agree: Each package, with some overlap, offers faster ways to set up, manipulate and document analysis tasks.

"This field is super rich, and it's going to get richer," says Abul-Haj, based on his 10 years-plus of experience incorporating both MATLAB and Mathcad in his design workflow. "For example, MATLAB allows you to process large amounts of data in ways you often just can't do in the FEA and CFD codes themselves, while Mathcad lets you bring in libraries of WYSIWYG formulas for quick calculations, and is awesome for the automatic unit-conversion alone."

Extending these capabilities even further are PTC's Windchill, MathWorks' Simulink, and MapleSim, helping users gain

A Quick MATLAB Example: Refining MEMS Dimensions

An engineer is using MathWorks' MATLAB software to design a MEMS device represented as a finite element analysis (FEA) model. Two topics of interest are:

1. computing the maximum stress in the device per a specific design input (a geometric dimension), and

2. calculating that dimension's optimal value such that it minimizes the maximum stress.

For the first requirement, batch FEA results are imported into MATLAB, where the curve-fitting functions produce an analytical curve and identify the maximum stress. An app is also created that lets a non-FEA expert graphically experiment with the design input.

For the second requirement, optimization solvers in MATLAB solve for the optimal value of the targeted dimension.

—PJW

system-level insight, verify numerical calculations and document design processes as part of the complete design cycle.

A Great Place to Start

Brent Edmonds, senior director, PTC Mathcad, offers a top-level description in terms of his product's workflow benefits: "First, there's the calculation engine. Mathcad can consume inputs and, based on the algorithms or formulas the user has put in, will crunch the numbers and produce a solution; from that aspect, it's a scientific calculator on steroids.

"The second piece," he continues, "which starts to differentiate Mathcad from other math tools, is its ability to capture documentation as the engineer works. You can free-flow-enter text and explain design decisions, such as 'We are going to optimize these input parameters to our CAD, CFD or FEA analysis for the following reasons; here are the performance envelopes and the requirements from the market or the customer, and I chose these standard equations over those for these reasons.'"

The ease of writing/entering equations, data, graphs and images, as well as new plotting capabilities, makes Mathcad seem like a magic, mathematical whiteboard, Edmonds says.

Specific to improving engineering simulations, Mathcad also offers optimization and design of experiments (DOE) preprocessing functions that help users cut down on the number of FEA or CFD runs they need to perform, which he points out can offer significant time savings.

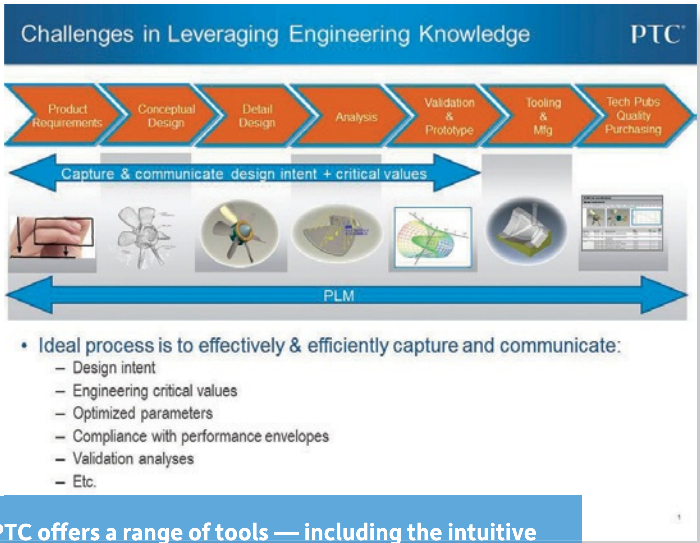
By letting users essentially write and draw as if on scrap paper, Mathcad worksheets present a human-readable appearance, he adds. When you purchase the optional targeted e-book libraries (such as Roark's Formulas for Stress and Strain), you can cut and paste equations without retyping or scripting, and modify them for your own purposes; you can also add notes documenting where your references originated. All these forms of documentation serve, as Edmonds puts it, as a kind of glue to communicate critical design info as the project moves from one team member to another.

Professional mechanical engineer Gerry Dail, president of MCB Engineering Consulting, is another proponent of bringing Mathcad into the design workflow for model verification prior to analysis.

"A lot of times, the boundary conditions that need to be applied to some structural analysis require closed-form calculations to get a handle on either the displacements or the forces under consideration," Dail explains. "I use Mathcad to document what I was thinking at the time, and to make sure results appear reasonable."

Other features in Mathcad that Dail says give him an edge include data plotting and statistical analysis (with no need for C or Fortran coding).

Mathcad supports writing application programming interfaces (APIs) that can be used to automatically pass data bi-directionally between itself and an analysis package, saving time and avoiding retyping errors. And Edmonds says current PTC projects will improve Mathcad integration with the company's Windchill PLM product, exposing more data (i.e., search and



PTC offers a range of tools — including the intuitive Mathcad engineering calculations software — that supports the engineering design workflow, helping users easily capture and communicate design details. ***Image courtesy of PTC.***

pull actual values without opening up the Mathcad file) and allowing a Mathcad worksheet to be stored as a Windchill document. The latter would move right along with other types of data for easier team collaboration.

Exploring Data with MATLAB

How do you visualize flow-field data that's in the form of a 1,000-x-1,000 matrix? What if you need to derive or interpolate quantities that aren't explicitly available from your simulation results file? Can you optimize a performance spec based on hundreds of simulation runs across multiple variables? MATLAB software from MathWorks answers these and other tough, large-scale post-processing analysis questions.

MATLAB is both a high-level language and an interactive environment that supports numerical computation, visualization and programming. In other words, it's a sophisticated tool that helps you make the most out of your FEA or CFD simulation data, from curve fitting and image processing to spectral analysis and geometry optimization.

Here are a few ways MATLAB could make you more productive in using FEA/CFD software:

- **Automate FEA/CFD simulations.** Set up and simulate multiphysics (MP) models for various conditions (material properties, geometries, boundary conditions, mesh/solver options) rather than manually step through those conditions in the analysis software interface.
- **Extend FEA/CFD analysis.** Use MATLAB domain-specific tools for data acquisition, signal processing, statistics and more, and develop custom pre- and post-processing routines.
- **Optimize MP designs.** Use the add-on Optimization Toolbox with MATLAB to optimize design parameters based on custom objective/constraint functions.
- **Share FEA/CFD models with non-experts.** Create interactive MATLAB apps that let others try varying the input data and conditions (with a graphical "slider," for example) and visualize results.

Abul-Haj says MATLAB allows him to process large amounts of data in ways he simply can't do in his high-end analysis software.

"I can write a script file to read CFD data and much more exactly extract variables of interest, such as what the flow at a specific region is," he explains, noting that without MATLAB, he would have had to anticipate ahead of time the sub-region where he was most interested and build a flow boundary there, to be able to display that kind of data. Abul-Haj also uses the MATLAB Dynamic Data Exchange (DDE) Toolbox to operate the optical/illumination design package Zemax from within MATLAB, in real time.

MathWorks also offers Simulink, a multidomain simulation environment tightly integrated with MATLAB, and Simscape for modeling physical systems. Assemblies from CAD software such as SolidWorks can be imported into this environment, integrated with control algorithms, electrical motors, hydraulic actuators, and logic to perform dynamic simulations. This lets engineers study the impact of mechanical design on system-level performance.

A good example of the use of MATLAB, Simulink and Simscape to design a dual-clutch transmission is at MathWorks.com/videos/physical-modeling-introduction-75883.html, which includes physical models, state machines, and control systems.

Wolfram, Mathematica and the Connected Devices Project

Mathematica V9, a highly flexible computational tool from Wolfram Research, offers the tagline "seamlessly flow ideas to results." As another well-regarded contender in the math tools arena, it applies intelligent automation to tasks involving numerical computing, data acquisition/analysis, visualization and much more.

But a new application for the software's underlying Wolfram Data Framework is its use to connect and live-query the growing world of smart devices, from GPS systems to fitness monitors. Bringing a standard way of curating and working with the mind-blowing amounts of data this entails, the Wolfram Connected Devices Project (Devices.Wolfram.com) is delivering a common language that could form the basis of "The Internet of Things" now encompassing devices in your car, home and pocket.

—PJW

Bringing Maple into the Mix

More choices for creating analytical models based on mathematical formulations come from Maplesoft, with its Maple 17 and MapleSim products (see "MapleSim 6 Goes Social," *Desktop Engineering*, October 2013). At its simplest, Maple lets you do in-depth math and write software solutions, while MapleSim gives insight on how an entire system will interact — even for multibody and multi-domain systems. Both offer extensive documentation and collaboration tools.

"Mathematics don't lie, numerical calculations do" is a distinction sometimes easy to forget but wisely offered by Amir Khajepour, the Canada Research Chair in mechatronic vehicle systems and a professor of mechanical and mechatronic engineering at Ontario's University of Waterloo. As an analyst and Maple user designing suspension and control systems, he sees the value of using more than one type of software to support the trend of building fewer prototypes.

"The only way to do this is to make sure that what the FEA simulation software is telling you is absolutely correct, or at least within a 10% to 15% margin," he says. "Getting a second view with Maple's mathematical approach is much stronger than only a numerical analysis."

Laurent Bernardin, executive vice president and chief scientist at Maplesoft, similarly points out the synergy between his company's MapleSim and traditional simulation software: "MapleSim is a bit different from finite elements, where you look at one part, or one aspect of a system, and look at details. It's about taking a system-level view."

Bernardin offers as an example a simulation model for an entire vehicle, including the drivetrain, the control systems, etc. — and if it were a hybrid vehicle, "the battery system would be in there as well." MapleSim models are assembled by putting together a block diagram, using library-based or custom components ranging from simple gears and hydraulic valves to electric motors, drivetrains and exhaust systems, and can include hardware-in-the-loop (HIL). The resulting view is not as detailed as an FE or CAD model, but the simulation provides an idea of how the entire system will behave and interact.

Users define the physical connections in terms of inputs and outputs, and the software simulates the operational system behavior. Results could include graphs of the torque in a shaft or the speed of a wheel, or even a 3D animation — for example, how a robot arm moves in space.

Once you've done the simulation, you can use Maple to do more in-depth analysis, working at the equation level.

"Maple is an interactive environment for doing mathematical and engineering calculations," Bernardin says. "When you connect Maple and MapleSim, you're able to get the entire set of system equations that represent the behavior of the system-level model."

Maple users could do a Monte Carlo analysis, looking at the uncertainty of a given parameter and how variations in that parameter would affect the system behavior, or perform an optimization on a set of parameters to maximize, say, fuel efficiency.

Math tools are all worth a closer look. Any time you can work faster, reduce errors, squeeze more insight out of a simulation and create a better "paper trail," you've improved your company's bottom line. As Khajepour puts it, using mathematical tools gives you another dimension to analyze the behavior and stability of complex systems in ways that just don't exist in numerical packages. **DE**

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

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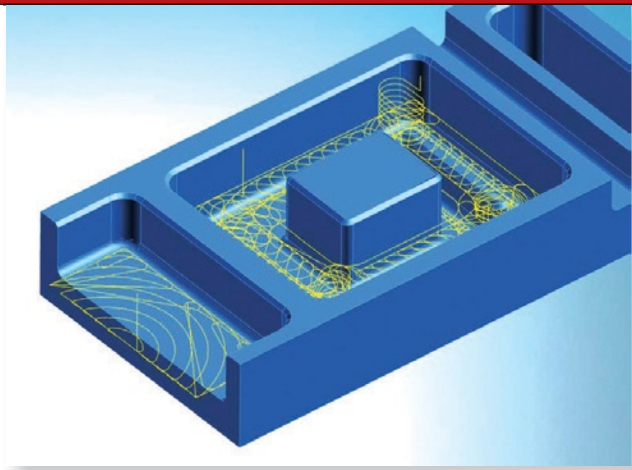
Subtractive **Adds Up**

Designing for, and with, computer-aided manufacturing in mind can save product development time and money.

BY JAMIE J. GOOCH



OPEN MIND'S hyperMAXX high-performance cutting module, which is fully integrated into hyperMILL.

When it comes to prototyping and manufacturing parts via subtractive technologies, as opposed to the additive manufacturing (AM) methods used by 3D printing, speed is the name of the game. Sending the right tool for the job and material along the most efficient path is a key feature of computer-aided manufacturing (CAM) software.

For example, SolidCAM trumpets its iMachining milling technology as saving "70% or more in CNC (computer numerical control) machining time." In Mastercam X7 from CNC Software, Inc., users can select an Optimize cut order checkbox that "reduces unnecessary motion and shortens the length of the toolpath," according to a blog post from the company. PTC Creo Complete Machining Extension "enables you to directly machine simple or complex product geometries with NC toolpaths optimized for manufacturing lines," according to the company. And Siemens says its NX CAM feature-based machining technology can reduce programming time by as much as 90%.

"Today, toolpath efficiencies are often inherent in the CAM software, but are different between different brands of software," says Alan Levine, managing director at OPEN MIND Technologies, which develops hyperMILL CAM software. "Users may have many buttons to control aspects of the toolpath process such as start points, transition air moves, feed-rate control and more. But high-performing systems will achieve optimization 'out of the box' and often not require much tweaking by the CAM programmer. Many CAM software have fundamental differences in how they manage trimming toolpaths to stock conditions."

Efficient Doesn't Mean Dumbed Down

With such out-of-the-box functionality of standalone CAM software, and the availability of CAM plug-ins for popular CAD packages — including Dassault Systèmes' SolidWorks and Autodesk's Inventor — can CAD experts become CAM experts by checking the right boxes? Not necessarily.

"There are things outside just the cutter path that yield the best results and an experienced machinist will always be able to dial in a strategy just a little more to fit it to their tastes," says CNC Software's Marketing Coordinator Michelle Nemeth. "A benefit of good CAM software is that those machinists can save those preferences to a library for future use — passing on their experience to newer machinists."

Levine agrees that experienced CAM users generally have a strategy in mind, and then make selections within CAM software to meet their needs given a particular cutting scenario. They take variables such as machine tools, holder systems, cutters, material, quality specification and more into account — factors that inexperienced CAM users may overlook.

"This is especially true for applications with harder materials, or parts requiring small cutter sizes or higher precision, where deeper knowledge of manufacturing techniques must be included in the programming process to obtain the intended results," Levine says.

He notes that users may have different definitions of optimal machining. Some may want to reduce cutting times; others may want higher quality output — and still others may value reduced wear and tear on the tool and machine above all else. For these reasons, it is difficult to optimize CAM software for everyone out of the box.

Integration Grows Deeper

Just like the traditional design, simulate, prototype, test, manufacture model has been revolutionized by the widespread acceptance of simulation-led design and rapid prototyping technologies, the relationship between CAD and CAM is getting closer. As a whole, the design-build cycle is becoming more collaborative and integrated, as technologies overlap and break down traditional job descriptions.

In what may be a sign of things to come, Autodesk, known for its design software, has made a number of acquisitions in the CAM market — namely HSMWorks in 2012 and Delcam earlier this year. (*Editor's Note: For more information on Autodesk's CAM moves, see "CAM Heads to the Cloud" by Kenneth Wong, March 2014.*)

"Integrating CAM with CAD has many benefits and has become very popular in recent years," says Levine. "The primary efficiency is revealed by sharing the same model database between design and manufacturing tasks, without translating through neutral file formats or possibly reverse-engineered interfaces."

On the flip side, "having CAM tied to the CAD software means a single seat of software is tying up both those tools," notes Nemeth. "It also can pose a challenge if the shop either uses different CAD packages or needs to machine CAD files from different sources," she says.

Integrated with CAD or standalone, a design engineer who understands the repercussions of design modifications before they're made can save time down the line. One way to do that is by simulating the toolpaths required to create the part. Software like Spring Technologies' NCSIMUL Machine can not only verify and validate CNC coding, but can help design engineers review and optimize their designs based on the characteristics of the particular machines being used to prototype and/or manufacture the parts they are designing. Design engineers can reduce engineering change orders coming from the factory floor — and CAM programming times — by making sure their designs are capable of being milled in an efficient manner.

As the lines between CAD, CAM and simulation continue to blur, CAD users new to CAM shouldn't be intimidated by what may at first appear to be a steep learning curve.

"Any CAD experience will translate into a shorter learning curve for the CAM user," says Nemeth. "Just understanding how geometry is defined and what is available for editing geometry will make the learning curve flatter." DE

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

INFO → **Autodesk:** Autodesk.com

→ **CNC Software, Inc.:** Mastercam.com

→ **Dassault Systèmes:** SolidWorks.com

→ **Delcam:** Delcam.com

→ **HSMWorks:** HSMWorks.com

→ **OPEN MIND Technologies:** OPENMIND-Tech.com

→ **PTC:** PTC.com

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

→ **SolidCAM:** SolidCAM.com

→ **Spring Technologies:** SpringPLM.com

A Name Worth Noting

Micro-Star International's GT70-2OL mobile workstation offers great price and performance — from a company you may have never heard of before.

BY DAVID COHN

We recently received a new mobile workstation from MSI (Micro-Star International). If that company is not familiar to you, perhaps it is a name worth noting. MSI, based in Taiwan with offices in the U.S. and Canada as well as throughout Europe, the Middle East and Asia, was founded in 1986 as a motherboard and graphics card manufacturer. Today, it manufactures consumer and commercial electronics including notebooks, all-in-one PCs, servers, workstations, industrial PCs, household appliances, car infotainment products, multimedia systems and communication devices.

After spending some time working with the MSI GT70-2OL mobile workstation, we came away impressed. A fourth-generation Intel Core i7 processor powers the system, which is housed in a nicely sculpted black, brushed aluminum case. With overall dimensions of 16.75x11.25x2.38 in. (WxDxH), this notebook is definitely on the large size. At 8.25 lbs., it is also heavier than other mobile systems we have recently reviewed. It also comes with a large external power supply that adds an additional 2.25 lbs. to the total package.

Unlike many of those other systems, however, MSI does not offer a lot of configuration options. What you see is what you get — but what you get is a mobile workstation with a fast CPU, high-end graphics, great display, big hard drive, and lots of memory at a very attractive price.

The system we received was powered by a quad-core 2.4GHz Intel Core i7-4700MQ with integrated Intel HD Graphics 4600. This mobile processor has a maximum turbo boost speed of 3.4GHz, a 6MB cache, and a fairly frugal thermal design power (TDP) rating of 47 watts. Our MSI mobile workstation also came with 16GB of memory installed as a pair of 8GB 1600MHz small outline dual in-line memory modules (SO-DIMMs). Both the CPU and memory come standard in the base configuration; with two additional memory sockets, the MSI GT70-2OL can accommodate up to 32GB of RAM.

Also standard was an NVIDIA Quadro K4100M GPU, with 4GB of DDR5 memory and 1152 compute unified device architecture (CUDA) cores. This high-end mobile discrete graphics card enabled the GT70-2OL to deliver some of the fastest graphics performance we have ever recorded.

It's What's Inside That Counts

Lifting the lid reveals a beautiful, 17.3-in. full HD backlit LCD display with a native resolution of 1920x1080 and a nice 102-key SteelSeries backlit keyboard with a separate numeric keypad. A 720p webcam is centered above the display, with a single microphone to one side, while a touchpad with two dedicated buttons is centered below the keyboard.

Six quick-launch buttons above the keyboard let you quickly access the Windows Media Play, increase the speed of the system fan, toggle the keyboard backlight, switch the system into airplane mode, turn off the LCD, and access a System Control Manager application for adjusting multiple system settings. To the right of these are caps lock and number lock indicators. A pair of stereo speakers is located in the upper corners above the keyboard.

A power button located in the middle of the quick-launch buttons glows white when the system is using the integrated Intel graphics, and amber when the discrete NVIDIA GPU is active. This is just one of the many features we have not seen before in other systems. Another thing we have never seen before is a small toggle switch located to the upper-left of the touchpad, which glows amber when the touchpad has been turned off.

LEDs along the front edge of the case indicate Bluetooth, Wi-Fi, battery status, sleep state and hard drive activity. The right side of the case houses a pair of USB 2.0 ports as well as an optical drive that comes standard with both Blu-ray Disc and DVD read/write capability. The left side sports an exhaust fan vent, three USB 3.0 ports, and audio jacks for headphone, microphone, line-in and line-out as well as an SD card reader.

Mobile Workstations Compared

		MSI GT70-20L mobile workstation (2.4GHz Intel Core i7-4700MQ quad-core CPU, NVIDIA Quadro K4100M, 16GB RAM)	**Eurocom Racer 3W** mobile workstation 2.4GHz Intel Core i7-4700MQ quad-core CPU, NVIDIA Quadro K1100M, 16GB RAM)	**BOXX G OBOXX G2720** mobile workstation 3.6GHz Intel Core i7-3820 quad-core CPU, NVIDIA Quadro K5000M, 16GB RAM)	**Eurocom Panther 4.0** mobile workstation (3.1GHz Intel Xeon E5-2867W 8-core CPU, NVIDIA Quadro K5000M, 16GB RAM)	**Lenovo ThinkPad W530** mobile workstation (2.90GHz Intel Core i7-3920XM quad-core CPU, NVIDIA Quadro K2000M, 16GB RAM)	**HP EliteBook 8560w** mobile workstation 2.30GHz Intel Core i7-2820QM quad-core CPU, NVIDIA Quadro 2000M, 16GB RAM)
Price as tested		$3,200	$2,172	$5,895	$6,800	$2,592	$4,063
Date tested		11/25/13	11/10/13	5/28/13	4/20/13	12/29/12	5/1/12
Operating System		Windows 7	Windows 7	Windows 7	Windows 7	Windows 7	Windows 7
SPECviewperf 11	higher						
catia-03		72.47	28.97	73.23	65.87	34.82	27.49
ensight-04		50.62	17.38	61.24	61.01	18.40	18.46
lightwave-01		64.39	31.53	78.03	65.85	62.75	48.21
maya-03		112.33	51.20	111.58	102.18	62.04	58.12
proe-05		18.38	9.43	16.06	13.82	15.58	9.77
SW-02		55.00	24.95	63.26	55.06	39.48	35.85
tcvis-02		60.63	27.70	60.91	59.28	30.63	23.12
snx-01		59.76	23.17	63.57	64.62	25.14	19.85
SPECapc SolidWorks 2013	higher						
Graphics Composite		5.27	3.63	2.72	2.26	2.06	n/a
RealView Graphics Composite		6.27	3.97	2.93	2.42	2.18	n/a
Shadows Composite		6.26	3.95	2.93	2.42	2.18	n/a
Ambient Occlusion Composite		13.00	5.35	6.09	5.14	3.76	n/a
Shaded Mode Com-posite		5.78	3.83	2.66	2.41	2.13	n/a
Shaded with Edges Mode Composite		4.80	3.44	2.78	2.12	2.00	n/a
RealView Disabled Composite		2.62	2.55	2.02	1.72	1.65	n/a
CPU Composite	ratio	3.74	3.99	3.61	3.72	3.59	n/a
Autodesk Render Test	lower						
Time	seconds	60.33	55.83	79.20	57.33	62.00	89.83
Battery Test	higher						
Time	hours:min	4:34	3:47	1:15	1:14	6:09	2:37

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

The rear of the case contains a Kensington lock slot, the power connector, an RJ-45 LAN port, a 15-pin VGA port, a mini-DisplayPort, HDMI connector, and an additional air vent.

The MSI GT70-2OL motherboard, based on an Intel HM87 chipset, is made by Micro-Star International. Standard features include integrated Sound Blaster Cinema sound, Bluetooth 4.0, a Qualcomm Killer DoubleShot LAN and wireless LAN with a/b/g/n capability, and a 1TB 7200rpm hard drive.

Battery life also proved to be quite good. With the GT70-2OL switched to power-saving mode, the 12.4 volt 86.6 amp hour battery kept running for 4 hours and 34 minutes.

Excellent Results, Great Price

Of course, all of the standard features and impressive battery life mean nothing if the system doesn't perform well. But as we've already hinted, the performance of this MSI mobile workstation was equally impressive. On the SPECviewperf test, the GT70-2OL outperformed every other mobile system we have ever tested with the exception of the BOXX GOBOXX G2720, a system costing twice as much. Keep in mind, though, this test focuses solely on graphics performance and is not necessarily a good guide to overall productivity benefits.

On the SPECapc SolidWorks 2013 benchmark, which is more of a real-world test, the MSI mobile workstation, turned in test results that were not only faster than any other mobile workstation we have ever tested, but results that rivaled or exceeded those of desktop workstations as well.

It was only on the multi-threaded AutoCAD rendering test where the edge definitely goes to systems with fast, multi-core CPUs. But while the GT70-2OL lagged behind other systems we have recently reviewed, it did so only by a small margin.

In fact, if we have any criticisms at all of the MSI GT70-2OL mobile workstation, our issues are relatively slight. The cooling fan, which was generally quiet, became more pronounced during heavy CPU loads (such as during our rendering test), with air leaving the side exhaust port reaching 125°F, although the bottom of the case stayed under 100°F. We also encountered several instances where the optical drive did not initially respond after loading a disc.

Other than those minor issues, we were very impressed by the GT70-2OL mobile workstation. MSI offers either Windows 7 Professional 64-bit or Windows 8 included in the price, and backs the system with a 2-year limited warranty. And unlike many other lesser-known brands, this MSI mobile workstation is independent software vendor (ISV)-certified for Autodesk software as well as SolidWorks and Adobe Creative Suite 6.

Perhaps the most impressive feature of all is that this mobile workstation sells for $3,200 as configured. That is also the base configuration. **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 → Micro-Star International: MSI.com

MSI GT70-2OLWS-683US

- **Price:** $3,200 as tested ($3,200 base price)
- **Size:** 16.75x11.25x2.38 in. (WxDxH) notebook
- **Weight:** 8.25 lbs. as tested, plus 2.25-lb. power supply
- **CPU:** 2.4GHz Intel Core i7-4700MQ quad-core w/6MB cache
- **Memory:** 16GB 1600MHz DDR3 SDRAM (32GB max)
- **Graphics:** NVIDIA Quadro K4100M w/4GB memory
- **LCD:** 17.3-in. diagonal (1920x1080)
- **Hard drives:** 1TB 7200rpm SATA
- **Optical:** Blu-ray Disc burner
- **Audio:** headphone, microphone, audio line-in, audio line-out, built-in microphone and speakers
- **Network:** integrated Killer E2200 Gigabit Ethernet (10/100/1000 NIC); Killer N1202 a/b/g/n wireless
- **LAN:** integrated Bluetooth 4.0
- **Other:** three USB 3.0, two USB 2.0, SD card reader, 15-pin VGA, mini DisplayPort, HDMI, 720p webcam
- **Keyboard:** integrated 102-key keyboard with numeric keypad

Luxury Yacht Design Takes a New Tack

Simutech Solution Corp. uses realistic simulation to craft a better boat.

While it's widely recognized that HTC smartphones, Garmin GPS devices and a sweeping array of big-brand laptops are staples of the Made in Taiwan (MIT) effort, it's a lesser-known fact that luxury yachts (those measuring 80 to 120 ft.) are a booming business in Taiwan. The country is now sailing portside with market leaders like the United States, Italy, The Netherlands and Germany.

Producing high-quality boats at comparatively low prices, Taiwan's luxury yacht industry reached a peak in 1987, with the country exporting 1,755 vessels for an export value of more than $190 million. But rising labor costs and the appreciation of the Taiwanese dollar took its toll over the years, and the industry had to weather its share of storms.

These days, Taiwan's luxury yacht sector is back on course — with the country surpassing Germany as the sixth-largest yacht maker last year, according to yachting magazine *ShowBoats International*.

With an E-Composites report pegging growth for the global recreational yacht market at an annual rate of 7% between 2005 and 2012, the Taiwanese luxury yacht sector has been looking to shore up its position and head off European, North American and, more recently, Chinese competition. To do so, the country's Economic Planning and Development committee has identified luxury yacht production as an emerging core industry — and a variety of efforts are underway to advance growth in this area.

One such plan is the construction of a dedicated yacht-building precinct as part of the Kaohsiung Port City Reconstruction project. On the technology and manufacturing front, industry players are promoting the use of computer-aided engineering (CAE) and advanced simulation to foster innovation among Taiwanese yacht makers, while helping them decrease overall cycle times.

"While many yacht companies, shipyards and naval architects have adopted Dassault Systèmes' CATIA application in the last three years, the value of numerical simulation and the concept of digital design evaluation are still not broadly promoted in Taiwan," notes Ray Tsai, technical director of Simutech Solution Corp., which provides consulting services for Dassault Systèmes' SIMULIA application. "Lots of yacht companies don't know there is a powerful tool that could immensely improve their design, with shorter cycles and better systems integration."

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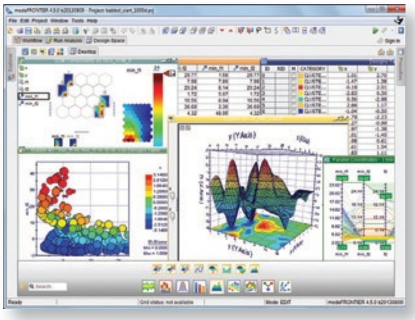
SPOTLIGHT

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

Editor's Picks

by Anthony J. Lockwood

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



ESTECO Releases modeFRONTIER 4.5

Includes tools for investigating design options and algorithms for optimal solutions.

Version 4.5 of modeFRONTIER focuses a lot on usability. For example, it has an enhanced GUI (graphical user interface) for intuitive project handling as well as a customizable drag and drop palette. It has a new Parameter Chooser that's designed to simplify the integration of third-party software first by helping find and choose input and output parameters in a model and modeFRONTIER variables, then by automatically setting up integrations.

Version 4.5 also debuts a new Run Analysis dashboard that has smart widgets that give you control over an ongoing optimization process.

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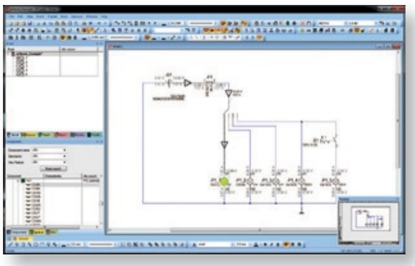

Zuken Extends E3.series Electrical CAD Software

Extension adds DC functional analysis and circuit checks.

The E3.series is a modular, integrated suite of Windows applications for the design and documentation of wire harnesses, cable assemblies, control systems, and panel layouts as well as fluid design for hydraulic and pneumatic systems. Through a single project database, it provides multiple views and access to schematics, cable plans, control panels, and fluid details. Files are linked and associative, and it supports the major MCAD and PLM/PDM platforms. It has intelligent parts libraries of symbols and components, real-time rule checks, as well as the ECAD features and functions to go from concept to manufacturing to deployment and service.

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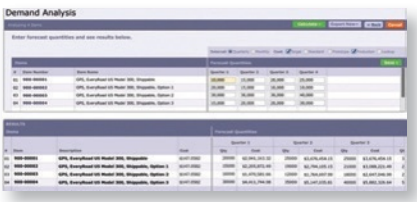

Arena Expands Its Cloud-Based PLM Product Suite

Now allows for visibility into component usage across your entire portfolio.

Arena Projects is a project management system with real-time updates. It ties your project schedule to your product record. You can set schedules, assignments, and metrics. You can invite your supply chain partners to participate, monitor quality processes, and create all sorts of reports to help you keep things rolling.

Also new is Arena Exchange. It is an ad hoc collaboration facility. Arena already has a capability for ongoing collaborations, but Arena Exchange is designed for quick action with your suppliers as well as theirs, whether they are Arena users or not.

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PCB Design System Releases Mobile Touch App

Offers customization features to develop macros for fast access to functions.

Zuken's CADSTAR Touch App uses your Android or iOS mobile device's Wi-Fi connection to communicate with a PC running CADSTAR somewhere on the your local network. It lets you interact with CADSTAR layouts and control CADSTAR functions through your Android or iOS tablet or smart phone.

The CADSTAR Touch App uses all the mobile device interface functions you would expect, such as pinch to zoom, drag to pan, and double tap to view all. Androidians can also control CADSTAR Touch App with their voice. You can also use CADSTAR Touch App to operate functions in Microsoft Word, Excel, PowerPoint and Internet Explorer.

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Robot Construction Crew

Harvard researchers have developed tiny, termite-inspired robots that can construct complex structures without any supervision using a form of "group intelligence."

The TERMES system was developed by engineers at the Harvard School of Engineering and Applied Sciences (SEAS) and the Wyss Institute for Biologically Inspired Engineering at Harvard. It is based on the concept of stigmergy, a process in which parts of a system communicate with each other by changing and sensing the environment, just like bees operate when building a hive.

The robots in the Harvard project have been able to construct pyramids and towers from foam bricks by following basic rules and reacting to the behavior of the other robots. The technology could potentially be used to build structures in dangerous environments, or even on other planets.

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Testing Takes Loud to New Levels

The European Space Agency's Large European Acoustic Facility (LEAF) includes a 36x54-ft. wall that can reach 154 decibels by pumping nitrogen into horns, to simulate the noise made during a rocket launch.

At full strength, the sheer force of the sound could kill someone; that's why the only things sitting in front of the horns are expensive satellite systems that are being stress tested.

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Fuel Cell Vehicles Arrive

Toyota plans to launch a fuel cell-powered sedan in the U.S. later this year. The automaker has been showing off the Toyota FCV at auto shows, and says that unlike other fuel cell vehicles, this one will be available for the mass market at an affordable price. The company expects the FCV to get 300 miles per tank of compressed hydrogen.

Hyundai and Honda also plan to roll out fuel cell vehicles in the U.S. However, according to research firm IDTechEx, there are still significant cost and performance obstacles. The cost of one hydrogen charging station equals that of six electric fast-charging stations, and producing hydrogen is an expensive and inefficient process.

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Modeling the Bat Wing

Researchers at Virginia Tech have taken fruit bat wing measurements to create a computer representation of wing motion and airflow that they hope to use for developing robotic vehicles that fly in a similar fashion.

The team found that bats dynamically change their wing shape and size during flapping to maximize force. The surface area of the wings increased by nearly 30 percent on the downward stroke, and then decreased by 30 percent on the upward stroke to reduce resistance. This creates coefficients of force that are two to three times larger than the static wings on airplanes.

"We'd also like to explore other bat wing motions, such as a bat in level flight or a bat trying to maneuver quickly to answer questions, including: What are the differences in wing motion, and how do they translate to air movement and forces that the bat generates? And finally, how can we use this knowledge to control the flight of an autonomous flying vehicle?" says Danesh Tafti, professor in the Department of Mechanical Engineering and director of the High Performance Computational Fluid Thermal Science and Engineering Lab at Virginia Tech.

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Commentary

By Hubert Lobo

Integrating Material Testing into Inputs for CAE

The use of material data constitutes an important input to new-product development as companies use computer simulation to reduce real prototype testing. Simulating real life creates a need to approximate complex phenomena such as crash/drop, creep, fatigue and the non-linear behavior of metals, rubber, plastics, foams and composites. Failure to properly describe these behaviors in simulations results in poor correlation to reality and unacceptable risk, as simulation results are used in predictive design decision-making. In other words, there is a strong interest to manage this risk.

The problem is a complex one that requires the creation of the right kind of material data, as well as conversion of this data into the proper simulation inputs. The phenomenon being simulated must be understood; it is often a multi-variate situation where the material is simultaneously seeing a variety of effects such as temperature, rate and the environment, for example. With careful consideration, the variables can be reduced to a simpler set suitable for simulation.

The challenge lies in calibrating the model with material data.

For example, it would be fairly simple to realize that the effect of temperature on the properties of a sheet metal car door can be neglected in a crash simulation, but must be considered for the inner plastic door panel. Polymers used in biomedical implants would be best tested at 98.6°F and in a saline environment.

Material Testing and Calibration

Material testing must be performed to precisely quantify the physical behavior at the required conditions. The testing is often different from conventional testing, because the data are not used for comparative purposes but aim for absolute accuracy; the data represent the real material in the mathematical calculations of the simulation.

Accordingly, everything matters — including the validity of the actual experiment, the precision and traceability of the test instruments, and the expertise of the test technicians to ensure that the test is carried out correctly.

The material data must then be prepared for simulation. Most simulation programs do not simply accept material data as an input. Instead, they provide material models — mathematical formulas that represent different kinds of behavior, such as linear elasticity for metals; elasto-plasticity and viscoelasticity for plastics; hyperelasticity for rubber; rate-dependent, creep and fatigue models, to name a few. These models may be simple or complex, depending on what is being simulated.

In each case, the challenge lies in calibrating the model, a conversion process whereby the material data are converted into numbers that form the parameters of the model. Unfortunately, this step contains a high level of uncertainty, because of a lack of well-defined methodology and the complexity of the mathematical conversions.

While some CAE software solutions have provided tools to perform this conversion step, most rely on the skill of the CAE analyst to perform this task. A few material models exist that will actually absorb material data as input; for example the work of Paul A. Du Bois with respect to the Fu-Chang model for foams. Tools such as Matereality's CAE Modelers can assist with this conversion process and write material cards, the esoteric data files that form the input for simulation.

Verification and Validation

Additional pitfalls for successful simulation include the setting of a number of parameters and variables — unrelated to the material data but often contained in the material card. Because of the large number of such uncertainties, many successful analysts will conduct a verification and validation (V&V) step to confirm that the material model is performing correctly.

A simulation is carried out of a simple experiment that explores the validity of the simulation. The simplest case is for the simulation to give back the raw experimental data of the test: for example, a stress-strain curve from the tensile test used to generate the material model.

More complex validations would seek to explore the validity of the model in alternate or multiple modes of deformation, like shear and biaxial tension. Such validations are usually reserved for more complex models that hold the capability of handling situations such as hyperelasticity for rubber and SAMP for plastic crash modeling. Validations quantify risk and give much-needed confidence to the analysts as they begin to use the material model to explore the real-life experimental space of the physical prototype that the simulation seeks to replace. DE

Hubert Lobo *is president of DatapointLabs, LLC, Ithaca, NY. Send e-mail about this article to DE-Editors@deskeng.com.*

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