DE

Technology for Optimal Design Engineering

CELEBRATING 20 YEARS

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by Jamie J. Gooch

Technology Doesn't Stop, Neither Should Education

Engineering departments are full of specialized knowledge accumulated via years of experience that is critical to each company's particular product design and development workflow. Losing that knowledge as engineers retire or change positions is a big hit to productivity. If that knowledge could be captured and shared, then the entire organization could continuously build on what it does right and fix what it could do better, rather than being trapped in a cycle of knowledge loss and re-learning.

It's an easy concept to grasp, but a more difficult one to implement. Even smaller companies, where everyone is in the same building, struggle with knowledge capture and sharing. In larger, global organizations, a concerted effort is required that places significant value on professional development. UTC Aerospace Systems is meeting that challenge with its learning distribution system, the Academy of Engineering Excellence. UTC Aerospace Systems is the world's largest supplier of aerospace and defense products with 41,000 employees worldwide.

How UTC Aerospace Systems implemented a company-wide learning distribution system.

"We trained 17,953 people last year in 286 courses," says Mary C. Bollash, manager of the Academy. Those are even more impressive numbers when you consider that Bollash's staff consists of herself and one staff member. The key to the Academy's success is the support Bollash receives from the company's leadership and its subject matter experts

The Academy of Engineering Excellence relies on 75 fellows who are experts from the company who have gone through a rigorous process to demonstrate their expertise and learn how to teach and mentor others, Bollash says. "Fellows are the best of our technical best," Bollash says.

Those fellows are responsible for developing courses to share their knowledge with their co-workers, with Bollash's assistance.

"My background is instructional design for online learning, so I'll help them to try to make each course as engaging as possible," Bollash says. She has a doctorate in adult education and a master's degree in instructional design. "They're the content experts," she says.

Make Learning a Priority

Bollash says education has always been important at UTC Aerospace Systems and at parent company United Technologies (UTC). The company's leadership views employees as UTC's best resource and a goal is having the best educated workforce on the planet. UTC has invested more than $1 billion in employees' formal training since 1996 as part of its Employee Scholar Program. The Academy at UTC Aerospace Systems grew from the need to capture and share what employees have learned.

"What our leadership realizes, is that we have so much talent, we have to make sure it gets transferred," she says. "If we have an expert and they know so much, and they don't share that knowledge, then when that person is gone the knowledge is gone. Because we're so spread out globally, we need a vehicle to spread that knowledge."

The UTC Aerospace Systems Academy of Engineering Excellence is that vehicle. The technology used in many of the courses includes video conferencing and electronic white boards that are shared with Academy students all over the world. Training can also take the form of hands-on labs and break-out sessions, in addition to online interactivity. The live lessons are captured, archived, and are available for asynchronous playback to accommodate learners in different time zones or learners who just want to review content covered. Additionally, these recordings are often used to develop training content such as self-paced e-learning courses.

Bollash demonstrated how part of the technology works by virtually presenting at the CD-adapco STAR Global Conference that took place in Prague, Czech Republic, from her office in the U.S. CD-adapco and a handful of other outside partners contribute training to the Academy, but the majority of courses are taught by UTC Aerospace Systems employee experts.

Looking ahead, Bollash is working toward getting courses certified for continuing education credits by the International Association of Continuing Education & Training. The association could also help Bollash in her efforts to benchmark the courses.

By placing a high value on learning, UTC Aerospace Systems is helping to ensure its future success. New engineers have access to the company's accumulated knowledge, giving them an immediate advantage as the company builds on its expertise. **DE**

Jamie Gooch *is the editorial director of* DE. *Contact him at DE-Editors@deskeng.com.*

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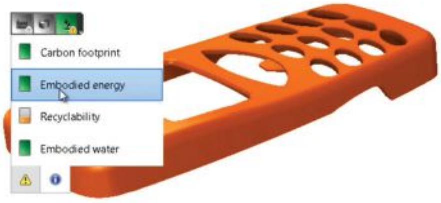

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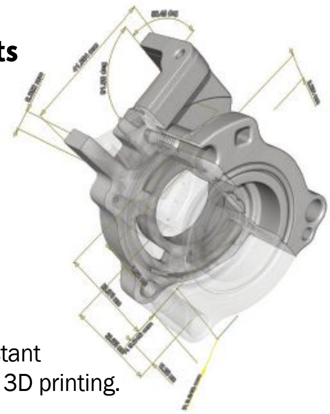

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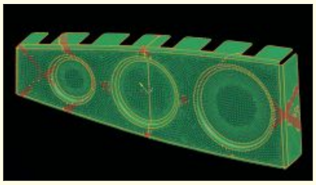

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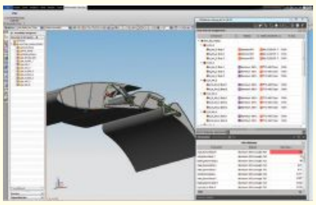

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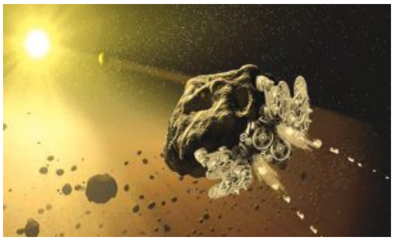

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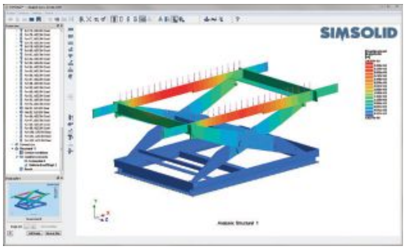

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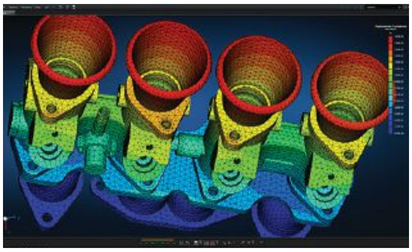

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Siemens PLM Introduces New Simcenter Portfolio

The core Simcenter offering includes computational solid mechanics, finite element analysis, computational fluid dynamics, multibody dynamics, controls, physical testing, visualization, multidisciplinary design exploration and data analytics.

"Siemens' predictive engineering analytics vision and digitalization solution strategy looks at product performance information more holistically to address the tremendous challenge that manufacturers face ..." says Chuck Grindstaff, president and CEO, Siemens PLM Software. "With Simcenter we are taking the next step in our journey to implement that strategy, building on the significant investments Siemens has made in recent years through internal R&D, strategic acquisitions of industry leaders such as LMS and CD-adapco, and continuing with future developments and expansion."

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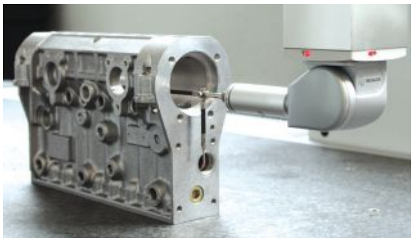
New Compact Probes

The new series of HP-S-Z1 compact probes from Hexagon Metrology are designed for CMM (coordinate measurement machine) tactile scanning.

The HP-S-X1 range of tactile scanning probes includes the HP-S-X1C centrally mounted version for high-stability in measurement. The HP-S-X1S and HP-S-X1H models offer the option to use an indexing probe head for better part accessibility. In the latest versions, the HP-S-X1C and HP-S-X1H models accept horizontal styli of up to 100 mm, while the HP-S-X1S can now take horizontal styli of up to 20 mm without changing modules. A standard interface allows all the probes to be used on Hexagon probe heads.



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NI, HP Enterprise Work on Big Analog Data Solutions

The partnership between National Instruments and HP Enterprise is expected to result in the availability of a pre-tested, best-in-class hardware and software combination for solving engineering data management problems and making decisions from sensor data more effectively, the companies state. These solutions will be based on NI DataFinder and HPE Moonshot systems.

"The DataFinder-Moonshot Big Analog Data solution is a potent combination, making it easier for engineers to rapidly deploy and gain insight from manufacturing, test and Internet of Things (IoT) data," said Tom Bradicich, VP and GM of servers and IoT systems at HPE. "With this pre-tested solution, HPE and NI are helping our customers to reduce their integration risks."

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Nastran, Patran 2016

According to MSC, Nastran 2016 uses an enhanced Automated Component Mode Synthesis (ACMS) method with Shared Memory Parallel (SMP) computing to deliver better performance and the ability to effectively use more cores for higher user productivity. SMP Parallelization can now be used to reduce the overall wall time stiffness matrix computations and stress recovery. Seventy-five percent parallel efficiency has been achieved with four threads with the job running three times faster than with one processor, the company says.

Patran 2016 has enhancements for nonlinear and fatigue analysis capabilities.

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CADSTAR PCB Updated

Updates have been made to the Trunk End Router so that improved routing patterns are generated for differential pairs. Coupling is maintained and skew is improved. Now, previously manual tasks are carried out automatically — and are significantly closer to the route an expert user would choose themselves, the company states.

Support for Etch Factor definition is available in the Configuration Editor and Constraint Manager. This is compatible with former trapezoidal conductor support, and etching for half-planes is available.

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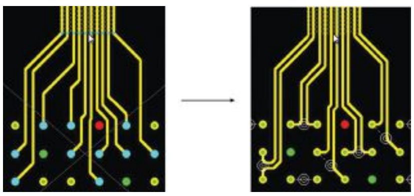

Intel Introduces Xeon E5-1600 v4 Series

The processors are equipped with Intel vPro technology, which lets engineers remotely manage their workstations. It also delivers up to 1.6x more application throughput performance than a four-year-old workstation on the same processor line.

Also featured in this new family is Intel Turbo Boost Max Technology 3.0. This enables increased single and dual core turbo performance. With this feature enabled, the foreground application (or any application the user chooses) gets an extra boost of performance — up to 200 MHz — by getting up to two cores running in Turbo Boost dedicated to it, Intel says. For example, if users have an eight-core processor, two of the eight cores will run at up to 4GHz and be dedicated to that application.

The E5-1600 v4 family has 8/16 cores, up to 20ML3 cache, 2400MHz max memory speed with DDR4 and support for up to 3TB of memory in a single workstation system.

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➜ For more coverage of new products for design engineering teams, visit deskeng.com/de/products

Cornell Offers an Option for 'Rapider' Prototyping

A research team at Cornell University has developed a new option for building and modifying prototypes.

Cornell's prototyping research, which has been published as "On-The-Fly Print: Incremental Printing While Modeling" simply makes changes to the existing prototype, rather than starting from scratch with every iteration.

The On-the-Fly system operates using a standard plastic filament 3D printing system that has been outfitted with a retractable cutting blade, and a misting system to help cool extruded filament. The platform has also been altered, allowing for five degrees of freedom by moving and tilting to offer different facings to the extruder head. A magnetic system allows for an object that has been partially built to be removed and examined, before replacing it in exactly the same spot to continue with a build.

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Airbus Unveils 3D-Printed Airplane

We've seen aircraft parts created via additive manufacturing, and entire cars produced with 3D printers. Now Airbus has debuted the world's first 3D printed aircraft. Thor (Test of High-tech Objectives in Reality) is a tiny airplane that made its debut at the Berlin air show in early June.

You can't ride in it, but the 46-lb. pilotless airplane presents a major step forward in the aerospace industry.

While neither the two electric motors nor the control were printed, the remainder of the 50 parts of the craft were created using polyamide. Thor is just 4 meters (13 ft.) long and is really more of a drone than an airplane. It took roughly a month to print.

"This is a test of what's possible with 3D printing technology," Thor project head Detlev Konigorski told the AFP. "We want to see if we can speed up the development process by using 3D printing not just for individual parts but for an entire system."

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Avant-Garde Architecture

It's been four years since Rapid Ready first reported on Enrico Dini's D-shape construction method that employs AM rather than manual labor. The latest idea is to use D-shape to build avant-garde architect Janjaap Ruijssenaars' Landscape House.

The Dutch architect first unveiled his creation in 2013, and essentially dared some company to figure out a way to make it a reality. Landscape House is based on the visual appeal of a Mobius Strip. Rather than hard edges and firmly defined boundaries, Landscape house is meant to draw the eye to the continuity of design. For the last three years the house has remained an open challenge, and now BAM has responded.

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3D Printing Stem Cells

Nano Dimension, a company associated with 3D printed electronic components, has teamed with Israeli stem cell research company Accellta to test a 3D bioprinter that uses stem cells.

The two companies tested the printer in May and plan to launch a venture focused on stem cell printing, ultimately bioprinting human organs and tissues.

"3D printing of living cells is a technology that is already playing a significant role in medical research, but in order to reach its full potential, for the field to evolve further, there is a need to improve printing speeds, print resolution, cell control and viability as well as cell availability and bio-ink technologies," says Amit Dror, CEO of Nano Dimension.

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A Plan to Turn Asteroids into Spacecraft

NASA's long-range plans for space exploration include a number of different possibilities for asteroid mining. It has reached out to the private sector for additional ideas. Made in Space has risen to the challenge with the idea of leveraging 3D printing to convert asteroids into autonomous spacecraft that transport themselves to mining facilities.

Made in Space has already contributed to our future in space with its work on 3D printing capable of operating in a zero-g environment. Project RAMA (Reconstituting Asteroids into Mechanical Automata), is designed to leverage future advances of additive manufacturing and in-situ resource utilization to realize efficiencies in asteroid redirect missions.

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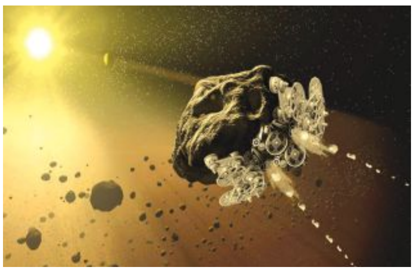

➜ For more coverage of 3D printing technologoes, visit rapidreadytech.com

The Science of Simulation

From May 23 to 25, Boston hosted "Science in the Age of Experience," Dassault Systèmes' second event in its series of global events. Why science when the company has traditionally been known for engineering? "Science is at the very heart of what we do," said Bernard Charlès, president and CEO. "It's really about creating something new."

"Simulation is just on the tipping point on the specialist to democratization scale," said Scott Berkley, CEO of SIMULIA. "To drive innovation, simulation needs to be an integral part to the decision making process early in the design."

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On the Eve of Petascale/ Exascale Computing

At the NAFEMS Americas 2016 Conference (Seattle, June 7-9), Dr. Steve Scott, senior VP and CTO of computer systems provider Cray, discussed how access to high-performance computing (HPC) is changing the way engineers conduct simulation.

Before his keynote address titled "HPC Trends and their Impact on CAE Simulation," Scott kindly agreed to respond to the questions posed by *DE*.

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IoT World 2016: Using AI for Business Intelligence

Ushered in by the beat of La Roux's "Bulletproof," Gavin Whitechurch, founder of IoT World, stepped up to the stage to deliver his welcome address.

"We started three years ago on a street in Palo Alto," he said. "We set up for 350 people, but got 700. Last year, in San Francisco, it was 5,800. And here, we're expecting 10,000 people. That shows you the amazing growth of the IoT space."

This year's IoT World (May 10-12) took place in Santa Clara, CA. The show's sponsors included Microsoft, Hitachi, SAP, HP and Avenet. Executives from the sponsoring tech giants joined the onstage discussions, their enthusiasm tempered with concerns for the unknowns in IoT.

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Siemens PLM Connects with Solid Edge ST9

Announced at Siemens PLM Connection in Orlando May 17, the latest release of Siemens' Solid Edge software (Solid Edge ST9) for CAD is scheduled to ship this summer.

It will provide flexible access to Solid Edge with cloud-based licensing, user preferences and collaboration tools. In addition, the company says the new built-in data management capabilities will enable users to easily index their CAD models, while the new migration tools will enable rapid conversion of legacy design data from virtually any CAD system. For more comprehensive data management capabilities, Solid Edge ST9 is designed to facilitate an upgrade path to Siemens' Teamcenter portfolio digital lifecycle management software.

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RAPID 2016 Presented An Industry of Opportunity

In May, the Orange County Convention Center in Orlando housed everything additive manufacturing. As an attendee, you were able to find any type of system, software, material and accessory in the exhibit hall. The show floor was enhanced by a host of courses and presentations of various design techniques, applications and 3D printing industry topics. Ultimately, RAPID gave the engineering community a look at an industry that is paradoxically well established and brand new.

"We are entering an age of innovation in 3D printing," said Todd Grimm, president of T. A. Grimm & Associates, as part of his kick-off presentation.

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Intel at Computex 2016

The opening act for Intel's keynote at this year's Computex (Taipei, Taiwan, May 31-June 4) was a virtuoso Wushu artist's martial arts sequence, augmented with the digital rings she wore. Navin Shenoy, Intel's corporate VP and GM for the Client Computing Group (CCG), praised the Wushu act as "an amazing example of the intersection of art and technology."

He believes the 50 billion connected devices that are expected to come online in 2020 represent "a new cycle of growth." According to him, "personal devices will create more and more data, which will beget more data centers, which will beget more devices."

As the leading chip maker, Intel has a vested interest in making its processors the center of this cycle. The company highlighted two star products at the show: the Intel Core i7 Extreme Edition and the Intel Xeon E3-1500 v5. Intel is also eyeing the AI (artificial intelligence) development initiatives, fueled by machine learning.

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by Beth Stackpole

Uphold HPC Leadership

Much ado is made about the United States' imperative to maintain the strongest military, but in today's technology-driven world, American exceptionalism in high-performance computing (HPC) may be just as important to the country's long-term future.

HPC is the centerpiece of modern competitiveness, as essential to U.S. national security as it is to scientific discovery and commercial innovation. In particular, HPC is a critical enabler of new product design and development, serving as the platform for robust simulation studies that help manufacturers virtually validate and test ideas to come up with optimized solutions that aren't feasible or cost-effective with traditional physical prototyping methods. America's ability to maintain its leadership position developing HPC technology, including making it readily accessible to both large corporations and small-to-mid-size businesses, is a critical objective — and one that should not be taken lightly.

A recent report released by the Information Technology & Innovation Foundation (ITIF), "The Vital Importance of High-Performance Computing to U.S. Competitiveness," raised concerns about an eroding U.S. HPC position as the race intensifies and countries like China, Japan and Russia amplify their own HPC development efforts. While the ranking of the world's fastest supercomputers has remained static for the last few years, the deck was shuffled upon the November 2015 launch of China's Tianhe-2, which boasts a peak theoretical performance speed of 54.9 petaflops. The Tianhe-2 is twice as fast as the second fastest supercomputer — the United States' Titan — that operates at a maximum speed of 27.1 petaflops from its home base at Oak Ridge National Laboratory in Tennessee.

We need to maintain HPC initiatives to advance technology.

As it that wasn't alarming enough, China is said to be furiously at work to best its own record, planning to release of a pair of 100-petaflop-capable supercomputers this year. The U.S. is by no means standing still. The Department of Energy (DOE) contracted with IBM and NVIDIA to launch two 150-petaflop supercomputers, but their entry is not expected until the 2017-2018 timeframe. And the real long-term race, according to the ITIF report, will come down to which country develops the first "exaflop" HPC platform, a milestone being tackled not just by the United States, but by the European Union, China and Japan — all with a 2020 target date.

Time to Act

Stephen Ezell, vice president of Global Innovation Policy at ITIF and one of the lead authors of the report, says we're at an inflection point with HPC. "This is a technology where global leadership is fiercely contested," he notes. "While the U.S. position remains strong, if we don't commit ourselves to making continuing investments, we will rapidly continue to lose ground."

Maintaining our leadership in producing and using HPC technology is equally important. Manufacturing HPC equipment provides a robust source of employment, exports and economic growth. Plus, there are no guarantees that U.S. companies and research entities could get access to state-of-the-art HPC technology if it was primarily manufactured in another country, Ezell says. Finally, HPC systems are often the result of co-design partnerships between vendors and customers, a relationship that is critical to advancing the frontier of HPC systems, he contends.

While the situation is by no means dire, the ITIF has made a credible case, both for the importance of HPC for competitive advantage and for why the U.S. should work to maintain its lead. The Obama administration seems to get the message and has taken some steps in the right direction. The National Strategic Computing Initiative, launched in July 2015 by way of executive order, is a federally funded R&D effort intended to keep the U.S. at the forefront of HPC development, including building exaflop supercomputers, making HPC resources more available to the public and private sector, and helping HPC application developers be more productive.

There are also efforts underway to bring HPC resources to smaller companies. The National Center for Manufacturing Sciences (NCMS) has created a dozen centers across the United States to help connect manufacturers with HPC resources, and the Ohio Supercomputer Center's AweSim program, a result of a partnership between the OSC and simulation experts, also assists SMEs with simulation-driven design.

Beyond those initiatives, the ITIF report recommends we:

- hold hearings on the NSCI and the intensifying race for global HPC leadership to keep the issue front and center;
- authorize and appropriate NSCI funding levels;
- reform export control regulations to match the reality of cur rent HPC systems;
- continue work on technology transfer and commercialization activities at the country's national labs; and
- emphasize HPC in federal worker training programs and in relevant Manufacturing Extension Partnerships. DE

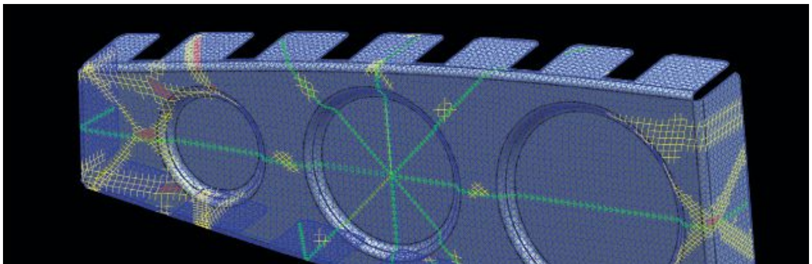
Beth Stackpole *is a contributing editor to* DE. *You can reach her at beth@deskeng.com.*

The Symbiotic Relationship Between Materials and Manufacturing

A look at the interdependencies in composite design, the material makeup and the manufacturing methods.

KENNETH WONG

There's no such thing as damage-proof design. It's a reality that most manufacturers have to accept. Patrick Morelle, Siemens PLM Software's senior marketing manager for composite products, revealed the aerospace manufacturers' strategy. "Their approach is to come up with damage-tolerant design," he says. "It means the design allows the damage to occur in a controlled way."



Composite airplane rib showing material behavior and fiber orientations resulting from the manufacturing process using Fibersim. *Image courtesy of Siemens PLM Software.*

One way to control damage is to predict where, when and how it would propagate. When working with standard materials (metal or plastic), engineers rely on structural analysis, computational fluid dynamics (CFD), and finite element analysis (FEA) software packages to simulate and predict a wide range of failure scenarios. But composites — made by combining two or more materials as fiber strands and plies — demand a more sophisticated form of simulation.

Damage simulation is just one aspect of composite design. Some industry experts and insiders have come to realize that, with composite products, the material-making process and the manufacturing process are inseparably linked to the product's performance.

"With composites, the manufacturing process itself is a constraint on the design. If you don't consider it, you may quickly arrive at a design that cannot be manufactured," says Morelle. "CAE technologies have integrated models to assess damage growth in composite airplane components and fuselage. Today, they constitute the designer's guideline, not only to replace expensive real physical testing, but also to answer what-if questions very early in the design cycle."

Composition Studies

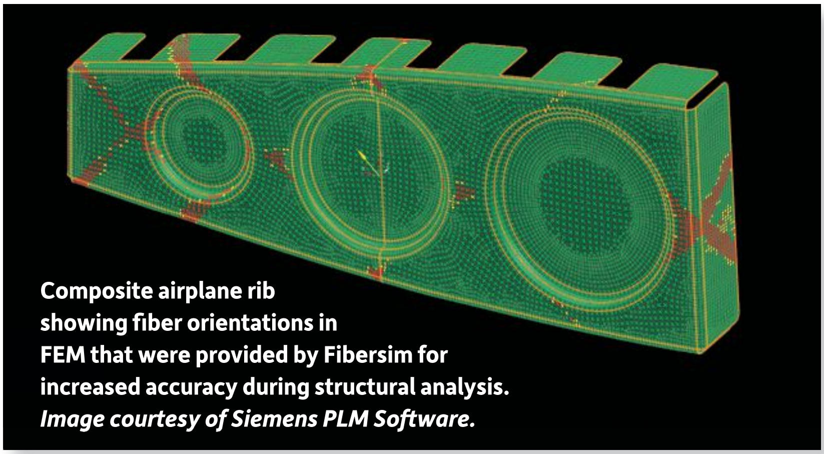
The fact that composites are made or designed is both a blessing and a curse. Because they're produced with fiber strands and plies, engineers can experiment with different configurations in fiber direction and ply stacking order to arrive at the desired stiffness, flexibility and durability.

But it also means the process of material making has to be examined, analyzed and perfected. Siemens PLM Software markets its Fibersim software solutions to engineers working with composites. It's developed to integrate with three industry-standard CAD packages: Siemens PLM Software's NX, Dassault Systèmes' CATIA and PTC's Creo.

"Because it's CAD-based, Fibersim brings together the key aspects of composite product development — part shape, material form and manufacturing process — that provide awareness of the material behavior and fiber orientations," says Leigh Hudson, director of Product and Market Strategy for Fibersim at Siemens PLM Software. "The ability to share the resulting definition and behavior between structural, design and manufacturing engineers ensures the performance optimization of composite parts."

Dassault Systèmes, known for its 3DEXPERIENCE platform, believes its BIOVIA product line provides a critical capability to address composites design and its relation to underlying molecular/atomic structure. BIOVIA is focused on the scientific determination of materials, properties, characteristics and behavior. "The first priority is to understand the materials and how they behave. We address that with the combination of capabilities in design and simulation capabilities within the CATIA, BIOVIA and SIMULIA brands," says Rani Richardson, CATIA business consultant at Dassault Systèmes.

Last April, engineering software maker Altair acquired Multiscale Design System (MDS). In the announcement, Altair called the acquisition a move to bring "tighter solver integration for composite material modeling, fatigue and multiphysics." Uwe Schramm, Altair's CTO, says: "We will continue to develop, enhance and invest in MDS as part of HyperWorks while retaining an open architecture approach with respect to other third-party solvers. Altair is committed to creating good interfaces and continuing to build partnerships to excel in the domain of composite materials."



Composite airplane rib showing fiber orientations in FEM that were provided by Fibersim for increased accuracy during structural analysis. ***Image courtesy of Siemens PLM Software.***

Among MDS' products are MDS-OP, for parametric optimization of woven fiber architecture; and MDS-FT, for simulating damage initiation and propagation in fiber structures. "MDS allows you to model composites at the fiber matrix level. It lets you see what's happening at the micro-mechanical level. It's a good way to look at fatigue initiation, crack propagation and fiber breakage," says Robert Yancey, vice president of Additive Manufacturing at Altair.

Computer-Assisted Design Exploration

Whereas engineers once decided on the shape of the products based on domain expertise and aesthetic preferences, they now increasingly turn to software that can mathematically compute and recommend the best (or optimal) geometry. With traditional materials, computer-assisted optimization is an option; with composites, it may be compulsory. "You have so many degrees of freedom with composites that you can quickly get lost if you don't get some guidance from optimization algorithms," says Morelle.

But robust, time-tested algorithms for optimizing composites are not easy to come by. Morelle explains: "Design variables are so different in composites than they are in metals. You can easily adopt the present optimization methods to anisotropic composite materials, but you have new constraints to satisfy, like the composite stacking sequence. Some of the rules are difficult to implement in an automatic optimization algorithms, but will have to be taken into account in future optimization strategies."

Reflecting on his own early experience as a budding designer, Jesse Blankenship, CEO of Frustum, says: "Optimization tools were very prevalent but not helpful, because they targeted the needs of stress analysts. Designers were very interested in them but had a hard time making use of them. You had to be very determined."

That's why he founded and launched Frustum in the beginning of 2014 to offer an integrated optimization platform for designers. The software Generate is described as an "optimization platform that brings design and topology optimization together as one."

"If you're going to optimize a large structure to be made in composites, you don't necessarily need a different set of algorithms," Blankenship notes. "But you will likely need a different set of objectives, constraints and material considerations. Setting up an optimization for a composite part, for example, will be fairly different from setting it up for the same design in metal."

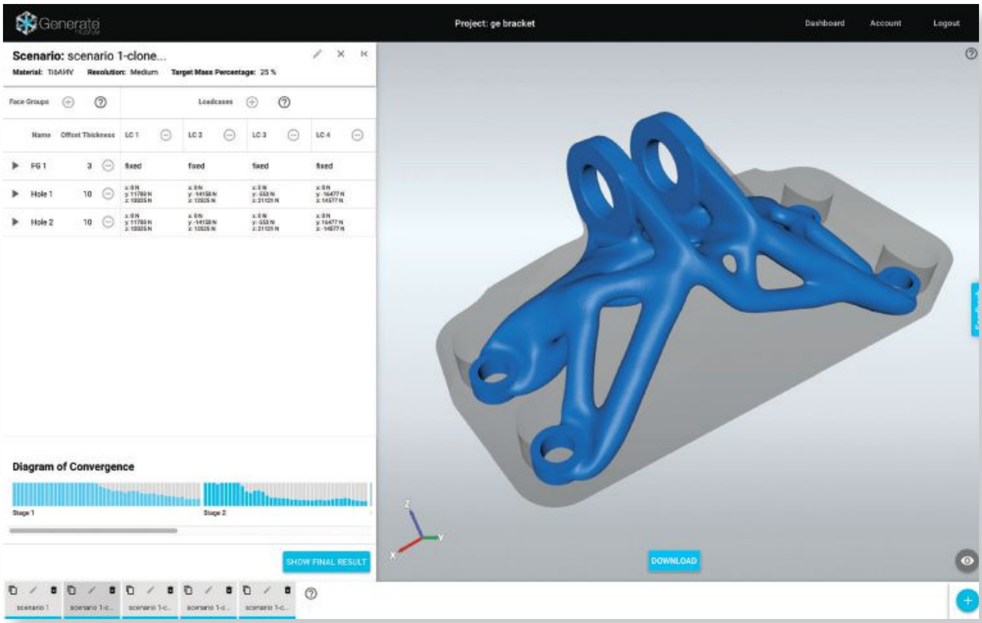
Constructed out of woven fibers and plies, composites do not stretch, break or bend the same way in all directions as metals do. The fiber direction and the ply stacking order affect the performance of the finished composite products. Existing optimization methods use stress and strain calculation — the foundation in FEA — to determine where the design needs reinforcement, and where materials can safely be removed. Incorporating additional factors — like ply stacks and fiber directions — to account for their effects on composite products' performance is a daunting software development challenge.

Layered Complexity

The combination of additive manufacturing (AM) and composites offers some manufacturers a way to reduce assembly complexity by replacing hundreds or thousands of discrete assembly components with a single large frame or structure. But applying large-scale industrial AM to composites invites new challenges not found in the more modest 3D printing projects.

"Composites manufacturing itself is additive with some subtractive machining and, from a traditional continuous fiber standpoint, is performed with automated fiber placement and tape laying. Fibersim provides the ability to design for these traditional AM processes through knowledge of the machine parameters that affect the design and material behavior," explains Siemens PLM Software's Hudson.

Altair's Yancey adds: "The automated tape-laying machines lay down strips of composite material. Then you cut the strips so you can get straight edges or stair steps at the end of the plies. But sometimes there's a difference between what the designer turns in and what manufacturing can actually make. Some corners cannot be made with machines; some curvatures might cause problems; sometimes you cannot get the angle you designed in the ply."



nTopology plans to deliver an optimization software to help engineers make better 3D-printed parts. *Image courtesy of nTopology.*

Simulating composite construction usually involves simulating the effects of draping composite laminates on curved surfaces. "Our software gives you a way to simulate the forming operation, to see what the angles would be like across the surface," says Yancey. "There are sophisticated software packages that do this, but they tend to be fairly expensive. Our customers tell us they don't need a solution that's 100% accurate, but want something that gives them general guidance. So we included that feature in Altair's HyperMesh."

Dassault Systèmes' Richardson identified three hurdles to industrial adoption of AM: "The first is understanding the materials and how they behave. We address that with BIOVIA. The second issue is functional generative design, the capability to create more organic optimized shapes with design for additive manufacturing. That's topology optimization, the area for generative design [algorithm-driven design]. The last is manufacturing process control. It's important to make sure the so-called optimal topology is manufacturable, and to build the support structures as needed for the manufacturing process."

Dassault Systèmes is preparing to release a CATIA module, titled Generative Design Explorer (GDE). Richardson said the GDE is built on top of TOSCA, the company's optimization software. By placing it inside CATIA, Dassault Systèmes is "putting topology optimization in the hands of designers," she adds.

A Growing Appetite for Lattice

The advantage of lattice and honeycomb structures for lightweight design is beyond dispute. Their porous construction allows a volume to be filled with less material than solids. Their network of nodes and stems reinforce one another, resulting in tremendous sturdiness and resistance. CAD and simulation software makers are now in a race to develop tools that can facilitate such designs. It's not practical to model lattice structures one beam at a time, one node at a time. Therefore, the preferred approach is to let the software fill a predefined geometric volume with microelements, using robust automation algorithms.

In 2014, Autodesk bought the London-based Within Labs, which specializes in generative design or algorithm-generated geometry. The acquisition gave the design software giant the foundation technology for Autodesk Within, released in July 2015. Several months prior to Autodesk Within's debut, Altair announced it had added a solver to model, analyze and simulation lattice structures in its OptiStruct software.

Altair added lattice structures to its OptiStruct software last year. With OptiStruct's topology optimization, areas between full density and open spaces can automatically be filled with lattices in an intelligent manner, providing weight-efficient structures that mimic structures seen in nature. "We have seen good interest in this technology in aerospace, medical and architecture markets, and have developed the necessary interfaces to go from lattice topology optimization results to additively manufactured parts," Yancey comments.

About a year and a half ago, nTopology transitioned from a consultancy to a software company.

According to its site, its founders have but one goal: to help engineers make better 3D-printed parts. The company writes: "Our software offers a fluid transition from mechanical design to DFM (design for manufacturability), and allows for both explicit and computer assisted creation of highly complex lattices structures … With our unique combination of generative, manual and simulation-based design tools, we let engineers create parts whose functional requirements are baked right in. With Element, you can optimize lattice structures with respect to user-defined inputs, imported data or our integrated FEA, letting you make the right parts for your application, every single time."

"Our free product, Element Free, is pure lattice design software — it doesn't have any built-in simulation or optimization," reveals Spencer Wright, vice president of Product at nTopology. "But in the coming months we'll be both releasing our own FEA modules and integrating with commercially available packages, enabling Element to simulate your structure and then use those simulations to drive the design."

Producing lattice structures with composites it not incomprehensible, but it would require new approaches. "Composites work better with tension than with compression, so you want to direct your forces along the fiber strands to make it work best for you. The difficulty is in adding variability [in lattice thickness, density or distribution]. Our software gives you an intelligent way to do that," notes Wright.

Because generating and displaying complex lattice networks is compute-intensive, nTopology Element requires a healthy amount of RAM and a modern graphics card with up-to-date drivers. The company tests its software with both AMD and NVIDIA's professional hardware.

A lot of the times, the output — the software-proposed optimal shape — requires additional work, because it's seldom in a manufacturing-ready state. Mathematically optimal shapes, as it turns out, are invariably too rugged, unorthodox and asymmetrical to be produced in traditional machines and cutting tools. Frustum's Blankenship believes he can change that. "We are focused on giving you geometry output that can be manufactured. Instead of using the output from the optimization as the inspiration for your design, you can use the output from our software as the design," he says.

Blankenship says Frustum Generate is targeting much more than structural analysis in its optimization calculations. "We are doing research into using other objective functions to inform the geometry — we'll consider fluid dynamics, thermal stress, even resonance frequency. In the future, you'll see more vendors focusing on producing manufacturable geometry, based on your input for preferred manufacturing method."

That is the goal for Blankenship. Currently, the beta version outputs 3D printable geometry but is not sophisticated enough to produce optimized shapes that are also manufacturing-ready for all kinds of materials and methods. "But within a year, that's what you'll see coming from our software," promises Blankenship.

Frustum Generate is available for both cloud-hosted and on-premise deployment. "One of the reasons we run our software in the cloud is to bring the high resolution to the designer, who otherwise would need to purchase a lot of hardware to bring the computing power required," says Blankenship. "The ability to conduct analysis in higher resolution, with a higher number of finite elements, generally yields greater accuracy.

Materials and Manufacturing Methods

Frustum's Blankenship anticipates additive manufacturing will play a bigger role in industrial operations in the near future, both in optimized direct parts and optimized manufacturing processes. "AM is no doubt a promising technology for mass production," he says. "You can make an actual frame with it, or the mold needed to make the frame. Five years from now, we'll see much more mass-production using 3D printing because the performance payoff is so great. In fact, we are already seeing some injection molding companies using AM as part of their process to eliminate costly steps."

Founded in early 2014, Frustum describes its software Generate as an "optimization that brings design and topology optimization together as one." ***Image courtesy of Frustum.***

The prevalent sentiment in manufacturing is to encourage the design team and manufacturing team to work closely together. With composite design, this strategy is critical to the success of the project. "In aerospace, there is a very good understanding of how to design a composite part for an elected manufacturing process," Siemens PLM Software's Hudson says. "Automotive is still investigating design and manufacturing options for the use of composite within a high volume production environment. Realizing the true value of composites relies on an understanding of the material behavior in the context of the manufacturing process to overcome both structural and manufacturing challenges." **DE**

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

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→ **Autodesk:** Autodesk.com

→ **Dassault Systèmes:** 3ds.com

→ **Frustum:** Frustum.com

→ **nTopology:** nTopology.com

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

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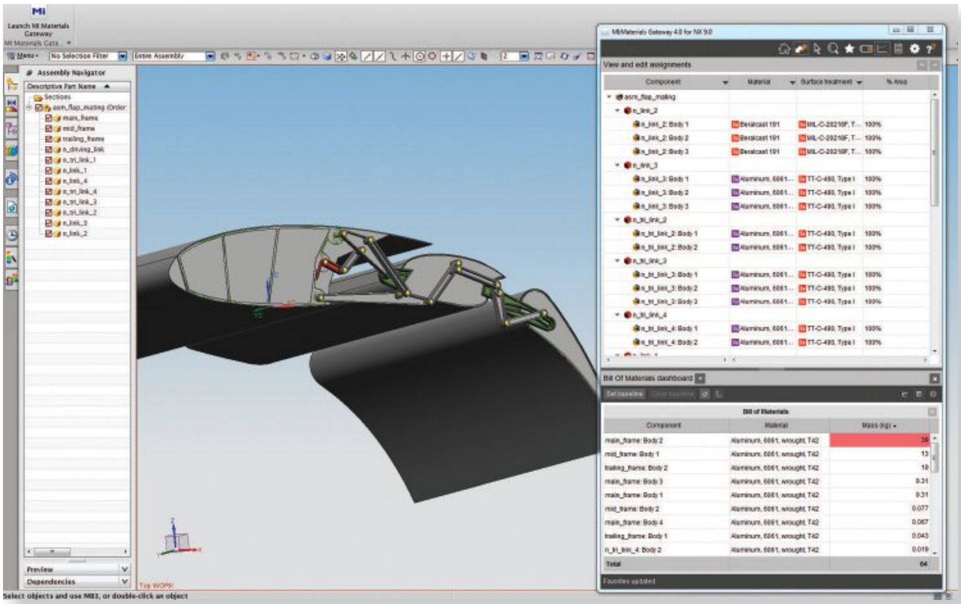
Many Layers to Address

The role of testing services and data providers in the era of composite design.

BY KENNETH WONG

Kurt Munson, HBM Prenscia's engineering manager for the nCode product line, once worked at a lab that tests structural components. He uses personal banking as an analogy to explain product durability. "It's just like a bank account," he says. "With each incident of damage, you take out a certain amount. If you have big-ticket items that incur a lot of expenditure, the account runs out quickly. Small damages accumulated over time also drain the account. Soon, you go broke."



The Granta material database incorporated into the NX CAD program. *Image courtesy of Granta Design.*

To extend the analogy, then fatigue or durability testing must be like ascertaining the account balance. It's a way to figure out how much damage a product can sustain before it goes broke, in a manner of speaking. "Durability tests are usually done on a candidate part [a design that's theoretically suitable for production]," says Munson. "You build a prototype and then run physical tests to see if it can survive the expected lifespan, the amount of corrosion, usage cycle and structural loads."

Testing objects made with composite materials, however, proves far more challenging than metal parts. "The manufacturing process and details of a composite product play a very large part in determining its ability to withstand loads," Munson says.

Even the decisions made as the composite component is created — fiber strand direction, fiber layup, curing, cooling, molding methods, to name but a few — significantly affect the end product's strength, durability and flexibility. That makes material characterization and the ability to model the behavior of parts as manufactured a critical part of composite design.

Accelerated Lifecycles

Suppose a typical hood is expected to last five years. It isn't practical for a manufacturing client to wait five years to get results from a durability test on a new hood design under consideration. A testing service provider must figure out a way to accelerate the hood's lifespan.

"In such a case, the test lab would accelerate the process, perhaps with a pneumatic machine that continuously executes the same operation — the opening and closing of the hood — for the expected cycles to replicate what happens to the object in its lifetime," says Munson.

The test is relatively straightforward with something as small and disposable as a door handle. You can run tests on dozens of units; you may even deliberately break a few to understand its failure modes. But what if the prototype is on the scale of a Joint Strike Fighter aircraft? "In that case, you may only get one chance to test it," Munson says.

For replicating a metal product's lifetime experience, environmental factors may be negligible. But not so with products made with composites. "A humid environment or an arid environment can affect a composite part's ability to carry load. So the same composite part may behave differently in humid Florida and arid Arizona," says Munson. The impact of temperature on composites is "another puzzle," he added.

The use of composites began in aerospace, closely followed by automotive. Both industries consider composites ideal for lightweighting projects, aimed at cutting weight and material from products. More recently, medical equipment makers and other industries began to take an interest in composites. "With devices that need to live in strange environments, like stents inserted into the human body, it may be very difficult to replicate and study some failure modes, such as environmental degradation," Munson points out.

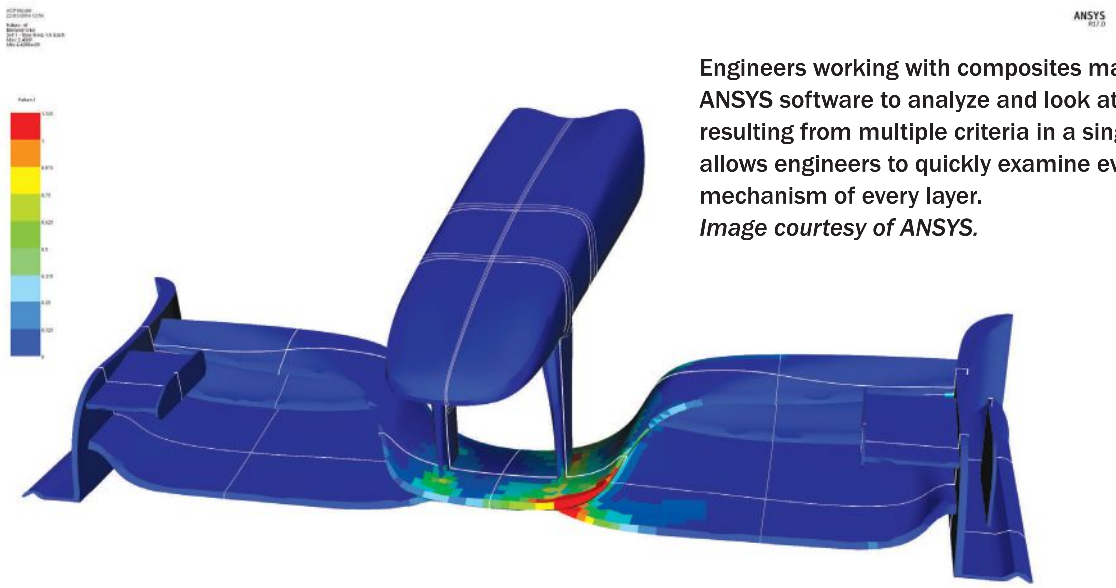
In addition to software development, HBM Prenscia maintains the Advanced Materials Characterization and Test (AMCT) Facility in Derbyshire, England. Material testing — testing samples in order to characterize the physical behavior of materials' elasticity, stress-strain response, durability with respect to fatigue or creep, among other things — lays the foundation for digital simulation. Published material data is often incorporated into simulation software programs like those from ANSYS, Siemens PLM Software, Dassault Systèmes or COMSOL.

Digitizing the Act of Production

Engineers working with steel, iron or plastic don't have to worry about the material-making process. Such standard materials, supplied by established vendors, behave in a fairly uniform manner. But composites are different: They're designed by combining multiple materials (for example, fiber-reinforced polymer) through weaving and layering. The number of possible configurations — the formulas for how the fiber strands and plies are put together — is virtually infinite. In a sense, the material is created at the same time that the component is manufactured. Therefore, the act of manufacturing itself demands analysis.

Conventional finite element analysis (FEA) packages for structural, heat exchange, airflow and fluid flow studies aren't designed for this type of micro-scale simulation. Recognizing this need, simulation software vendors began developing or acquiring composite-specific tools, designed to simulate the composite-making process.

ANSYS Composite PrepPost is just such a tool. It's the direct outcome of ANSYS' 2013 acquisition of EVEN, whose specialty is composite analysis and optimization software. The company writes: "Engineering layered composites involves complex definitions that include numerous layers, materials, thicknesses and orientations. The engineering



Engineers working with composites may use ANSYS software to analyze and look at failure resulting from multiple criteria in a single plot. This allows engineers to quickly examine every failure mechanism of every layer.
Image courtesy of ANSYS.

challenge is to predict how well the finished product will perform under real-world working conditions. Simulation is ideal for this when considering stresses and deformations as well as a range of failure criteria."

"Composite material behavior is very dependent on how they're laid up. Three layers of materials arranged at 45° to one another gets you very different results from two layers at 90°. The performance difference is determined all the way down at the fiber and epoxy level," says Richard Mitchell, lead product marketing manager for Structures at ANSYS.

In aerospace and automotive lightweighting projects, to "optimize" generally means to identify areas where materials can be safely removed without compromising the craft or the vehicle's safety and structural integrity. But with composites, optimization is far more complex.

ANSYS's optimization solution is DesignXplorer, integrated with its Workbench product for parametric analysis. "You have to decide what you want to optimize, what you want to see in the results," says Mitchell. "Do you want to see the amalgamated stress fields? Or look at the stresses layer by layer? Do you want to find the optimal number of layers for a particular region? Or the best angle or shape of the mold? Then you can set some limits in the software, set some goals, leave some things as variables, and ask the software to find the best solution."

Coupon Testing vs. Part Testing

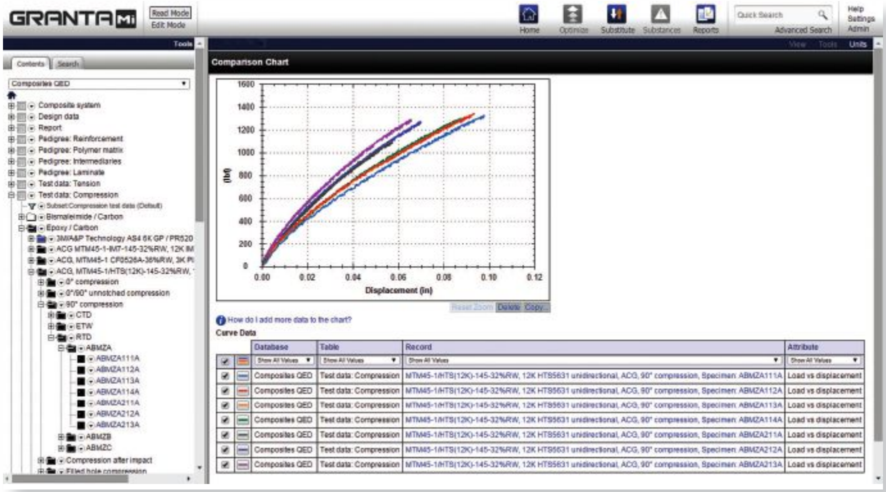
Testing service providers, like HBM's Advanced Materials Characterization and Test (AMCT) Facility, can ascertain the mechanical characteristics of a material by conducting a series of controlled tests on samples or coupons. The outcome is a digital file or record that describes the material's physical properties. Manufacturers usually use the data to decide whether a material is suitable for a project. Simulation and analysis software makers also incorporate such data into their products, allowing users to easily assign material properties to their digital models for software-based performance studies.

Durability tests or fatigue tests are usually conducted on a physical prototype. In such tests, the sample is typically subjected to repeated destructive operations to simulate normal wear and tear during its lifespan. The goal is to ensure the product, as designed, can withstand the anticipated pressure, heat and stress from routine usage. Running durability tests on small parts is straightforward; however, testing large structures may require special rigs, to be constructed specifically for the test. Therefore, the size and simplicity of the prototype dictate the cost. Some testing labs can conduct both coupon testing and durability studies. Others only provide the former, not the latter.

Building Composite Libraries

HBM Prenscia is an exception. Most simulation software makers do not operate their own material testing facilities the way HBM Prenscia does. So companies using simulation must determine the material properties needed for input to simulation codes themselves; or access material data from specialist third party providers. One company that offers help with both options is Granta Design, located in Cambridge, UK.

"For some properties, materials types, or conditions there's limited 'off-the-shelf' data available — composite fatigue might be an example — due to cost and time factors to sufficiently cover the in-service conditions and laminate architectures," says Stephen Warde, vice president of Granta Design. "Here, the focus is on doing your own testing.



Comparing composites test data in Granta's Composites QED data module. ***Image courtesy of Granta Design.***

Granta helps enterprises to manage and analyze that data so that it can be consumed, for example, in simulation. In other areas, in-house testing is supplemented by great reference resources — examples would be MMPDS (Materials Properties Development and Standardization) for aerospace alloys or the NCAMP (National Center for Advanced Manufacturing Performance) project for continuous fiber composites. These types of datasets most likely cover materials with highly predictable behavior. For example, there is generally greater coverage of short/long fiber composites, and less of continuous fiber composites. Granta's role is to collect this data from disparate sources and make it available digitally in one place, in a format that is ready for use."

Granta doesn't perform material testing; however, it helps organizations manage and use their test data. It also collects and licenses data from trusted partners and public sources into a cohesive library, accessible through its software. Granta's software is integrated into some leading design software packages. Granta's MI: Materials Gateway app appears in some simulation software. It's dubbed "Gateway" because it gives direct access to the Granta material database from within leading simulation software.

Warde emphasizes the factors that make good data management and analysis, complemented with good reference data, are important. "Composites are not coherent 'bulk materials,' where a test on a standard sample generates properties that are valid in a wide range of circumstances. Continuous fiber composites, for example, are made up of a number of different components and mostly fabricated when manufacturing a part: their properties will be highly dependent on factors such as the exact layup of the components, the exact manufacturing process, and the geometry of the part. Getting useful test data can require a very large number of different tests in order to cover property space for a given composite: and even these will in most cases only provide a guide to the exact performance of a final part."

Composite Conundrums

A common complaint about FEA programs is that their user interface (UI) is too complicated. Initially developed for experts, they invariably feature an overwhelming array of menus, input fields and options that discourage novices and general designers. Many simulation software makers are actively seeking ways to simplify the UIs to make their products much more accessible; however, the near-infinite permutations of composites present a dilemma.

"I don't want to see our customers spending more time learning the software than doing engineering," ANSYS' Mitchell says. "Their job is engineering, not to debug the software or learn how an advanced feature works. Yet, for something as complex as composites, we need to give the users a lot of controls and options. But we have to deliver them in a way that is easy to navigate."

For those working with composites, the quest for accurate, reliable material data will likely be ongoing. They may commission testing labs to ascertain the characteristics of the composites they created in-house for a specific purpose. They may also rely on published sources to get the data. Most likely, they'll use a combination of the two.

"Since many organizations will get simulation data by both of these methods, it's valuable to both manage in-house data and provide access to as much relevant reference data as possible through a single system. That's what Granta does," says Warde.

Despite the additional burden and work involved, engineers are increasingly employing composites in their products. That in and of itself is a testament to the benefits of composites. **DE**

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

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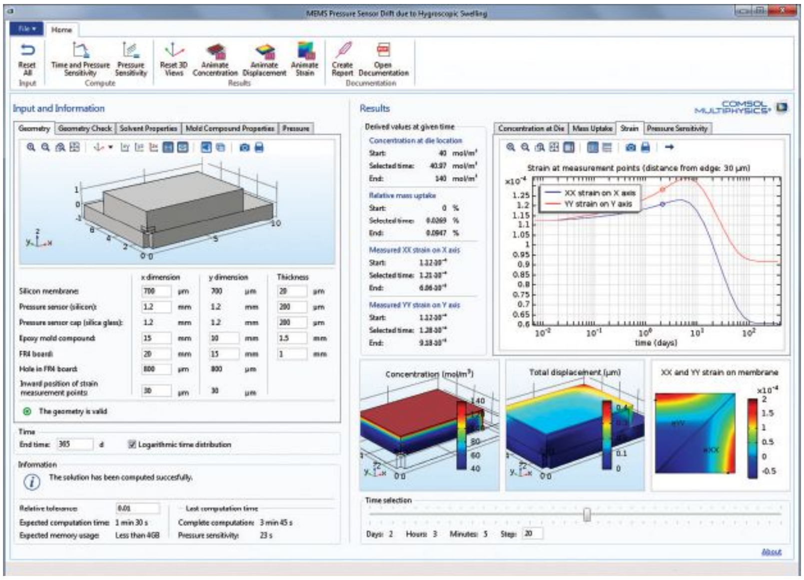
Simulation at the **Nanoscale**

What's new, what's changed and where you can go for more.

BY PAMELA J. WATERMAN

When discussing nanotechnology and simulation, imagine Schrödinger's cat (or perhaps Alice's Cheshire version) is peering over your shoulder, pointing out that nanoscale simulation software could approach a problem from the top-down or from the bottom-up, with each way having its pros and cons. One could push current analytical limits down, by scaling existing technologies past those of microelectromechanical systems (MEMS) devices. Or one could take an upward path, managing atomic and molecular physics in ways that simulate practical, manufacturable devices. Either way, the cats point out, the task involves many factors and application-specific goals that must be carefully considered.

Fortunately, compared to just five years ago (see "Twinkies, Tennis Rackets and Nanotechnology," deskeng.com/de/?p=4495), simulation tools that take on this task continue to evolve on both commercial and university/consortium fronts. *DE* takes a look at what you can use right now, with a focus on electrical and mechanical applications.



This COMSOL Multiphysics application simulates the drift of measured strain in a MEMS pressure sensor due to hygroscopic swelling. To calculate drift for different scenarios, the user can control the geometric design of the sensor, solvent properties, and material. *Image courtesy of COMSOL.*

Commercial Simulation Packages

For perspective, SmallTech Consulting, a California firm that provides expert consulting services in several micro- and nano-related technical and business disciplines, offers this general description: "Nanotechnology is the study, design, creation, synthesis, manipulation and application of functional materials, devices and systems through control of matter and energy at the nanometer scale. Further, it entails the exploitation of novel phenomena, including the properties of matter, energy and information at the molecular, atomic and sub-atomic levels."

With so many possible angles, nanotech-scale computer simulations (sometimes just called modeling) represent a very active field, as evidenced by the ongoing support of the U.S. National Science Foundation (NSF). However a number of companies already offer commercial packages that help designers apply the benefits of nanotechnology to diverse, real-world products.

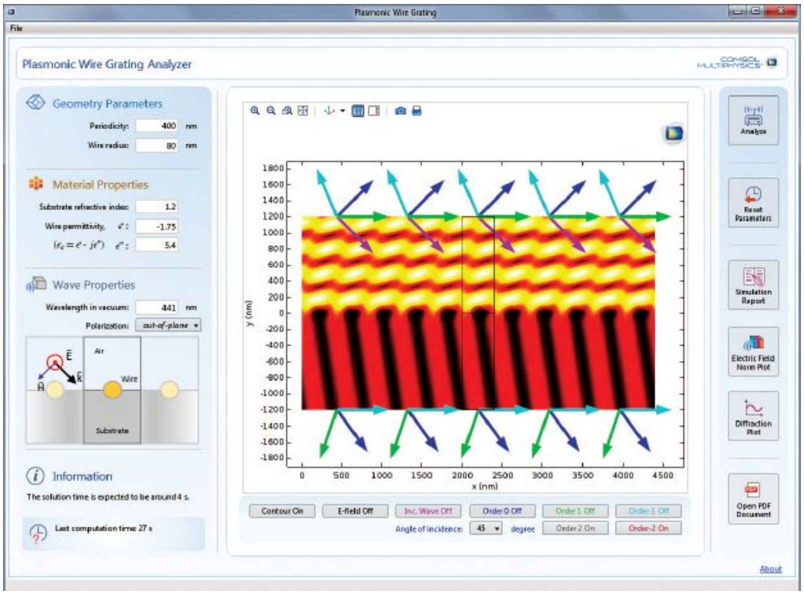
Altair markets FEKO software as part of its HyperWorks suite, supporting the design of such devices as antennas, microstrip circuits and RF components. As a comprehensive electromagnetics (EM) code (including method of moments [MoM]), finite element method (FEM) and frequency- and time-domain finite difference (FD) solvers, FEKO lets users model structures, assign materials/boundary conditions and run simulations all with a sophisticated yet easy-to-use graphical user interface (GUI). One FEKO user is Dejan Filipovic, a professor in the Antenna Research Group in the Department of

Nanocars Race on Atomic Course

This fall, a very short car race will test the driving (and fabrication) skills of an international group of nanotech scientists. At the crossroads of physics and motocross, the competition will feature nano-cars made from about a hundred atoms and measuring a few nanometers in length. The race will take place in a laboratory at CEMES, a materials science research center in Toulouse, France. Lasting a few seconds, the "race" is really for fun, but the groups will be testing interesting manufacturing and electronic-control methods at nanoscales. See more: http://goo.gl/XibYwc .

Electrical Computer and Energy Engineering at the University of Colorado at Boulder, who applies the software to EM analysis of nanowires.

"Modeling nanowires is not an easy task," says Filipovic, "since the constitutive parameters, specifically complex conductivity, make the system matrix [for computations] poorly conditioned." However, because the main engine in FEKO uses MoM, "one can set up a problem with many different material wires in arbitrary orientations and still solve it on a desktop. You can study wave propagation including standing waves, coupling and near- and far-fields around these structures to help you better understand the phenomenology." His group studied impedance, efficiency and patterns for nanowire antennas with FEKO.



This app, created from a COMSOL Multiphysics model, computes the diffraction efficiency for reflected and transmitted waves interacting with a wire grating on a dielectric substrate. The app reports the electric field norm plus reflectance and transmittance for a given angle of incidence. *Image courtesy of COMSOL.*

COMSOL Multiphysics analysis software has been used for years in a range of relevant applications, from nanoscale heat transfer to nanofluidics to wave optics, supported by one or more add-on modules. Bjorn Sjodin, COMSOL vice president of Product Management, says his company's software can handle structures down to a bit smaller than 1,000 nanometers, using FEM, finite volume method (FVM), boundary element method (BOM) and particle tracing method. For smaller sizes, he suggests working with software that uses quantum mechanical approaches (not currently offered by COMSOL).

With composite materials so much in the news, current COMSOL user applications stories include: "Buckling Behavior of 3D Randomly Oriented CNT Reinforced Nanocomposite" and "Nanoscale Simulation of Electric Field Enhancement in Polymeric Nanocomposites." Sjodin notes the latter subject is of interest, because, "although nanocomposites enhance mechanical and thermal properties, they may lower the dielectric strength of a material and make it worse as an insulator."

Materials Studio software from Dassault Systèmes' BIOVIA (formerly Accelrys) offers users a modeling/simulation environment to help predict the relationship between a material's atomic/molecular structure and its macroscale properties. Among the materials the tool handles are catalysts, polymers, composites, metals, batteries and fuel cells. Materials Studio includes a graphical user environment called Materials Studio Visualizer that lets users construct, manipulate and view molecular and mesoscale structures; it is complemented by quantum, classical, mesoscale and statistical solution methods that handle various particle sizes and time scales.

Addressing true atomic-scale modeling of nanostructures is QuantumWise of Copenhagen, Denmark. Founded in 2003, the company has developed a series of numerical analysis tools that go "up to nanoscale" as opposed to having scaled traditional methods "down to nanoscale." Its products can be used sepa-

Online Nanotech Resources

Association for European Nanoelectronics (AENEAS) - aeneas-office.eu; good source for nanotech-related technology and business activity in Europe

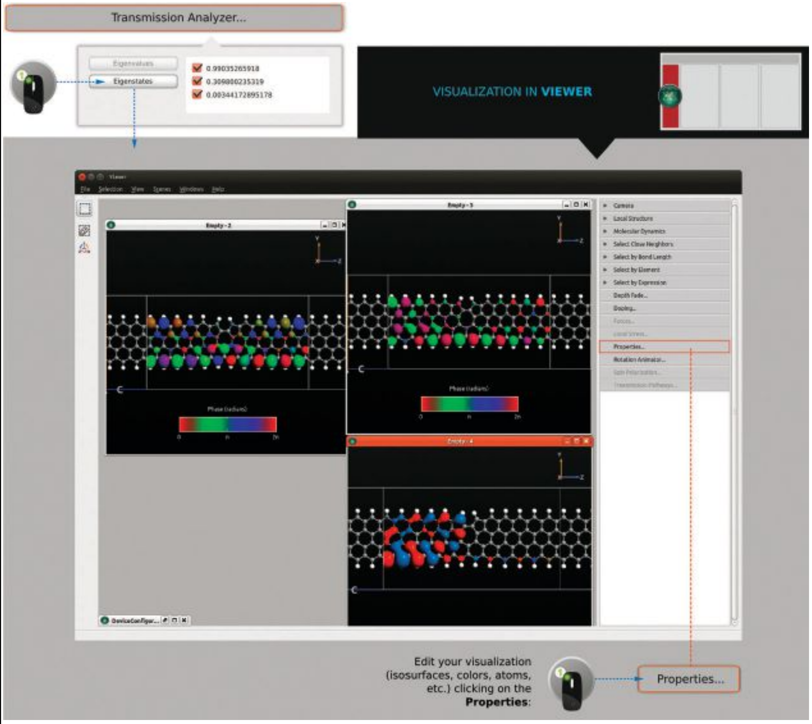
NAFEMS – NAFEMS.org; this group's conferences often include presentations on nanotechnology

Nanohub.org – a growing online collection of live software tools, models and educational resources

Nanotech-now.com – broad resource for consulting, technology assessments and general nanotech information; includes an informative glossary under their Press Kit tab

Nanotech scale interactive chart – htwins.net/scale2; fun interactive visual with lots of examples showing nanotech-scale items in proportion

Nanowerk.com - portal for nanotech-related news, resources and a material database; includes a great overview of current applications of nanotechnology



Electronic transport properties through a graphene nanoribbon that includes a distortion, analyzed and visualized with Virtual NanoLab from QuantumWise. ***Image courtesy of QuantumWise.***

rately or together, typically for semiconductor and electronics applications, though also useful for more general chemical and material simulations. Its tools include Virtual NanoLab (VNL) plus three versions of the Atomistix ToolKit (ATK) for different levels of theory and different scales – ATK-DFT (based on first principles), ATK-SE (semi-empirical approach) and ATK-Classical (classical potential).

Virtual NanoLab simplifies many tasks within nanotech modeling and simulation, and is extremely helpful for working with structures and data produced in other software. First, it contains an atomic 3D builder tool that reduces user time for setting up and verifying advanced structures. Second, it serves as a GUI (graphical user interface) for all ATK products, supporting easy scripting and results visualization. And third, it works as an interface not only for the ATK packages but also for transferring models to and from other solver codes. All elements have been designed for user efficiency.

This is not an exhaustive discussion of commercial software. Other simulation products exist for targeted applications, such as APSYS (Advanced Physical Models of Semiconductor Devices) from Crosslight and Sentaurus Device from Synopsys, both for semiconductor device design and analysis.

Open-Source Nanotech Software

A quick web search for nanotech simulation software immediately turns up the website nanoHUB.org. This organization deserves special mention as a portal for online, free access to more than 400 nanotech-related software programs that run in a browser. The site includes models, courses, datasets, and collaboration tools for working with nanoelectronics, nanophotonics, metamaterials and more, and is operated by the Network for Computational Nanotechnology. Simulation tools (mostly open-source) appear to run as applets but are operated transparently by Purdue University and other grid resources in the cloud.

Quantum Espresso, overseen by the Quantum Espresso Foundation, is another option. It offers "an integrated suite of open-source computer codes for electronic-structure calculations and materials modeling at the nanoscale." And, back to semiconductor topics, nano-archimedes is a Technology Computer-Aided Design (TCAD) tool "for the simulation of various technology relevant situations involving the dynamics of electrons such as the transport in nanometer-scale semiconductor devices."

University, Research Group Activity

Consultancies, universities, government-funded initiatives and online software projects represent the other side of active nano-simulation work. One nanotech-oriented consulting company with more than 30 years' experience is CFD Research Corporation of Huntsville, AL. It specializes in R&D of computational physics software and applications for government and commercial products, and has already transitioned 20 technologies into the market. CFDRC Technical Fellow Vernon Cole says their most relevant work is in materials modeling, ranging from atomistic and molecular scales up to the fundamental characteristics of microstructures. Much of their work predicts properties and degradation effects of thin films and other coatings.

The new National Nanotechnology Coordinated Infrastructure (NNCI), as announced last September, comprises 16 NSF-funded sites plus a coordinating office (administered out of Georgia Institute of Technology) and will give academic, small business and industry-researchers access to a national network of user facilities. Building on the innovations and discoveries of the National Nanotechnology Infrastructure Network (NNIN), the NNCI involves 27 universities and will include a unified web portal as a user entry point to test equipment, modeling/simulation tools and computational resources.

There are dozens of other universities and consulting groups conducting research to improve nanoscale simulation tools.

At Arizona State University in Tempe, AZ, the work by Dragica Vasileska of the School of Electrical, Computer and Energy Engineering is a stellar example of nanotech research with real-world applications. One project her group has addressed is the ongoing challenge to reduce transistor size. The effort involves investigating self-heating effects. They developed a multi-scale model for thermal transport that balances the energy exchange between electron motion (a particle model) and thermal transport (fluid models involving optical and acoustic phonons), necessary to account for all relevant effects in such nanodevices. Professor Vasileska has also contributed 19 tools to nanoHUB.org, including SCHRED (a self-consistent Schrödinger-Poisson solver) and PREDICTS1D, a tool that simulates copper migration in cadmium-telluride solar cells and the effects on reliability, durability and efficiency.

Besides offering electron-beam lithography, thin film and other fabrication services, the Cornell NanoScale Science and Technology Facility (CNF) also hosts "a diverse suite of simulation tools for nanoscale systems including codes for first principles calculations, photonic devices, molecular dynamics and nanoscale transport." The facility's high-performance computing center supports remote access and serves as a software test-bed to ensure code robustness prior to wide-spread distribution.

The University of Michigan PRedictive Integrated Structural Materials Science (PRISMS) Center is dedicated to accelerate predictive materials science for structural metals in general, and magnesium in particular. The PRISMS software development program is based on an integrated suite of multiscale/multiphysics computational codes hosted on GitHub (https://github.com/prisms-center). Although these tools are suitable for solving a broad range of analysis tasks, the Center's focus on metals addresses alloy composition, prediction of tensile properties and calculation of fatigue behavior. DE

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

INFO ➜ **Altair Engineering:** Altair.com

➜ **Arizona State University/School of Electrical, Computer and Energy Engineering:** ECEE.Engineering.ASU.edu

➜ **CFD Research Corp:** CFDRC.com

➜ **COMSOL:** COMSOL.com

➜ **Cornell NanoScale Science and Technology Facility:** CNF.Cornell.edu

➜ **Crosslight:** Crosslight.com

➜ **Dassault Systèmes BIOVIA:** 3ds.com/products-services/biovia/plm-solutions/

➜ **nano-archimedes:** nano-archimedes.com

➜ **nanoHUB.org:** nanoHUB.org

➜ **National Nanotechnology Coordinated Infrastructure:** NNCI.net

➜ **Quantum Espresso:** Quantum-Espresso.org

➜ **QuantumWise:** QuantumWise.com

➜ **SmallTech Consulting:** SmallTechConsulting.com

➜ **Synopsys:** Synopsys.com

➜ **University of Michigan/PRISMS Center:** PRISMS-Center.org

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Nanotech: A COMSOL Perspective

COMSOL Multiphysics software handles a range of physics types and applications through its targeted add-on modules. Bjorn Sjodin, company VP of Product Management, describes some general nano-level criteria that dictate when to use either a "continuum" or molecular dynamics analysis method.

For **structural mechanics** at the nanoscale, as long as the device is not too small, you can use standard structural analysis methods for elasticity, as built into COMSOL Structural Mechanics Module and MEMS Module, just as you would do for a macroscopic structure. However, when device sizes are micro- or nano-sized, non-traditional forces may be important that would never be relevant at macroscale. For example, electrostatic forces from surface charges could dominate as well as intermolecular forces such as van der Waals forces. In the MEMS module, electrostatic forces can be modeled out of the box and van der Waals forces can be modeled by typing in user-defined mathematical expressions.

At nanoscales, **heat transfer** cannot be modeled without taking the molecular and atomic structure into account, as it is traveling in the form of waves, or phonons; in a metal this would be vibrational waves in the lattice of atoms. In addition to these waves, for some materials one may need to take into account the movement of the electrons. In the end, one may have to work with two temperatures, one for the atomic lattice and one for the electrons — which is very different than at the macroscale.

Electromagnetic simulations at nanoscales are not that much different than at the macroscale — again, as long as the device sizes aren't too small. If you get down to the atomic or molecular scale, then quantum mechanical effects come into play, requiring (non-COMSOL) dedicated quantum mechanical software typically using the Density Functional method.

The traditional way of performing **fluid flow** simulations is by solving Navier-Stokes continuum-flow equations or some versions of them. But at the nanoscale you are reminded of the fact that Navier-Stokes equations are only an approximation of a more complicated reality (known as the Chapman-Enskog solution to the Boltzmann equation). If the fluid device size is not very small, then you may get away with modifying the boundary condition — something that is known as slip flow. COMSOL users use the Microfluidics Module for this type of simulations. For even smaller sizes (or equivalently lower pressures) one may need to use completely different methods. One technique is to use molecular flow methods. This assumes the fluid molecules are traveling along straight paths and bouncing off the walls of the container that holds the fluid. This technique is applied in the Molecular Flow Module.

Going Green

New software is enabling engineers to bring sustainable packaging to the front of the design process.

BY JESS LULKA

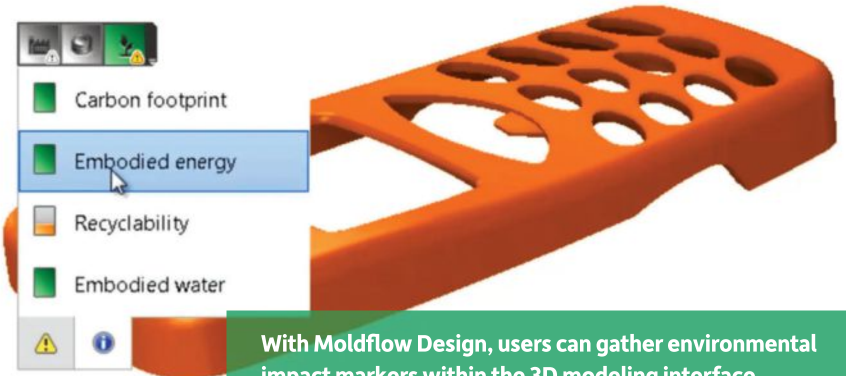
There is a lot of design that can go into one package. And, to create a good design, engineers must create something that is not only structurally sound, but also aesthetically appealing to the average consumer. To meet these goals requires the use of design, simulation and now lifecycle applications as integrated engineering workflows expand to include sustainable design processes.

According to a report by Mordor Intelligence, the current market for global green packaging is expected to reach $274.15 billion by the year 2020. This includes packaging that is recyclable, reusable or degradable.

"We're seeing more green options in packaging — recyclable, reusable and degradable — as manufacturers reduce source material creating lighter primary and secondary packaging, thus reducing waste," says Paula Feldman, director of Business Intelligence PMMI, an association for packaging and processing technologies. "We expect this practice to increase in the coming years as CPGs (consumer packaged goods providers) strive to meet consumer demand."

Adam Gendell, senior manager of the Sustainable Packaging Coalition (SPC) says packaging has to be part of the conversation about using natural resources in a sustainable way. "Products almost always carry higher levels of environmental, economic and social implications," he says. "For the protection of products, it's essential to use the right amount of packaging in order to maximize the benefits of the product and minimize its impacts."

Ultimately, the goal is to create packaging that not only has an efficient design and manufacturing process, but can also have a low environmental impact once it leaves the factory. This can lead to different design considerations up front.



With Moldflow Design, users can gather environmental impact markers within the 3D modeling interface. ***Image courtesy of Autodesk.***

"You're looking at things that are often not designed to last very long," says Dawn Danby, senior sustainable design program manager at Autodesk. "That question of the lifetime of a product is really different. You're also looking at really wanting to recover as much valuable reusable material as possible."

It's also about balance, says Gendell. "In all our work we've never once come across a situation in which one packaging design option was clearly more sustainable than anything else. Every decision introduces trade-offs. The sustainability community can't tell industry that any one sustainability characteristic is more important than another, so there are judgment calls to be made," he explains.

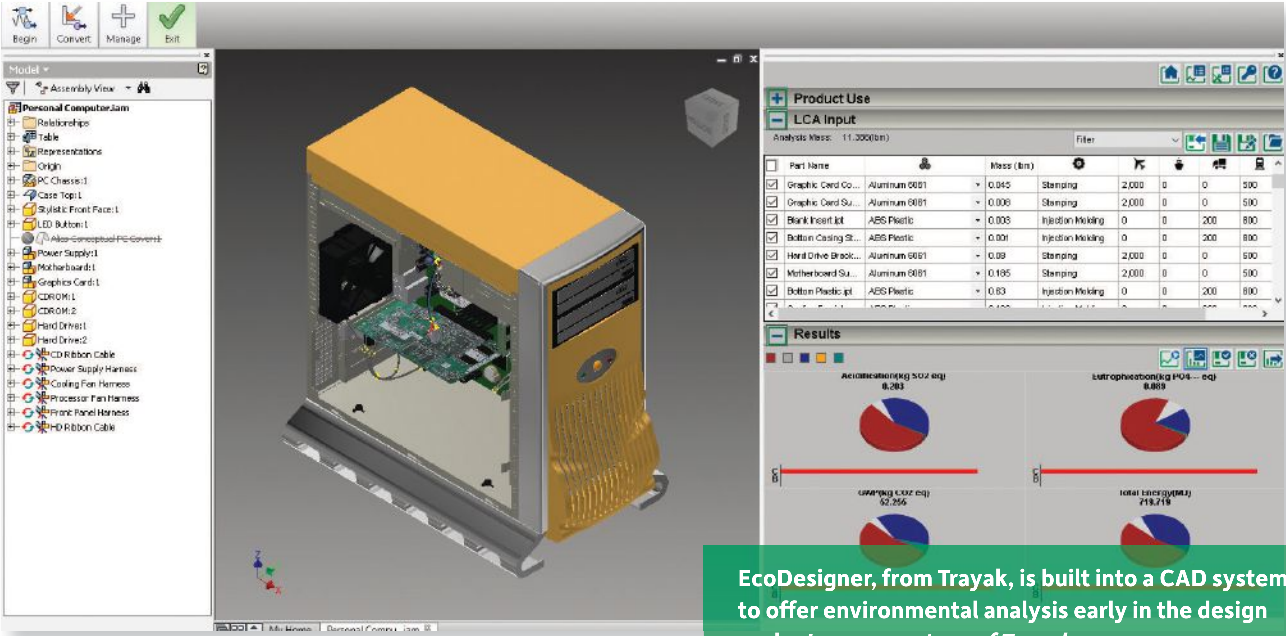
Materials Matter

A primary way to ensure sustainable packaging design is to investigate different material options. But, this can pose challenges for designers because the amount of available materials for green design is often a much smaller pool.

"You're trying to think of materials that are inherently low impact," says Prashant Jagtap, president and CEO of Trayak, a product sustainability consulting and software provider. "There's also the idea of using materials that are bio-renewable, [such as] plastics from ethanol or paper from renewable sources."

To help with material selection, Danby says Autodesk offers the Eco Materials Adviser. Integrated into Inventor, this add-on can help address environmental requirements with access to Granta Design materials data. In the packaging world, it's an interesting opportunity to identify where the points of recycling are, according to Danby. "The palette of materials is smaller. The Eco Materials Adviser will give [users] access to many, many materials and a lot of detail," she says.

However, it's important to look at considerations beyond materials — application is also key. "The same product



EcoDesigner, from Trayak, is built into a CAD system to offer environmental analysis early in the design cycle. *Image courtesy of Trayak.*

could require more of one packaging material type than another to get the same performance characteristics. Packaging materials are rarely interchangeable on a one-to-one basis. Put in the proper context of a specific packaging option, though, winners can be identified," says Gendell.

To help companies understand what sustainable packaging is, the Sustainable Packaging Coalition created a standardized definition in 2005. On its website, it states that sustainable packaging:

- is beneficial, safe and healthy for individuals and communities throughout its lifecycle;
- meets market criteria for both performance and cost;
- optimizes the use of renewable or recycled source materials;
- is manufactured using clean production technologies and best practices; and
- is effectively recovered and utilized in biological and/or industrial closed loop cycles.

A Holistic View

Just like traditional design, engineers must consider how a product moves throughout the entire design-to-manufacture process. Considering the lifecycle is also a way for designers to identify pain points in the sustainable design process. "A lifecycle view of packaging tells us there are many areas that should be improved," says Gendell. "Industry has shifted toward a more comprehensive understanding of packaging, and the packaging sustainability improvements are evident."

When it comes to looking at the entire lifecycle of a sustainable design, it's necessary to implement software that can offer extended lifecycle assessment (LCA), which goes beyond simplified data management. "The traditional PLM is about developing products and launching products or packages. But their focus is mainly on time to market or innovation and just trying to do things efficiently," says Jagtap. "Where as sustainability, on top of focusing on certain parts [of PLM] you're also focusing on what type of materials and you need to go much more upstream than traditional PLM to try and understand the impact [of a package]."

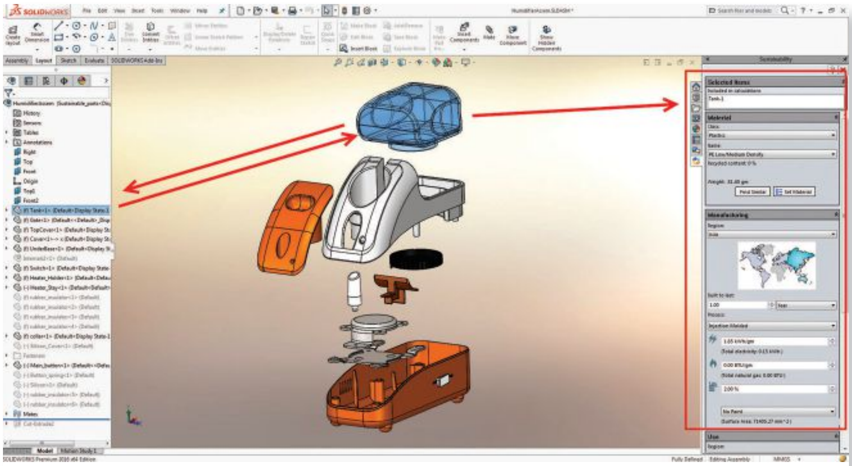
It's also important to consider the package's end of life, something that might not always be built into current software offerings.

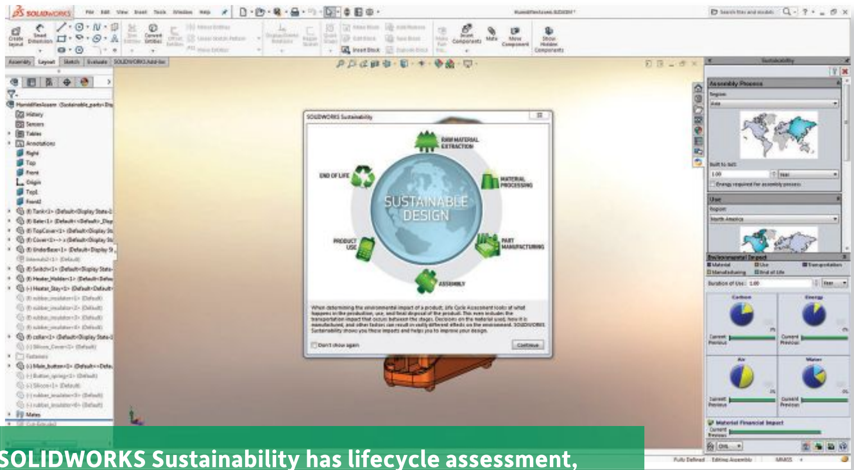
Using lifecycle analysis is also another way to identify optimal designs early within the design process. "Running a lifecycle assessment on your design concepts as you go helps make the best decisions on material selection, design for recycling, minimized energy consumption and end of product life use that will identify the design with the least environmental impact," says Eric Leafquist, senior product manager at SOLIDWORKS.

Tools of the Trade

While a part of developing sustainable packaging is knowing how to implement the right design techniques, software can also play a large role. Giving users access to tools so they can consider sustainability earlier in the design process is a major effort of Autodesk's Sustainability Group, Danby explains. "It means they're doing much more integrated thinking," she says.

Along those lines, the SPC has developed COMPASS — in partnership with Trayak — to provide cradle-to-grave analysis of environmental impact. "A design team can use COMPASS to compare design options and learn relative intensities of environmental impacts





SOLIDWORKS Sustainability has lifecycle assessment, material selection and end of life considerations built directly into the software. *Images courtesy of SOLIDWORKS.*

like greenhouse gas emissions and water consumption," says Gendell. The organization also has websites that can help designers get an overview of what sustainable packaging entails and how to understand recyclability.

In addition to COMPASS, Trayak offers a host of software for creating sustainable designs all across the workflow. The offerings from Trayak — EcoDesigner, EcoImpact, EcoLabel and EcoScore — are all part of a main portfolio, notes Jagtap. This is "to help mainstream sustainability," he says. EcoDesigner is embedded into the CAD system to bring the day-to-day designer access to environmental impact analysis and incorporate design-for-environment principles. "What we're trying to do is let the CAD system be the main place [for sustainable design]," Jagtap says.

Autodesk also offers Trayak's EcoDesigner software for the Autodesk Inventor ecosystem. EcoDesigner LCA provides designers with the insight to quantify the effects of material decision, sourcing options and manufacturing processes early in the upstream design stages.

SOLIDWORKS also brings its features directly into the design stage with the availability of an LCA tool, environmental impact dashboard, baseline measurement, material database search capability and customizable reports. "Having SOLIDWORKS Sustainability (and other analysis tools) fully integrated inside SOLIDWORKS enables very fast iterations of design-analysis-design that speeds the refinement process for the engineer," Leafquist says. "It is the fastest way to work without the need for export-then-import to other, separate tools." Recently, the company has integrated these tools into SOLIDWORKS Premium, added more materials and updated the user interface.

While Autodesk doesn't have specific branded tools for sustainable packaging design, Danby says that the company is looking to help its users leverage the current offerings of Inventor and Fusion 360 to get in a greener design mindset. "Really what we're looking at is 'how do we encourage people to use the tools that we have?'" she says.

One initiative is Autodesk's Sustainability Workshop, an online research to help teach engineers the practice of sustainability in engineering and design. There's a lot that can be done with the existing simulation capabilities that are now available, Danby says.

Ultimately, what these organizations are seeking to do is soften the learning curve for sustainable packaging and product design — especially because it's gaining more traction within the design industry. "In many ways, sustainability is similar [to finite element analysis]," says Jagtap. "You could have lifecycle experts, but we're trying to bring that deep expertise, knowledge and analysis to the engineer much earlier in the design cycle." **DE**

Jess Lulka *is associate editor of* DE. *Send e-mail about this article to DE-Editors@deskeng.com.*

INFO ➜ **Autodesk:** Autodesk.com

➜ **Dassault Systèmes SOLIDWORKS:** SOLIDWORKS.com

➜ **Granta Design:** GrantaDesign.com

➜ **PMMI:** PMMI.org

➜ **Sustainable Packaging Coalition:** SustainablePackaging.org

➜ **Trayak:** Trayak.com

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A Digital Stitch in Time

Initiatives are reshaping Lockheed Martin's original vision for the digital thread.

BY RANDALL S. NEWTON

With all the talk in the last few years about the Internet of Things (IoT) and the Industrial Internet of Things (IIoT), some concepts and notions regarding the use of 3D data in manufacturing are being revisited. One term from the previous decade getting a reboot is "digital thread." What started as a way to describe using model-based definition (MBD) for delivering data to the factory floor has become a metaphor to unite physical and digital manufacturing processes in ways previously considered unrealistic or impossible.

The phrase digital thread was coined at Lockheed Martin to describe using 3D CAD data to directly drive CNC (computer numerically controlled) milling or composite programming systems for carbon fiber placement. In both cases, the physical piece is the result of an unbroken data link that stretches back to the original computer model of the part; the unbroken data path was the digital thread.

A consortium of aerospace and defense manufacturers gathered in 2011 to discuss the digital thread concept for the first time. The goal of their newly formed Computational Manufacturing Alliance (CMA) was to find common ground where both makers and users of the technology who needed to create a digital thread could work out data interchange issues. The goal was rooted in an interoperability agenda of plug-and-play connectivity where data producers and data consumers would be linked in a common data stream originating from a common data source. From that beginning, it has evolved into a vendor's alliance, where software makers including Right Hemisphere, Delta Sigma, FARO, Kuka Integration and VRSI, work on tools to support a common workflow between engineering, process planning, manufacturing process and measurement.

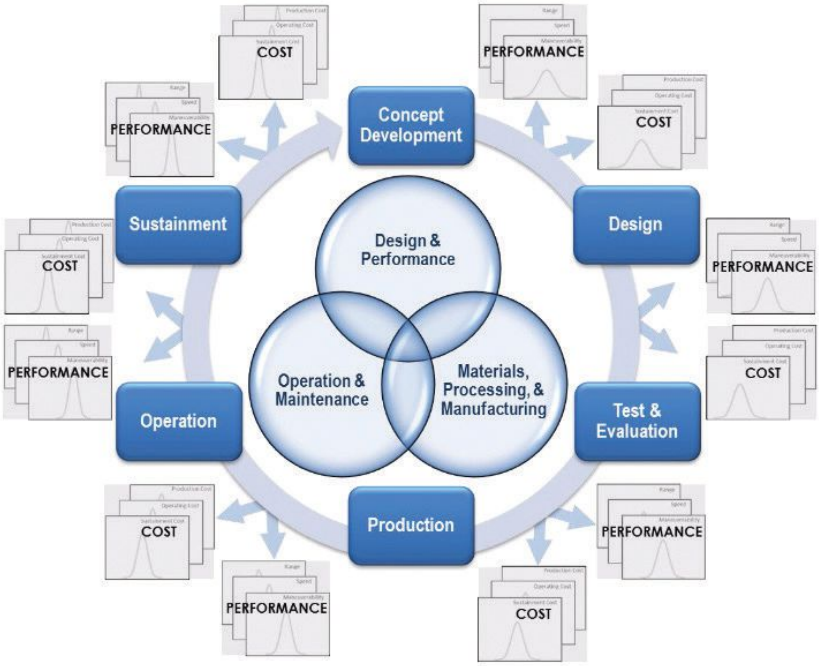
Since then, the idea of the digital thread has expanded beyond a single model driving a single process, to a more global expression of the goals for a model-based enterprise (MBE) in manufacturing. Private industry, the government and academia are all working on expanding the scope of what full engineering-to-manufacturing connectivity can become. Along the way, other concepts have come to the front as the vision for a digital thread expands. At the top of the list are two concepts: make the digital thread a bi-directional data flow, and utilize a digital twin philosophy of data utilization.

The U.S. National Institute for Standards and Technology (NIST) is working with all stakeholders in advancing the digital thread philosophy. It defines the digital thread as "a way for different machines in a manufacturing process to all follow the same set of digital instructions." This is slightly different than Lockheed Martin's original definition, but a more holistic one. There is not just one digital thread from one CAD model to one machine in a factory; elements of the same model must connect to a variety of destinations, and there must be two-way communications.

Existing manufacturing processes use design feedback loops, but they are generally informal and not sufficiently automated (if at all). Initial designs specify fit and form requirements as geometric dimensions and tolerances, included in an MBD as the Product Manufacturing Information (PMI). But there is no formal means of sharing this design intent with part inspection, and certainly no two-way data flow. NIST is advancing the notion of "PMI 2.0" to drive a new standard of high-level information requirements and to close the gaps, connecting geometric, PMI and functional data in a two-way flow with manufacturing. NIST has started a GitHub repository where it is working with interested parties and hosting open software that addresses technology needed to create the envisioned digital thread.

From Digital Thread to Digital Twin

If the digital thread is a two-way line connecting engineering with manufacturing, there has to be a way for the data



A systems diagram for creating a digital thread. *Image courtesy of U.S. Air Force.*

on the engineering side to update based on input from manufacturing. This is the foundation for the evolving concept of a digital twin. More than a CAD model, the visual and technical database of design intent becomes a digital mirror image of not only the imagined product, but the finished one as well. The digital twin holds analysis data, scan data from prototypes or finished product, as well as inputs from all corners of the enterprise where data is contributed manually.

CAD vendors are starting to describe their models as digital twins, but the exact definitions vary (see "Digital Twins Land a Role In Product Development," deskeng.com/de/?p=27352). What is common is the notion of two-way communications between the digital model, the machines that make the physical instantiation — and increasingly, the manufactured object itself, as internet-enabled products come to market.

Outside of the CAD vendor community, other stakeholders are pushing for consensus on what constitutes both the digital thread and digital twin. One leader in seeking a common definition and deployment of digital twin technology is the U.S. Air Force (USAF). In a research report approved for public release, USAF says it is advocating day-to-day use of a "tightly integrated digital thread and prototyping process to enable agile development." Another approved release describes the combination of digital thread and digital twin as the "game-changer that provides the agility and tailorability needed for rapid development and deployment, while also reducing risk."

In the USAF Global Horizons report on technology visions, digital twin is defined as "the creation and use of a digital surrogate of a material system to allow dynamic, real-time assessment of the system's current and future capabilities." The "digital surrogate" is a "physics-based technical description of the weapon system resulting from the generation, management and application of data, models and information from authoritative sources across the system's lifecycle."

The USAF technology vision paper also enumerates specific benefits in going to a digital thread/digital twin process:

- streamlined resolution of system performance issues;
- reduce late discovery of system performance deficiencies;
- identification of risk at decision points;
- quantification of risk at decision points;
- informed trade space exploration;
- yield and rate improvements via agility on the shop floor (adaptive machining, virtual assembly, etc.); and
- infrastructure to generate, capture, organize and use relevant data.

The Next Generation Buzzword

Having coined the term digital thread and having used the concept as a technology adoption mission slogan, Lockheed Martin is not resting on past efforts. It is now describing the next generation of digital connectivity. Led by Dennis Little, vice president of Space Systems, Lockheed Martin aims to combine three separate digital domains — virtual reality, 3D printing and digital processes — to "radically streamline its entire approach to creating complex products." Lockheed Martin is calling this the Digital Tapestry and the company envisions it as the final goal for a fully digital product lifecycle.

"The Digital Tapestry ties everything in our production operations together digitally, from concept to product realization," says Little. "It's an end-to-end digital approach where everything is connected — from concept, design, simulation, manufacturing and assembly, to testing and getting the final product to the customer. Our goal is not to break a single thread in the digital process." DE

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

INFO → Computational Manufacturing Alliance: Compufacturing.org

→ Lockheed Martin: LockheedMartin.com

→ U.S. Air Force: AF.mil

→ U.S. National Institute for Standards and Technology: NIST.gov

Microsoft **Flexes** Its Agile Muscles

Using agile development methodologies, Microsoft's hardware groups were able to standardize and consolidate on OnePDM in less than a year.

BY BETH STACKPOLE

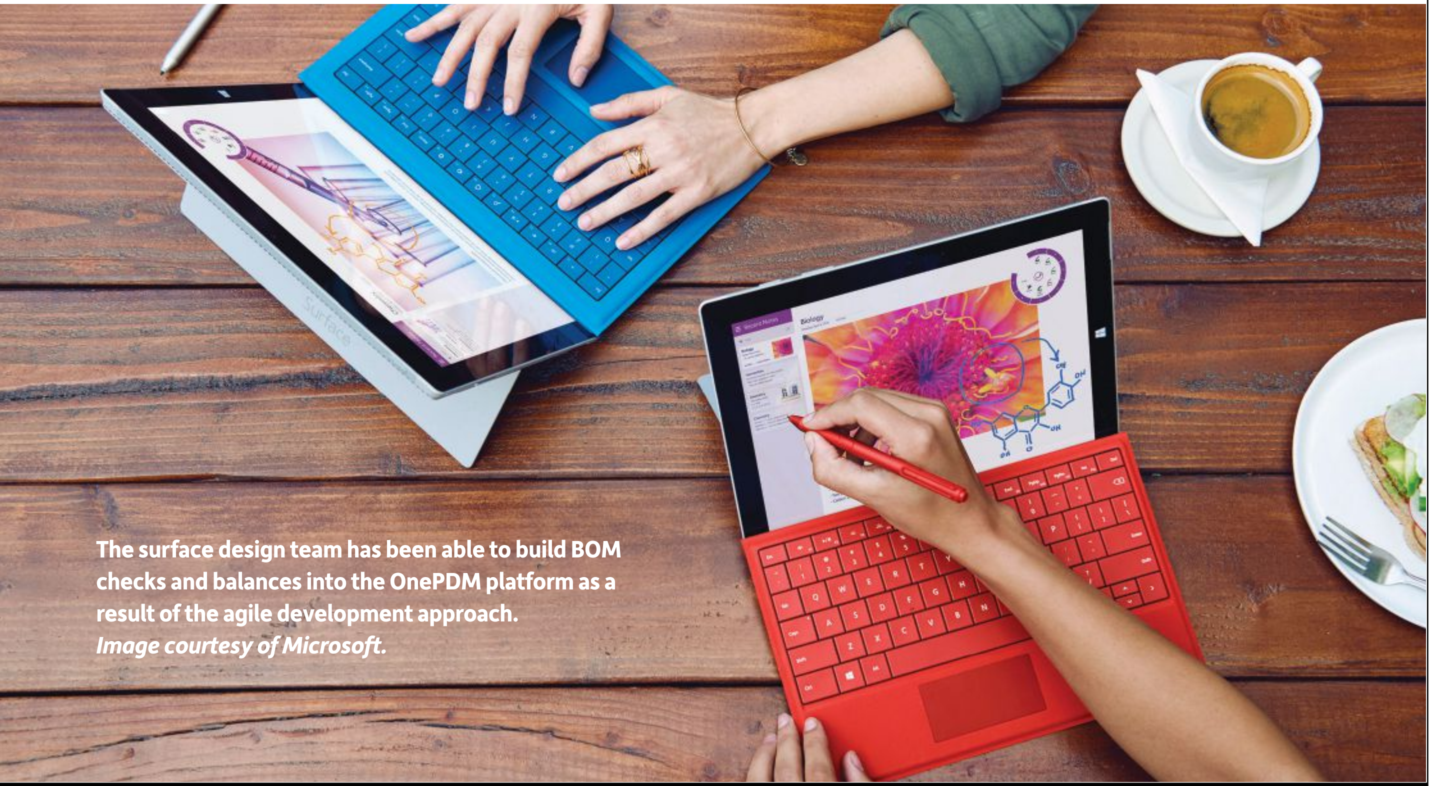
Robust, dynamic, easily configurable — hardly words most would use to describe traditional PDM (product data management) or PLM (product lifecycle management). But when Microsoft set out to consolidate and standardize its hardware groups on a core product development platform, its alternative approach — building on top of an open, cloud-based PLM platform and leveraging its expertise in agile methodologies — led to a global deployment completed in record time and packed with more functionality than its previous PLM systems.

While agile has gained prominence in software development circles, the discipline is typically not associated with PLM initiatives, which are infamous for lengthy deployment cycles and implementations that don't adequately reflect current user requirements or are too bloated and complex to be useful. The Microsoft group, having lived through similar experiences in the past, decided to take the chance on an agile approach to PDM/PLM to meet an aggressive timetable for empowering its engineering teams with critical product data.

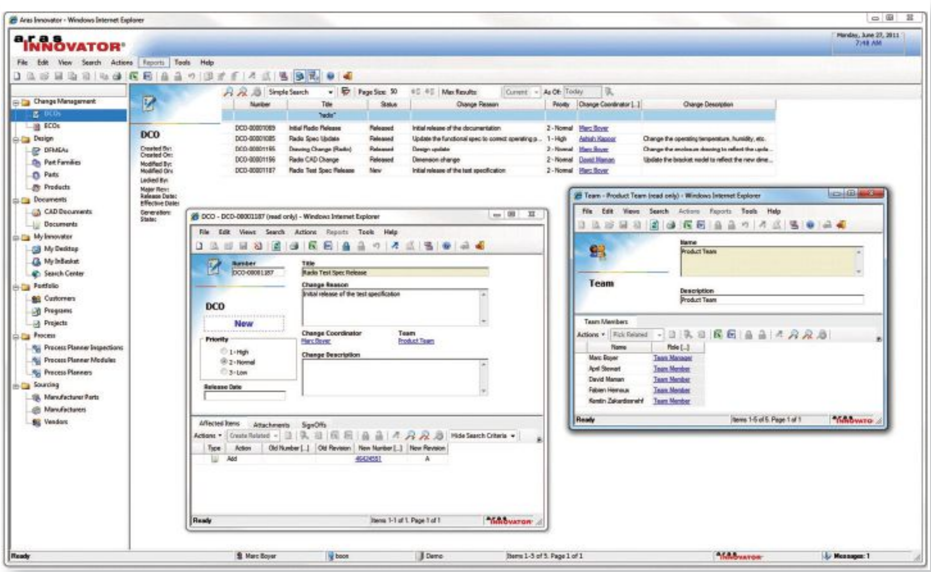
"We needed it yesterday and we couldn't afford to wait two years using a traditional [PLM development] model," explains Boris Cononetz, senior business operations and program management manager at Microsoft, who spearheaded the agile PDM initiative. "We had to figure out how we could do that when everything else — all the consultants, products and people in this space — run massive, monolithic programs that take way too long. We had to think differently."

Thinking differently was essential because of the task Cononetz and his team set out to accomplish. Fresh off its April 2014 acquisition of the Nokia cell phone business, Microsoft took a hard look at its hardware portfolio and found a variety of units operating as individual startups, using their own product development suites and data management tools and doing their own highly specific customizations. There was little to no collaboration across product development teams, the supply chain was replicated for every product, there was minimal reuse and far too much duplication of effort, he explains.

At the same time, the entire Microsoft company was moving rapidly to the cloud and there was a requirement for all the development platforms to stay in sync with the most current offerings in the Microsoft software stack, including Win-



The surface design team has been able to build BOM checks and balances into the OnePDM platform as a result of the agile development approach.
Image courtesy of Microsoft.



Aras Innovator serves as the open platform at the heart of Microsoft's OnePDM implementation. *Image courtesy of Aras.*

dows 10. Traditional PLM and PDM platforms, including the disparate smorgasbord already in use throughout all the various hardware divisions, did not support a cloud-based delivery model nor were they upgraded regularly enough to stay in sync with the latest Microsoft technology. "We were using third-party tools that were anywhere from three to 10 years lagging behind what we were rolling out internally at Microsoft," he explains. "Those kinds of [compatibility] problems were creating substantial issues."

Deciding to Go Agile

Against that backdrop, the Microsoft device teams saw an opportunity to migrate toward a centralized PDM/PLM solution, but more importantly, a single platform and PDM process that could be used consistently across all of the various hardware lines. Because historically the different Microsoft business groups funded their software initiatives and did not regularly share systems, the move to standardize around a central PDM/PLM platform was a big cultural shift, Cononetz says.

"We wanted to have product data be our strength so we could leverage that as a core foundation," he explains. "That way, when we were ready to launch another product, there was a strong foundation of data already there that would be easy to find, search and classify correctly."

The requirement to run in the cloud, coupled with the need for continuous updates and rapid deployment capabilities essentially ruled out traditional PDM/PLM products and processes. Also, all of the disparate PDM/PLM already in place used different data models and were highly customized, which meant things broke down quickly when something needed to be changed. Moreover, the existing PDM/PLM platforms already in house were better suited for heavy industrial equipment or automotive industry processes, Cononetz says, and not nearly as friendly for the fast-paced world of consumer electronics.

"A lot of capabilities we desperately needed weren't there," he says. "We also needed to make changes constantly, and with the older tools and methodologies, which are large and highly integrated, if you tweak something, everything else starts to break."

After months of evaluations and hands-on testing, the team was comfortable making its bold move: Using a third-party, Azure-certified platform (in this case, Aras Innovator) as the base foundation for OnePDM and pursuing an agile development route as opposed to traditional waterfall methods. With waterfall approaches, there are long cycles spent gathering in-depth requirements, developing a solution, testing and mov-

PTC Jumps on the Agile Bandwagon

When thousands of attendees descended on LiveWorx 2016 in June, there was a lot of talk about the transformative power of the Internet of Things (IoT) and some pretty mind-blowing demonstrations of IoT-enabled products and services. To help companies get products over the IoT goal line, PTC rolled out a concept that is much closer to its product development roots.

The company kept circling back to agile engineering, the concept of applying many of the same principles now so prevalent in software development to the design of physical products. The reason design engineers should acquaint themselves with proven agile concepts like sprints and scrums? According to PTC CEO Jim Heppelmann, agile methods are critical to helping companies respond rapidly to feedback from customers as they dive into the complexity of developing IoT products, as well as to accelerate how quickly these new innovations get to market and disrupt existing business models.

"The biggest problem with agile for [product development] is prototypes," Heppelmann says. "Prototypes are easy, free and fast with software. They're hard with product development. In order to do agile for cross-discipline digital products, you need some agile/scrum capabilities [as well as] PLM and ALM — to manage all the data that's there."

MORE ➜ deskeng.com/virtual_desktop/?p=/11876 ing into production only when the entire project is complete. With the agile approach, the Microsoft team worked in short, iterative three-week sprints on a very specific set of objectives, sometimes releasing functionality to the business owners in 24 hours for initial feedback.

Applying agile methodologies to PDM/PLM deployment is an unusual step, says Doug Macdonald, director of Product Marketing at Aras. Macdonald maintains that many companies are just not that comfortable with agile methodologies, and not every PLM platform lends itself to the approach. Innovator's model-based architecture, ease of customization, and support for the cloud made it a good fit for Microsoft's already robust and well-established agile processes, he says.

The upside of agile? "Reducing the risk that you spend a lot of time developing the wrong thing that wasn't quite what the users wanted," he says. "Agile takes that risk away almost entirely because the cycles are so short, you can't be too far away from [what] user want."

The Birth of OnePDM

The OnePDM team developed a roadmap that documented and prioritized the capabilities needed for a minimally viable product (MVP), along with the iterative path of additional features that would be added over time. Stakeholders, including software developers, product owners and engineers, and process specialists, met daily in scrum meetings to evaluate business processes and OnePDM capabilities to see if they could work across the various hardware business units.

The result was pretty groundbreaking for a PDM/PLM implementation, Cononetz says. Instead of the typical 18 to 24 month implementation cycle, the Microsoft crew was able to get its first OnePDM release out in six months, and within a year it was able to replace its old PDM systems and deliver new functionality. "We built the same capabilities or better in nine months than what it had taken us about seven or eight years to create with the previous systems," he says.

Phil Nixon, senior component engineering manager for the Xbox product group, has lived through two implementations of a PDM system, and says the OnePDM agile approach gave his team members far more input over functionality and business processes. "We had a lot of mistakes with the previous program and when we came down to the end of the timeline, it didn't work well and the interface was horrible," he says. "The ability to see how things are going to be in short cycles enables us to immediately say this process isn't going to work or we need this information. That way, we're able to correct changes before the end of the line when the system is dumped on us."

Mike Brittain, operations, PM manager for Microsoft's Surface group, is also bullish on the benefits. The agility of the sprint teams means the stakeholders could see things in two to three week cycles, enabling them to easily realign or add features instead of going down the wrong path, he says. Because of that, Brittain's group was able to build bill of materials (BOM) checks and balances into OnePDM that didn't exist in previous PDM/PLM systems, which has saved his group hours of manual labor. "In our old PDM, we might be able to add things on a quarterly basis and we were lucky if it got into that release," he says.

Microsoft has anywhere from 300 to 500 concurrent users working in OnePDM, and there have been 6,000 new users on boarded since February — about five or six times the number that ever used the older PDM platform. While PDM functionality was initial objective, the platform has been expanded to include portfolio management requirements and integration with SAP, and the long-term plan is to extend it into other PLM areas, including CAD integration.

The Microsoft team was able to migrate all of the existing hardware products onto the common OnePDM platform, plus they did the full data migration, consolidating two systems. Going forward, the plan is to consolidate a third and add additional PLM functionality. "OnePDM is now finally hitting OnePLM," says Cononetz. **DE**

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INFO → **Aras:** Aras.com

→ **Microsoft:** Microsoft.com

Stress in FEA Part 3

A look at von Mises and principal stresses.

BY TONY ABBEY

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In part two of this series (deskeng.com/de/?p=30077), we looked at directional stresses in the XY plane of the structure shown in Fig. 1. It is a cross brace, supported at the left-hand edge by two lugs and loaded at the right-hand edge through two additional lugs. The structure is sitting in the global XY plane.

In this article we are going to look at two further types of stress: principal stress and Von Mises stress.

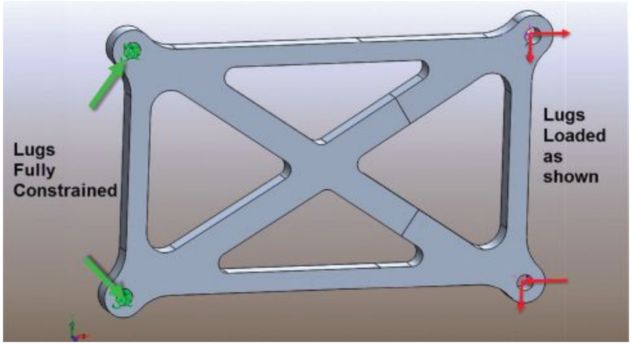

FIG. 1: Cross brace structure showing constraint and loading set up.

Principal Stresses

In the previous article we focused on the Cartesian stresses SX, SY and SXY. We saw that for a particular coordinate system these were the stresses in the local X, Y direction and XY plane, respectively. We rotated the stress system from the basic XY coordinate system to two other coordinate systems to look at local 'cut' directions. In fact, we can rotate the stress state to any coordinate system we want. It is important to realize that we are always describing the same stress state, but just viewing it from a different angle.

Fig. 2 shows the equations that can be used to calculate the stress in a local coordinate system, by using a rotation through an angle. These are exactly the same equations that will be used by your post processor to flip from one coordinate system to another. You may remember having to plot these transformations by hand using the Mohr's circle construction. It was very convenient to do it this way before electronic calculators came along. (I will take a look at Mohr's circle in more detail in a later article.)

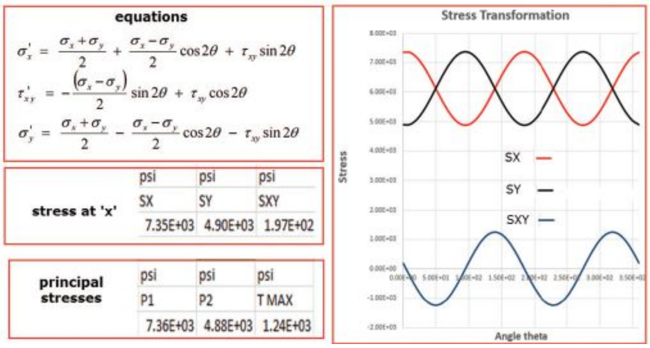

FIG. 2: 2D stress transformations.

We're going to pick a datum point on the structure, adjacent to the top right hand corner lug. This is shown in Fig. 3, where we also see the stress contours for Cartesian SX, SY and SXY stresses. The stress values at the datum point are shown in the Fig. 2, labeled "stresses at x." If we substitute these values into the equation in Fig. 2 then we can plot the variation stress at the datum point as we rotate around all the possible local coordinate systems. The resulting plot is shown in Fig. 2.

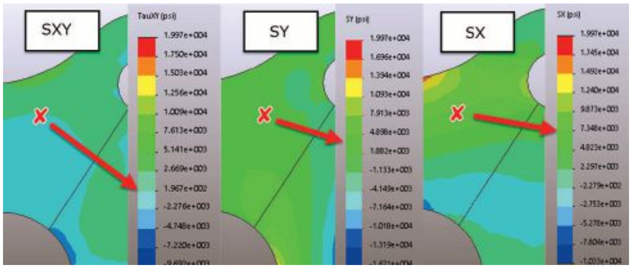

FIG. 3: Stresses at the datum point x.

Looking at Fig. 2 we can see that the stress varies in a cyclic manner as we rotate around the full 360°. There are some other interesting rotation angles we can see in this plot. The direct stresses SX and SY peak together at the same rotation angle. At this rotation angle the shear stress SXY drops to zero. The biggest and smallest direct stresses we find at this particular angle are called the principal stresses. The values are shown in Fig. 2.

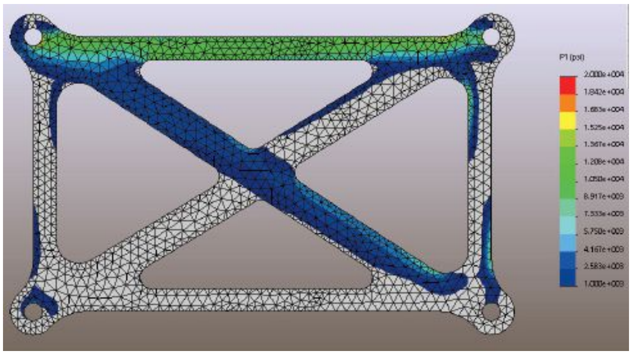

FIG. 4: P1 stress distribution for the overall structure.

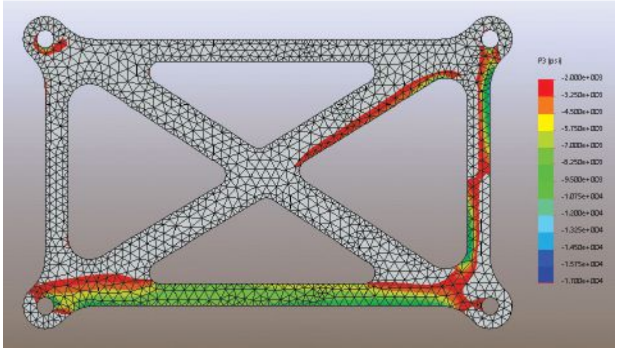

FIG. 5: P3 stress distribution for the overall structure.

In a 2D stress state these are labeled as P1 and P2. There is a further angle where the shear stress SXY is a maximum. This value is called maximum shear stress. We actually have a 3D stress state in this structure, although the dominant responses are in the XY plane. For a 3D stress state the principal stresses become P1, P2 and P3. Usually, P2 is a very small stress and we are only concerned with the values of P1 and P3. The menu selection for 3D contour stress plotting usually contains P1 and P3 principal stress components.

Fig. 4 shows stress contour plot of the maximum principal stress P1. This is a useful way of seeing the biggest tensile stress flow direction. I have clipped the contour at around the zero stress line so tensile stresses dominate. The gray zone contains either very small tensile stresses, or compressive stresses. If the P1 stress level is compressive then it means that the stress state is always compressive, no matter what angle we choose for a local coordinate system. So, a quick eyeball of this structure shows that the top member is totally in tension throughout its depth. The transverse member (top left to bottom right) has a small tensile stress flow. The right hand vertical member has localized tensile regions, which are clearly the positive side of the bending distribution. We plotted this bending distribution in the last article.

The contour plot in Fig. 5 shows the P3 distribution through the structure. Again, I have clipped this plot so only compressive stresses are shown. By definition, any region that has a minimum (most negative) P3 stress that is positive, must be a tension dominated region. These regions are now in the grayed out zone. The two plots in Figs. 4 and 5 are complementary: They show, respectively, the zones of tensile and compressive dominated structure.

Figs. 6 and 7 show, respectively, contours of maximum and minimum principal stresses P1 and P3 for the local lug region. The insert XY graphs show tensile principal stress running along the top lug fillet radius and compressive principal stresses running around the side fillet radius. These two figures illustrate how useful the principal stresses are. By definition, along a free surface, the stresses must be tangential and will naturally form principal stress directions. Running a line plot along the surface will show the distribution of peak stress. This really is the only way that this can be visualized and it is a powerful investigation tool.

I find that contour plotting of principal stresses segregated into tensile and compressive dominant regions is a useful approach. However, the more normal way of presenting principle stresses is via a vector plot. Figure 8 shows a vector plot of the P1 principal stresses running around the lug region. The tensile dominated regions are shown clearly, however the compressive dominated regions "fizzle out," with very small values of P1. Fig. 9 shows the complementary plot of P3 principal stresses and the compressive zone around the fillets can be seen very clearly. Again, the small smaller values of P3 associated with the tensile

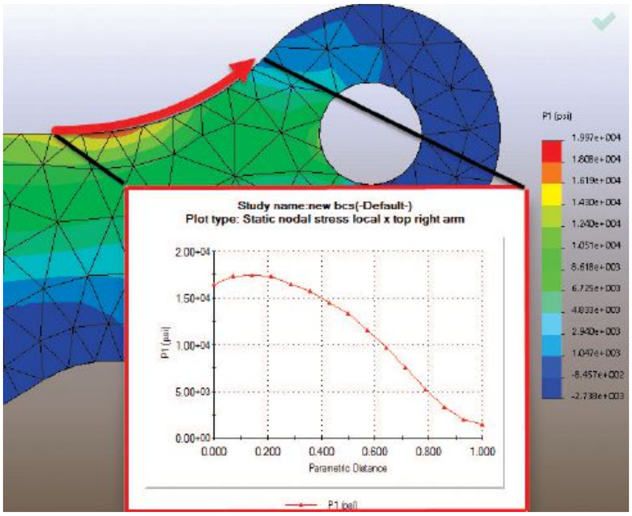

FIG. 6: **Tensile principal stress running around the top lug fillet radius.**

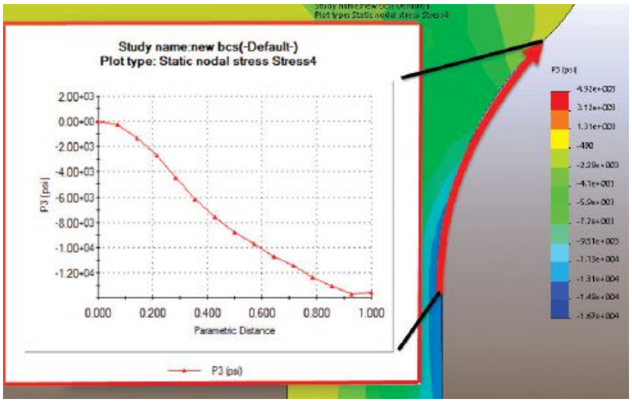

FIG. 7: **Compressive principal stress running around the side lug fillet radius.**

regions are "fizzling out."

In this particular post-processor, we plot P1 and P3 vectors separately as shown. Other post-processors will allow an overlay of P1 and P3 vectors perpendicular to each other. Both are equally valid representations; some analysts prefer two plots that distinguish P1 and P3 more clearly, some prefer to have a combined plot. Whichever we use, there is no doubt that the vector plots give a good representation of the flow of the stress. This is one of the most useful aspects of principal stress plotting. The main difficulty is that the small P1 stresses in a compressive zone and the corresponding larger P3 values in the compressive zone can also spoil the visualization (what I have described as "fizzling out"). I prefer to segregate the two plots and control the clipping of the vector values carefully to aid visualization.

P1 principal stresses are useful when considering fatigue and fracture. We may not be completely sure of the relative orientation of a stress flow and a crack. The most damaging orientation will be at 90°. We can use the P1 principal stress as an upper bound estimate for the biggest tensile stress we can ever see across the crack in this region. In a similar way, a critical compressive stress can be found by using the P3 principal stress. In the region prone to buckling it can be difficult to assess the relative orientation between the slenderest direction (which is most prone to buckling) and the dominating compressive stress. By assuming a value P3 for stress, then we have defined the worst case.

Von Mises Stress

Finally, we come to the most common stress plot in normal use and you may wonder why I have left it for last. The reason: It is difficult to explain what von Mises stress means unless we have a good understanding of the contributing component stresses. The Von Mises stress equation for 2D is:

$$S_{VM} = \sqrt{Sx^2 + Sy^2 - SxSy + 3\,Sxy^2}$$

We do actually have a 3D state, but this component's response is predominately in-plane. I have ignored the SZ, SXZ

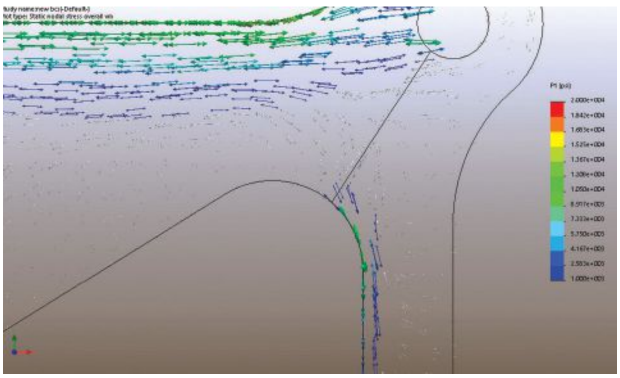

FIG. 8: **P1 principal tensile stresses running around the fillet radii of the lug region.**

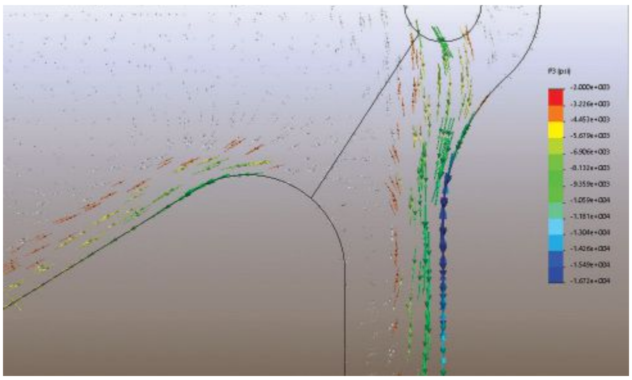

FIG. 9: **P3 principal compressive stresses flowing around the fillet radii of the lug region.**

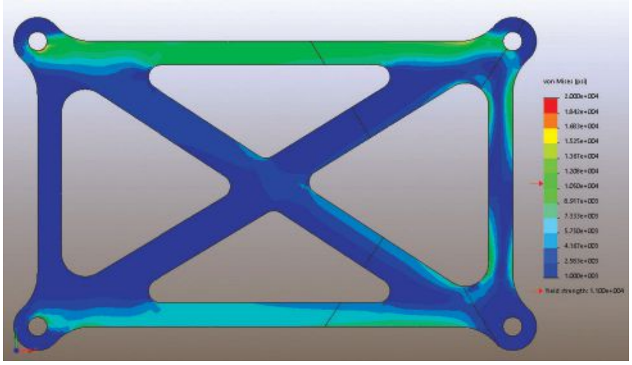

FIG. 10: Von Mises stress for the overall structure.

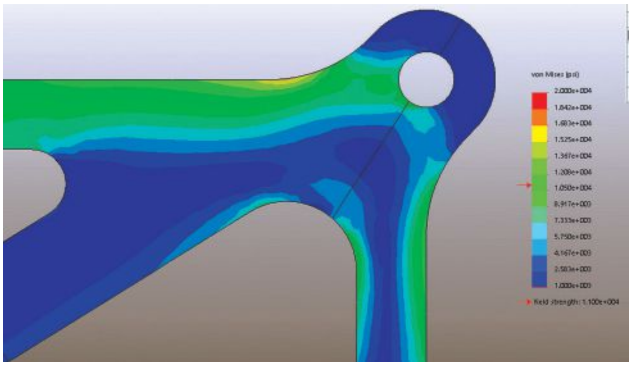

FIG. 11: Von Mises stress for top right corner

and SYZ through thickness stresses for this article. Looking at the equation in Fig.10 we can see that each stress component is squared and there is an interaction term between SX and SY. The shear stress SXY is factored by three. Imagine a stress state with SY and SXY at zero; the von Mises stress then equals SX. The same argument applies to pure SY stress. However, if we have a pure shear stress, then the von Mises stress is factored by square root of 3. This last observation agrees with the general case where the shear yield stress is lower than tensile yield stress. I will go into more detail about yield criteria, such as Von Mises yield, in a later article.

Fig. 10 shows the von Mises stress distribution for the overall component. We see that there are three or four regions of high stress. This is the big advantage of the von Mises stress plot; it allows us to identify problem areas. The von Mises stress level can be compared directly to tensile yield stress and gives a good indication of margins over potential plastic response.

On the other hand, the main disadvantage of the von Mises stress plot is that we are encapsulating all the stress components into one scalar value. If we only plot von Mises stress, then we miss two important factors and cannot tell whether the stress state is tensile or compressive. We do not know whether the stress state is direct stress dominated or shear stress dominated.

Fig.11 shows the lug region with von Mises stress contours. The stress concentrations can be seen, but clearly we need to differentiate between tension and compression. The differential between tension and compression is important in fatigue analysis — we need to know whether we are in a beneficial compressive stress state or an aggressive tensile stress state. For relatively thin or slender structures we are also concerned that the compressive stress state may induce local buckling. By default, a linear static analysis is not going to pick this up, so we need to inspect carefully for any suspect regions. Finally, in many ways, shear is a more damaging stress state than direct stresses, so it is as well to be aware of its presence.

A Recipe for Stress Investigation

In summary, we have three main types of stress that we can use for investigation: Cartesian stresses, principal stresses and von Mises stress. I normally run through them in the following order when post-processing a finite element analysis model.

1. **Von Mises stress.** This is checked as an overall indicator of stress distribution and stress concentration location. The margins over yield are identified.

2. **Cartesian stresses.** Regions flagged up by the von Mises stress plot are broken out into separate Cartesian stress plots SX, SY and SXY. This is fairly straightforward for 2D dominated responses as shown in this article. However, a 3D responsemay require an approximation to in-plane and through thickness directions to aid visualization. Transformation into convenient local coordinate systems, to align with the structural with the local structural configuration, will help visualization. The objective of the Cartesian stress plots is to show which stress types dominate.

3. **Principal stresses.** Contour and vector plots of maximum and minimum principal stress are very useful to give a sense of the stress flow. The stress values can also be used where worst-case compressive or tensile stresses, or maximum shear stresses are needed.

It is quite a learning curve to go on from the usual von Mises contour plot to more in-depth usage of Cartesian and principal stresses and local coordinate systems also add a level of complexity. However, if you are serious about understanding the nature the stress inherent in components, then it is worthwhile to investigate these techniques. Typically, this will be an exercise on two fronts; becoming comfortable with the physics of stress states and also with the advanced tools found in the post-processor interface. DE

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Lenovo ThinkPad P70: The Price/Performance Leader

Lenovo's first new 17-in. mobile workstation in years is a winner.

DAVID COHN

We have reviewed many Lenovo workstations over the years, most recently the flagship ThinkStation P900 (deskeng.com/de/?p=25553). But, we cannot remember the last time we looked at one of the company's mobile workstations. With the arrival of the Lenovo ThinkPad P70, however, we rectify that situation.

According to Lenovo, the ThinkPad P series is a new line of notebooks created for professionals who need the highest performance from a mobile workstation. The P70 marks the top of the line, addressing the needs of designers and engineers who run the most demanding applications and want a large screen and lots of storage. It is also the first new 17-in. mobile workstation Lenovo has released since 2009.

The Lenovo ThinkPad P70 comes housed in a charcoal gray case. The base is sculpted from magnesium and aluminum and the top is molded in glass fiber and polyphenylene sulfide. The system measures 16.38 x 10.85 x 1.35 in. and weighs 7.9 lbs. The rather large, flat, 230-watt external power supply (7.81 x 3.87 x 1 in.) adds another 2.1 lbs., including its cables.

Raising the lid reveals a 17.3-in. display and a 105-key backlit keyboard with separate numeric keypad that ranks as one of the best laptop keyboards we've encountered in quite a while. Lenovo offers a choice of three different IPS (in-plane switching) matte surface displays, including FHD (1920x1080) with or without touch. Our evaluation unit came with a 4K UHD (3840x2160) panel rated at 92% of the NTSC color gamut, adding $260 to the price. A 720p webcam flanked by a pair of microphones is centered above the display.

A round power button is located adjacent to the upper-right corner of the numeric keypad while a fingerprint reader is positioned to its lower-right corner. A newly designed touchpad with three dedicated buttons is centered below the spacebar. The touchpad is coated with a premium material called "crystal silk," which Lenovo claims helps resist wear and provides a smoother feel. There is also a red pointing stick nestled between the G, H and B keys with its own three buttons directly below the spacebar. A pair of stereo speakers are concealed below a perforated screen just above the keyboard. The caps lock and number lock keys each have their own LED as do separate keys dedicated to the speakers and microphone. There

The Lenovo ThinkPad P70 comes in a dark gray sculpted case and delivers excellent performance. *Image courtesy of Lenovo.*

INFO ➔ Lenovo: Lenovo.com/ThinkStation

Lenovo ThinkPad P70

- **Price:** $3,623 as tested ($1,862 base price after online savings)
- **Size:** 16.38x10.85x1.35 (WxHxD) notebook
- **Weight:** 7.9 lbs., 2.1 lb. power supply
- **CPU:** 2.8GHz Intel Xeon E3-1505M v5 w/8MB Smart Cache
- **Memory:** 16GB DDR4 ECC at 2133MHz (64GB max)
- **Graphics:** NVIDIA Quadro M5000M w/4GB GDDR5 memory
- **LCD:** 17.3 in. UHD 3840x2160 IPS with color calibration sensor
- **Hard Disk:** 500GB SSD PCIe-MVMe
- **Floppy:** None
- **Optical:** None
- **Audio:** Built-in speakers, headphone jack, built-in microphone array
- **Network:** Intel Dual-Band Wireless-AC (2x2) 8260, Bluetooth 4.1, one RJ45 jack
- **Modem:** None
- **Other:** Four USB 3.0 (one always on), mini DisplayPort, HDMI, SmartCard reader, media card slot, express card slot, 720p webcam, two Thunderbolt 3/USB Type C connectors
- **Keyboard:** Integrated 105-key full-size backlit keyboard with numeric keypad
- **Pointing device:** Integrated touchpad with 3 buttons, pointing stick with three buttons, fingerprint reader

is also a hard drive activity light located below the display.

Recognizing that color temperatures and screen brightness can drift over time, Lenovo also includes a color sensor (a $70 option on the base model), located to the left of the touchpad. A color calibration tool appears in the Windows taskbar and turns red if you haven't calibrated the display in more than 30 days. A single click starts the X-Rite Pantone calibration software that uses the sensor to ensure that the display quality remains consistent and accurate over the life of the computer. After choosing the desired settings, you simply follow the instructions to close

Mobile Workstations Compared

	Lenovo ThinkPad P70 17.3-inch 2.8GHz Intel Xeon E3-1505M v5 quad-core CPU, NVIDIA Quadro M4000M, 16GB RAM	Lenovo ThinkPad P50 15.6-inch 2.8GHz Intel Xeon E3-1505M v5 quad-core CPU, NVIDIA Quadro M2000M, 16GB RAM	Dell Precision 7710 17.3-inch 2.9GHz Intel Xeon E3-1535M quad-core CPU, NVIDIA Quadro M5000M, 32GB RAM	Eurocom Sky X9 17.3-inch 4.3GHz Intel Core i7-6700K quad-core CPU, NVIDIA Quadro M5000M, 64GB RAM	Dell Precision M3800 G2 15.6-inch 2.3GHz Intel Core i7-4712HQ quad-core CPU, NVIDIA Quadro K1100M, 16GB RAM	HP ZBook 14 G2 14-inch 2.6GHz Intel Core i7-5600U dual-core CPU, AMD FirePro M4150 and Intel HD Graphics 5500, 16GB RAM
Price as tested	$3,623	$2,353	$3,890	$6,781	$2,109	$2,115
Date tested	2/12/16	3/21/16	1/23/16	1/23/16	5/25/16	2/20/16
Operating System	Windows 7	Windows 10	Windows 10	Windows 10	Windows 8.1	Windows 8.1
SPECviewperf 12 (higher is better)						
catia-04	80.54	42.44	75.57	102.23	15.16	15.09
creo-01	66.69	43.01	55.78	84.55	15.36	16.57
energy-01	6.39	4.12	9.00	10.52	0.34	0.06
maya-04	54.93	33.08	43.43	75.56	13.85	9.09
medical-01	27.23	18.53	31.21	40.75	4.30	2.70
showcase-01	46.70	22.02	48.07	45.87	8.55	7.58
snx-02	112.86	60.01	63.33	87.30	15.30	20.06
sw-03	88.04	64.70	82.02	121.63	25.41	29.21
SPECapc SOLIDWORKS 2015 (higher is better)						
Graphics Composite	4.62	3.56	3.88	6.07	1.85	1.75
Shaded Graphics Sub-Composite	2.41	2.89	2.40	4.36	1.70	1.30
Shaded w/Edges Graphics Sub-Composite	3.42	3.63	3.21	5.58	2.27	1.32
Shaded using RealView Sub-Composite	3.41	2.95	2.85	5.07	1.57	1.16
Shaded w/Edges using RealView Sub-Composite	5.89	4.92	4.93	8.36	2.76	1.88
Shaded using RealView and Shadows Sub-Composite	3.87	2.68	2.94	5.17	1.38	1.39
Shaded with Edges using RealView and Shadows Graphics Sub-Composite	6.19	4.30	4.85	8.11	2.29	1.61
Shaded using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	7.97	3.30	5.70	6.81	1.12	2.90
Shaded with Edges using RealView and Shadows and Ambient Occlusion Graphics Sub-Composite	12.01	5.01	8.74	10.28	1.74	3.40
Wireframe Graphics Sub-Composite	3.02	3.26	2.99	3.76	2.36	2.27
CPU Composite	3.47	2.51	2.56	3.03	2.41	3.14
SPECwpc v2.0 (higher is better)						
Media and Entertainment	2.60	2.43	2.57	3.38	1.22	0.87
Product Development	2.32	2.05	2.73	3.16	1.08	1.05
Life Sciences	2.56	2.49	3.18	3.91	1.12	0.90
Financial Services	1.14	1.15	1.19	1.40	0.96	0.53
Energy	2.27	1.86	2.66	3.13	1.09	0.66
General Operations	1.41	1.25	1.48	1.70	0.82	0.76
Time in Seconds						
Autodesk Render Test (lower is better)	50.00	82.80	85.60	64.90	79.83	124.28
Battery Test (higher is better)	5:15	4:37	5:30	2:17	5:34	7:28

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

the lid and allow the tool to calibrate the display, which takes just over a minute.

Lots of Choices

The Lenovo ThinkPad P70 is built around one of the latest Intel quad-core Skylake processors. The base configuration, with a starting price of $2,069, comes with a 2.6GHz Intel Core i7-6700HQ CPU. Other choices include the 2.7GHz Core i7-6820HQ and the 2.8GHz Intel Xeon E3-1505M v5 processor that came in our evaluation unit, adding $315 to the price. That CPU has an 8MB Smart Cache, a 45-watt thermal design power (TDP) rating, and a maximum turbo frequency of 3.7GHz. As we have witnessed in other reviews, systems equipped with these new 14nm processors benefit from significant performance improvement and much greater battery life. While not the fastest CPU in the new Xeon E5-1500 family (the Dell Precision 7710 came with the 2.9GHz E3-1535M and Intel just released several other processors with base frequencies between 2.8 and 3.0GHz), the E3-1505M delivered an excellent balance of speed and longevity.

Although the CPU includes integrated Intel HD Graphics P530, like other mobile workstations the ThinkPad P70 includes discrete graphics in the form of an NVIDIA Quadro GPU (graphics processing unit). The base P70 configuration uses a Quadro M500M with 2GB of memory. Other choices include the Quadro M3000M and M5000M. Our system came with an NVIDIA Quadro M4000M (adding $650), with 4GB of GDDR5 memory. This 100-watt GPU provides 1,280 CUDA (compute unified device architecture) cores, a 256-bit interface and a bandwidth of 160GB per second.

Lenovo offers lots of memory options. The base P70 configuration comes with 8GB of non-ECC DDR4 memory. Other choices include up to 64GB and ECC memory is an option. Our system came with 16GB of ECC RAM (adding $150 to the cost), installed as a single 16GB DDR4-2133MHz SODIMM (small outline dual in-line memory module) in one of the two memory sockets concealed beneath the keyboard. While these are a bit difficult to access, users can add more memory using the two additional sockets accessed by removing the bottom cover.

Although the entry-level system comes with a 256GB SSD SATA3 OPAL2.0 drive, our evaluation unit came with a 512GB SSD PCIe-NVMe drive, installed in one of the two PCIe slots and adding another $350. This is a very worthwhile choice, because PCIe-NVMe M.2 drives can achieve peak data transfer rates more than three times that of SATA drives. The P70 can accommodate a second identical drive ($950) as well as hard drives of 500GB and 1TB capacities, and the system supports RAID 0 and 1 configurations.

Connectivity options also abound. The right side provides a combo microphone/headphone jack, three USB 3.0 ports, a media-card slot, an ExpressCard slot, a mini DisplayPort connector, and a security lock slot. The left side houses an always-on USB 3.0 port that can charge USB devices whenever the computer is connected to AC power, even if the system is off. There is also a smart card slot and a serial ultrabay that can accommodate an optical drive or secondary hard drive on some models. The rear panel provides two Thunderbolt 3/USB Type C connectors that can be used with external displays or storage devices. There is also an HDMI port, RJ45 Ethernet jack and the connector for the external power supply. The bottom of the case features a docking connector and an easily removable battery. Inside the battery compartment you will also find a micro-SIM card slot. There is also a pair holes designed to drain liquids in the event you accidently spill on the keyboard.

Dual-band Wi-Fi and Bluetooth come standard. Although an 8-cell 96Whr Li-Ion battery is the only choice, it kept our ThinkPad P70 running for a respectable 5.25 hours, just 15 minutes less than the Dell Precision 7710. The Lenovo mobile workstation remained cool and nearly silent throughout our tests, exactly what one expects from a high-quality workstation.

Lots of Power

The Lenovo ThinkPad P70 also lived up to all expectations in terms of performance. On the SPECviewperf benchmark, which focuses on graphics, the P70 scored near the top, even outperforming the Dell Precision 7710 on most datasets.

On the new SPEC SOLIDWORKS 2015 benchmark, the ThinkPad P70 also outperformed every other mobile workstation we have tested to date, with the exception of the Eurocom Sky X9, which was equipped with a CPU normally found in desktop systems and a more powerful GPU.

The Lenovo ThinkPad P70 also turned in excellent results on the very demanding SPECwpc benchmark, although its high marks were slightly below those of several other systems we recently reviewed.

And on the AutoCAD rendering test, the Lenovo ThinkPad P70 turned in the best results we have ever recorded for a mobile workstation, completing our test rendering in an average of 50 seconds despite being equipped with a slightly slower CPU than many of its modern competitors. These results continue to prove Lenovo's ability to combine and configure quality components to achieve optimum performance.

Although the base configuration comes with Windows 10 Home (Windows 10 Professional is a $30 option), Lenovo pre-loaded Windows 7 professional 64-bit, likely due to the fact that some engineering applications are optimized for this older operating system. But Windows 7 is not optimized for 4K displays. As a result, even with display scaling set to 200% (the default is 150%), many dialog boxes were difficult to read. Those purchasing a system with a 3840x2160 display should consider switching to Windows 10, which is optimized for such high resolutions.

While the standard warranty covers the system for just one year with depot or carry-in service included, additional coverage is available at the time of purchase that can extend the warranty for up to five years, including accidental damage protection. We counted 18 different warranty options — our system came with a three-year warranty. Lenovo also offers a ThinkPad workstation dock ($299) that works with P50 and P70 workstations and provides lots of additional ports — a great option for anyone who travels often but works at a desk when in their office.

The ThinkPad P70 is certified on more than 100 different applications from ISVs (independent software vendors) including Autodesk, Dassault Systèmes, PTC and Siemens PLM Software. You can build a custom configuration via the Lenovo website (where our P70 priced out at $3,623 after an automatic 10% online discount) or purchase a fixed configuration through Lenovo's Business Partner Channel (where our P70 was listed for $3,745). Either way, the Lenovo ThinkPad P70 is priced lower than its competition, making it the new price/performance leader. **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.*

Sibling Rivalry

Lenovo ThinkPad P50

The Lenovo ThinkPad P50 is nearly identical to the P70, except smaller and lighter. ***Image courtesy of Lenovo.***

Just as we were finishing our review of the P70, Lenovo sent us its ThinkPad P50, the new 15.6-in. addition to the P series line of mobile workstations. Other than its smaller size (14.86x 9.93 x1.02 in.) and weight (5.72 lbs.), it is nearly identical to its larger sibling. Thanks to its smaller 170-watt power supply, total weight is just a fraction over 7 lbs.

Although base P50 configurations start at $1,322 for a system with a 2.6GHz Core i7 quad-core CPU, a 1920x1080 display, an NVIDIA Quadro M1000M GPU, 8GB of RAM and a 500GB 7200rpm drive, we received a fully-loaded version equipped with the same 2.8GHz Intel Xeon E3-1505M v5 Skylake processor, a 15.6-in. version of the gorgeous 4K UHD (3840x2160) IPS (in-plane switching) display panel, 16GB of 2133MHz ECC memory and a 512GB SSD (solid-state drive) PCIe-MVMe. Our ThinkPad P50 even included the color sensor and X-Rite Pantone calibration software like the P70.

In fact, the only significant difference between the P50 and P70 systems we received were the graphics. Our P50 came with an NVIDIA Quadro M2000M equipped with 4GB of GDDR5 memory and 512 CUDA cores. The ThinkPad P50 can accommodate up to 64GB of memory and two SSDs.

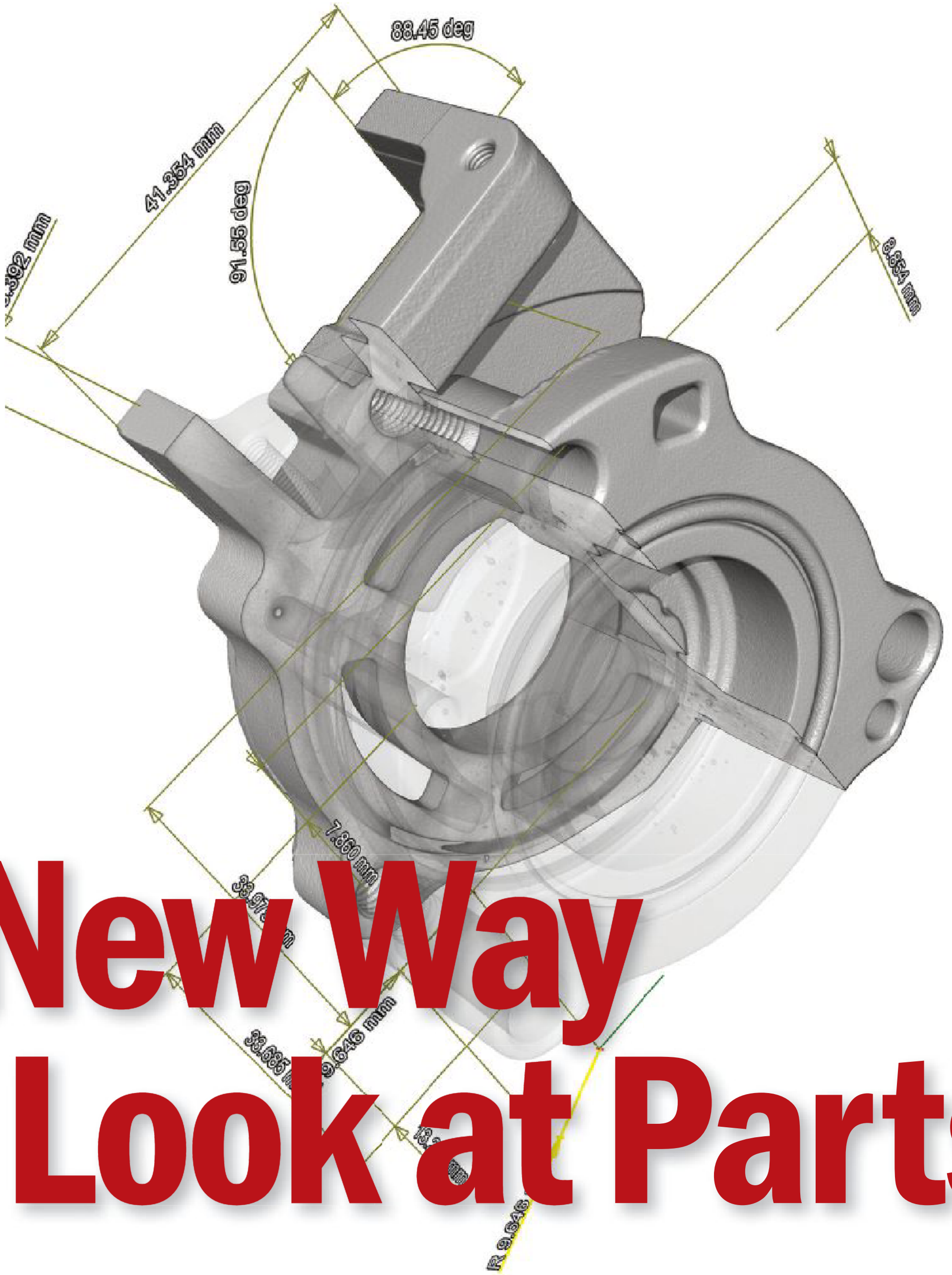
The right side of the P50 provides a single audio jack, two USB 3.0 ports, a mini DisplayPort connector, and a security lock slot, while the left side houses only an ExpressCard slot, SDXC slot and an optional Smart Card reader. The rear panel provides a single Thunderbolt 3/USB Type C connector, HDMI port, RJ45 Ethernet jack, two USB 3.0 ports including one that can charge devices, and the power connector. The bottom of the case features a docking port and a removable 6-cell battery that kept our system running for 4.6 hours.

Although equipped with the same CPU, memory and hard drive as the P70, the less-powerful GPU caused the ThinkPad P50 to lag behind its big brother in our benchmarks. That said, the P50 still outperformed most systems we tested last year. With a price as tested of just $2,353 the P50 is a great mobile system with ample power that is easier to carry and more affordable than its larger sibling.

INFO ➔ Lenovo: Lenovo.com/ThinkStation

Lenovo ThinkPad P50

- **Price:** $2,353 as tested ($1,322 base price)
- **Size:** 14.86x9.93x1.02 in. (WxHxD) notebook
- **Weight:** 5.72 pounds plus 1.35 pound power supply
- **CPU:** 2.8GHz Intel Xeon E3-1505M v5 w/8MB Smart Cache
- **Memory:** 16GB DDR4 ECC at 2133MHz (64GB max)
- **Graphics:** NVIDIA Quadro M2000M w/4GB GDDR5 memory
- **LCD:** 15.6 in. UHD 3840x2160 IPS with color calibration sensor
- **Hard Disk:** 512GB SSD PCIe-MVMe
- **Floppy:** None
- **Optical:** None
- **Audio:** Built-in speakers, headphone jack, built-in microphone array
- **Network:** Intel Dual-Band Wireless-AC (2x2) 8260, Bluetooth 4.1, one RJ45 jack
- **Modem:** None
- **Other:** Three USB 3.0 (one always on), mini DisplayPort, HDMI, SmartCard reader, media card slot, express card slot, 720p webcam, one Thunderbolt 3/USB Type C connector
- **Keyboard:** integrated 105-key full-size keyboard with numeric keypad
- **Pointing device:** Integrated touchpad with 3 buttons, pointing stick with 3 buttons, fingerprint reader



A New Way to Look at Parts

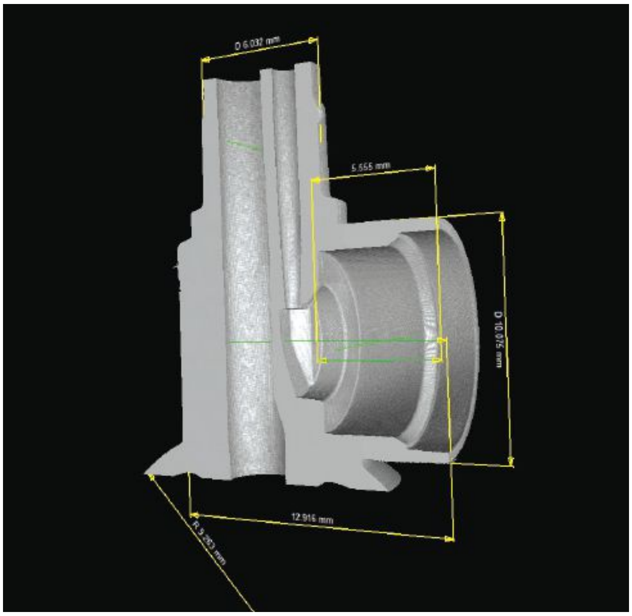
CT scanning is gaining popularity in product design and verification.

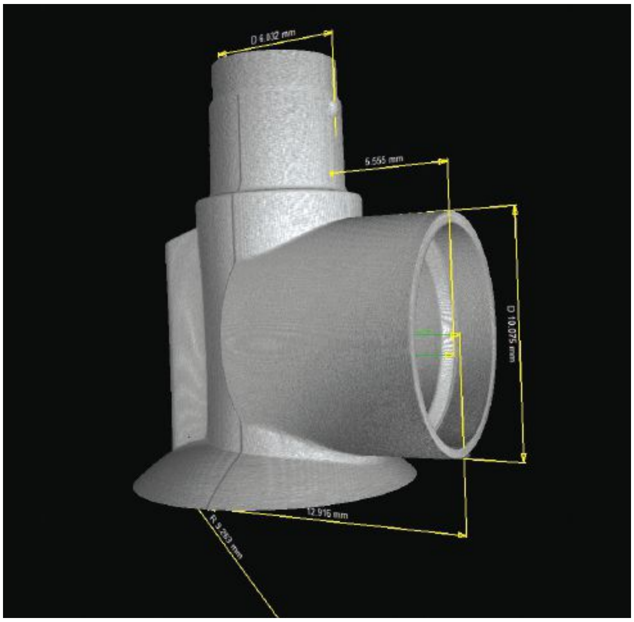
BY BRIAN ALBRIGHT

Computed tomography (CT) scanning has traditionally been associated with medical applications. However, the technology has increasingly been adopted by industry as a non-destructive testing alternative, and for precise measurement/metrology applications. CT scanners are used for reverse engineering, quality control, ensuring internal contact points are made after assembly, to determine material porosity and to make CAD file comparisons.

CT scanning is part of the rapidly growing market for 3D scanning, which Allied Market Research estimates will generate revenues of $5.7 billion by 2021 and experience a CAGR of 13.6% over the next five years.

CT scanning allows companies to capture precise dimensions of both internal and external structures in a completely non-destructive manner. Using multiple X-ray images, CT scanning solutions create voxel (volumetric pixel) data sets to create images. Parts are rotated in the scanner and imaged hundreds of times. The 2D images are combined into a 3D point cloud.





CT scanning lets engineers obtain measurements of internal and external structures without having to disassemble a part. *Images above courtesy of Exact Metrology. Image on opposite page courtesy of Jesse Garant & Associates.*

In emerging additive manufacturing markets, CT scanning is the only way to confirm the quality of internal structures without breaking a completed part.

"With highly complex plastic parts you can do analysis and inspection of a higher quality than you could ever dream of using conventional methods," says Giles Gaskell, applications manager at Wenzel America. "There's no limit to what you can see and how small a feature you can measure. Conventional measurement isn't cutting it on complex parts. For injection molded or additively manufactured parts, CT is the answer."

Wenzel (which is headquartered in Germany) added CT scanning to its metrology offerings via its acquisition of Volumetrik in 2008.

"CT scanning is really growing and growing for these applications," says Steve Young, owner of Exact Metrology in Cincinnati, whose company previously offered a wide variety of external scanning and metrology solutions. "We really look at this as the next logical step."

Exact Metrology now has two CT scanners operational (in two different facilities), and plans to add a second machine to its Cincinnati location. According to Young, they will likely invest in equipment that will allow them to scan larger or denser parts. "Each of the different scanner is trying to do something unique, so I could ultimately see us having several scanners for different applications," he says.

Unprecedented Visibility

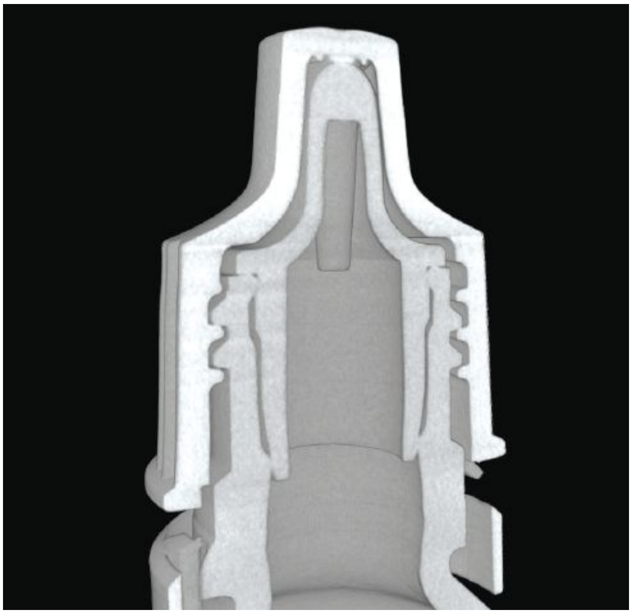
CT scanning can provide incredible internal details for a variety of parts and materials. "We've scanned small plastic pieces that couldn't be examined if they were broken apart, aerospace parts, and other critical parts," Young says. "We scanned a part that was made of glass-reinforced plastic, and the customer needed to understand how the glass fibers were aligning once the part was molded. We were able to show them that so they could fix a flaw in their process."

For measurement and quality control, CT can provide highly accurate data on a variety of parameters, and for a wide array of materials. "I can scan a whole, unopened box of liquid gel caps, for instance," Young says. "I can tell you the volume of the liquid in each pill, the wall thickness of the gel pill without opening the box."

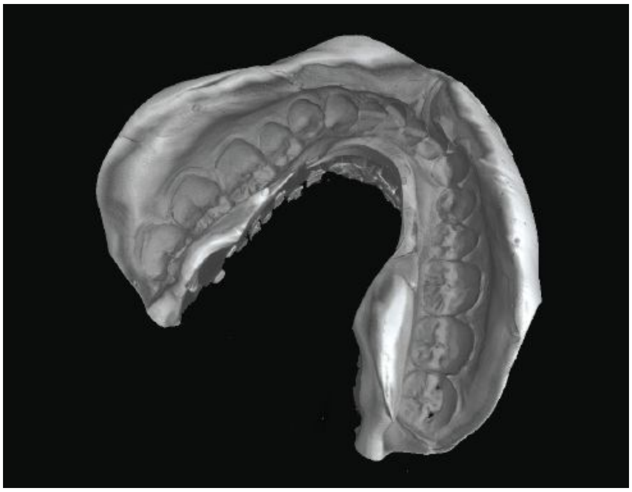
That's particularly important in industries like medical device manufacturing, aerospace and automotive where regulatory requirements call for very high standards of quality. "There's a lot of pressure to be able to prove out the quality of designs," Gaskell says. "This is also increasingly an issue because people are turning to advanced methods of manufacturing such as additive manufacturing and 3D printing."

The key advantage to CT scanning is that it provides an alternative for inspections that otherwise required destruction of the part. "With traditional methods, even if we cut a part into pieces and scanned the parts, we still couldn't see porosity or other features," Young says.

Additive manufacturing techniques are also driving demand for CT scanning services. One of the key advantages of 3D printing is that you can create and manufacture parts that couldn't be made any other way. Because of that, they also can't be inspected or measured using traditional means. At this year's RAPID con-



In this use case, teams captured data for component analysis with CT scanning. *Image courtesy of Exact Metrology.*



The technology is used in a host of dental and medical spaces because the FDA requires exact measurements for complex designs. *Image courtesy of Exact Metrology.*

ference, Gaskell presented a session titled "If You Can't Measure it, You Can't Sell It," that tackled that very problem.

"If you think you are going to make medical devices or aircraft parts and actually get them approved, that's not going to happen if you can't measure them," Gaskell says. "The only way to do that is with a CT machine."

CT also has an advantage in measuring other types of difficult items. Gaskell points out that, in addition to the heavy industries his company services, another common item that needs scanned are bottle caps. "Bottle caps and bottles are extremely difficult to measure," Gaskell says. "Bottle caps are hard because the most important feature is the back of the thread. CT scanners are perfect for that."

Complex, Expensive Equipment

While CT scanning is proving its value, many companies would be hard pressed to justify purchasing their own equipment. Industrial CT scanners can cost anywhere from $200,000 to $500,000 (although there are a few less expensive models), and calibrating them for scanning different types of materials takes significant expertise.

Generally, the denser the material, the larger the power source you'll need to shoot through the part. Focal spot sizes can also be adjusted. "With a smaller spot size, you get more precision," says Jesse Garant, president at Jesse Garant & Associates Metrology Center, which provides 3D part inspection services. "With a lager spot size, you get a faster scan."

In some cases, multiple small parts can be scanned simultaneously in one CT unit, which can improve speed and cost.

"It's a complex technology," Garant says. Garant's lab works with Tier 1 parts suppliers in the automotive and aerospace industries. "The service providers and manufacturers are trying to simplify it for the end user," he says.

Wenzel, for example, sells CT machines and offers scanning services. Many of the company's service bureau customers are clients who need measurement or reverse engineering services, but that can't rationalize purchasing the equipment themselves.

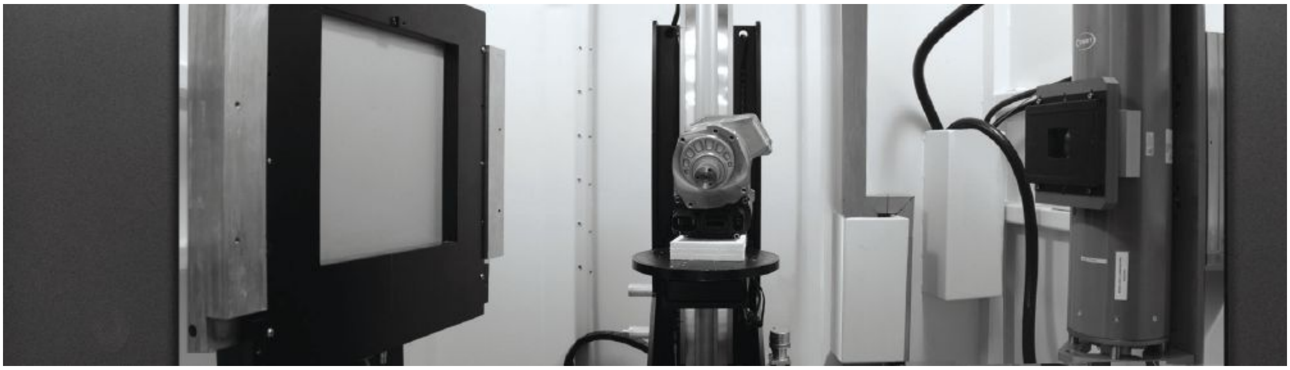
That's why it has been difficult for manufacturers to invest in their own CT equipment and they typically turn to service providers. A machine can be configured to scan particular parts at a particular density, but if you try to scan something else with the same machine you'll need an experienced operator who can adjust the settings. "Many manufacturers are acquiring CT systems, and then realizing that while it worked for one application, it's not the right tool for 75% of their other parts," Garant says.

Before considering buying a scanner, make sure it will work for multiple parts and that you can keep the machine busy enough to justify the expense. There are also different types of X-ray detectors and scanner types that offer trade-offs in speed and image quality. "Do your homework," Garant says. "If buying a machine is not the right fit, a service provider may be more feasible."

CT Scan Limitations

While CT scanning provides visual information that is unobtainable via other methods, there are instances where it does not work. For example, there are sheet metal applications that aren't well suited for CT scanning. "You may need a specific type of machine for that, or you can look inside a section for a specific weld, but it's very much on a case-by-case basis," Garant says.

Very large and very dense pieces (an iron casting several feet across, for example) also won't work. "We don't want to try to shoot through those parts because it requires too much energy," Garant says.



Users should evaluate CT scanning for part inspection on a case-by-case basis, as some machines may not be suitable. *Image courtesy of Jesse Garant & Associates.*

Most industrial scanners max out at parts that are a few feet across. And unlike metrology scanners, CT systems are not mobile — they can weigh as much as 20,000 lbs. "Scanning large items is not a mainstream capability," Gaskell says. "The part has to fit in the box; it's not like a hospital CT scanner where you can measure a patient however big they are."

Small 3D-printed parts made of tungsten carbide, silver, gold or other materials are also difficult to scan. "They are small, but if you are trying to image out the internal pores, we need so much energy to shoot through them that it can be difficult to get a good image," Garant says.

Highly detailed aircraft parts made out of cobalt chrome or Inconel are also challenging. "No CT scanner can measure more than around three inches of Inconel to a metrology standard," Gaskell says. "You can see through it, but you can't get accurate measurements. You'd have to combine methods. So you could use a CT scanner to confirm features are in the part, but you'd have to sample the parts and cut them up to measure it."

Another weakness is scanning parts made of multiple materials. "We had a water pump housing that was made of plastic and brass," Young says. "We had to put enough power through to scan through the brass, but the image quality on the plastic was heavily artifacted. It looked like a sandstorm, but the brass came out perfectly. The data for the plastic was too noisy to use."

Software Advancements Driving Improvements

Over the next several years, CT scanners are expected to get faster while prices drop. That will be enabled, in part, by faster data processing.

"We are able to pass that savings on to the client," Garant says. "A scan isn't tying up a $100,000 computer for five hours; now it's down to 15 minutes."

Scanner manufacturers are improving equipment performance to reduce scattering and image artifacting, and calibrating the equipment for measurement and inspection applications.

Software advancements are also going to be critical for overcoming some of the physics challenges CT scanning faces when it comes to very dense materials. "There are power limitations on what you can do, but we need to maximize what we can do within those limits using the software," Gaskell says.

Service providers and vendors, meanwhile, are trying to spread the word about the potential of CT for these industrial applications. "We're really trying to get in front of people and educate them," Young says. "Some customers know about CT scanning and some don't. Typically they call up with a problem and ask if there is a way to see inside a part. They don't necessarily know how we're going to do it."

"There's still a massive learning curve for this industry. We've been using CMM for 40 years, and people are still learning what that technology can do," Garant says. "As people become more comfortable and experiment with CT scanning, we'll see the market continue to grow."

That growth should accelerate as equipment prices come down. Wenzel offers at least one machine that sells for a little over $100,000, which is roughly a tenth of what the cost was several years ago.

Gaskell sees a huge opportunity in the additive manufacturing space, where he says many companies have yet to realize the measurement challenges they'll face as they attempt to get regulatory approval for parts that are destined for aircraft and other applications. "I know of instances where companies have spent millions of dollars on 3D printing, and the most accurate measuring tool they have is a set of calipers," Gaskell says. "That's where we are right now. I see massive potential market for CT. We're at a tipping point." **DE**

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

INFO → **Exact Metrology:** ExactMetrology.com

→ **Jesse Garant & Associates:** JGarantMC.com

→ **Wenzel America:** WenzelAmerica.com

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Engineering a Robotic Smart Home Interface

Designing a new home personal assistant is a mix of CAD, human modeling and 3D printing.

BY MICHAEL BELFIORE

For Cornell University robotics professor Guy Hoffman, new devices demand new engineering approaches. Case in point, a new smart home interface, called Vyo, that he and his colleagues created in collaboration with Korean telecommunications company SK Telecom. Rather than merely a touch screen or smartphone app, the interface takes an unusual form: A social robot. Their design process took an equally unusual turn.

A New Vision for Robots

Hoffman's vision of robots in the home does not include "little white astronauts," as he calls the conventional notion of how domestic robots should look. Instead, he says, such robots should "do justice to the term 'home,'" and blend in with their surroundings, looking more like appliances or pieces of furniture, and behaving in non-human but also decidedly non-robotic ways. "Robots are not human and they're not to be confused with humans," Hoffman says. "A natural interface does not mean a human-like interface."

He and his collaborator, Oren Zuckerman, got a chance to put this vision to the test when managers from SK Telecom approached them in early 2015 to create a new device for the home that would fit in with the company's strategy for innovation. After considering a number of possibilities presented by

A sketch and finalized prototype for the Vyo robot are pictured. ***Images courtesy of Guy Hoffman.***

Hoffman — who was then co-director of the Media Innovation Lab at the Interdisciplinary Center Herzliya in Israel — the company selected the Vyo concept for development.

The completed robot prototype stands about a foot tall and weighs about 4 lbs. Its glossy white finish evokes the home appliances it was designed to control. It consists of a flat base on which a user places physical icons, or phicons, representing different appliances that the robot can control. An articulate head peers down intently with a single eye-like circle at the icons, and bobs to acknowledge spoken commands and queries. To adjust the setting of an appliance, a heater for example, the user slides the icon on the tray and sees the adjustments being made on a screen embedded in the top of the robot's "head."

For design inspiration, Hoffman drew from the appearance of a microscope he saw in a school supply store window, which he iterated in a series of sketches that he made on an iPad. The iPad sketches were a departure for Hoffman, who had previously used paper for concept sketches. "I very quickly found out that it makes me very productive," he says of iPad sketching. "I ended up doing a lot of sketches in a short amount of time. Also, they're much easier to share with my collaborators."

Next came a series of exploratory animations made with Blender, an open-source animation software. These animation sketches helped the team make choices about where to place the motors that would animate the robot. "The placement of the motors affects the personality of the robot even when it is doing the same movements," says Hoffman.

Hoffman and his team — which included research assistants Michal Luria and Benny Megidish along with co-principal investigator Oren Zuckerman, and SK Telecom project manager Sung Park — also looked beyond the lab to achieve Vyo's lifelike movements. It was here that the team's process took a decidedly unorthodox turn.

Multidisciplinary Design

To further refine the kind of interaction that Hoffman was looking for — where the robot bows differentially and invites interaction with non-verbal communication — the team recruited specialists in disciplines not normally associated with robotics. Actors, for example.

Professional actors role-played a butler and a householder to demonstrate how the butler should behave to be as helpful yet unobtrusive as possible. As a result, a posture of quiet attentiveness became the robot's default behavior. The actors also informed the robot's notification behaviors, for example looking around for a user's help when an appliance needs attention.

The team further refined the robot's movements with the help of laser-cut wooden components and parts such as joints — designed in Autodesk Fusion 360 and SOLIDWORKS — that were printed on a Stratasys uPrint SE 3D printer. "Printing variations of the robot's joint attachments enabled to team to quickly explore the robot's movements with a variety of linkage structures," says Hoffman.

A professional puppeteer manipulated a puppet made from the wood blocks and 3D-printed joints to enable the team to further experiment with movement. Puppets were also presented to test subjects to collect data on their reactions to specific behaviors and sizes for the robot.

Hoffman says that this kind of far-ranging multidisciplinary approach is crucial for his work that blends the arts and engineering in an effort to create robots that pay more respect to our essential humanity than conventional interfaces and devices. "In some ways, you can do everything on a smartphone today," says Hoffman. "But that reduces the human-machine interaction to tapping your finger on a glass screen and watching colorful animations. In my mind this doesn't comprise the full human experience."

Ambassador to the Future

The team incorporated their findings from the acting improvisation, puppetry and user testing into the software, structure and electronics of the finished prototype. They built the prototype gradually, replacing the wooden parts as the structural elements were designed and printed one at a time. For control, the team picked the Raspberry Pi 2 Model B computer and developed the software in Java and Python. The team had to code control software for the motors because they didn't exist for the Raspberry Pi.

Vyo's camera is designed to detect faces as well as phicons and allows it to respond to people who approach it. The 1.8-in. LCD screen, exposed to the user through a bowing gesture designed to evoke grace, display the status of devices under the robot's control. A speaker provides spoken notifications. Dynamixel MX-64, MX-28 and XT-320 motors drive the robot's five degrees of freedom. Five layers of paint and sanding give Vyo a finished appearance.

Hoffman and his team completed Vyo in November 2015 to an enthusiastic reception at SK Telecom headquarters in Seoul.

Hoffman — who moved to his current post at Cornell in April — is now at work on follow-up projects, including a companion robot for autistic children and a wearable robotic arm to give users an extra hand. It's all in the service of creating a better future for both robots and people. "I often hear people say: 'You try to make robots that are like humans.' I disagree. I want to make robots that will engage humans in an emotional and respectful way. There's a difference," he says.

Michael Belfiore's *book* The Department of Mad Scientists *is the first to go behind the scenes at DARPA, the government agency that gave us the Internet. He writes about disruptive innovation for a variety of publications. Reach him via michaelbelfiore.com.*

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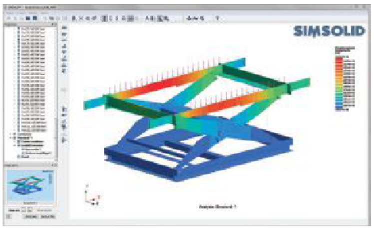
Serapid Adopts SIMSOLID For Optimization

The FEA tool helps heavy load transfer company quickly analyze its rigid-chain industrial lifting products.

BRUCE JENKINS, ORA RESEARCH



Serapid designs, manufactures and installs systems for transfer of heavy loads based on its "rigid chain" technology. Essentially a chain that can push, the technology consists of interlocking links that behave like a chain yet lock like a rigid bar, providing a telescopic actuation mechanism that is environmentally friendly and works in harsh environments. Serapid's custom solutions range from individual components to turnkey stage systems, and encompass a variety of applications in industries as diverse as architecture, nuclear, medical technology, defense, automation, quick die change, engineering, manufacturing, theater and entertainment.

Bob Adams, engineering manager at Serapid, reports that he and his team just completed a successful evaluation and initial set of design studies using SIMSOLID, a new structural simulation tool that works directly on imported CAD geometry, eliminating the two most time-consuming and labor-intensive aspects of structural analysis: CAD geometry simplification and mesh preparation. As a result, Serapid is now in the process of implementing SIMSOLID to expand its use of simulation across all its product lines.

SIMSOLID was first brought to Adams' attention by Gennadiy Evenchik, a Serapid design engineer who specializes in its theater lifting systems and was the firm's most intensive user of its existing structural analysis tool. "I was really a bit of a hard sell" on SIMSOLID, says Adams. "I've taken graduate courses in finite element analysis (FEA) – I've done the math the hard way. I know what makes a good finite element model; I know what makes a bad finite element model. That is the thing I've been working with internally, trying to teach my guys how to constrain a model, because if you have bad constraints, you can have pretty pictures but they're meaningless."

"So Gennadiy is coming up and telling me, 'Hey, there's this new simulation package out there, it's better than the older ones,' and I'm thinking, 'FEA is FEA – come on.' But he keeps telling me, 'This is the greatest thing.' So one day, I told him to go ahead, try to simulate something and we'll see.

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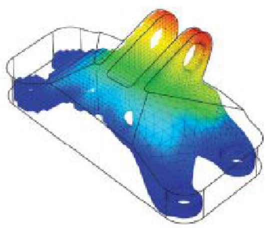
Topology Optimization, DMP Help Complete Design Challenge

Frustum and 3D Systems lightweight a GE aircraft bracket with metal 3D printing.

The conundrum of balancing the design of a part with the constraints of manufacturing has existed since the Industrial Revolution. Conventional manufacturing techniques have limited capabilities to realize complex geometries or organically shaped compoents in a cost effective way. This can result in components where functionality and performance are a trade-off.

Now that 3D printing, especially Direct Metal Printing (DMP), has become a viable manufacturing alternative, the constraints imposed by traditional manufacturing have been removed. In response to this, software tools for multi-disciplinary design optimization are now emerging to deliver a convergence point: Topology optimization software is now capable of generating the most efficient designs for one-step manufacturing on the latest generation of DMP systems. Basically, what you model is what you manufacture.

This confluence of technologies was demonstrated recently in a project undertaken by software company Frustum and 3D Systems' On-Demand Parts service, Quickparts. The project was a publicized challenge by GE Aircraft to reduce the weight of an aircraft bracket while maintaining the strength needed to meet all of its functional requirements: primarily supporting the weight of the cowling while the engine is in service.



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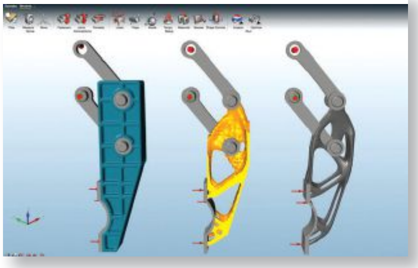
Editor's Picks

by Anthony J. Lockwood

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



solidThinking Inspire 2016 Released

The software blends features for CAD and structural analysis.

Inspire 2016 has been enhanced with a capability to compare results across multiple runs and loading scenarios in one table. Another enhancement brings new load types for temperature, velocity, acceleration, G-loads and enforced displacement for simulating precise loading conditions.

Also key is a new PolyNURBS functionality that can help you create manufacturable designs from topological optimization results with NURBS geometry. Because Inspire supports export formats like ACIS, Parasolid, STEP and STL, users can flow optimized designs to a 3D printer.

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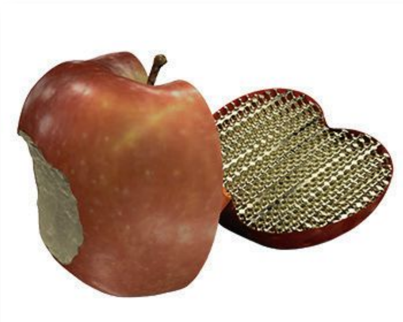

3D Systems Launches Geomagic Freeform 2016

Direct scan data and input capabilities have been enhanced.

This version of Freeform sees improved 3D CAD and direct scan data input functionality and a number of features to enhance 3D printing, including tools to fix low-grade 3D data for 3D printing, manufacturing or file format exports.

A key new feature, the StructureFX toolset, provides 3D lattice and structure tools. With it, users can select an existing pattern or create custom complex, internal and external lattice structures for lightweight designs.

It comes in two flavors: Geomagic Freeform and Geomagic Freeform Plus, providing tools for design, sculpting and advanced manufacturing.

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New Large-Format Media Options Available

Canon has expanded its offerings for the Océ ColorWave 500 and 700.

What Canon Solutions America has done is extend the Océ ColorWave 500 printing system's application range by increasing the number of media options from 12 to 26. What this means is that you can now print plain old documents, CAD files, GIS maps, architectural drawings, banners, backlit signs and even window clings all on one device.

The new offerings include a 27-lb. Premiere Xtreme (XTRM) bond, a 4-mm clear polyester film (4CFI) and a 2-mm clear polyester film with low-tack adhesive (CCLG).

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MSC Software Ships Apex Eagle

The release brings enhancements to Modeler and Structures.

Apex Eagle sees major updates to Apex Modeler, its CAE-specific direct modeling and meshing module, and its fully integrated and generative structural analysis solution module, Apex Structures. MSC says it has received reports that Apex Eagle's enhancements have accelerated complex assembly layout modeling and validation by up to 10x compared to previous versions.

The software includes new part representations and connection types for modeling and validating complex assemblies. There's also support for 2D shell elements, and 3D tetrahedral and hexahedral meshing.

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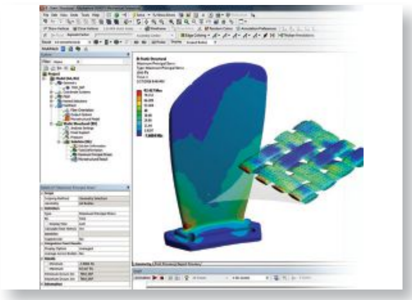
Integrate Composites Analysis into ANSYS

MultiMech is a tool available for Workbench.



MultiMech provides a two-way coupled multiscale FE analysis so that both a part and its underlying material microstructure solve concurrently. MultiMech means that you can use realistic representations of your material microstructures to simulate how those microstructures affect the linear, nonlinear and fatigue performance of your part as well as simulate how applied loads affect a part's material.

With MultiMech for ANSYS, users can create and test composites with multiple types of reinforcement and execute progressive damage analysis on pretty much any type of composite.

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MSI Releases Virtual Reality Ready Workstation

The WT72 6QN is an entry-level engineering workstation for design.

This new system from MSI is equipped with the new NVIDIA Quadro M5500 mobile GPU (graphics processing unit). Called the WT72 6QN, this workstation is packed with components primed for 3D CAD, rendering and analysis.

The WT72 6QN comes with a variety of NVIDIA technologies to maximize the VR experience like VRWorks, a suite of APIs (application programming interfaces), libraries for VR developers, VR content rendering technology and the like. The WT72 mobile workstation series is certified for Autodesk's VRED 3D visualization and virtual prototyping software, and 3D modeling software.

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Dell Announces Industrial PC Options

Portfolio is designed for Internet of Things and industrial PC computing power.

The Embedded Box PC 3000 Series and PC 5000 Series are fanless, ruggedized systems designed to MIL-STD 810G specifications.

Users can configure the Embedded Box PC series with Intel CPUs, storage devices, mounting and labeling options. There are all sorts of wired and wireless I/O options like CAN bus, RS-232/RS-422, Gigabit Ethernet and wireless WAN. They can be used them with or without a keyboard and monitor. They support Windows and Ubuntu, and Dell offers security and manageability options, support and deployment services.

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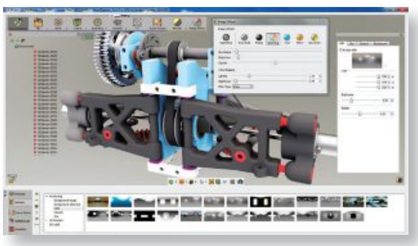
SimLab Soft Introduces SimLab Composer 7

Program lets users build, animate and render models.



SimLab Composer 7 provides workbenches, which are toolkits optimized for a particular visualization process. It lets you import a 3D model no matter its size and format, then easily access a workbench for the tools to build a scene, texture, render, simulate, animate and publish it.

It has plug-ins for design systems like Fusion 360 and Solid Edge that create an active link between them and SimLab Composer, which keeps data in sync and simplifies updating visualizations after model changes. Users can publish renderings, stills and animations.

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Commentary

by Ted Miracco

Software Piracy: A Growing Epidemic

Software piracy — the use of software not legitimately paid for and used according to license terms — is a worldwide epidemic. Statistics from the Business Software Alliance (BSA) show that 42% of software installed globally is not properly licensed, resulting in lost revenue of over $63 billion.

But lost revenue to software vendors is only part of the problem. The economic effects of software piracy undermine the entire U.S. economy, where much of the software is developed, by giving companies that use software without paying for it, an unfair advantage over those who build the purchase of software into their cost of doing business. It damages brands through distribution of substandard products and exposes customers to a range of IT risks including malware, security breaches and data loss.

The practice exposes customers to a range of IT risks.

What is Software Piracy

Software is typically sold as a license that allows the purchaser to install and use the software with specific rights such as number of computers or users. Cracking is the modification of software to remove or disable copy protection so the software can be used without purchasing a license, or such that it can be installed on multiple computers. Users of pirated software typically fall into four general categories: hard-core pirates, soft pirates, piracy victims and rogue companies.

Hard-core pirates believe that all software should be free and include hackers. Soft pirates are those who find free or low-cost versions of software online. These versions are dangerous as they are not only illegal, but are also sometimes infected with malware or spyware. Piracy victims do not realize their software is counterfeit — they are not aware of who installed the software or are not familiar with terms of the license agreements. Pirated software is sometimes pre-installed or sold to victims by a dishonest distributor or reseller. Rogue companies are organizations that rely on pirated software as a competitive advantage in the market. Rogue company management teams are complicit in the crime, as opposed to an individual employee or group of employees.

The rogue approach is quite prevalent in China, where, according to the BSA, approximately 90% of the software in use is counterfeit. Chinese organizations routinely export cheaper manufactured products designed using pirated software to the U.S. and Europe, hurting local manufacturers and causing job loss and other long-term economic damages.

Piracy Solutions

Large software vendors have begun to fight back using tactics such as site audits, search warrants to inspect and confiscate computers with stolen software, and costly litigation for copyright infringement. While effective, these approaches are disruptive and expensive. Small- and mid-size software companies simply lack the resources, legal expertise and hard evidence required to prosecute.

License management solutions exist in theory to make sure only legally purchased software is deployed on systems. However, the reality is that these systems are easily circumvented and cracked licenses are readily available for anything and everything on the market. While many companies employ license management solutions, simply knowing your software has been hacked is only half the battle. You must have proof in order to go after offenders and either persuade them to become compliant or in some cases resort to legal actions.

A new approach that works a bit like a silent alarm or an electronic site audit has recently been introduced. This solution is essentially a second line of defense that backs up the license manager and deals with evidence after the software is cracked. It not only provides tamper detection to determine if software has been compromised, it also provides data acquisition, reporting back details on who, where, what and how often the software is being illegally used.

Conclusion

The problem of software piracy is growing as emerging economies ramp up to compete with the U.S. and Western Europe. But many companies are fighting back by adopting newer software piracy identification technologies that enable them to track illegal users and recover significant revenue. DE

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