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TECHNOLOGY FOR DESIGN ENGINEERING

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by Jamie J. Gooch

Optimization vs. Complication

Let's face it: Product complexity hasn't just outpaced our ability to manage it, it's lapped us as we sit in departmental meetings, search our computers for the latest versions of project files and wait for analysis and test results to run. Why?

Faster computing, ubiquitous connectivity and more capable sensors have led to electronics being integrated into products that were previously only mechanical. At the same time, more powerful electronics can be packed into smaller design envelopes, increasing the engineering complexity inherent to electromagnetic interference, computational fluid dynamics and embedded systems. Of course, electronics require software, which further increases product complexity. It's a snowball effect, and it's just starting to roll down the mountain.

Even as we pack more features into everything from cell phones to aircraft, we need to make components smaller and lighter to satisfy consumer demand, energy requirements and competitive pressures. That means simulating and testing new materials, optimizing designs to use only the amount of materials needed without loss of strength, and designing for new, advanced manufacturing techniques. But the role of the design engineer is no longer limited to computing with CAD and CAE, prototyping and product testing. It's increasingly about data.

Embrace the right technologies to manage product complexity.

More Data, More Complexity

The much-ballyhooed Internet of Things (IoT), in which the devices and machines in our factories, homes and pockets communicate with one another, is the prodigy of Moore's Law. As the IoT matures, it brings with it product complexity challenges that will dwarf what design engineers face today, thanks in part to the data it will produce. Experts predict that by 2020, the world's 8 billion people will make use of 50 billion connected devices, generating 50 trillion gigabytes of data.

Much of that data deluge will be parsed into useful information meant to inform product design decisions. As products report back on how they're being used and serviced in the field, design engineers will have the ability to update product functionality via software. Many predict the IoT will lead to even shorter product design cycles, some of which are already mimicking fast software development turnaround times.

The added complexity is too much for any engineer to handle alone, so collaboration with colleagues in other engineering disciplines, coworkers in other departments and business partners and clients who might be on other continents becomes even more critical. Decision makers up and down the supply chain, from the board room to the factory floor, also need access to design engineering data. Sharing the right data with the right people at the right time to allow good decisions adds yet another layer of complexity to the product design cycle.

Design engineers can fight fire with fire by investing in the right technologies to simplify product design when possible, avoid unnecessary complications, and manage complexity when it's inevitable.

Optimize Design Engineering

Tomorrow's products being researched and developed by engineers today will change the world. How you respond to complexity will dictate the rate of innovation. Thankfully, engineering software and hardware are easier to use than ever, speeding up complex calculations and producing results that enable real-time decision making. That's why *Desktop Engineering* is devoting this annual Optimization Special Issue to technologies and processes that design engineers can use to manage complexity across all phases of product development.

Topology optimization software provides engineers with more options to remove complexity by quickly conceptualizing combined parts and new structures that cut down on over-engineering and wasted materials. Engineering design software advances are helping engineers automate processes and solve multiphysics challenges early on in the design cycle to enable simulation-led design. Data management software creates a central repository of product knowledge that drives collaboration, traceability and product lifecycle management efforts.

On the hardware side, affordable 3D printing helps speed up the product development cycle by allowing engineers to quickly explain complicated designs, or even manufacture short-run end-use parts, some of which would be too complex to manufacture otherwise. And, of course, high-performance computing via workstations, clusters, servers and the Cloud is the primary enabler of design optimization.

Engineers can choose to look at new design engineering technology in two ways: as yet another complication to their already difficult jobs, or as an opportunity to better manage today's complex product requirements. Only the latter will position themselves for success in the connected-product future. DE

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

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Tony Abbey, Brian Albright, Mark Clarkson, David S. Cohn, John Newman, Frank Ohlhorst, Beth Stackpole, Peter Varhol, Pamela J. Waterman

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Peerless Media, LLC
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Future Workforce Education: Boeing's Next Epic Challenge

For the better part of a year, a cross-functional team is tasked with designing, building and testing an unmanned aerial vehicle (UAV) that can collect data on soil and water distribution to help farmers boost crop yields and food production. The dispersed team leverages state-of-the-art tools like PLM (product lifecycle management) software and social technologies to collaborate and conduct design reviews while enlisting Stratasys 3D printers to output the structure more efficiently and for less cost.

The team, made up of students from university partners, is the first to participate in Boeing's AerosPACE (Aerospace Partners for the Advancement of Collaborative Engineering), a program designed to help the company educate the next generation workforce and close a skills gap that threatens to undermine its future ability to compete in the industry.

"The pond is getting smaller and we're trying to figure out what we can do to build capacity here," says Michael Richey, PhD., a cognitive scientist and associate technical fellow at Boeing, who is one of the key forces behind the AerosPACE program.

Boeing and other aerospace companies are facing a mass exodus as the number of employees hitting retirement age is projected to increase by 50% over the next five to six years. With AerosPACE, Boeing is enlisting key university partners like Georgia Institute of Technology, Brigham Young, Purdue, Tuskegee and Embry-Riddle Aeronautical University, to create a capstone project that will help attract the best and brightest to the aerospace and defense sector while evolving the engineering curriculum to address key skills gaps.

"The system of systems is a big focus at Boeing and it's really important for our future workers," Richey says. "With today's global business model of partners geographically dispersed and working together on whatever you are building, you have to understand how to optimize what you are working on within the context of where it fits within a system. That's a critical skill."

Also critical to educating this new workforce, according to Richey, are real-world experiences — not just textbook learning. As a result, AerosPACE is centered around "Epic Challenges," typically grounded in some sort of social context and acquainting team members with the realities of life in an engineering role, from dealing with project timelines, RFPs (request for proposals) and budgets to mastering modern-day design and collaboration tools, including CAD, simulation and PLM software.

As part of the initial AerosPACE capstone project, three multi-university student teams built a UAV capable of monitoring farmland to improve crop yield. *Image Courtesy of The Boeing Co.*

— B. Stackpole

White House Hosts 3D-Printed Ornament Design Challenge

In partnership with the Smithsonian and the maker community site Instructables, the White House launched a 3D printed ornament design challenge at the end of October. The official announcement came from the President's Office of Science and Technology Policy. It reads, "Once again, President Obama and the First Lady will welcome tens of thousands of visitors from around the country to tour the holiday decorations — and those that can't make it in person will have the chance to explore the décor online … And this year, for the first time ever, we're inviting makers and innovators around the country to participate in the White House 3D-Printed Ornament Challenge!"

By the Nov. 10 deadline, the challenge had registered 227 entries, ranging from dangling ornaments with the Commander in Chief's image to sleighs bearing the American flag and a miniature replica of the Freedom Tower. The entries are submitted as STL file. Some of the entries appear to have been designed in professional CAD programs. Others may have been built in consumer-friendly programs like Tinkercad.

For the winner, the prize is a chance to make history. The announcement says "A selection of the winning ornament designs will be 3D printed and displayed in the White House during the holiday season; featured on the Smithsonian's state-of-the-art 3D data platform, 3d.si.edu; and will join a small collection of White House ornaments in the political history division of the Smithsonian's National Museum of American History."

— K. Wong

Luxion KeyShot 5.1 Features Patterning Tool and Customizable Materials

In early November, Luxion released KeyShot 5.1, a new version of its rendering program. The upgrade comes with, among other things, new procedural materials that offer a lot more customization options; and a patterning tool to easily create multiple instances of imported 3D objects.

KeyShot 5 (released in May) introduced KeyShot Cloud, a feature that lets you get access to downloadable assets hosted in the cloud. The on-demand library augments the materials, back plates and environments that come with the installation. With version 5.1, users get a lot more control over the look of some of the procedural materials. When working with materials like camouflage or brushed metal, you can use slider bars to adjust the texture mapping and density of patterns. This gives you the ability to configure the look of the materials to match the size of the 3D object.

KeyShot 5.1's Pattern tool lets you create multiple instances of the same object, which can be treated differently with materials.

Pattern and Scattering Tools

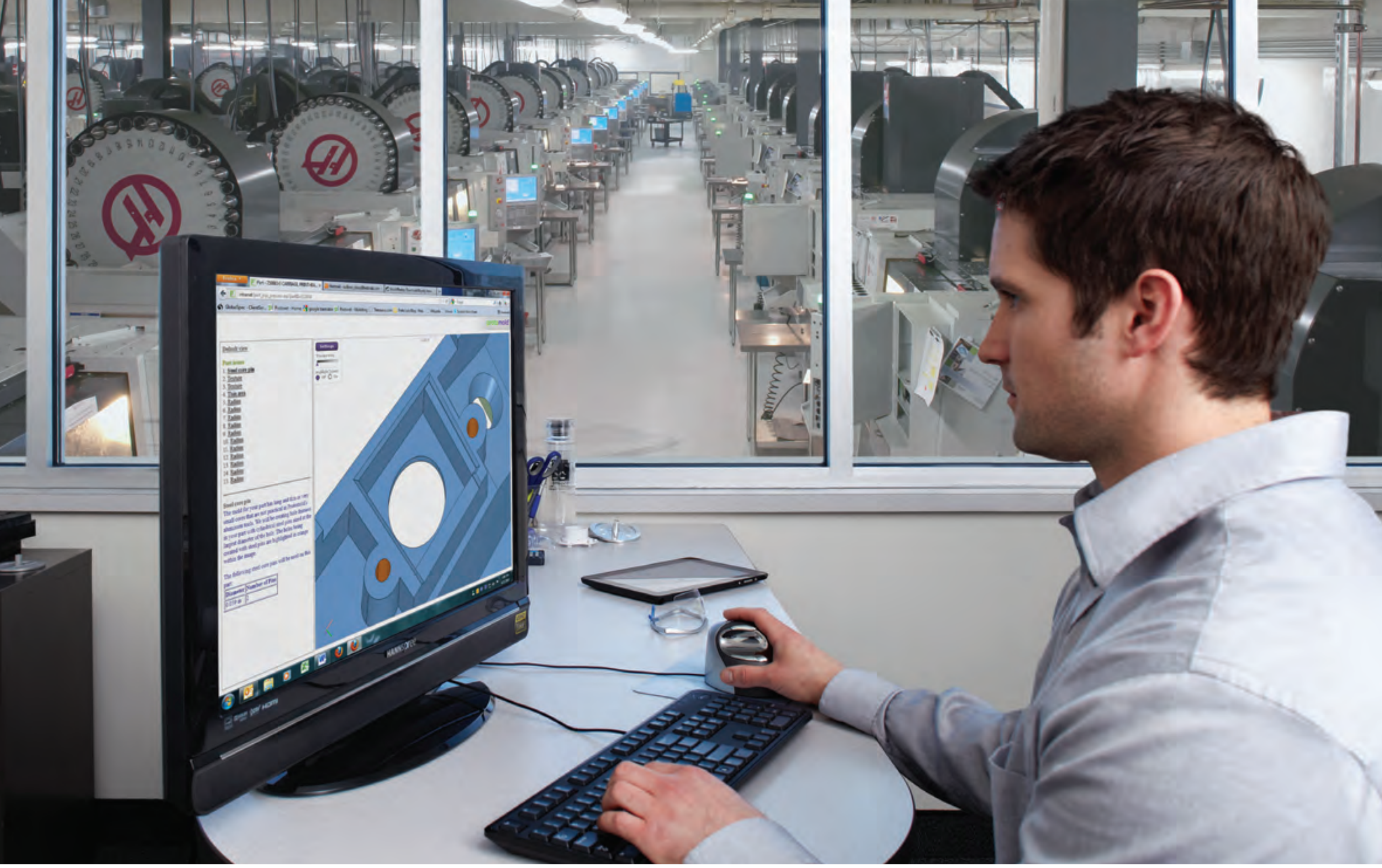
If you need to duplicate a single object into a small group or cluster, before you choose the Copy and Paste option, you may want to check out KeyShot 5.1's Pattern tool. The tool lets you create multiple instances of a single object. But more importantly, you can treat each instance as a separate object. So the color and texture applied to the original object won't automatically show up on the rest of the pattern members. You may apply different materials and looks to all instances in the pattern.

The Pattern tool gives you the ability to align spawned objects in a row or in a circular pattern. But what may also be useful is the scattering tool, which introduces randomness to the placement. This will particularly be handy if you're trying to create a flock or an army with the same random placement observable in reality.

KeyShot 5.1 follows the same tradition the original software established — a simple, easy-to-use rendering program driven by physically accurate ray-traced rendering. Those who use the software on touch-enabled devices (such as Windows tablets) will have an easier time navigating the interface — it now supports multi-touch. As you might expect with an incremental release, version 5.1 comes with a lot of tweaks and enhancements to provide a better user experience.

— K. Wong

Watch a quick video of Luxion KeyShot 5.1 in action at deskeng.com/virtual_desktop/?p=9499.



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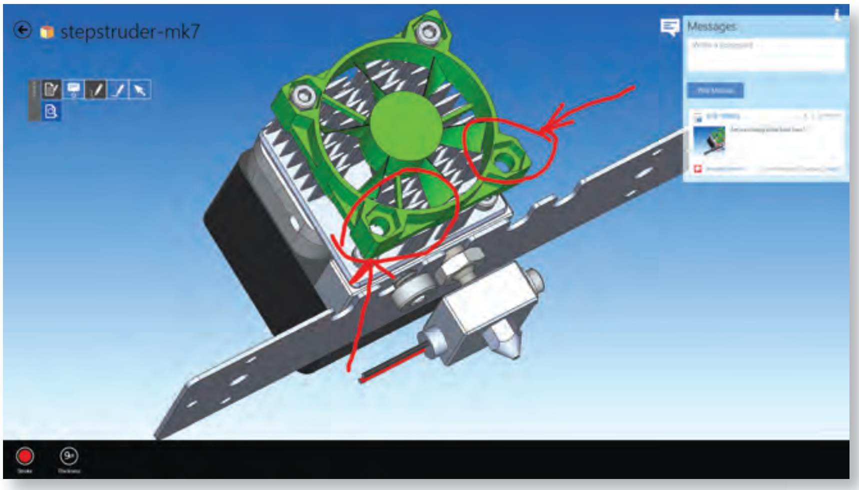
by Kenneth Wong & Beth Stackpole

Aras Launches Mobile Strategy to Expand PLM User Base

Aras is now looking to break new ground in the mobile arena with a pair of new apps and a plan for partners to create an ecosystem of their own custom-designed mobile solutions. Aras sees mobile as an opportunity to make design data available to users outside of the traditional 3D CAD space who might leverage the information for different use cases, and who otherwise might not have had access to the data, according to Peter Schroer, Aras president.

"This is not targeted at the design engineer sitting in front of CAD on a 24 in. screen — the mobile use case for those guys is not very compelling," Schroer says. "The work they are doing is massive, and a big screen makes sense."

Yet, the same 3D CAD files and other product-related data is just as important to manufacturing engineers, quality engineers, suppliers and top management — an audience that has traditionally shied away from PLM (product lifecycle management) due to its complexity and less than friendly user interfaces.



The Aras Flow mobile app enables mark-up and secure social collaboration throughout the enterprise and extended supply chain. *Image Courtesy of Aras.*

Bringing PLM to the People

That's exactly where Aras' mobile strategy comes in, Schroer said. "Aras' strategy is to make PLM ubiquitous so all employees can make decisions based on the strong fundamentals of what's approved and what's not approved," he says. "The thousands of users in manufacturing and quality are not going to log into [PLM] because it's too heavy and they can't use it. We need to bring PLM to where they are, and mobile makes a ton of sense for that."

To do so, Aras is announcing a pair of new mobile apps along with a development strategy aimed at cultivating an ecosystem of partners who can build their own custom mobile apps.

Aras Flow, released in November, combines workflow and secure social capabilities to foster collaboration among constituents during the design process and to aid in better decision-making. The app lets an engineer kick off a workflow or launch a discussion thread during the design process to explore whether a part should be machined or cast, for example, or to solicit specific information from a supplier. The collaborators can engage in real-time chat and have all the information they need to provide context to the discussion from their mobile device.

"It has the immediacy of a text, but it's a text from the PLM system," Schroer says, which is central to the issue of security. "Users want the immediacy and convenience of mobile, but they need to do it within the PLM security context. Facebook is great to get people collaborating on a topic, but it's simply not where you want to put secure PLM data. You need to replicate that data in a secure infrastructure, and we call that secure social."

The other app, Component Finder, is a component search tool based on a full-blown product Aras announced in October. Aras partnered with IHS to connect the organization's cloud-based CAPS Universe Electronic Component Data into Aras PLM to help design teams quickly find the right parts based on availability and environmental compliance, among other factors. The mobile app will let users tap into the IHS database directly on the shop floor or from wherever they are, fostering greater flexibility.

Along with the apps, Aras is releasing a drag-and-drop toolkit that will allow developers and enterprises to easily create their own role-specific and purpose-built apps for Aras PLM. "The two out-of-the-box Aras apps are the tip of the iceberg of our mobile strategy," Schroer says. "We want to enable the community to create thousands of apps themselves. There's potential for a lot of really high value, interesting use cases — things we haven't thought of."

Aras' mobile apps will be available initially through the Microsoft Apps store.

— B. Stackpole

Pros Need Professional-Grade Workstations

New workstations equipped with powerful graphics turbocharge design engineering.

Mounting product complexity and shrinking time-to-market cycles have engineers in a constant race against the competition. Faced with such high-octane product development challenges, anything less than a professional-grade workstation comes up short on the horsepower and reliability to keep productivity humming at an optimal pace.

To help engineering organizations stay in top form, AMD and Dell have partnered on a line of workstations specifically tuned to run demanding CAD/CAM and design visualization software. The latest Dell Precision workstations, available in both desktop and mobile configurations, integrate such high-powered components as Intel Xeon CPUs, advanced storage and memory, and AMD FirePro professional graphics processing units (GPUs) to optimize performance for handling large data sets and to set new benchmarks for realism when performing complex visualizations.

Powered with the AMD FirePro W-Series of GPUs, the new Dell Precision workstation line offers engineers and designers a robust platform specifically calibrated to deliver optimal 3D performance, image quality and levels of reliability simply not possible with consumer-grade desktop systems. AMD and Dell also work closely with leading 3D design tool vendors to ensure the FirePro-injected Dell Precision workstation line is fully certified to run CAD/CAM, CAE, and visualization applications. Certification on professional design engineering software from Autodesk, Dassault Systèmes, PTC and Siemens PLM Software ensures maximum performance and reliability for design engineers.

A Look Under the Hood

The new Dell Precision workstations offer configurations to meet a range of engineering needs. The base Precision Tower 5810 model, stocked with an Intel Xeon E5-1630v3 quad core processor and AMD FirePro W5100 GPU with 4GB of on-board memory, is primed to handle complex 3D CAD modeling with the occasional simulation or CAM visualization. The Dell Precision Tower 7910 uses a pair of Intel Xeon E5-2687W v3 processors and a higher-end AMD FirePro W7100 GPU with 8GB of memory to tackle the most sophisticated engineering jobs.

AMD's latest FirePro W-Series powers the new Dell Precision line of professional workstations.

Dell also packs professional computing and AMD FirePro graphics into a line of Precision mobile workstations for design professionals who need to take large dataset handling, sophisticated 3D modeling and visualization capabilities on the go.

Key to driving performance on the new Dell Precision workstations is AMD's latest generation of FirePro W-Series GPUs. The new line packs up to 2x more graphics memory and more graphics power, resulting in significant application performance gains and image quality improvements. The AMD FirePro W-Series also supports PCI-Express 3.0 top-to-bottom, which delivers maximum data transfer rates at 32GB/s for handling large datasets, as well as top-to-bottom support for the latest 4K ultra high-definition displays. The AMD FirePro W-Series can accommodate up to six such displays from a single GPU.

Thanks to the latest improvements, the AMD FirePro W-Series loads 3D models quickly, delivering throughput that accelerates engineering productivity. Features such as fast full-scene anti-aliasing and support for advanced real-time shading functions, including SolidWorks' RealView with Ambient Occlusion, enable AMD FirePro GPUs set the bar high for realistic design visualization that brings 3D CAD models to life and turbocharges digital design strategies.

To find out more about how AMD and Dell are collaborating to advance workstation performance, including details on their professional line of GPUs and workstations, visit www.fireprographics.com/dell.

Stratasys Announces Multiple New Offerings

Stratasys released 11 new products at EuroMold 2014, including new materials and new additive manufacturing (AM) systems. New systems include six additional PolyJet systems featuring the company's triple-jetting technology, the process used by the Objet500 Connex3 launched earlier this year.

Two new Fortus systems offer Stratasys' patented Fused Deposition Modeling (FDM) technology.

Another new system that made its appearance at is the Objet Eden260VS. According to the company, the new 3D printer will offer 6μ resolution alongside soluble support.

Stratasys also rolled out a new desktop AM system with the Objet30 Prime. The system offers PolyJet technology on a smaller scale with options for 12 different materials.

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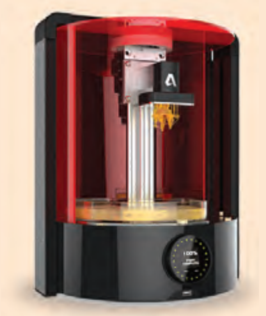
Autodesk Places $100 Million in Spark Investment Fund



Autodesk recently announced a $100 million donation to the Spark Investment Fund. This new fund will assist, "... entrepreneurs, startups and researchers who push the boundaries of 3D printing technology and accelerate the new industrial revolution," according to the company.

The new fund will allow companies and individuals involved with additive manufacturing research and development a chance to apply to participate in the Spark Investment Fund's portfolio. In addition to potential financial benefits, those selected to join the fund will become part of the Spark partners program. Partners gain access to marketing and developer services to help spur innovation.

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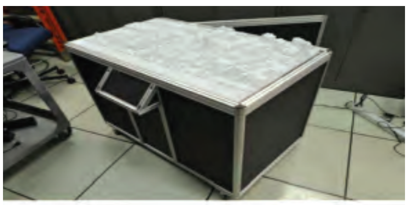
3D Printing Helps Visualize Big Data

More powerful computers are making it easier and faster to process massive amounts of data, but actually making sense of Big Data is still a challenge. How can you effectively boil giant data sets down in a way to help users visualize what the results mean?



Researchers at MIT's Lincoln Laboratory have come up with one possibility: using 3D-printed models and projection to provide a concrete representation of big data.

Zachary Weber and Vijay Gadepally printed a 3D model of MIT's campus (dubbed LuminoCity) out of translucent plastic. A projector connected to a laptop illuminates the model, altering colors based on different data inputs.

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3D Printing Makes Gartner Top 10

3D printing has risen to the number-three spot on the Gartner top 10 strategic technologies list for 2015. It came in just behind computing everywhere and the Internet of Things on this year's list.

While the technology first entered the top 10 last year, it has risen in the ranks because of the number of enterprises that have deployed systems for prototyping and other applications. The technology has now reached a phase where it can provide a true return on investment, as measured by Gartner's "hype curve."

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Printed Heart Models are Class 1 Medical Devices

When physicians at the New York-Presbyterian/Morgan Stanley Children's Hospital were faced with performing complex heart surgery on a 1-week-old baby born with congenital heart disease, they turned to 3D printing to prepare for the procedure. The hospital sent a CT scan of the heart to Materialise, which created a digital 3D model of the heart using its Mimics solution, and then printed a highly detailed replica. The doctors used the model to find a way to repair all of the heart defects in one procedure.

Materialise has now listed its 3D-printed cardiovascular HeartPrint models, a service provided as part of the Mimics Innovation Suite, as Class 1 medical devices in the U.S. and European Union markets. The classification allows the company to add HeartPrint models to its pre-operative planning offerings.

"It's definitely going to be standard care in the future and we're happy to be leading the way," said Dr. Emile Bacha, a congenital heart surgeon and Director of Congenital and Pediatric Cardiac Surgery at New York-Presbyterian / Morgan Stanley Children's Hospital.

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HP Reimagines the Possibilities of 3D Printing

HP calls Sprout an immersive computing platform that redefines the user experience. *Image courtesy of HP.*

It was about a year ago that HP CEO Meg Whitman announced the company's intention to build 3D printers, igniting all sorts of speculation.

Finally, in October of this year, HP introduced a new 3D printing technology called Multi Jet Fusion as part of an initiative it calls "blended reality." At the webcast launch, the company promised to "announce what it believes to be the year's most groundbreaking technologies that will help close the gap between the digital and physical worlds, empowering consumers and professionals to create, interact and inspire like never before."

"We believe it can change the world," said HP Executive Vice President, Printing and Personal Systems, Dion Weisler of the "blended reality" vision during the launch event. The Multi Jet Fusion technology is just part of that vision — the offramp, as Weisler called it.

Samples printed by the HP Multi Jet Fusion 3D printer on display at the launch event. ***Photo by Evan Agostini/Invision for HP/AP Images.***

A Proposed 3D Printing Revolution

While technical details were sparse, Multi Jet Fusion technology appears to leverage HP's strengths in inkjet printing and scanning to place more than 350 million drops per second at 21 microns. According to HP's press release, Multi Jet Fusion uses a "proprietary multi-agent printing process utilizing HP Thermal Inkjet arrays that simultaneously apply multiple liquid agents to produce best-in-class quality that combines greater accuracy, resiliency and uniform part strength in all three axis directions."

HP says its newly announced Multi Jet Fusion 3D printer is 10 times faster than competing technologies. It is slated to be widely available in 2016. ***Image courtesy of HP.***

HP says it is 10 times faster than competing technologies, providing an example of 3D printing 1,000 gears. The company says such a task would take 83 hours with material extrusion, 38 hours with laser sintering and just 3 hours with HP Multi Jet Fusion.

HP also said Multi Jet Fusion will not only be faster and higher quality, but will cost less than competing 3D printing systems, and that it will cost less to operate. The company is targeting industrial customers and says it could "revolutionize traditional manufacturing."

While the 3D printer was revealed on stage, as were parts created by it, it is not immediately available. HP is currently working with beta customers and plans for a widespread release in 2016. Weisler said Multi Jet Fusion is currently capable of printing in color, and the company is working to add built-in material "elasticity" and texture to parts. The company cites a number of possibilities — including form, texture, friction, strength, elasticity, electrical, thermal properties and more — that could be possible in the future with Multi Jet Fusion.

Technology to Enhance Creativity

If Multi Jet Fusion is the offramp, the onramp to closing what HP sees as the chasm between technology and creativity is Sprout. Sprout is a platform based around hardware that incorporates a touchscreen computer, 3D camera, and a projector that allows users to interact with physical and digital elements on a canvas that sits in front of the screen.

HP released a software development kit for Sprout that allows others to develop applications for it. A few big names, such as Evernote and Martha Stewart, have already developed apps for the platform.

Sprout launched in November, and though it is initially targeted toward artists and consumers, Weisler said the platform will eventually be extended to education and commercial applications. It's easy to imagine design engineers placing a part on the canvas to work with at the conceptual stage, or even exploring a CAD model with their hands using Sprout.

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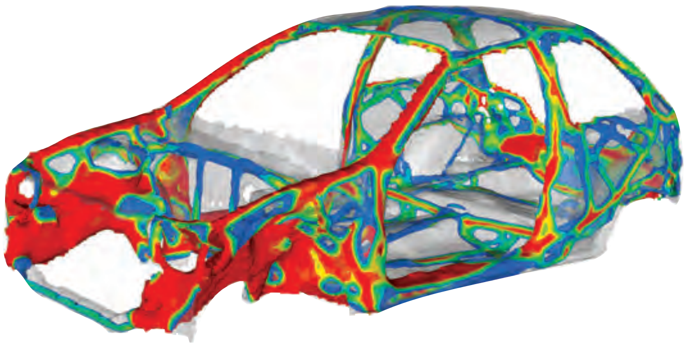
Optimization Drives Design

Optimize every stage of product development with an integrated workflow that democratizes simulation and analysis.



Altair OptiStruct is a proven structural analysis solver that can be used for complex linear and non-linear problems under static and dynamic loads.

There's no question that simulation-driven design has dramatically altered the engineering landscape, helping companies condense development cycles, better refine products, and greatly diminish costs.

Optimization is the next logical step, driving a paradigm shift that replaces trial and error engineering with a new way of thinking about design problems. In lieu of the traditional iterative process in which engineers create, test, and validate designs only to identify problems, make changes, and start all over again, optimization-led design challenges engineers to formulate problems in a different manner. By following a systematic set of steps—from identifying what could change as well as the design goals and non-negotiable requirements—optimization leads organizations down a different path. It leads them toward greater innovation, the exploration of lightweighting opportunities and the discovery of potential failure modes that might not be visible to the average design engineer.

However, the dynamic duo of simulation and optimization has primarily been limited to domain experts, often only tapped mid-stream or later in the design cycle. Limited access to these tools and proven design practices compounds the highly iterative and time-consuming design process, requiring multiple hand-offs between design engineers and CAE specialists, which does little to streamline workflows or help teams achieve optimal results.

What if organizations could break this cycle, bringing simulation and optimization to the wider pool of non-experts? By putting these practices well within reach of mainstream design engineers, not just domain specialists, companies could unleash the power of optimization-driven design throughout the entire development process, particularly during the early design stages when it's easier and less expensive to make changes.

Optimizing early provides a variety of benefits. Design concepts are more likely to meet requirements, minimizing the back and forth between team members. Optimizing during the early concept stage also gives engineering organizations a jump-start on identifying optimal structure, system, materials distribution, and weight targets while improving safety, durability, and other performance attributes. The end result is a streamlined development process, which cuts back on costly prototypes and ensures aggressive time-to-delivery objectives are met.

Barriers to Mainstream Adoption

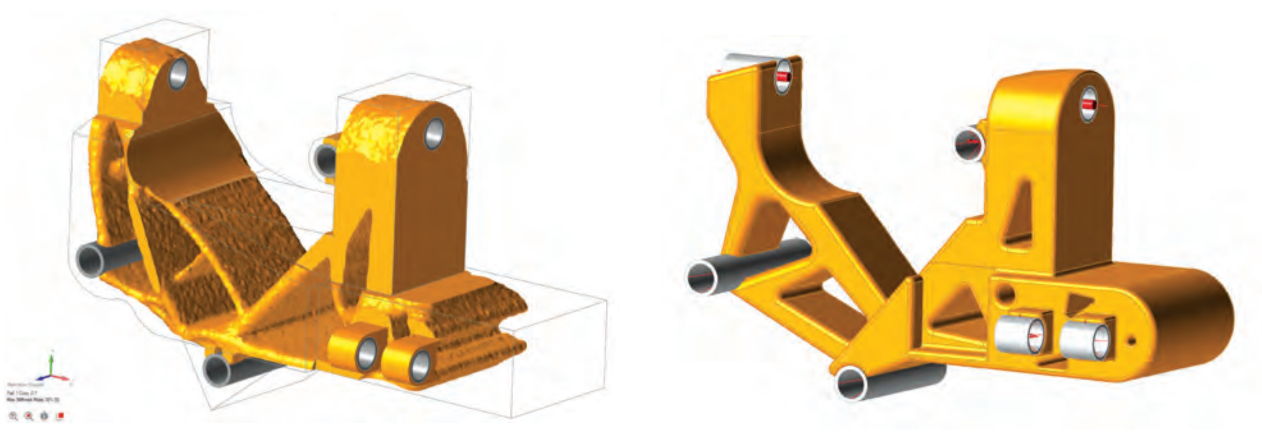
Despite the many benefits, there have been long-standing barriers to the adoption of early-stage simulation and optimization as a mainstream practice. Time is a major hurdle for most organizations, which are under constant pressure to compress development cycles to stay abreast of the competition. Without access to the proper tools, moving to an optimization-driven design culture is a challenge for most organizations, which are already struggling to release products in a timely fashion.

In addition, existing simulation and optimization tools are primarily tuned for an expert audience, not the mainstream user. Most simulation and optimization offerings wrap highly sophisticated functionality in a complicated user interface that is out of reach for the average design engineer, who doesn't have the time or the inclination to master the tools let alone learn highly specialized skills.

The "2013 Simulation-Driven Design" study, conducted by Lifecycle Insights, highlights many of these challenges. Sixty-one percent of respondents to the survey said their simulation analysts do not have enough time to run simulations frequently enough, with more than half (53%) claiming their fast-moving design cycles just can't accommodate a protracted simulation process.

Nevertheless, organizations' enthusiasm for simulation- and optimization-based concept design is not dampened by these challenges. According to the Lifecycle Insights survey, 70% of survey respondents called the practice essential for avoiding development delays and reducing the costs associated with testing, prototyping and change orders. Almost half (48%) said simulation and optimization were instrumental for

Altair's solidThinking Inspire can be used to 1. import or sketch a part, 2. defeature it, 3. assign materials and loads, and 4. then generate an ideal shape with the click of a button using mathematical optimization. Once a shape has been optimized, Inspire can help 5. confirm the part's performance so that the part can be 6. refined in a CAD program.



Using Inspire, an engineer can iterate an optimized concept like the trunnion on the left, which can be the impetus to create the final, functional design (right).

lowering product costs, helping to reduce material requirements and allowing for the specification and purchase of right-sized components.

Optimization-Ready Solvers for All Stakeholders

Altair, a leader in the simulation and optimization space, is committed to changing the dynamic. The company has set its sights on opening up simulation and optimization practices to mainstream engineers, fostering their use throughout the entire development workflow.

For traditional CAE experts, Altair offers OptiStruct, a proven structural analysis solver that tackles complex linear and non-linear problems under both static and dynamic loads. With its built-in finite element and multi-body dynamics technology combined with advanced optimization algorithms, OptiStruct lets engineers analyze and optimize structures and mechanisms for their strength, durability and noise, vibration, and harshness (NVH) characteristics.

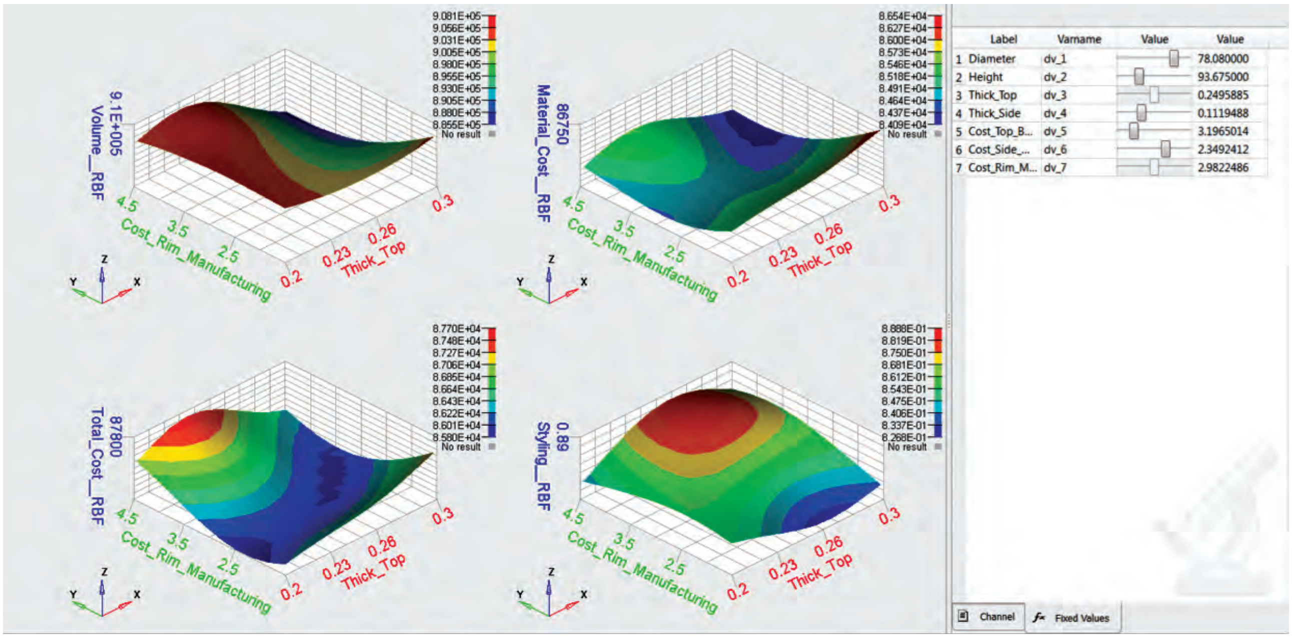
While OptiStruct has the muscle to tackle the most complex design problems, Altair's solidThinking Inspire unleashes the power of simulation and optimization on a far simpler scale. Built on the same algorithms and optimization kernel as OptiStruct, Inspire masks the complexity surrounding simulation and optimization and makes it palatable for a less simulation-savvy audience. For example, the software treats tasks like creating meshes and boundary conditions in a way that's familiar to non-experts so they can immediately dive in. Through its intuitive user interface, Inspire performs such tasks with the click of a button, opening up a world of optimization possibilities for design engineers without any handholding or direction from time-strapped simulation experts.

In addition to its intuitive user interface, Inspire delivers simulation and optimization capabilities that meet the needs of design engineers. It can depict stress distribution, displacement, or deformation characteristics like traditional CAE tools, plus Inspire helps design engineers determine the optimal load path and where materials can be removed to improve the design.

Key to this ability are Inspire's concept generation techniques, which find the best material distribution in a design space for a given set of loads. With Inspire, engineers simply define a design space that represents the volume where a design could exist, and establish the loads and other boundary conditions. The software figures out the optimal shape via mathematical optimization.

Inspire's free-form shape approach is in direct contrast to CAD tools, which work with parametric shapes defined by parameters such as length or diameter. While shape dimensions can be varied using CAD solutions, the overall shape remains constant, diminishing how far teams can go with optimization. In comparison, Inspire helps design engineers easily identify the optimal shape that balances the greatest strength with the least amount of material—all via a few mouse clicks.

Put to work in the early concept stage, Inspire's topology optimization capabilities help ensure the design process starts with a concept that comes very close to established performance targets. This helps to dramatically reduce overall development time, provides a more cost-effective way to study multiple concept possibilities, and zeros in on material-optimized designs that weigh less and cost less.



Altair HyperStudy helps engineering teams examine trade-offs among multiple disciplines to understand the ramifications their decisions will have on the entire system.

A Continuous Optimization Workflow

The real promise of Altair's simulation and optimization strategy comes when OptiStruct and Inspire are used by both sets of users as part of a continuous engineering workflow. Design engineers can work with Inspire to come up with concepts that meet basic performance requirements, while CAE experts pick up where they leave off, leveraging OptiStruct's more advanced functionality like non-linear optimization to further refine designs. To complete the picture, Altair offers HyperStudy, a multi-disciplinary design tool that provides optimization and design-of-experiment functionality to help engineering teams examine trade-offs among multiple disciplines like fluid or multi-body dynamics.

In the early stages of a new design, many factors need to be considered, such as weight, fuel consumption, packaging, structural performance, ride and handling, cabin noise and vibration. The requirements of these factors often conflict with each other, and it is not easy to find the right tradeoff between the wish lists, market requirements, and compulsory regulations. To find the right system design, engineers need to explore design alternatives for the entire system and understand the trade-offs. Once a design alternative that strikes an acceptable balance is identified, targets can be cascaded to sub-systems and components for further optimization. In this scenario, HyperStudy plays a role in creating the trade-off curves, and OptiStruct and Inspire handle the structural sub-system and component concept design and optimization.

Polaris, a snowmobile manufacturer, is one company driving efficiencies and design improvements throughout its engineering workflow thanks to the use of OptiStruct and Inspire. On a specific chassis project with pretty rigorous weight reduction goals, Inspire was tapped during the concept stage to quickly identify the basic shape and engineering, while OptiStruct was brought in to refine the shape for manufacturability and stress requirements. Inspire and OptiStruct were also paired to help evaluate the weight-reduction potential of using aluminum as a substitute for steel in several subassembly structures.

Not only did OptiStruct and Inspire help Polaris engineers substantially reduce the weight of the structures, it also greatly reduced the number of design iterations—going from 10 to 12 cycles with the traditional CAD/FEA loop down to five or six with Altair's optimization-infused analysis tools.

As Polaris and others are fast discovering, simulation and optimization work best as an integrated team that is put to use continually throughout the design workflow. By democratizing the practices so they are within reach of mainstream engineers, not just experts, companies can achieve dramatic engineering efficiencies that will steer them on a course to greater innovation.

For more information, visit Altair.com/optimize.

Optimization Timeline

1985 Altair is founded in Southfield, MI, focused on engineering consulting.

1993 Jeff Brennan joins Altair from the University of Michigan, and a collaboration between the two entities gives birth to OptiStruct, Altair's breakthrough optimization technology that finds the best material distribution in a design space for a given load.

1996 Altair takes development in house and renowned optimization experts Harold Thomas and Yaw-Kang Shyy join the firm. Nine months later, the first version of the new generation of OptiStruct is released.

1999 Altair releases the HyperWorks CAE suite with an innovative pay-per-user licensing model.

2002 Airbus engages Altair to weight optimize the Airbus A380 aircraft wing ribs and soon after, Boeing adopts the technology.

2006 Altair acquires Mecalog Group, adding the RADIOSS structural analysis solver for highly non-linear problems to its HyperWorks CAE suite.

2008 Altair opens the first Optimization Center in Toulouse, France, where Altair consulting engineers work with Airbus engineers to solve weight reduction challenges.

2009 Altair adds solidThinking Inspire to its portfolio, providing a tool that lets design engineers quickly and easily investigate structurally efficient concepts.

2011 Through acquisition, Altair fleshes out its HyperWorks suite with AcuSolve, a general-purpose CFD solver.

2014 HyperWorks 13.0 and Inspire 2014 is released.

Chasing a Dream

Dream Chaser on the runway at NASA's Dryden Flight Research Center in Edwards, CA. *Image courtesy of NASA.*

Sierra Nevada Corp.'s Dream Team works together on an international effort to bring back a shuttle-like spacecraft.

BY JAMIE J. GOOCH

Mankind has been living in space continuously for 14 years. The International Space Station's (ISS') first module launched atop a Russian Proton rocket in 1998. Less than a month later, Space Shuttle Endeavor delivered the next module, which began the biggest single construction job in human history — ultimately combining resources from the U.S., Russian, European, Canadian and Japanese space agencies. Now roughly the size of a football field, the ISS has been visited by more than 200 astronauts from 14 countries.

But America hasn't transported any of those astronauts since the space shuttle was retired more than three years ago. The return of Atlantis from the ISS in 2011 marked the end of 30 years of space shuttle missions. Fifty years after Alan Shepard became the first American and second person to travel to space, all manned space flights to the ISS became dependent on Russian Soyuz spacecraft.

Space Shuttle 2.0

The shuttle's retirement coincided with the success of NASA's Commercial Orbital Transportation Services (COTS) program, which incentivizes private companies to develop space vehicles to deliver cargo into low orbit, and the start of the related Commercial Crew Program (CCP) to do the same for manned spaceflight.

The privatization writing was on the wall well before the last shuttle launched. A California company named SpaceDev, known for its work with microsatellites and rocket motors, wanted in on the trend.

"We started thinking, 'What would you do if you were going to recreate the shuttle?'" recalls Mark Sirangelo, who was chairman and CEO of SpaceDev before it merged with Sierra Nevada Corp. (SNC) in 2008. Sirangelo is now corporate VP of SNC's Space Systems. "We didn't have a lot of resources, so we looked for previous vehicles that would fit the bill."

Sirangelo found what he calls the company's "space utility vehicle" under a tarp in the corner of a hangar in NASA's Langley Research Center in Hampton, VA. The HL-20 was a spaceplane concept that would be able to land horizontally on conventional runways. It had initially been developed to augment the space shuttle when NASA planned to have up to 10 crewmembers manning the ISS. The idea was to use it as a rescue vehicle for the crew, but it was scrapped when NASA decided not to man the ISS with that many crewmembers.

The mockup in the hangar was created as part of a cooperative agreement among NASA, North Carolina State University and North Carolina A&T University. It had been used for physical crew testing, ensuring all crewmembers could board and operate the vehicle in their spacesuits. What was most attractive to Sirangelo, however, were the 1,200 wind tunnel tests Rockwell International's Space Systems Division had performed on the design. All told, the HL-20 hid more than nine years of engineering development under that tarp.

"In the light of a new day and new thinking process, we went in and made two critical decisions," Sirangelo says. "One: Let's take a vehicle that already had almost 10 years of work on its outer mold line and a lifting body design that has 20 years of development; and two, let's mate it with an existing rocket, the Atlas V."

Those decisions saved significant time and money vs. starting from scratch, but the HL-20 was still just a platform. It had no avionics, life support or propulsion systems, nor did it have any of the software required for command and control, rendezvous or docking. To create what would become the Dream Chaser reusable spacecraft, SNC decided to form a Dream Team.

Balancing Collaboration and Complication

"We've taken the approach on Dream Chaser that we prefer to team up and integrate technology rather than being vertically integrated," says John Roth, VP of Business Development at SNC's Space Systems. Roth was formerly president of MicroSat Systems Inc. before it was acquired by SNC in 2008. "Some companies try to develop all the technology themselves. We take the tack that we're not experts in everything."

The Dream Chaser Dream Team consists of aerospace industry members, including Lockheed Martin, United Launch Alliance, Draper Laboratory, Aerojet Rocketdyne, MacDonald Dettwiler & Associates Ltd., UTC Aerospace Systems, Jacobs, Moog Broad Reach, Siemens PLM Software, Southwest Research Institute, and many others. SNC is also working with nine U.S. universities and nine NASA Centers and facilities. Finally, the company has established cooperative agreements with the European Space Agency (ESA), the German Aerospace Center (DLR), and the Japanese Aerospace Exploration Agency (JAXA) to explore potential low-Earth orbit missions, following the model of global cooperation set by the ISS.

The Dream Team simplifies the Dream Chaser development by not re-inventing the wheel — or, in this case, the rocket. "We use subsystems and technology that have heritage," Sirangelo says. "Simplicity comes in a lot of forms. In my world, simplicity is focusing on things that need to be created, not on creating something someone else has already made."

Bringing existing technology experts together allows SNC to shorten its development time, and working with other space agencies on their programs enables the company to diversify the Dream Chaser platform. SNC has won more than $337 million in contracts and awards from NASA for crew transportation development, but Boeing and SpaceX

The lifting-body design of Sierra Nevada Corp.'s Dream Chaser enables it to potentially land on any commercial runway and draws comparisons with the space shuttle. *Image courtesy of SNC.*

were ultimately chosen to continue in the CCP to potentially taxi astronauts to the ISS as early as 2017.

However, variants of the Dream Chaser could be used for cargo missions, grappling and removing space debris, and conducting scientific experiments for NASA, ESA, DLR, JAXA or private companies. Multiple partners and objectives boost the vehicle's flexibility, but also increase the danger of adding collaboration complications to an already complex engineering workflow.

In addition to the multi-CAD environments represented in the Dream Team, SNC itself is divided into six different business units. Even within the Space System business, which was formed in part by a number of acquisitions, different engineers are accustomed to using different design engineering software.

Bringing all of those engineering teams together exposed some weaknesses in working with large computer-aided design files, Roth says.

"We found out right away that there were some big limitations in some of the CAD packages," he adds. "Just the size of Dream Chaser CAD models and complexity with life support, avionics, etc., was way more complicated than a satellite system, for instance. That's how we settled on the NX platform."

Simulation-led Design

Roth says SNC realized a 20% time savings using Siemens PLM Software's NX integrated product design, engineering and manufacturing software. "In other products, CAD models took forever to load, save and manipulate," he says, noting that system crashes were a common occurrence. "It was a big complaint from the engineers."

John Curry, senior director and co-program manager of SNC's Dream Chaser program, supports Roth's viewpoint. Curry is a former Space Shuttle and Space Station Flight Director from NASA. He joined SNC in 2010 to lead Dream Chaser's integrated systems design, development, test and evaluation efforts.

Curry says simulation-led design is the key to reducing costs while improving safety.

"We want to (send people into space) 10 times more safely at 1/20th of the previous cost," he says. "Doing rapid prototyping via simulation first is a faster path."

But that path was being obstructed by the file sizes required.

"Our CFD (computational fluid dynamics) file sizes are 10s of megabytes to 10s of gigabytes in size," he says. "On the CAD side, the current top assembly takes about 8GB of memory on my machine. When I export it into STEP (Standard for the Exchange of Product model data) files, the top assembly is nearing 2GB of total data. We have over 8,000 parts in our current top assembly."

SNC uses files in the STEP format to share models with its partners who are using different CAD software. Internally, the company uses NX for CAD and for pre- and post-processing of computer-aided engineering (CAE) files, with Nastran as its solver. Siemens' Teamcenter is used to manage CAE and design data.

"All the stuff we do in terms of how work proceeds is done in design cycles," Curry says. "All requirements have to sync at the same time. Efficiency is critical, and we can't afford to make mistakes."

Heritage and Humanity

The recent tragedy that led to the death and injury of Virgin Galactic's SpaceShipTwo test pilots, underscored by the self-destruction of Orbital Sciences' Antares rocket just after its October launch, illustrate why mistakes are not an option in spaceflight.

In SNC's case, there is currently only one Dream Chaser that is being used for testing.

"We pushed a lot of our hardware requirements upfront," Sirangelo says. "The Space Shuttle Enterprise flew five times, and never went into orbit. We followed that path of building a vehicle for testing."

Sirangelo says SNC is proud of the Dream Chaser's space shuttle heritage, but new software technology adds functionality and complexity that shuttle engineers didn't encounter.

"In effect, we are creating something that has never been done," he says. "The space shuttle has flown 135 times, but it was not a software-driven vehicle. I have more software power in my laptop than the space shuttle had. While the general perception is that we're a smaller, more efficient version of the space shuttle, the truth is it's a completely different type of vehicle."

The Dream Chaser requires fully autonomous flight. SNC, which was responsible for the final minute of the so-called "seven minutes of terror" that allowed the Mars Rover Curiosity to land, is familiar with the demands and complexity of robotic flight.

NX Nastran is used to run numerous analyses on the global FEM. All operational environments and load cases are evaluated to ensure structural strength and stability across the entire platform. *Image courtesy of SNC.*

"It's not just the software, it's how the software integrates with all the other things that need to happen," Sirangelo says. As an example, he calls out Dream Chaser software that could predict the weather so that it can direct hardware to correct for wind gusts — all while traveling at 17,500 mph. That's a decision humans can't make fast enough.

But to develop that software as part of a complex system, relationships are key. To ensure all of the Dream Team members finish their design cycle requirements at the same time might require one partner to work overtime or change gears. "It requires more than just technology," says Sirangelo. "It requires good relationships with partners so they'll push ahead when needed."

He says success is dependent upon being able to build relationships where everyone has common view. When used in an efficient workflow, the design engineering technology — from CAD, simulation and visualization software to workstations and prototypes — support that common vision.

"Transparency makes simplicity," Sirangelo says. "The technology tools we use enable the transparency that allows simulation-led design to begin earlier." **DE**

Jamie J. Gooch *is editorial director of* DE. *Send e-mail about this article to DE-Editors@deskeng.com*

INFO ➜ NASA: NASA.gov

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

➜ **Sierra Nevada Corp.:** SNcorp.com

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

Lockheed **Tackles** Test Data Complexity

Data management software helps accelerate test data analysis on F-35 program.

BY BRIAN ALBRIGHT

Managing design test data can be a complex and arduous process. Managing test data for a massive, multi-billion-dollar, multi-national aerospace project is an even more monumental task, but one that is manageable with the right tools.

Lockheed Martin's F-35 Lightning II Joint Strike Fighter (JSF) program is tackling just such a massive data challenge as it performs full-scale testing on aircraft airframes to ensure they meet life design requirements. With specialized software tools, the company has been able to provide deliverables ahead of schedule — an important achievement, particularly in a program that is almost as well known for its delays as its technological innovation.

The F-35 Lightning II Joint Strike Fighter is shown during a test flight. *Images courtesy of Lockheed Martin.*

In fact, the F-35 static and durability testing program is bigger than any program in the history of Lockheed, and is being performed faster rate than historical programs thanks to the use of nCode Automation and Glyphworks software. The tools have helped Lockheed manage the complexity involved with accessing, sharing and acting upon test data to improve and modify designs.

"These large scale tests generate tremendous amounts of data that must be monitored and stored for assessment," says Marguerite Christian, senior manager, F-35 SD Structures Test IPT at Lockheed. "In support of this testing, nCode Glyphworks is used in association with nCode Automation to store and process static and durability test data. These tests are a key element of the structural certification of the airframe design."

According to Chris Gray, applications engineer at nCode, the tests at Lockheed generate too much data to be managed manually. "In typical, non-aerospace implementations, tests might generate 200 channels or parameters," Gray says. "Lockheed is generating anywhere from 1,800 to 3,000 channels."

The nCode software is used to analyze and manage data from static tests that apply worst case loading conditions, and durability tests that repeat the loading of thousands of load steps to replicate several lifetimes of the aircraft in service.

Since 2006, Lockheed has used nCode Automation to help engineers manage, search for, access and examine key F-35 test data. Engineers can download data sets on demand and report back results. Engineers are also able to share data with other project partners, and perform automated time, frequency, statistical and fatigue analyses.

The company uses Glyphworks, a test data analysis system for durability and fatigue analysis, to evaluate how behavior of the structures have changed over time, which could indicate cracks or other system issues.

Monitoring Thousands of Channels

Lockheed uses the nCode software to help manage data from two types of tests: static and durability. In the static tests, the aircraft are exposed to certain loads to simulate the types of loads experienced if a pilot would bank left, for example. The load is applied for a period of time while measurements are taken. In the durability tests, the load conditions change at a faster rate.

According to Christian, the static test articles utilized nCode Automation to store a combined 70GB of data for all three F-35 variants: F-35B (Short Take-Off and Vertical Landing), F-35A (Conventional Take-Off and Landing) and F-35C (Carrier Variant). Stress engineers in Texas, Georgia, California and the United Kingdom used HBM MD Client software to remotely monitor strain data in near real time throughout the test program.


In the F-35 program, Lockheed Martin uses nCode software to store, analyze and manage data.

"Using the processed data from MD Client the engineers monitored each test and when warranted, issued a pause or abort command to help safeguard the test," Christian says. "Each static test simulated a different load case such as the air pressure and inertia loads encountered in flight during high-g pull-ups, negative-g push-overs, and roll maneuvers."

A series of approximately 150 test conditions applied loads at different levels: 60% design limit load, 115% design limit load and 150% design limit load (ultimate load). Each full-scale static test article had more than 3,000 channels of data monitored and recorded. nCode Automation served as a data warehouse during the F-35 static testing and is the software product used for the F-35 durability tests currently in progress.

The durability test articles use nCode Automation and nCode Glyphworks to store and process data for all three

New Model Aids Machining of Composite Components for F-35

Among the design innovations featured in the F-35 Joint Strike Fighter aircraft are components made of composite materials. Last year, Third Wave Systems was awarded a contract by the United States Air Force Life Cycle Management Center to expand its machining modeling technology to composite materials used on the airplane.

Under the $3 million contract, the company will develop a physics-based machining model of the Cycom 5250-4 bismaleimide (BMI) material used on a fan inlet case from GKN Aerospace. Third Wave will also work with airframe builders Triumph Group and Northrop Grumman, along with machining supplier Janicki Industries, to perform similar activities for the Cycom 977-3 and AFR-PE-4 resin systems.

"The machining operations are the last operations in production," says Troy Marusich, chief technical officer at Third Wave. "The composites are abrasive and the tools wear out quickly, and when you have tool wear the composite can splinter, fray and delaminate. These are expensive parts and difficult to repair and to make conforming once you introduce defects at the machining stage."

Third Wave is modeling the machining process to better understand how cutters can be redesigned. "We can evaluate the new designs digitally and modify them based on our predictive models, so when we make a prototype we have a higher degree of confidence that they can see improvements through the cutter design," Marusich says. "We're also predicting the amount of wear that the design would experience, and then improving it so the tools don't wear out as quickly."

Third Wave received a $2.1 million Phase II SBIR (Small Business Innovation Research) project in 2008 through the U.S. Naval Air Systems Command to implement high-performance machining technologies in the V-22 and F-35 programs. For the V-22 program, Third Wave partnered with Bell Helicopter and NAVAIR suppliers to improve the production of titanium-based structures through analysis of cycle times and cutting forces. For the F-35, the company analyzed existing machining practices to reduce distortion seen when machining forged aluminum bulkhead components.

Having a full-scale composite machining modeling software helps reduce costs and manufacturing times, and improve component quality. Third Wave estimates that the solution could reduce composite machining times by 20 to 35% and tooling costs by 20%.Once completed, the model could be used for a variety of composite materials across the Department of Defense supply base.

"There are also ceramic matrix composites that could benefit as well, and that would be for high-temperature applications like in a jet engine," he adds. "That would enable new components for jet engines, which could reduce costs and make the engine more efficient."

F-35 variants. Each test article includes 1,800 to 2,000 channels of strain gage data. Depending on the type of spectrum applied, a series of nine to 15 Glyphworks flows are processed daily to translate raw data and collate lists of channels to assess against pre-defined criteria.

The Glyphworks flows capture maximum and minimum strain levels and compute average values, standard deviation and slope for load cases that repeat throughout the load spectrum.

"Any drift or step change in the strain data is flagged by Glyphworks, which compares the most recent data to historical data collected as the test is running," Christian says. "Test data for lists of flagged channels are reviewed visually using Glyphworks to identify areas of concern that require further evaluation and inspection."

The output and plots generated by Glyphworks flows are then compiled at the end of each test block and presented in reviews with engineering and customer personnel.

The software has allowed the company to perform the post processing of more than 4,000 channels of test data much faster than under legacy programs, the company says. The full airframe and HT component test for F-35A and F-35B variants were completed five months ahead of baseline schedules thanks to this faster processing capability. The schedule savings allowed incorporation of expanded capability tests without impacting flight clearance support.

The solution has also provided a common format for partner teams in other geographies to assist with mitigation and resolution of any test anomalies, which reduces down time and saves costs.

"It's also completely repeatable," Gray says. "There's no human element in the statistical analysis."

Lockheed is effectively managing the analysis of test data that would otherwise be impossible without an army of full-time engineers. In fact, it's doing so with a degree of speed and accuracy that would be unattainable using manual analysis.

"The nCode software products have proven to be essential enablers to efficiently execute these critical large scale F-35 structural tests," Christian says. **DE**

Brian Albright *is a contributing editor to* Desktop Engineering. *Send e-mail about this article to DE-Editors@deskeng.com.*

INFO ➜ **Joint Strike Fighter:** jsf.mil

➜ **Lockheed Martin:** lockheedmartin.com/us/products/f35.html

➜ **nCode:** ncode.com

➜ **Third Wave Systems:** thirdwavesys.com

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Testing Rolls into Early-Stage Design

Testing is moving out of its silo and into the early design workflow to help minimize costly, late-stage design changes.

BY BETH STACKPOLE

Test early and often is the latest battle cry for engineering organizations aiming to be on the cutting edge. As a result, they're making testing an integral part of early-stage design, just as they've done with simulation.

Embracing simulation earlier as a means to facilitate design exploration as opposed to design validation is all part of the push to shorten cycle times, reduce costs and bolster innovation. With that movement well under way, some companies have turned their attention to testing, recognizing the potential for similar benefits by shifting what has traditionally been a late-stage task into the concept and detailed design phase.

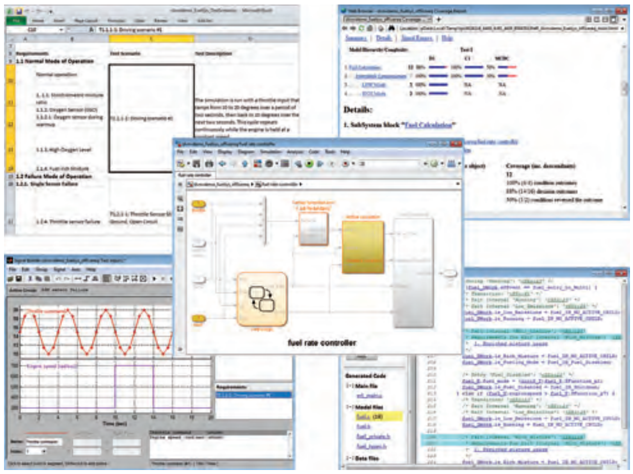
"Aside from manufacturing, testing is the second most expensive aspect of the entire product development timeline," says Dawn Lissy, president and founder of Empirical Testing Corp., a lab focusing exclusively on medical device testing. "When you have time and money involved, it's imperative to do it correctly and do it at the beginning stage of design."

While the aerospace and automotive sector practice a more parallel design and test path, other industries with less complex products have been slower to follow suit. Now that all types of products are becoming more complex, equipped with built-in sensors and flush with embedded software systems, companies have more at stake if problems surface too late in the game.

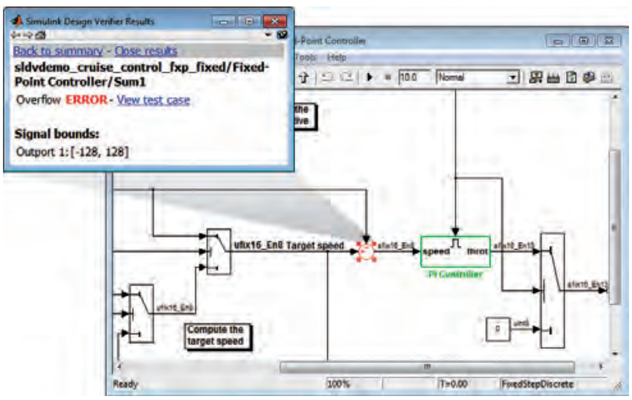
"Not so long ago, you could put a car together and drive it around the test track," says Paul Barnard, marketing director, Design Automation at MathWorks. "That development process works well when you have relatively little electronics involved or don't have any critical safety systems, but as soon as you start dealing with high complexity, the equation changes. It's just a lot easier and less expensive to fix problems if you can find them early in the process. It's all about working out requirements and ensuring things are designed right from the beginning."

Sequential Processes and Silos Keep Testing Off Track

Traditionally, the test-development phase kicks off when the design is complete. Testing has remained isolated, and team members are typically handed specifications and test requirements over the proverbial wall, only after the design is well underway.



Simulating systems with modeling tools such as Simulink Verification and Validation helps facilitate upfront testing. *Images courtesy of MathWorks.*



Tools like Simulink Design Verifier from MathWorks can be used for error detection in a model as part of a comprehensive upfront testing plan.

This strategy of treating testing as a sequential, not parallel process to design, is problematic on a variety of levels. Project deadlines are likely to slip, putting pressure on engineering teams to consolidate the testing process to save time, which can lead to quality issues. Moreover, a lack of collaboration between design and test engineers means test strategies may not be entirely in sync with product requirements and objectives. It also reduces the potential for reusing test strategies and plans for future products.

Some of the silo mentality is due to the fact that test equipment is often not easily connected to Windows-based enterprise systems or platforms like PLM (product lifecycle management) and requirements systems, notes Kyle Perkuhn, product marketing engineer at National Instruments. "The biggest problem with being siloed is having to manually communicate everything, which can delay the project schedule," he explains. "There is a lot of manual communication that has to happen both in and out of test engineering because it's so disjointed from those platforms."

Often times, early testing is discouraged because companies are leery of putting prototype hardware through its paces, according to Gary Delserro, president of Delserro Engineering, a reliability test lab that specializes in automotive, defense and aerospace product testing. "Many of our clients do early testing and many don't," says Delserro. "The biggest fear for those that don't is that they are working with an immature product or prototype so if they get a failure, it might not be a meaningful failure."

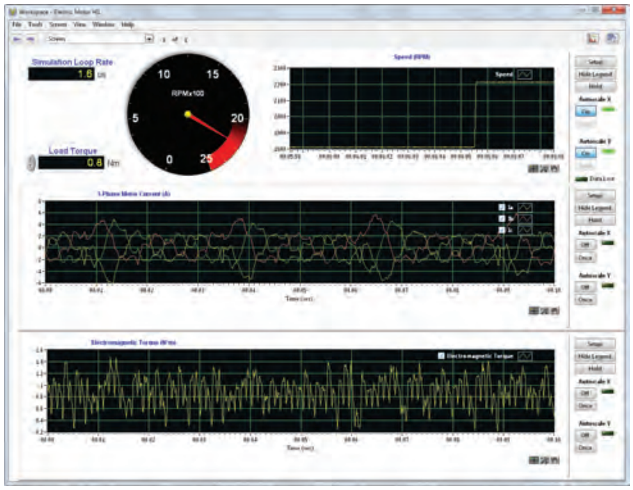
System Modeling Drives Earlier Testing

Cultural issues aside, there are a variety of new technologies that are advancing testing's role further up in the design process. The growing use of simulation and modeling software is a huge enabler, allowing product development teams to test the behavior of a particular part or a complete system in the virtual world, before any software code is actually written or a CAD model becomes a physical component.

MathWorks' Simulink Verification and Validation, and its Simulink Design Verifier are two such modeling tools that can play a role in early-stage testing, says Jay Abraham, MathWorks' product marketing manager for Verification and Validation. Simulink Verification and Validation, for example, connects the system model to requirements and ensures the model adheres to various modeling standards, while Simulink Design Verifier is used to prove out that a design meets the requisite requirements.

These tools can be used in lieu of waiting for code to be written or a physical system to test, Abraham explains, using a controller with a hydraulic actuator as an example. "If you build a system model that includes a model of the actuator, you can run tests to gauge the bandwidth or response time of that actuator," he says. When the final system is built, you can employ the same test using hardware-in-the-loop simulation, "but you get the benefit of not waiting to get the code before running it on the hardware."

Performing this kind of system modeling and system testing also helps break down the silo culture that has kept testing on the front-line design fringes. "We talk to our customers about



Thanks to its ability to import simulation models from a variety of leading modeling environments, National Instruments' VeriStand can simulate system components, which aids the testing process. ***Image courtesy of National Instruments.***

using these system-level models because they tend to pull domains of expertise together," Abraham says.

From a hardware perspective, some things lend themselves to early testing. For example, failure analysis or testing that exposes product weaknesses should definitely be done earlier in the design phase when it's less expensive to fix a problem, says Delserro. In contrast, some reliability tests set up to measure how long a product might last in the field aren't the best candidates for testing too early in the prototype stage.

Education about the time and place for testing remains a top priority, Empirical Testing's Lissy says. It's a constant struggle to get companies to understand how long the testing process can take, she explains, as well as why they shouldn't cut back on testing despite on-going pressures to shrink development cycles.

"A lot of people don't understand how long testing takes, especially if you don't have the right parts or right amount of parts or if something doesn't go to plan," she says. "Everyone ends up pushing to extend the product design timeline, but when it comes to testing, they all want to hurry up. You need a high level of communication to ensure you come up with the best test plan that balances the risk profile — in other words, the right test solution for the problem at hand." **DE**

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

INFO ➜ Delserro Engineering Solutions: DESolutions.com

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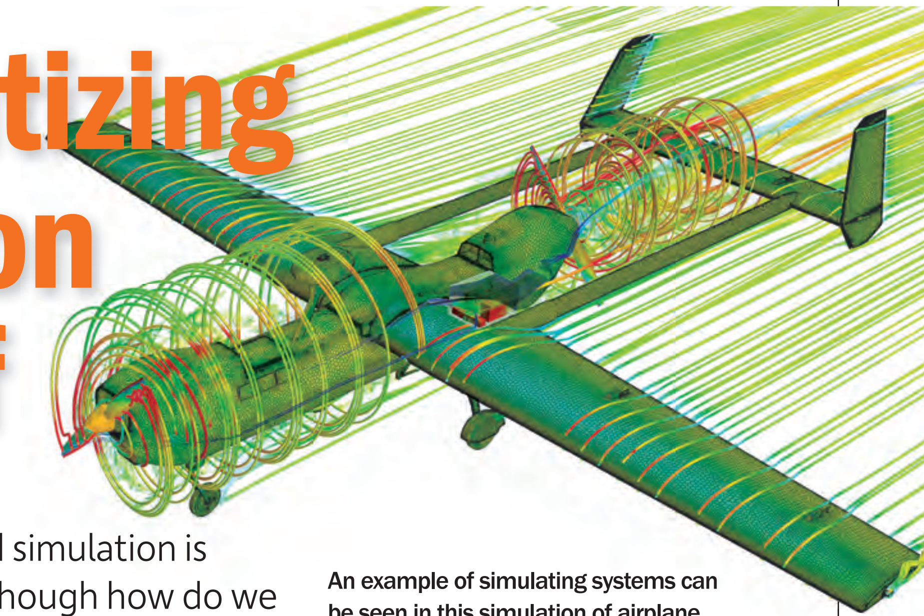
Democratizing Simulation Takes Off



An example of simulating systems can be seen in this simulation of airplane streamlines. *Image courtesy of CD-adapco.*

The technology for analysis and simulation is becoming more accessible — though how do we close the gap between analysts and engineers?

BY MARK CLARKSON

About 20 years ago, the CEO of a major simulation application developer told me simulation was most definitely not for the masses, and that the very idea was risible. Since every simulation a designer did would have to be re-done by a specialist who actually understood how to set up the analysis, it was an utter waste of time.

While I didn't agree then — and certainly don't agree now — he wasn't entirely wrong for the time. Computer hardware wasn't up to the task. Computer software wasn't up to the task. And, frankly, most designers weren't up to the task either.

"We created a product called Hypershape Pro back in 1996," says solidThinking President Jim Hassberger. "It was our OptiStruct FEA solver inside the Pro/E environment, which would allow designers to leverage simulation and, specifically, topology optimization, to improve their design process. It [was] met with a lot of challenges — the biggest was that designers at that time […] weren't, for the most part, degreed engineers. They struggled to understand loading, and to know what their loads were, and companies weren't set up so that designers were a part of that process. The market wasn't ready for it and companies weren't structured to take advantage of it."

These days, designers are likely to be degreed engineers. In fact, it is often the young engineers who are introducing new tools to small and medium-sized companies. And larger companies are set up differently, says Hassberger, with different disciplines working together in teams.

"We all as a community have lived with the requirements that simulation has demanded over the years," says David Vaughn, VP of Worldwide Marketing at CD-adapco. "Simuation has been used by experts out of necessity. It was complex. However, especially over the last 10 years, there's been a lot of progress made toward reducing the complexity of the software. I think we've come a long way."

Today's accepted wisdom, in contrast to that expressed 20 years ago, is that the sooner in your design process that you can leverage simulation, the better.

"If you can push decision making up front, the cost of changing the decision is significantly less," says Todd McDevitt, senior marketing manager at ANSYS. The sooner you know your design is going to fail, the cheaper it will be to fix the problem.

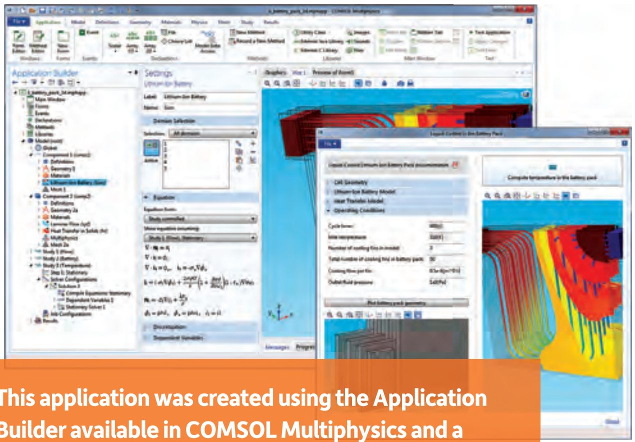
Today's companies are ready to embrace more upfront simulation. Computers are astronomically faster and the simulation software has evolved, becoming faster and, to some extent, easier to use. "Today, there's so much automation to help with setting up the analysis," says McDevitt. "The user environment is friendlier. Instead of using terms that speak to the mathematician, we make an effort to have the software speak to the engineer."

Make It Easy

You still have to know what you're trying to accomplish, of course. "I would emphasize that anyone doing [simulation] has to understand the engineering problem they're looking at," says Keith Meintjes, practice manager, Simulation and Analysis, at CIMdata. "The issue is that the simulation software can be very difficult to use. So, even though you understand the engineering problem, you're faced with software that can take years of training. The battle is to decrease the requirement for the application-specific knowledge that people need."

Vaughn says that battle between simplicity and necessary sophistication is still being fought.

"There are still two sides of the story," he says. "You do have to have some knowledge as a user to interpret the results. You



This application was created using the Application Builder available in COMSOL Multiphysics and a model of a Li-ion battery pack. The user can test different operating conditions, battery geometries, and other parameters in order to find the desired thermal behavior. *Image courtesy of COMSOL.*

have to understand the basic engineering problem to interpret the results. If an engineer is going to interpret aerodynamic results, he should know aerodynamics, but that's not to say he has to know CFD (computational fluid dynamics) algorithms."

The other side of the story depends on the software developer leading its customers through the best way to use the software. That doesn't mean the software should just be simplified, but that the customer has to understand how to harness the software's power in the best way to solve his/her particular simulation issue.

Simulate, Repeat

"People want to do more simulation, not just for validation at the end of the cycle, but iteratively," says Derreck Cooper, director of Simulation Products, Autodesk. "They want to try as many design variations as they can. Design engineers are exploring a lot more ideas before throwing them over the wall for validation. Before, they would do one or two designs and give them to the analysis guy. He would run the analysis and say, 'This is going to break.' The turn-around time could have been a week, because he's got everyone giving him designs to check." It doesn't take many iterations of this to become a serious bottleneck in your design cycle.

If a design engineer can identify and eliminate elementary design problems on his/her own, they'll be sending fewer bad parts on to analysis, freeing up analysts' time for more sophisticated work, such as validation at the end of the cycle. And that's good because those analysts tend to be expensive and busy and — let's be clear about this — will always be needed for critical validation and certification work. Putting simulation tools in the hands of designers in no way changes that.

"Simulation is a tool, like CAD or PLM (product lifecycle management software), to maximize productivity," says Vaughn. "It's very important, but at the end of the day it is a tool in the toolbox. Innovation comes from engineering design."

Build Me an Application

"The typical user of a simulation package like COMSOL Multiphysics," says Bjorn Sjodin, vice president of Product Management for COMSOL, "has a PhD or several years of experience just doing simulation modeling, and they have trained on their specific package. They are typically a scientist, high-level engineer or an academic researcher. They have a thorough understanding of the theory of simulation."

They're also bombarded with constant simulation requests from a much larger group of people in product development and production. "They send a result to a guy in production," says Sjodin, "but he comes back and tells them to change a parameter, run the simulation again and send it back." Repeat ad nauseam.

One solution is to conceal the complexities of simulation inside a friendly wrapper. "COMSOL's Application Builder lets the user take the simulation model and wrap a custom user interface around it," says Sjodin. "The result is an application with a simplified, dedicated user interface and some easy-to-understand results. The user of such an application doesn't need to know anything going on under the surface."

These applications can be deployed to a wide audience from designers to managers to vendors to that guy in production. Rather than change a parameter and ask for another run, says Sjodin, "they can do it themselves."

Templates, Wizards and More Tools

If you can't give designers a custom application, maybe you can give them a template. Wizards and smart templates provide a lot of welcome hand-holding. "Templates and wizards help the non-traditional user set up their analysis," says ANSYS' McDevitt. "A lot of organizations have a methods group that will further customize an application for their high volume analyses. Having tools that are customizable, that you can script, that are based on open standards, is important."

You can also embed simulation within designers' familiar tools. "Autodesk Nastran In-CAD," says Cooper, "puts NASTRAN FEA (finite element analysis) technology inside of Inventor and SolidWorks to allow designers and design engineers to simulate more physics in an embedded environment. You're now empowering engineers to do a lot of the standard engineering checks. Having access to simulation as part of the design process contributes to getting better designs out the door, faster."

You'll increasingly find simulation tools running quietly in the background — perhaps CFD (computational fluid dynamics) running behind a ductwork design or injection molding application, giving valuable feedback without requiring the designer to know much about how they work.

You filled out your template, ran your simulation, and your part failed. Now what? Simulation modeling isn't much good to you if it can't tell you where you went wrong.

"With solidThinking Inspire," says Andy Bartels, Inspire program manager, "we give the user the ability to take that original part and create a package space – the envelope where the part lives in the assembly. They apply loads and supports to that part, then run an optimization for mass, or maybe for stiffness. We will show exactly where to add material, or where to remove material. We've seen redesigns that double the stiffness of a part, purely through material layout: different holes, different rib locations, same material."

The resulting optimization isn't a finished part. "It's a better first initial guess for what that part will look like," says Bartels. The part based on that guess is much more likely to pass muster, come validation time.

Feeling Pressured? Try Community

Simulation modeling applications are expensive pieces of software. How will they become affordable to everybody? Vendors are answering with new pricing schemes, tiered, token-based and variously innovative. Companies are increasingly seeing simulation as a potential answer to many ills and are hungry for more.

And speaking of social media, "Vendors today are required to build a community," says Cooper, "[Communities] provide support from the vendors, but users are also helping one another. Sometimes, they're probably leveraging the knowledge of people that are competitive in their space. Building a community presence is critical to people being able to successfully use your software."

The upstream spread of simulation tools may take some of the burden off of analysts, but it's creating new responsibilities as well. "The companies that have been successful with this," says CIMdata's Meintjes, "have made the CAE experts responsible for the success of those who are less skilled." **DE**

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

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MSC *Rethinks* CAE Software with Apex

Company says its different approach to simulation software is already speeding up design studies.

BY PAMELA J. WATERMAN

In the world of mechanical analysis, the power of finite element analysis (FEA) software is extraordinary. However, the process of applying it has often been slow and linear. Create a CAD model, define materials, loads and boundary conditions, mesh the geometry, run the correct solver-type, troubleshoot any model errors that prevent successful analysis, study the results, modify the design geometry; repeat.

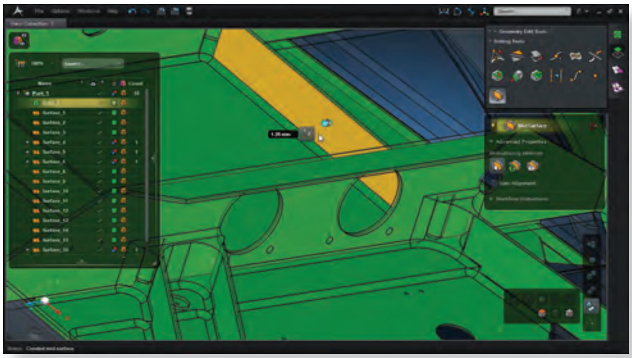
MSC Software has both compressed and expanded these steps with a new approach that helps users perform rapid "what-if" studies early to speed up conceptual designs. Its new MSC Apex family of software products, starting with MSC Apex Modeler and MSC Apex Structures, rearranges the traditional CAE process by simplifying model preparation, then combining what it calls computational parts and computational assemblies into mechanical systems that are quick to edit, share and rerun.

The company is responding to common complaints of design engineers trying to apply simulation in their workflow: the software is too hard to learn and use; cleaning up geometry and meshing takes too much time; moving models or results among designers, engineers and analysts is inefficient; simulation models are hardly ever useful to the full supply chain, and more.

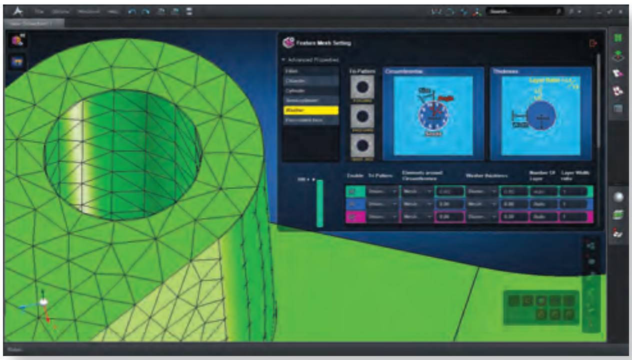
"With the MSC Apex Platform we created an environment with a unique user experience, that is easy-to-use, and easy-to-learn," says Hugues Jeancolas, MSC Software Apex product manager. "This ease-of-use is partly enabled by its unique CAE Specific Direct Modeling capability, and integrated solver methods."

Focusing on Ease and Speed

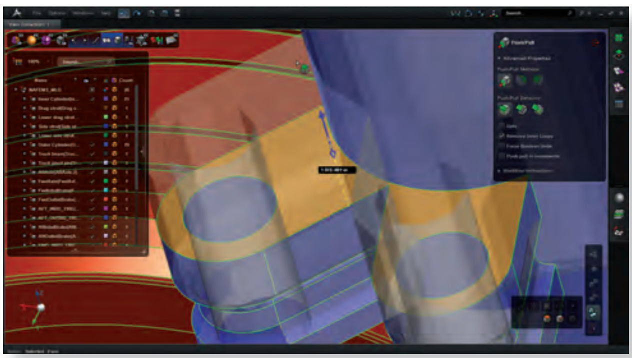
Simplifying the full CAD-to-mesh process is one of the goals of the MSC Apex system. From the very first step, users see a new look and feel for an analysis preparation user-interface. MSC Apex Modeler, launched in October, directly imports most standard CAD geometry file-types then operates with grab/move/release direct modeling for easy design geometry edits and repair. No pull-down menus or "OK" buttons are involved, relevant function icons are easily accessible from the surrounding frame, and a full-screen mode allows uncluttered views. Just as



With MSC Apex Modeler software, users can extract mid-surfaces from an imported CAD solid to prepare models for FE analysis. *Images courtesy of MSC Software.*



In MSC Apex Modeler, finite element mesh definitions can be set based on feature type and dimension.



MSC Apex Direct Modeling tools are designed to make editing geometry quick and easy.

important, the software supports fast de-featuring, recognition of chamfers and fillets, automatic extraction of mid-surfaces and multi-thickness surface model creation, all without going back to the original CAD package.

The MSC Apex system also saves time by validating each part prior to its use in an assembly then meshing the full assembly only once. When users make changes to the CAD geometry, the system automatically re-meshes just the portions of the geometry that changed, and displays the new mesh in real-time. The functions are so intuitive, Jeancolas says users can get up and running in just four hours. More than 100 how-to videos are embedded and directly accessible as each tool is employed.

Ian Draycott, engineering stress lead at TLG Aerospace, a Seattle-based aerospace engineering services company, has been using MSC software for years and MSC Apex Modeler since July. "Apex takes what used to be time consuming and frustrating geometry tasks using traditional solid modeling programs and turns them instead into efficient and satisfying tasks," he says. "The ability to create mid-planes on the fly and to quickly simplify geometry for meshing purposes is unmatched.

"With the dynamic meshing process, the results of changes to geometry and mesh parameters are immediately apparent. This allows the user to achieve a high quality mesh in significantly less time when compared to traditional meshing applications," Draycott says.

Rethinking Solver Technology

Users can feed the models into a traditional Patran/MSC Nastran analysis path, and MSC says Apex Modeler is already speeding up pre-processing for such analyses by factors of two to 10. However, the full benefits of the MSC Apex CAE system will be seen when users transfer meshed MSC Apex Modeler files into the add-on product MSC Apex Structures. This analysis solution, soon to be released in beta form, performs incremental validations of each part, which then feed into the FE analysis of a complete assembly. The software uses the concept of computational parts (CPs) as an equivalent for each component: It represents the effective part behavior based on user-defined boundary conditions, loads and materials.

Each CP is a mathematical model that defines the behavior independently from other parts in an assembly. A CP has a boundary called a communicator region, where the part can be connected to other parts. The initial release supports glue connections. Each CP is characterized by appropriate local boundary conditions as well as sensors defined by the key metrics that users want to capture. CPs can be either reduced via static or dynamic reduction, or not reduced for a full fidelity model.

Instead of reassembling and resolving an assembly the traditional way, the MSC Apex Structures solver first pre-computes part-behavior for each part in an assembly. With this new approach, when a change is made to a part, whether it is a material, boundary condition, or mesh change, the software immediately accesses the previously defined operating parameters and analyzes the modified regions, not the entire assembly. The combination of incremental validation and incremental solutions produces iterative results up to 10 times faster than without the use of CPs.

A CAE Modeling and Workflow Transformation

Designed to be highly interactive and appropriate for rapid design-envelope exploration analyses, MSC Apex will not replace MSC Nastran but will augment its capabilities. Final design validation and verification analyses are expected to remain in MSC Nastran. The MSC Apex platform will be extended to complement other MSC products, supporting multi-user, multi-discipline and multi-fidelity functions.

MSC Apex Modeler is currently for sale; the beta release of MSC Apex Structures (with CP-based linear structural and modal analysis capabilities) is planned to be available this year. **DE**

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

INFO ➜ MSC Software: MSCsoftware.com

➜ TLG Aerospace: TLGaerospace.com

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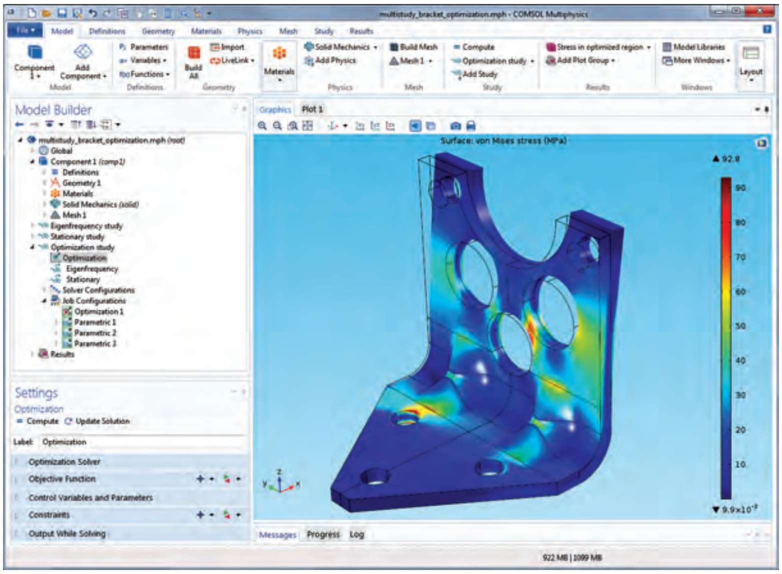
Optimization Leaders

Verify and Optimize Your Designs

Predicting the future with multiphysics simulations, and shape and topology optimization.

In order to achieve the best design, it is imperative that a product - and its interactions with its environment - be accurately modeled. While the multiphysics approach provides designers with numerical methods to account for coupled physics phenomena and achieve a real-world simulation, the job doesn't end there.

After creating a model of your product or process, you always want to further optimize your design. Different approaches exist, but all rely on defining an objective function that is used to optimize the model. Examples include minimizing weight, changing a set of design variables, optimizing within a set of constraints to keep an eye on feasibility and other requirements, or altering operating conditions that will define the scope of the application.



Multianalysis shape optimization of a bracket with COMSOL Multiphysics® where mass is minimized and constraints are placed on geometry, lowest natural frequency, and maximum stress in a static load case.

Shape Optimization

Shape optimization may imply predicting the shape of curves or surfaces to minimize or maximize a derived quantity. For example, it could be used to construct a wing profile that minimizes the drag coefficient but maximizes the lift coefficient. It can mean changing "simpler" parameters, such as the radius or position of screw holes, in order to minimize weight but maximize structural integrity.

Topology Optimization

The topology optimization method works by distributing a limited amount of material through a given space to maximize performance. In electronics cooling, for example, the shape of the channels in a heat sink can be optimized for maximum cooling power for a heat sink of a given size.

Multianalysis Optimization

Optimizations must sometimes be carried out using multiple analyses. For example, a static or dynamic analysis can be combined with an eigenfrequency analysis to constrain the allowed eigenfrequencies in a device or process.

High-fidelity multiphysics modeling in combination with optimization methods can efficiently predict the best possible design. The future looks bright for companies that have realized this potential!

About COMSOL Inc.

COMSOL provides simulation software for product design and research to technical enterprises, research labs, and universities throughout the world. Its flagship product, COMSOL Multiphysics®, is a software environment for modeling and simulating any physics-based system and for building applications in the electrical, mechanical, fluid, and chemical disciplines.

Contact Information:
1 New England Executive Park
Burlington, MA 01803
Phone: (781) 273-3322
Email: info@comsol.com

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Multidisciplinary Design Exploration Drives Innovation

Find the best design with an automated and efficient solution.

The real value of engineering simulation comes from its ability to improve a design through multiple design iterations by providing a stream of engineering data to drive the design process. Ultimately, this results in higher quality products that better fulfill customer expectations. However, in order to accurately simulate the behavior of the product when exposed to real-world operating conditions, engineering simulation tools that span a multitude of engineering disciplines are required.

Automated Simulation Process

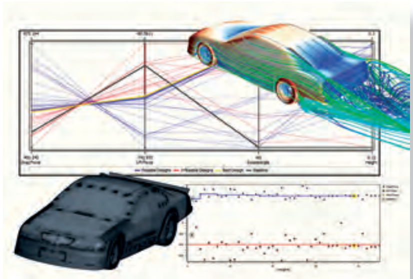
CD-adapco has pioneered "Multidisciplinary Design Exploration," through which multidisciplinary engineering simulations, including STAR-CCM+, are intelligently driven through a range of operating scenarios using HEEDS MDO (from Red Cedar Technology) and/or Optimate+.

HEEDS MDO is first used to integrate multiple software tools, such as STAR-CCM+, to define an automated simulation process, allowing you to represent the full multidisciplinary nature of the problem you are exploring. HEEDS MDO then uses the SHERPA search algorithm (developed by Red Cedar Technology) to efficiently search the entirety of complex spaces. As SHERPA is executed, it learns about the design space and alters its decision making as the solution unfolds.

Optimate+ is a STAR-CCM+ add-on that provides a scriptless solution for automation of design exploration helping engineers quickly set up, execute and post-process design studies, which include parameter sweeps, DOE and optimization using the SHERPA algorithm from within STAR-CCM+.

Powerful Licensing

POWER TOKENS are a needs-based licensing scheme that match license



resources to usage patterns. Using POWER TOKENS, the licensing cost of simulating multiple derivatives of a single design is reduced, allowing engineers to explore the whole design space at a fraction of the cost of traditional licensing schemes.

MDXploration can be used to gain a complete understanding of the performance of the product across the whole design space, accounting for all the factors that will influence performance of the product during its working life.

For more information visit:
www.cd-adapco.com

About CD-adapco

CD-adapco is the world's largest independent CFD focused CAE provider. Our purpose is to inspire innovation while reducing customer cost, through the application of advanced engineering simulation. CD-adapco uses "Multidisciplinary Design Exploration" to intelligently drive simulations through a complete range of operating scenarios, to completely understand the performance of the product across the whole design space.

Contact Information:
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Streamline the CFD Process With CONVERGE™

Never make a mesh again.

As organizations sprint at a breakneck pace toward product innovation and improvement, they often run into a hurdle in their computer-aided engineering toolchain: meshing. Meshing can be one of the most time consuming processes in the entire CAE procedure.

With inconsistencies between different meshes, diffusion due to mesh stretching, and trying to guess where to put more mesh for increased accuracy, the list of meshing issues is long. Add to that a complicated or moving geometry and the complexity of the mesh can increase exponentially.

Optimized Meshing

Convergent Science, Inc. has optimized the computational fluid dynamics (CFD) lifecycle by removing the user defined meshing process with CONVERGE™ CFD Software. CONVERGE™ automates the entire meshing process at runtime. The mesh is re-created for each time step with the addition of Adaptive Mesh Refinement (AMR). AMR adds increased meshing resolution where and when it is needed automatically. This new and innovative approach uses a completely stationary orthogonal Cartesian mesh. The ability to simulate complex moving geometries is handled just as easily as stationary geometries.

Optimized Detailed Chemistry

The automated meshing in CONVERGE™ not only optimizes your CFD lifecycle, it also allows engineers to accurately solve combustion analyses with detailed chemistry. Solving detailed chemistry with CONVERGE™'s AMR technology will reduce runtimes and increase accuracy by dynamically adding mesh resolution at runtime when and where it is needed, effectively optimizing the mesh for combustion during runtime.

Optimized Designs

CONVERGE™ comes fully equipped with a genetic algorithm optimization model. To put it simply, CONVERGE™ takes a "survival of the fittest" approach to design optimization and automatically initiates CONVERGE™ CFD simulations in search of an optimum product design. Utilizing this approach, the manual user interaction inherent in traditional design optimization is effectively removed.

About Convergent Science Inc.

Convergent Science, Inc., a world leader in computational fluid dynamics (CFD) software, was founded in 1997. The Convergent Science headquarters are located in Madison, WI with additional locations in New Braunfels, TX, and worldwide distribution. Its flagship product, CONVERGE™, is revolutionizing the CFD industry. The groundbreaking technology removes the user defined mesh and implements an innovative new process that fully couples the automated mesh with the solver at runtime. This process, combined with Adaptive Mesh Refinement (AMR), is shifting the paradigm toward predictive CFD.

Contact Information:
Phone: (830) 625-5005
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CONVERGENT SCIENCE

For more information visit:
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Optimization Leader /// Tormach LLC

Prototype Faster, More Affordably with Personal CNC

Move quickly through design iterations and reduce outsourcing costs with Tormach PCNC Mills.

Most product development firms outsource everything that needs machining, from prototypes, to jigs and test fixtures, and even the manufacturing run itself. This approach works, but it can be slow and expensive. In today's competitive landscape, successful design teams need to be responsive and agile.

That's where a Tormach PCNC mill can help. Tormach's Personal series of CNC mills are unique in the CNC machining world. They are positioned at a price point and performance level that makes in-house CNC a realistic option for engineers and product designers looking for affordable prototyping capabilities or low-volume manufacturing solutions.

Tormach PCNC: The Right Size for Product Design

Tormach's PCNC mills are used widely in all facets of product development: prototyping, niche and specialized manufacturing, customization and personalization, and testing and manufacturing equipment support. Customers run the gamut from product design teams in large corporations to small engineering firms and even individual design engineers. PCNC mills are enabling these groups to bring their ideas to market quickly and affordably in a way that wasn't possible before.

Tormach PCNC mills are designed to be easy to use and easy to learn; a skilled operator is not necessary. Starting at under $10,000, Tormach PCNC mills have a large array of options available for customizing to suit particular needs: Automatic Tool Changer, Digitizing Probe, Reverse Engineering Software, and more. Total cost of ownership is also low. Recurring annual maintenance costs are less than $500, on average.

TORMACH® PERSONAL CNC

For more information visit:

www.tormach.com/desktop

About Tormach

The people at Tormach are dedicated to enabling your ideas by delivering tools, accessories, and components of unprecedented value in the world of CNC. Whether you are involved in R&D, education, short-run production, or simply entrepreneurs with new ideas, Tormach products allow you to make what you need easier, quicker, and more affordably.

Our flagship products include the Tormach PCNC 1100 and PCNC CNC Milling Machines, affordable CNC mills that are configurable with options such as 4th Axis, Automatic Tool Changer, Digitizing Probe, and other options. All Tormach products are easy to maintain, easy to service, and have a low cost of ownership.

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Steering Optimization the Smart Way

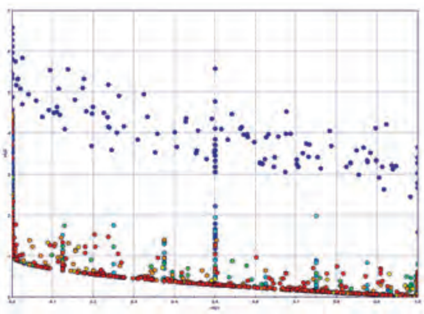
The newly released modeFRONTIER 2014 makes advanced optimization a one-click experience.

When ESTECO came onto the scene in the late nineties, optimization technology was in its early days; now it is an essential part of the engineering toolkit. As a pioneer in this field, ESTECO continues to provide industry with best-in-class optimization technology with the aim of making life easier for engineers.

As design complexity grows alongside demands for tools that reduce costs and speed up the design process, so does the need for technologies that effectively manage complexity, simply and rapidly. The newly released modeFRONTIER 2014 is the outcome of ESTECO's endeavour to drive the engineering design process in that direction, by giving users a simplified optimization experience and new features that open the platform to web-based collaboration.

One-Click Optimization

With the new proprietary ESTECO optimization algorithm pilOPT, modeFRONTIER 2014 advanced optimization is no longer the exclusive domain of experts; with one click, pros and non-experts alike can perform complex optimization processes simply by specifying one parameter. By combining global and local search, and balancing real and RSM-based optimization, pilOPT achieves good coverage of the Pareto front quickly and delivers a set of good and robust solutions every time, ensuring substantial time savings and the efficient use of computational resources.



Taking Optimization to the Next Level

Along with simplifying the optimization process, systems integration and management of complex multidisciplinary design scenarios are key to streamlining the engineering workflow. By extending the modeFRONTIER desktop paradigm to the SOMO web-based collaborative framework, ESTECO has created a virtual environment that enables geographically distributed design experts to solve complex problems cooperatively, effectively taking optimization to a new level.

ESTECO's forefront technology reflects its commitment to providing continuous support and innovative solutions for the evolving demands and requirements of its customers: ease of use, web-technology and effective collaboration management are the drivers ESTECO uses to improve the experience of designers on their road to the future.

About ESTECO

ESTECO is a pioneer in numerical optimization solutions, specialized in the research and development of engineering software. Perfecting engineering and reducing complexity in the design process is our vision. Our aim is to decrease the tedium and increase creativity by developing and maintaining cutting-edge software for integration, optimization and advanced data analysis.

Contact Information::

ESTECO North America
1221 Brickell Ave. Suite 900
Miami, FL 33131 U.S.A.

ESTECO SpA
AREA Science Park, Padriciano 99,
34149 TRIESTE (ITALY)

For more information visit:
www.esteco.com

Higher Eÿ ciency by Optimization

3DEXPERIENCE is about optimizing a company's business and products.

Quickly creating the best design for performance, weight, cost and other mission-critical factors is increasingly important in launching market-winning products. Finding the best option requires a multidisciplinary approach with multiple trade-off studies. To reduce physical testing, companies are expanding the use of virtual testing and design optimization technology.

Dassault Systèmes, the world-leader in developing 3D software applications, is delivering on a long-term strategy to provide the most powerful solutions for design optimization. Its SIMULIA realistic simulation applications provide the most complete, open and robust toolset available on the market.

Leading Technology

SIMULIA Isight is used to integrate multiple cross-disciplinary models and applications together in a simulation process flow, automate their execution across distributed compute resources, explore the resulting design space, and identify optimal designs based on user-defined parameters.

SIMULIA Tosca is the leading technology for non-parametric structural and fluid flow optimization. It delivers powerful optimization technology for design of lightweight, stiff, and durable parts and assemblies. With Tosca, product designs are created solely on a given design space and a defined optimization task. Innovative design proposals can be optimized earlier in the design process, reducing the number of physical tests.

The business value of these applications is significant and will increase dramatically as capabilities within Dassault Systèmes' **3D**EXPERIENCE platform. This will provide easier access to these powerful capabilities for users of CAD, FEA, and CFD technologies—not only from Dassault Systèmes, but also from its software partners. This openness ensures that manufacturing companies can leverage their current design and engineering software investments.

When applied as an integral part of the product development process, Dassault Systèmes' optimization technology will further enable companies to accelerate and achieve their quest for the best.

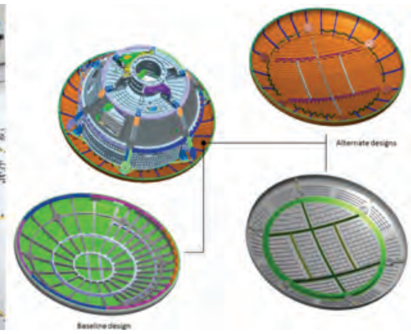
"The **3D**EXPERIENCE platform is all about optimizing a company's business and the products it offers," says Bernard Charlès, President and CEO, Dassault Systèmes. "Is it what customers want? Can we produce it quickly? Is it right for a sustainable future? These are the questions industry must ask to harmonize products, nature and life. And these are the questions our **3D**EXPERIENCE platform answers."

Contact Information:
1301 Atwood Avenue, Suite 101W
Johnston, RI 02919
Phone: (401) 531-5000

Optimize the Weight Away

NASA Orion uses Collier Research's HyperSizer software for composite and metal structural analysis and optimization.

Developing optimized, efficient designs is the goal of any engineer—especially when weight is a critical factor. While optimization has traditionally been the domain of technical specialists, Collier Research Corporation has developed an advanced, yet easy-to-use technology that fully bridges the roles played by general designers and expert analysts.



Version 7 of HyperSizer® software was fine-tuned during a recent project aimed at reducing the weight of the heat shield of NASA's Orion Multipurpose Crew Vehicle. Ideal for aircraft wing and fuselage design as well as spacecraft, wind turbine blades and ship hulls, V7 offers powerful, user-friendly, composite and metal structural analysis and optimization that can be used during both early concept and late design, pre-production stages. HyperSizer, the first-ever software commercialized out of NASA, produces optimizations with typical weight savings of between 20 and 40 percent.

Building on reconfigured core computing technology established in HyperSizer 6.4, Version 7 self-configures for different loading scenarios, requiring less input from engineers. In doing so, V7 provides a more flexible and open environment for third-party software, serving as an independent and neutral hub for industry-accepted CAD, FEA, and composites technologies. This role is pivotal for diverse engineering environments that rely on different toolsets and suppliers.

The Orion project made significant use of the streamlined process capabilities of V7, as well as new attributes developed specifically for analysis of the heat shield related to dynamic loading and non-linear material response.

V7 allowed the design team to quickly and easily compare different combinations of solutions, as well as the variables that influence the design. Within 10 weeks, they were able to study approximately 40 different variations of the heat shield configuration, designed in both composites and metal. These analyses informed discussions that led to a reduction of the final weight of the baseline design by 23 percent, eliminating hundreds of pounds of unnecessary weight.

About HyperSizer

On average, HyperSizer software reduces the weight of structures by 20-40%, an exceptional achievement for aerostructures. HyperSizer replaces the need for spreadsheets and "hand calculations" with automatically generated stress reports for FAA certification. HyperSizer customers are able to produce results faster and more accurately, giving them an edge over competitors.

Contact Information:
760 Pilot House Dr. Suite A, Newport News, VA 23606
Phone: (757) 825-0000
Fax: (757) 282-5853
Email: ivonne@hypersizer.com

HyperSizer

For more information visit:
www.hypersizer.com

From Excel to Enterprise App

Rapidly deploy spreadsheets as collaborative web applications.

It's been said that Excel® is the most commonly used engineering software. However, when spreadsheets are pushed beyond the role of a desktop solution into the role of an enterprise tool, serious problems arise. EASA helps companies overcome these issues by making spreadsheets "behave" like enterprise applications.

Spreadsheets in Engineering

Despite huge advances in CAD, CAE and PLM tools, spreadsheets remain widely used in engineering and manufacturing. Excel is flexible, easy to use, and powerful, and as such is a valuable tool for configuration, pricing and proposal generation; preliminary design; engineering calculations; and design tables for CAD.

If the author of a spreadsheet is also the main user, then Excel's desktop nature is acceptable. However, when a work-process requires the deployment of spreadsheets to multiple users, then complications occur.

Typical symptoms include:

- Multiple versions of important spreadsheets residing on many desktops.
- No version control — which is the correct and current version?
- No audit trail — who used which version of a given tool on a given date for a given project?
- No collaboration or ability to share results.
- Risks of exposed intellectual property
- No ability to link to other systems such as CAD, CRM, PLM.

EASA overcomes these issues by enabling rapid deployment of spreadsheets as collaborative web applications, accessible to any authorized user. This enables organizations to securely leverage the investment and intellectual property in existing spreadsheets, while avoiding costly mistakes due to usage errors and version control problems.

Benefits include:

- A repository of version-controlled tools; users cannot access an incorrect version.
- User-friendly browser-based interfaces ensure correct and consistent usage.
- Web applications can be linked with other enterprise software.
- Users can save their work to a central repository, facilitating collaboration.
- An automatically generated audit trail provides a record of usage.
- Intellectual Property is protected; users cannot see inside the "master" spreadsheet.

EASA

Streamline your software
Accelerate your business

For more information visit:
www.easasoftware.com

About EASA Inc.

The EASA platform enables codeless authoring and deployment of web applications that drive underlying models and processes. Our goal is to enable our customers to build and deploy applications that leverage existing models built with Excel, MATLAB, MathCAD, and most CAD/CAE tools, in turn empowering end-users to complete work processes more efficiently.

Contact Information:
1626 38th Avenue North,
St Petersburg, FL 33713, USA
Phone: (800) 711-5346
Email: info@easasoftware.com

Additive Optimized

Whether producing fully dense metal parts in titanium, or enabling additive and subtractive processing on single machine tool, Renishaw breakthroughs are core.

Desktop engineering is gradually being transformed into desktop manufacturing (or almost desktop) with Renishaw additive systems that can laser melt titanium, Inconel and aluminum powders to create fully dense, custom orthopaedic implants and complex parts that could only be imagined a few years ago. And that's just one of the disruptive technologies from the UK engineering leader that have optimized manufacturing process control, unmanned systems, spatial measurement, precision part measurement and motion control, to name just a few.

Renishaw has used additive manufacturing in its own engineering and production for more than 10 years, continuing to refine the process and its application. The additive metal systems it has commercialized are already producing parts that could never be manufactured by conventional processes, such as mold inserts, automotive and aerospace parts with internal structural lattices or conformal cooling channels. Renishaw breakthroughs include additive melting systems that are 98 percent efficient in utilization of metal powders.

Today, the company's high-speed SPRINT™ measurement probe is the enabling technology behind the convergence of additive manufacturing and conventional subtractive metalworking in a single machine tool. The SPRINT 3D contact scanning probe allows a machine to locate a part and determine its form and dimensions for adaptive processing with additive and subtractive operations. The new hybrid process is ideal for repairing complex forms, such as turbine blades. The SPRINT probe allows a single machine to automatically tailor an additive build and cutting tool paths

to repair blade edges and blend the roots. It enables a single machine to make repairs – traditionally a manual process – by precisely adding material where needed, then machining it flush and measuring the final product, all in one setup. It's a completely new manufacturing paradigm, but neither the first nor the last you'll see utilizing Renishaw technology.

About Renishaw Inc.

Renishaw is a global company with core skills in measurement, motion control, spectroscopy and precision machining. We develop innovative products that significantly advance our customers' operational performance and raise product quality. Our products are used for diverse applications including additive manufacturing to help reduce lead times and reduce tooling costs.

Contact Information:

Jeff Seliga
Renishaw Inc.
Phone: 847.286.9953
Email: jeffrey.seliga@renishaw.com

Ray Kemble
Kemble & Rude Communications Inc.
Phone: 513.871.4042
Email: rkemble@kemblerude.com

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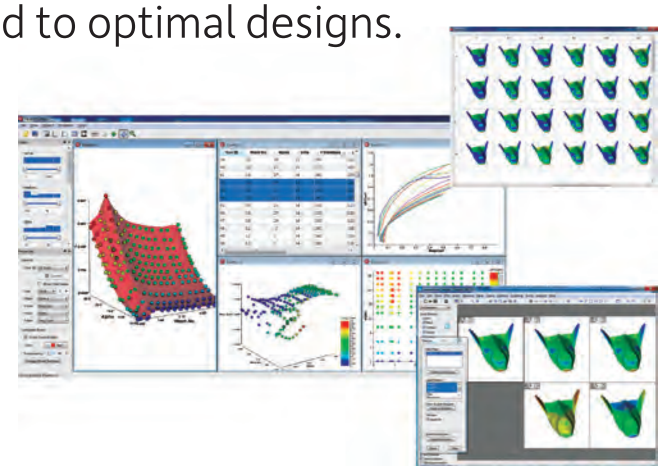
Simulation-based Optimization is a Powerful Tool for Engineering Design

Tecplot Chorus makes it fast and easy for engineers to identify potential solutions that lead to optimal designs.



Simulation-based optimization involves traversing a high-dimensional design space in search of design parameters that can maximize one or more objectives while satisfying a set of constraints. In engineering systems, this optimization can become quite complex.

In airplane wing aerodynamic design, for example, the objective function might be fuel economy while constraints may include operational considerations such as airport density altitude, or minimum runway length, payload, range and cruising speed. Structural considerations may include minimum wing thicknesses and maximum loads. At each potential optimal point in the design space, which contains parameters describing the wing geometry, these constraints must be satisfied. This can add up to dozens of dimensions that must be modeled and can yield many thousands of points in the design/operational space that must be evaluated.

Because simulations like computational fluid dynamics (CFD) are so expensive, surrogate-based optimization is often used. Surrogate models are functions that estimate the variation of integrated aerodynamic quantities, such as forces and moments, between the simulation points. They are cheaper to evaluate and can dramatically reduce the cost of the constraint optimization.

Tecplot Chorus can help identify the cause of problems encountered during simulation-based constraint optimization, including simulations that are insufficiently converged, inaccurate solutions, and insufficient operational space coverage in the simulation experimental design. Engineers can use it to visually analyze the distribution of cases and output variables in N-dimensional design/operational space. When results look suspicious, the problem is frequently in the setting of boundary conditions, turbulence models, or fluid properties and can often be detected by a quick examination of the field data from individual simulations using the 3D visualization capabilities in Tecplot Chorus.

Finally, Tecplot Chorus can be used to create surrogate models. Engineers can use it to evaluate the uncertainty inherent in the surrogate models and identify regions where additional simulation cases would be helpful. Ultimately, these surrogate models can be used in future optimizations.

tecplot® Master the View

For more information visit:
www.tecplot.com

About Tecplot Inc.

Tecplot delivers CFD post-processing software that allows engineers and scientists to discover, analyze and understand information in complex data, and to effectively communicate the results. Since 1981, Tecplot has been applying and influencing the latest advances in visualization technologies and plotting capabilities. With thousands of users worldwide, Tecplot has become a trusted name in data visualization.

Contact Information:
Tecplot, Inc.
3535 Factoria Blvd SE, Ste 550
Bellevue, WA 98006

The IoT Could Take the Guesswork Out of Design

The Internet of Things (IoT) holds the potential to better inform engineers throughout the design process.

BY BETH STACKPOLE

A quick Google search on the Internet of Things (IoT) shows no shortage of stories recounting how the technology is poised to transform everyday practices. From helping doctors facilitate proactive health care to arming service technicians with what they need to administer preventative product maintenance, the IoT also has the chops to alter day-to-day work for engineers, eliminating much of the guesswork that's become a routine part of the design process.

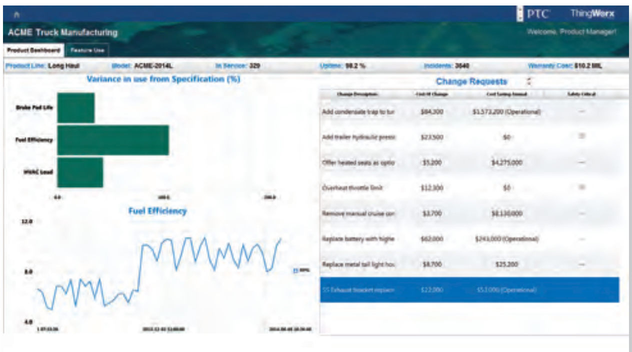
Next-generation products outfitted with embedded sensors, actuators and other technologies will be able to detect things about their environment — temperature changes, for example, or an imminent part failure — and communicate that information in real time over the standard Internet Protocol to a database accessible by engineers. From there, engineers could analyze this trove of product-related data as part of their regular workflow to guide future product designs, address persistent quality issues, and inject more realism into verification and testing procedures.

While there is huge potential for IoT to close the loop between engineering and how a product is used and performs in the field, the technology to do so is still relatively immature and it's very early on in the IoT technology adoption cycle, according to Michelle Boucher, vice president of engineering software research at Tech-Clarity, an independent research firm.

"There's a lot of opportunity for this data to be made available to engineers so they can make better decisions, but it's more of a visionary thing than actually happening, at this point," Boucher says. "The ultimate goal is for PLM (product lifecycle management) tools to be able read in the information and mine some of the data with analytics so it's accessible to engineers when they're using CAD or simulation tools and when they're making design decisions."

The Big Reveal: Customer Usage Patterns

Dassault Systèmes sees three primary roles for IoT data as it relates to product design, according to Michael Munsey, the company's director of semiconductor strategy. Products in the field would collect usage data that could be enlisted to make subsequent design iterations of a car or consumer appliance, ensuring the next generation performs more effectively for the customer. IoT data could also be leveraged to automate processes related to the product that would make its use case more efficient — for example, automating parts replenishment as well as predictive



Access to real-time data from the actual performance and use of smart, connected products can provide design engineers with valuable feedback to improve the quality and profitability of next-generation products.

A prototype application leverages PTC ThingWorx and PTC Windchill FRACAS to alert quality engineers to product failures as they occur while providing visibility into real-world conditions at the time of failure. *Images Courtesy of PTC.*

National Instruments' NI SOM (System on Module) enables design teams to deploy reliable, complex embedded systems faster because it is based on and has the same rigorous design standards as the LabVIEW reconfigurable I/O (RIO) architecture. *Image Courtesy of National Instruments.*

The LMS portfolio will play a key role in Siemens PLM Software's strategy to facilitate the collection and analysis of IoT data. *Image Courtesy of Siemens PLM Software.*

maintenance, Munsey says. Finally, an intelligent product design can minimize the need for human intervention via its ability to automatically adjust based on usage patterns and performance.

For engineers, the possibility of applying such real-time product usage data to the requirements process has significant advantages. Today, the requirements process is mostly manual, starting with a set of marketing and business requirements that get translated into functional specifications for the engineer. The ability to automate the flow of customer-driven usage data directly into a system-level design would give engineers a whole new set of requirements that would help ensure the right product is being developed at the right time, Munsey says.

"Now you have real-time customer use data that didn't exist before," he says. "The ability to understand how customers are using the products helps drive new features and functionality that customers need as opposed to trying to guess at what they need."

This capability would be particularly useful to avoid over-engineering products, a common practice that grossly inflates development costs. "We are already operating in a very complex world where the risk is huge," says Zvi Feuer, senior vice president and general manager of Manufacturing Engineering at Siemens PLM Software. "Companies take enormous precautions and build a lot of safety nets into products. With this data collected and analyzed in a smart way, you eliminate the need to overcome risk by overdesigning and making products unnecessarily complex."

Tom Shoemaker, vice president, EPLM segment at PTC, concurs, using an under-utilized air conditioner compressor in a car as a real-world example. "If you can see that something is being used in a certain way — for example, air conditioning is not running as much as initially expected — it becomes clear there is a need for a better system or a cost savings opportunity for OEMs (original equipment manufacturers)," he explains. "After releasing a product, all manufacturers almost immediately create a change request to take 10% of the cost out of the product. They know the product is over-engineered, they just don't know how. Feeding that information back so it could be used in the next variant of product would be extremely useful."

The real-time customer usage data collected by IoT devices could also be instrumental to improving test environments and simulation. For example, as opposed to analyzing test and verification data through post-processing analysis, a design team could directly tap into a repository of real-time data, time stamped with the event and sequence information, so they could pinpoint and understand exactly why and under what conditions a particular design failed, says Andy Chang, senior manager for academic research at National Instruments.

And imagine using that same real-time usage data to create the actual test environment as opposed to creating it through higher level modeling. "Using real data gathered by products in the field creates a more robust and comprehensive set of tests," says Munsey. "The evolution of driving verification and simulation off of real data is a huge advantage because engineers aren't guessing any more. They aren't trying to model predictive behavior, but rather are using real data to do the testing and simulation."

Both the simulation and test use cases converge with another big area where IoT data can lend a hand: Bringing design engineers directly into the loop on how the product is used in the field as part of their on-going quality efforts. "There isn't currently a closed loop system to what's happening in the field with products," says Tech-Clarity's Boucher. "All the little things that happen as a result of everyday use don't always get back to the engineers … so they don't know when something is returned or if there are quality issues."

Search and Analytics: The Next Big Thing

To ensure the IoT vision has impact for engineers, a number of things need to come together. The data from sensored products and production equipment needs to feed into a common repository that is organized and easily accessible to engineers. Most of the major PLM players, including Siemens PLM Software and

Dassault Systèmes, see that central repository being PLM, enhanced with new capabilities in the areas of search, for both structured and unstructured data, among other capabilities. Dassault's acquisition of Exalead, what it dubs information intelligence, and Siemens PLM Software's buy out of LMS move both companies toward being able to search, explore and analyze vast pools of internal or external, structured or unstructured data.

Yet there are limitations as to how much data you can effectively store in PLM, and requirements for robust analytics and visualization tools that can help engineers make sense of the IoT data and make it actionable for future designs. For example, while PTC's Windchill Product Analytics, part of its PLM portfolio, lets engineers drill down into compliance, performance and risk indicators on a product structure, it's not equipped to handle the so-called Big Data arising from IoT devices, Shoemaker says. That is an area that PTC has earmarked for future development, Shoemaker acknowledges, although he declined to provide more specifics.

National Instruments is also working on technology to help engineers make sense of what's undoubtedly likely to become a deluge of IoT data. For example, the NI System on Module (SOM), the smallest iteration of its embedded hardware, can be deployed much closer to the sensors and actuators on products or industrial test equipment, creating a platform that can help filter the data.

"Now that you can put embedded intelligence closer to the sensors and actuators, it means you can filter out the right signals and pass on only the information that's relevant to the design," explains NI's Chang. "Being able to use the most insightful data for design rather than just collecting all of the data existing on the system is they key."

What is also likely to be key is the establishment of a new role in engineering — that of data analysis expert, who is knowledgeable of the systems, IoT data and analytics, and who can help deliver information to engineers in a presentable way.

The reality is, in order for the IoT to truly transform the design process, it's got to be as seamless as possible for engineers to dig in. "If engineers can get access to information without disrupting their workflow it's going to empower them a lot more," says Boucher. "Otherwise, it's just one more thing to take a look at and they're already under so much pressure." DE

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

INFO → Dassault Systèmes: 3ds.com

→ **National Instruments:** NI.com

→ **PTC:** PTC.com

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

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Simplify the Design Path

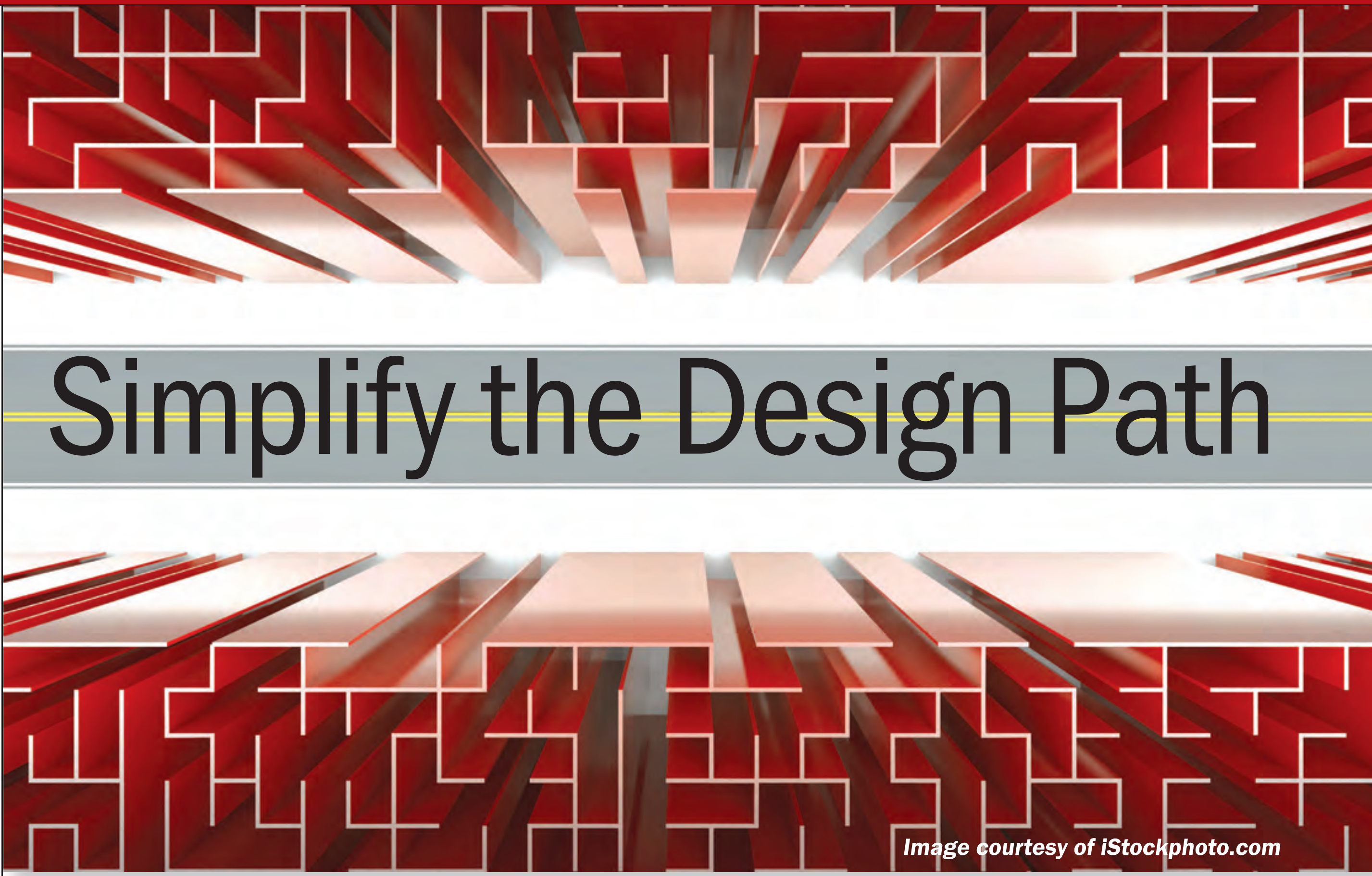

Image courtesy of iStockphoto.com

Consultants help designers and engineers navigate today's complex product development landscape.

BY JIM ROMEO

Rob Walker, a technology blogger for *The New York Times*, recently wrote about the "golden age of design" and pointed out that the respected and notable Silicon Valley venture firm Kleiner Perkins Caufield & Byers added John Maeda, the former president of the Rhode Island School of Design, as a partner. Walker said that the venture capitalist leader "has noticed more designers starting companies with the help of engineers, rather than the other way around."

This new model in product development has led companies like Google to invest more than $3 billion in Nest Labs, a company that makes aesthetically attractive smart thermostats; in fact, it was one of Google's largest investments ever. The same model helped Twitter's co-founder start Square — a company that allows a small square device to plug into a smart device and accept credit card payments — replacing the swipe machine.

A knowledgeable consultant can bring value to a product development team by showing them a path in a competitive landscape that is sometimes intimidating. For engineering design, consulting has taken on a new personality. Complexity consulting has arrived.

Creativity consulting helps navigate the complexities of the environment, buyer psychology, and all the supporting networks that surround design challenges. Today's consultants are called upon to solve and prevent problems and create value where little existed before. They also help clear the path to success by cutting through the thicket that designers face in today's world.

More Competitive on a Smaller Scale

Sara Gilbert, is president of Pinewoods Engineering in North Chill, NY. She says consultants have been common and necessary to bring in specialized expertise to achieve results.

"When I was employed by a large private consulting firm we would also outsource skills we didn't have, like wetland delineations," says Gilbert. "We had a very close relationship with the outsource firm. We would sometimes outsource components like architectural or survey that we had the capability to do but we knew smaller firms could do it much cheaper than we could. It was a way as a large company to make our projects more competitive on a smaller scale."

She adds that a consultant will sometimes roll up their shirtsleeves and get right into the design for the client, yet keeping it seamless as if they were an extension of the design activity.

"I am a hydraulics engineer, so I will prepare a design and report and work with their drafters to get the design on the plans," says Gilbert. "Most companies do not like to make it obvious to their clients that they are outsourcing."

Getting There, from Here

Jochen Gleisberg, partner, Operations Strategy group at Roland Berger Strategy Consultants based in Stuttgart, Germany, says optimizing the design process begins with defining the actual status quo and the strengths and weaknesses of the current organization or processes, and comparing the status quo against best practices from other companies within and without their own industries. This, he says, helps companies reflect on improvement, and define their own strengths.

Once the strengths are defined, his practice will define the to-be state by examining the status quo and finding where improvements are possible. From this, the to-be state is developed. For example, this may be reducing the time to market timeframe by X% he explains, or improving the interface between sales and engineering to enhance the process of defining specifications or developing a harmonized technologies and product roadmap.

He adds that it is very important to develop concrete actions for each candidate for improvement. "A concrete concept for the future state and the corresponding action or implementation plan needs to be derived," he says. "Here also external benchmarks [and] potentially open benchmarks, where the external consultants can moderate such a process, can help to define the optimum solution and also help to overcome the typical resistance against change."

The processes they moderate though, often are further challenged by cultural differences between the countries and associated markets they plan to enter. For example, Gleisberg cites his experience in the development of a global engineering network with sites in Germany, the United States and Japan. Before, each site had acted independently but must now act collaboratively as a global network.

"When we started to role out the new global organization and had global meetings, in the breaks all Japanese engineers would stand in one corner, the Americans in the next corner and the Germans in another one," says Gleisberg. "At the end of our project, the electrical engineers from all three countries were in a discussion in one corner, the mechanical guys in the next one, etc. Here you could see the change in mind set we had achieved."

Monitoring the Progress of Development

Overall, the external consultant plays a key role in helping the design engineer monitor the progress of development. "In all phases, the external consultants play a vital role in supporting the change management aspect," says Gleisberg. "Any optimization project within the engineering environment typically [requires a person or persons] who [are] supportive in optimizing the existing organization and processes and also people who are openly or secretly working against any change. In order to ensure a certain dynamic to overcome the initial resistance against change, the consultant plays a critical role."

Carl Smith, manufacturing solutions manager at IMAGINiT Technologies, says he believes the best approach to consulting for a complex design effort is to listen carefully. Initial fact finding and listening to client objectives and need is crucial in providing complex consulting.

"As consultants, we understand that addressing an engineering process involves folks that know the current practice and its problems from start to finish," he says. "Even the best perceived solution is a waste of time if there isn't adoption of the new strategy, so our strategic process and business analysis reviews are fact finding meetings that involve both group and individual interviews with the engineering team. Engineers tend to understand that the path from Point A to Point B can't always be a straight line; a change request or order process, for example, can be extremely complex with multiple levels of approvals, responsibilities and tiers. Our job is to provide the best combination of technology and automation to streamline such a process."

Smith adds that the fine art of simulation and modeling can create value for product development and process development for client needs. Simulating product ramifications is key in driving decisions about a product or project.

"We have a design simulation team that offers consulting services around CFD (computational fluid dynamics) and mechanical simulation where our clients will provide us with a baseline design and outline their design objective," says Smith. "For example, the client might have goals for thermal performance for a product with an eye on optimizing product performance before beginning physical prototyping efforts. It is well documented in optimizing design with a digital prototype [and] far more efficient; our simulation consultants have extensive experience to guide and advise our clients with product development."

Complex consulting speeds and improves product design and adds value. *The New York Times'* Walker, in his perspective on design's "golden age" expressed this sentiment well when he wrote "design has fundamentally changed the way we experience the world, from the way we interact with objects, to our expectations about how organizations are structured." **DE**

Jim Romeo *is a freelance writer based in Chesapeake, VA. Contact him via DE-editors@deskeng.com.*

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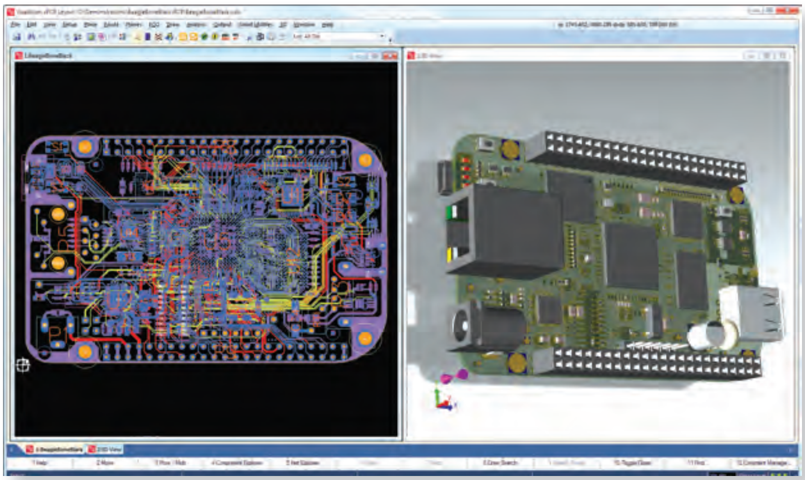
A Platform to Reduce Product Complexity

Using platform-based design can narrow down options for engineers and simplify the creation of new products.

BY DAVID GEER

Design engineers can avoid product design complexity and still meet product feature set requirements while standardizing on fewer product design platforms, creating engineering savings. Case in point, Volkswagen offers 69 different car models from only 16 design platforms. Why do they do it? Because companies that limit the variety of designs, modules and components earn a substantial profitability advantage, much of that due to the engineering savings that a platform approaches make possible.



BeagleBone is an example of public-domain, crowd-sourced design reuse. This layout is a version of the BeagleBone Black design created with Mentor Graphics' Xpedition Enterprise platform.

Platform Approach to Engineering Savings

While using a relatively finite number of product design platforms, companies can produce different products with distinct features. Because this is possible with a limited number of platforms, it is not necessary to endure the engineering expense of creating a new platform altogether each time they undertake a new product design. This can be a considerable savings because new platform design can require two to 10 times the engineering that a product on an existing platform does, says PTC's James Gehan.

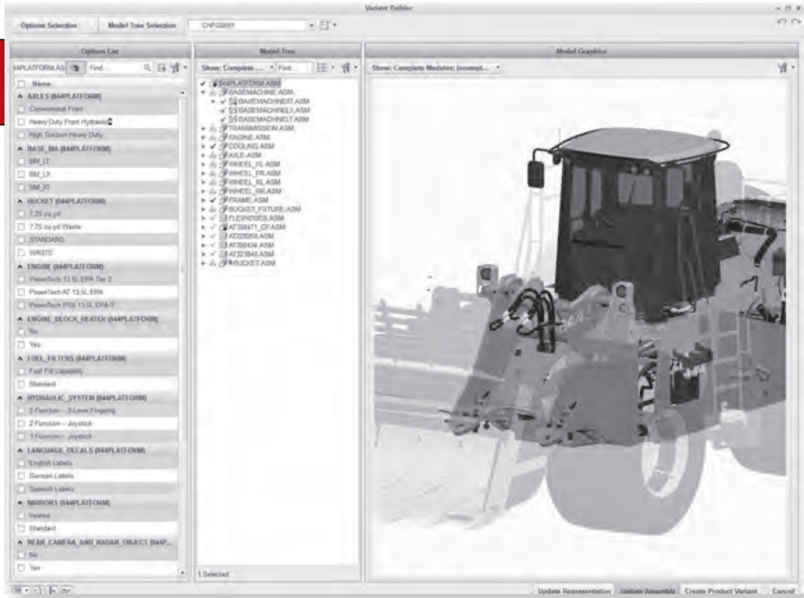
Platform-based design offers the benefits of standardization, which leads to a limited number of solutions to an engineering problem, solutions that are more certain to work due to certainties around compatibility and interoperability. Previously, a designer responsible for brake designs might manage about five different designs for multiple car models, for example. Now, they can develop brakes from two or three different modular designs to suit many different vehicles, says Gehan. "This saves engineering time and effort for the designer," he says.

Platforms produce engineering savings by changing the fundamental approach to managing product designs. "Before automobile designs were discrete assemblies and the configuration for the brake was inside that," says Gehan. Modular product designs make it possible for manufacturers to achieve a higher degree of interchangeability of brakes and to insulate changes in one part of the product (the rest of the car in this example) against adversely affecting another part of the product (the brakes).

Because of this insulation, design engineers are free to consider engineering savings that come when other designers use the design variants they create. If the designer is working with variants for a high-end, high-performance vehicle, he may know that the variants are for only this vehicle and will not likely be reused elsewhere. So he can design for best performance with less consideration for reuse.

But if the variants are for a frequently used vehicle design, then the designer must strongly consider reuse, according to Gehan. These considerations can lead to engineering savings for the designer's colleagues, who may save time and effort by reusing their predecessor's creations.

And the engineer who leverages existing, modular designs can complete overall design projects faster and still differentiate a product while using a common platform, says David Wiens, director of business development, System Design Division, Mentor Graphics Corporation. Using design platforms and existing modular designs also keeps design engineers from creating redundant parts that could have quality issues, says Wiens. In the circuit board designs that Wiens is familiar with, reusable designs



The PTC Creo Options Modeler is a dedicated app for creating and validating 3D modular product assemblies. It is a tool developed to create engineering design savings. ***Image courtesy of PTC.***

include data blocks, chipsets and variants.

Platform-based design enables engineers to package, specify and document designs in a way that makes it easier for other project deliverables to arrive more quickly, says Curt Jacobsen, principal, Technology Consulting, PwC. Design reuse becomes more likely when the design engineer has done the packaging, specification and documentation in such a manner as to facilitate reuse. This increases the value in the platform. "When other designers see that value, they start contributing more after the same example and the platform culture comes to life," Jacobsen says.

The Challenges in Platform-Based Design

Variants are invariably vexing. When designing a variant for a specific new product family, the design engineer must consider the interface that a modular design will connect to, for example, how the interface between the brakes and the rest of the vehicle will look. "With every new interface, there are different variables," says Gehan.

Reuse is a blessing but can also be a curse. One of the ways that platform-based design challenges the design engineer is that they need to think about the design in terms of how many different ways the vendor and other designers can package and reuse it, says Gehan. "As we get to higher levels of variability on the same platform, the number of ways different designers will use and reuse his designs becomes more diverse," he says.

The biggest challenge in is the time and effort it takes to properly capture it, document it, archive it on the front end of the project, and otherwise make it easy for others to retrieve and use later. "That process is five to 10 times longer than the creation of the design itself. You have to capture it as a separate block, keep the schematic, the layouts, and the constraints, and make it available for everyone else to use. But even with the challenges, the long-term benefits to doing so are huge," says Weins.

There are also some organizational challenges. "The architecture of a design reflects the organizational model of the product company," says Jacobsen. The most natural thing is for design platforms to evolve within certain divisions. It is better for all stakeholders to be involved. Platform-based designs can also take a long time because every stakeholder might want the design engineer to use their ideas.

Overcome Design Challenges

"We approach easing platform-based design [challenges] by using platforms throughout our products so that engineering has a consistent way to understand the platform and to validate and develop to the platform and any design variants," says Gehan. "Home-grown systems and approaches can't keep up with newer approaches because they are not modular." Platforms that make it easy for the designer to investigate the platform while providing multiple ways to package designs rule the day.

For challenges to design reuse, design engineers should have tools that understand and deal with reuse blocks, defining, documenting, and archiving them effectively. "It should be inherent in the toolset to be able to search that set of data after it goes into the library," says Wiens.

Fitness for reuse lies in design simulation options, which should prove the known good nature of the design using virtual prototyping. Before the prototype is built, these simulations should provide test and validation methods on the desktop computer to prove that the vendor can manufacture the product.

It is the design engineer's challenge to work against the propensity for designs to represent only certain product company divisions so that designs span product company divisions, giving all stakeholders a voice early on. To further avoid organizational challenges, there should be design governance and open discussion about the design. As to stakeholders having too much voice, the severity of this challenge can depend on the strength of will of the design engineer in making design choices that fall within his purview.

The platform-based approach to engineering design is the way that product vendors have gone or are in the process of going now. The best way to reduce product complexity in a platform-driven environment is to see the platform "glass half full" of design benefits and make ample use of them. **DE**

David Geer *is a freelance technology writer based in Northeast Ohio. Contact him via DE-editors@deskeng.com.*

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PSA Peugeot Citroën Goes Virtual

Car maker discovers better security, easier IT maintenance and cost reduction with virtual desktop infrastructure.

BY KENNETH WONG

Can you tell a virtual machine from a real machine in a blind test? It's not an existential philosophical question. The answer to that question gave one international automaker the assurance it needed to move its IT setup to 3D VDI, or virtual desktop infrastructure.

One day in early 2013, roughly six or seven employees from PSA Peugeot Citroën's (PSA) manufacturing facility in Vigo, Spain, turned on their computers and began working as they'd always done. They thought they were running their CAD programs and opening their assemblies on the remote workstations housed in the HP Blade servers in the onsite data center. What they didn't realize was that they were working with virtual machines, housed in an NVIDIA GRID server 978 miles away near Paris. They were part of a blind test, an early phase of the automaker's program to replace some of its engineering desktops with virtual machines.

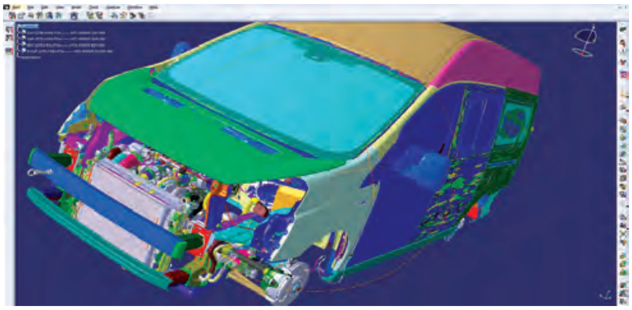
Singling out the Best Virtualization Candidates

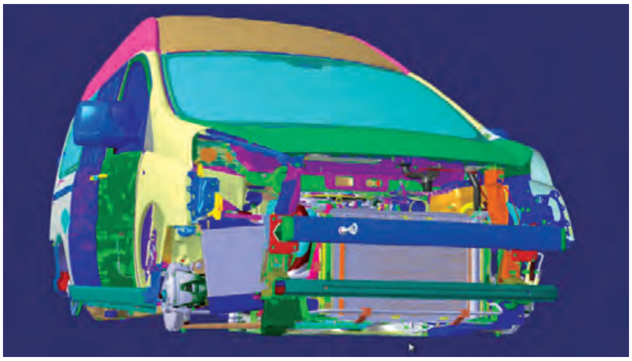
PSA's IT division oversees roughly 12,000 workstations, distributed across its global production sites. A segment of those 12,000 machines are in a one-to-one (1:1) remote setup, where each user is assigned one remote workstation housed in the data center. The IT framework was made possible by HP Remote Graphics software, which allows users to interact with their workstations from other client devices.

PSA has a decade-old partnership with NVIDIA, which champions the use of virtualization accelerated by graphics processing units (GPUs). In late 2012, with NVIDIA's help, PSA became an early adopter of the NVIDIA GRID, a virtualization solution based on NVIDIA's Kepler GPU architecture.

"We had ambitious goals defined for this project," says Alain Gonzalez, expert for Workstations, Graphics Systems & 3D Imagery at PSA. "We wanted to have the same quality of designs while reducing costs versus classical workstation usage. We also needed to provide virtual workstation power on demand, improve the security and consolidation of data, reduce maintenance and power consumption, and add mobility to our designers."

He explains that PSA workstation users can be separated into three distinct classes: entry-level users, midrange users and extreme or heavy users. "The best candidates for virtualization are the entry-level and midrange users with light to moderate needs for graphics," says Gonzalez. "The higher-end heavy users may not be ideal for virtualization, but we're going to evaluate their suitability later."





PSA Peugeot Citroën conducted a blind test in which engineers who were used to running Dassault Systèmes' CATIA software from their remote workstations were placed on virtual workstations powered by NVIDIA GRID instead. Test subjects didn't notice any difference in performance.

The Blind Test

When PSA got ready to launch its virtualization initiative, the IT department decided to conduct an experiment. Gonzalez and his colleague Thierry Regis, CAD workstation specialist at PSA, worked together to put a select group of engineers on virtual machines without their knowledge. "In terms of graphics performance or CAD performance, the blind-test subjects didn't notice any difference," says Gonzalez. "For them, the quality is the same as the 1:1 remote workstations."

The standard CAD package at PSA is Dassault Systèmes' CATIA V5, which relies on the GPU for the most graphics-intense visualization tasks. To provide CAD users with a generous graphics boost, the company designates each virtual workstation with its own dedicated virtual GPU.

Good News for At-Home Employees

While debating the pros and cons of virtualization, Gonzalez and Regis put together a list of benefits to justify the migration. Gonzalez says, "There are about 50 items on that list." One of the items — which was on the company HR officials' wish list — is the ability to accommodate more work-from-home employees. It's a common practice among U.S. tech firms, especially startups, but Gonzalez says the perk is not commonly available to workers in Europe.

"In the past, we weren't able to allow people who worked with CAD software to work from home because the cost to accommodate them with remote workstations was not reasonable," he says. "Today, the per-user cost has been reduced by 60%, so it's possible." (For more on this, see "Capacity Comparison.")

Now PSA also lets its contractors and suppliers connect to virtual workstations instead of remote machines. "About 300 contractors are now working with us using virtual workstations," says Gonzalez.

Since the design data resides only on the virtual workstations, which are on servers literally protected behind PSA's walls, the company feels secure about sharing its intellectual property with the contractors through the virtual setup.

Maintenance and troubleshooting also get easier in the VDI setup. "In the past, if something was wrong with an end user's machine, an IT person had to go to where the local workstation was located (under the user's desktop) to fix it. With the virtualized setup, if there's a problem with one virtual workstation, we switch it with another one. It takes just a few minutes," Gonzalez explains.

Since the IT person doesn't have to perform work on a physical machine, he or she could troubleshoot the virtual workstation remotely from anywhere. By the same token, when a designer or engineer needs to upgrade his or her memory to accommodate a particularly demanding workload (for example, to work on a larger-than-usual assembly file), the CAD support team can now remotely change the configuration of the virtual workstation without ever setting foot on the onsite data center.

"Now, the only time the CAD support team has to go onsite is when the end-user's client device or terminal (for example, the laptop he or she uses to connect to the virtual machine) needs repair or upgrade," Gonzalez says.

Capacity Comparison

Current virtual desktop infrastructure setup:

- Blade server supports 6 virtual workstations
- Enclosure houses 8 Blade servers (48 virtual workstations)
- Rack contains 3 enclosures (144 virtual workstations)

Previous remote workstation setup:

- Blade server supports 1 remote workstation
- Enclosure houses 16 Blades (16 remote workstations)
- Rack contains 3 enclosures (48 remote workstations)

The New Setup

PSA's current VDI is supported by NVIDIA GRID technology, which makes it possible for the company to deliver graphics acceleration along with the virtual machines. The case study published by NVIDIA describes the setup as follows: "[PSA's] existing rack-mounted infrastructure containing two to three enclosures with eight Blades apiece was updated and replaced with extension boxes housing up to six NVIDIA K3100M GPUs per CPU blade. Combining the CPU blades with the GPU extension boxes allows server administrators to provide six complete workstations and power 48 users per enclosure. This hardware was paired with Citrix XenServer, XenApp, and XenDesktop to deliver each remote user's allocated GPU and CPU resources."

The VDI setup could allow engineers to connect to the virtual workstations from mobile tablets, says Gonzalez. "But the issue is the screen space," he observes. "The current mobile devices have smaller screen, so it's not easy for CAD users to do the operations the way they're used to on larger monitors and laptop screens."

The primary motivation to pursue virtualization is cost, Gonzalez says. "Breaking down the per-user cost, it costs us 60% less to do with virtualization what we did with a 1:1 remote workstation setup," he estimates. DE

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

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➜ **HP:** HP.com

➜ **NVIDIA:** NVIDIA.com

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Year-End Workstation Evaluation

Four questions can determine if your workstation is up to the challenges ahead.

BY BETH STACKPOLE

It's the most wonderful time of the year and all, but in addition to the parties and presents, the end of the year is always a good time to take stock. For engineers, it's an opportunity to re-evaluate how well your workstation is holding up to support your design and simulation needs.

There are a number of factors that can help you determine whether a workstation refresh is in the cards before closing the books on 2014:

1. Is your team conducting the optimal number of design studies? There is no magic number, but given the growing complexity of products, regular and repeated design studies are a mandate. If your team is cutting corners on the frequency and type of design studies performed simply because it's a drag on the hardware, that could indicate the need for an upgrade.

2. Is analysis-led design a best practice? Does your company plan to push simulation up earlier in the design cycle to explore and optimize more alternatives prior to building physical prototypes? If so, a workstation that is three years or older may not be equipped with sufficient processor cores, memory, and other components to efficiently handle analysis-led design workflows.

3. Is your system optimized to run the latest simulation and CAD tools? To fully utilize sophisticated simulation and design software suites, make sure your systems meet the software's recommended requirements.

4. Is your workstation fast enough? If you are limited by the size or number of models you can simulate, or unable to test designs in a realistic virtual setting, you may need an upgrade.

Workstation Balancing Act

Computing hardware continues to improve, which further dates older equipment. For example, Intel recently launched its new Xeon E5-2600 V3 family of processors, based on its new 22nm Haswell microarchitecture that feature up to 18 cores. AMD also introduced three eight core CPUs built on its 32nm Piledriver architecture. Both AMD and NVIDIA have also launched new graphics cards that are faster and more efficient. (See "New Computing and Graphics Processors Drive Engineering Innovation," *Desktop Engineering*, November 2014.)

Computer manufacturers are already offering workstations with the new components, which means your older workstation just got slower by comparison. For instance, Dell claims its new Xeon E5-powered workstations with 2,133MHz DDR4 memory perform up to 4.7 times faster than the previous generation.

If your current workstation is just a year or two old, consider giving it a year-end boost by upgrading its RAM and installing a solid-state drive to satisfy your requirements for the new year. A computer that is three years old or older isn't likely to allow you to embrace analysis-led design practices on any grand scale.

New workstations make use of the new Intel Xeon E5-2600 V3 family of processors, as well as the latest graphic options from AMD and NVIDIA. *Image courtesy of HP.*

When specifying a workstation upgrade, balance these four components:

- **Processors**: Choose the fastest processor possible without necessarily opting for top-of-the-line performance.
- **Memory:** Configure system memory to be equal to or slightly more than two times the size of your largest CAD model.
- **Storage:** Whenever possible, solid state drives (SSD) should be part of the specification to ensure maximum impact.
- **Graphics:** Invest in the graphics that you need for your applications and workload.

Your current workstation may be able to support your needs, but the end of the year is the perfect time to ensure your most important enabler of optimized designs is up to the task. DE

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

INFO ➜ **AMD:** AMD.com

➜ **Dell:** Dell.com

➜ **HP:** HP.com

➜ **Intel:** Intel.com

➜ **NVIDIA:** NVIDIA.com

Structural Optimization: Philosophy or Science?

To achieve the best structural analysis, engineers must rely on more than software programs.

BY TONY ABBEY

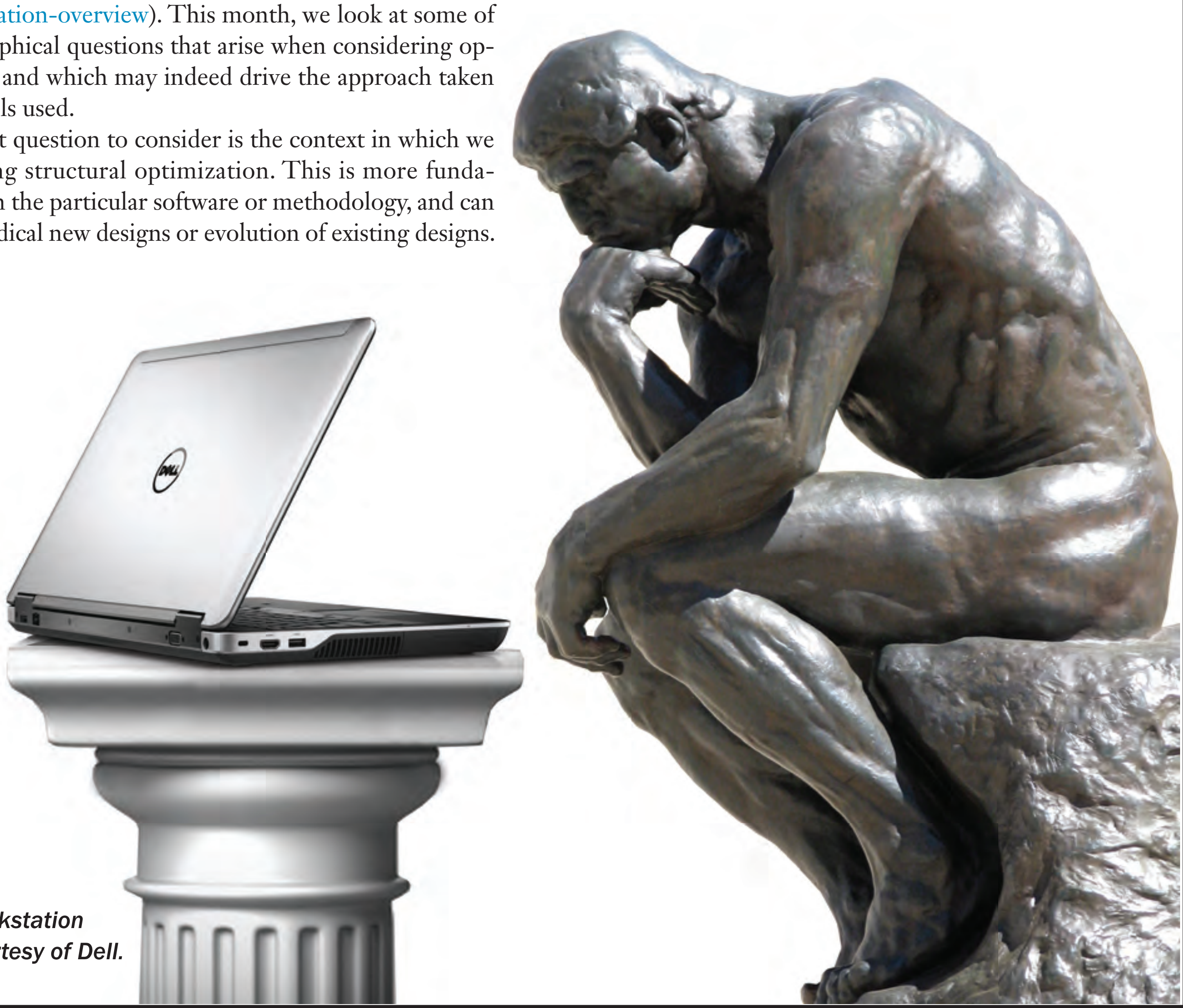
Editor's Note: Tony Abbey teaches live NAFEMS FEA classes in the US, Europe and Asia. He also teaches NAFEMS e-learning classes globally. Contact tony.abbey@nafems.org for details.

The December 2012 edition of *Desktop Engineering* included an article that introduced structural optimization concepts and methodology (see deskeng.com/de/an-optimization-overview). This month, we look at some of the philosophical questions that arise when considering optimization; and which may indeed drive the approach taken and the tools used.

The first question to consider is the context in which we are planning structural optimization. This is more fundamental than the particular software or methodology, and can embrace radical new designs or evolution of existing designs.

Radical New Designs

If we are looking for fresh new designs that break away from traditional configurations, then a topology optimization approach can be used. It is important to understand from the outset that we need to maximize the potential solutions that are achievable in practice and are considered optimal in a broad enough context.



Mobile workstation image courtesy of Dell.

Factors include:

- Uncertainty of operational environment
- Manufacturing feasibility
- Incompatibility with packaging requirements
- Ignoring of thin wall solutions
- Too radical a change from traditional designs
- Vulnerability to other environmental factors
- Aesthetic incompatibility

One of the biggest challenges to optimization is uncertainty of the operational environment. This can include external applied loads and boundary conditions. It may be that the overall design concept is not mature enough. For example an electronics chassis is to be mounted in a vehicle, but the location within the vehicle, attachment method, electronic component weight, maneuvering envelope, and crash scenarios have not yet been developed. In traditional finite element analysis (FEA) we would take care to idealize and analyze the structure with a view to providing preliminary sizing confirmation, approximate local response levels and other factors. We would expect to refine the model as the overall design progressed to a frozen state. How can we adapt this approach in an optimization strategy?

One way would be to use a robust optimization approach where the spread of uncertainty is included. Traditionally this is done with material properties and dimensional tolerances, but here variation in loading and boundary stiffnesses is more important. A robust optimization strategy relies on a very large number of analysis variations being run, evolving toward the most stable across a variation in input parameters.

Another approach would be to include the uncertain external design parameters into a multi-objective analysis. With two objectives we can look at trade off studies where each of the objectives is dominating in turn. In the electronics chassis example, these could become trends for resisting inertia loading level and supplying varying attachment stiffness. Useful guidance could be fed back into the overall design for the implications of high or low g loading with flexible or stiff attachment fittings. Typically hundreds if not thousands of design configurations would be evaluated. Each successful candidate design would be an optimum in its own right, so only best in class results are used for trade off studies. More than two objectives can be considered, but there is then a danger of not being able to visualize the tradeoffs in an intuitive manner.

It is interesting to note the traditional limitations to manufacturing are being overcome in some areas by 3D printing methods. We have all seen examples where an integral chain or gear train is produced which is impossible to manufacture and assemble using traditional methods. With the advent of structural materials into this arena, which allow further levels of optimization if they are orthotropic or anisotropic, wider possibilities emerge. I recently saw a 3D printed UAV (unmanned aerial vehicle) wing and blended body where the internal structure was more reminiscent of a bird's skeletal structure than a traditional spar and rib layout. Many radically new designs follow a similar relationship to natural structures, such as leaves, trees and root systems.

The UAV wing prompted an interesting discussion on where to store the fuel — or in general, packaging design. We often see topology optimization whittling away design space, but working around fixed "no go" volumes which are to contain fuel, electronics and motors. One of the challenges here is to avoid making upfront decisions about packaging volumes, which dictate the evolution of an "optimum" design, but in themselves are not optimal. I have not seen an integrated approach to this and would welcome examples. Conversely if the fuel volume is squeezed into available voids in the UAV optimum organic structure, then again we may be missing an overall optimum design, perhaps of a radically different configuration. In a similar way support and loading positions are often 'frozen' topology mesh zones, which remain intact. To be truly optimum the location of these zones should also be adaptable.

If we use 3D topology optimization to explore design space, then the resultant design will be biased towards organic 3D "solid" type structures. If the mesh fidelity in design space is high enough, then we can approach thin wall thickness. However there is no natural reason why the optimizer would recognize that a region of planar thin wall may be an ideal design trend. Again, I am not aware of any topology optimization tools that can recognize the emergence of a thin wall bias. The closest to this I have seen is when we have a 2D topology optimization space beginning to "checker board" over a region of the structure. Checker boarding occurs when an optimizer can't find a strong direct load path, so tries to spread the load through a physically unrealizable element based pattern of weak and strong material — rather like a sponge or honeycomb. It is useful to view this as an attempt to introduce an intermediate material thickness. I have successfully taken a region like this, defined it to be a thin shell idealization and turned the problem into a sizing optimization of the shell thickness.

Another possibility may be that the resultant design is too radical for the application. For example if the UAV wing concept described is to achieve certification in a manned aircraft then it would require an enormous amount of testing and analysis to validate the structure. No design guides for this type of configuration exist to help in the certification process and there is no operational experience. It is probably the way of the future, but it takes some time to establish the level of confidence required. However many applications will not be so restrictive and, in any event, selecting from a wide candidate configuration basis will always drive innovation. The level of radicalness needs to be tailored to the application.

When evolving a radical new design using topology optimization, the influence of loading and environmental issues beyond the basic design definition may have to be considered. For example a structure may be robust enough to survive all the defined load cases, but too fragile to be handled or assembled. A "chunky" structure that is traditionally only considered for strength requirements may now be a much more distributed slender structure, vulnerable to buckling or low resonant frequencies. A classic example of structural optimization saw the development of geodesic type aircraft structures, somewhat like a basket weave. These were lightweight, strong and stiff, but unfortunately had very poor fatigue characteristics.

Finally, the optimal solution may be aesthetically unacceptable. For consumer products, this may be a driving factor, but even cars, planes and ships are assessed this way. An organic, fibrous looking vehicle body may be ideal for stiffness, crash and crash worthiness, but may not have much curb appeal! An aircraft that is not contemporary in appearance may not inspire passenger confidence.

Evolution of Existing Designs

If a design is considered mature in terms of layout and configuration, then either sizing optimization can be used for fabricated structures idealized as thin shells and beams, or shape optimization can be used for thin shell or solid type structures.

Sizing optimization is based on changing the physical properties of the elements in the FEA mesh. This means the method is limited to idealizations using 1D or 2D elements. The method has a very long and successful history in industries such as automotive, maritime and aerospace with thin shell fabrications. The structural layout has been determined by other considerations, often using high level parametric optimization studies. The sizing optimization is then a search for an optimum within that pre-defined configuration.

However, I have started to see companies using this approach to evaluate stiffnesses of different load paths within a solid type component. A joint fitting, for example, can be broken down into bending and axial load paths with a high level of idealization using 1D elements. The motivation for such a drastic approach is to allow rapid sizing optimization of the simplified structure. This gives useful information about the importance of each load path and provides a direction for useful design evolution. The simplified structure also tells a clearer story as to "why" the structure is successful. Many thousands of configurations can be studied very quickly.

Traditionally, shape optimization used a fixed FEA mesh that was then distorted in some way, but kept the same topology. It was perhaps the most unusable type of optimization solution as methods to achieve candidate mesh distortions were tedious to set up and not very general. However modern methods have broken away from the traditional paradigm based on design variables (geometric features), objective function (mass) and constraints (stresses and deflections). Instead, the methods revert back to the very early optimality criteria approach. An optimality criteria, such as Fully Stressed Design, simply stated that a promising design evolution would follow a predefined criterion, such as trying to maximize stresses in all parts of a structural component to ensure it was working most efficiently. The modern shape optimization tools use more sophisticated criteria, such as stress homogeneousness (the stresses should flow smoothly throughout a structure) and control the mesh perturbations in a more sophisticated way, including re-meshing if required.

Shape optimization seems to work best when honing a mature design. For example quite subtle changes in hole or fillet profiles can make significant changes to local stress concentrations and hence fatigue life.

Overall, some caveats apply equally to refining mature designs as when evolving radical new designs:

- Uncertainty of operational environment
- Manufacturing feasibility
- Incompatibility with packaging requirements

General Observations

Whichever stage of optimization is being considered, some common recommendations include:

- The physics of the engineering structure must be fully understood before any meaningful optimization can be attempted.
- The FEA implementation of the structure must be sound, modeling errors will usually invalidate an "optimum" solution.
- The scope of the optimization study must be clearly defined — conceptual or derivative.
- The breadth of the study must be realistic. Will we be able to make sensible engineering judgments based on the answers we get back?
- Will the volume of output data swamp our decision making process?

There are many more practical or philosophical questions that could be asked to make sure that the "optimum" that is delivered is valid and meaningful to us in design. DE

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

3D Printing at Your Door

Start-up company 3D Hubs aims to bring additive manufacturing to a local level on a global scale.

BY JESSICA LULKA

The 3D printing market raked in $3.07 billion in 2013, achieving its highest compound annual growth rate (34.9%) in 17 years, according to industry research and consulting firm Wohlers Associates. While there is still plenty of room for growth, there are a number of 3D printers out there not living up to their full use potential.

Enter 3D Hubs, a company based in Amsterdam that looks to bring people in need of 3D printing together with 3D printer owners via decentralized, local manufacturing. Founded in 2013 by two former 3D Systems employees, the company now has Hubs all across the globe — from New York to Tehran. In fact, the company recently opened a second office in its New York community, which has 636 end users who can access 140 local 3D printers.

Members of regional communities can plan events to discuss ideas, show projects and help promote 3D printing technology. *Images courtesy of 3D Hubs.*

"We have now built the biggest decentralized production there is," says Filemon Schoffer, head of community at 3D Hubs. The network boasts over 8,000 Hubs, with new printers being added daily, according to Schoffer.

How Does 3D Hubs Work?

To create a print, 3D Hubs users can upload their files to a service such as Thingiverse or Cubify and select a local printer in the area. The Hub will then receive notification of the job and can decide to accept or decline the offer within 24 hours.

If a print job is accepted, the file is then sent to the team at 3D Hubs. The team checks the watertightness of the model and makes any needed repairs with automated software. Once the model has been prepared and is ready to go, the object is printed. The designer can then arrange to meet with the printer or simply have the prototype shipped. The company has also added 3D modeling, finishing, shipping and support material for Hubs that may need outside services.

Once an order is completed, customers have the opportunity to review it with a 5-star rating system. A Hub can be rated on the four following areas: print quality, service, speed and communication. This is also a chance for customers to provide feedback to the Hub and 3D Hubs.

If a service is unsatisfactory, or a dispute arises, Schoffer says the company will reach out to the respective parties and act as a moderator to figure out a solution for both. Because it's a young market, he says the company is proactive about fixing issues, but that disputes are rare within communities.

Pricing and Materials

The Hub owners themselves decide how much they decide to charge per print. When setting prices, 3D Hubs suggests owners price similarly to other community members. According to the company, average earnings per print are $38 (€30), but some jobs have earned more than $300 (€250).

Hub owners can list a printer for use at no cost. Once the Hub becomes operational, 3D Hubs takes 15% of each order for start-up costs, and the owner pays for materials. While any type of system can be used, Schoffer says 3D Hub's pricing system is optimized for Fused Deposition Modeling (FDM) printing.

Available materials vary depending on a specific Hub.

With over 8,000 printers worldwide, Hubs can offer materials such as PLA (polylactic acid), ABS (acrylonitrile butadiene styrene), FlexPLA, Wood, T-Glass and more.

Opportunities & Challenges

While targeted primarily to makers, engineering teams could make use of 3D Hubs. One option is to establish a Hub and start printing. This is an outlet for engineers to use their printing resources regularly and have the chance to earn money as well as collaborate with other designers in the area.

Additionally, engineers could use the service for their own 3D prints, possibly benefitting from faster delivery times and lower production prices if printers are found within their city or even neighborhood. In the ideal scenario, shipping is not needed, and the printer and end user can meet as soon as the project is completed, Schoffer says.

Some professional engineers are already using the service. For example, smartphone manufacturer Fairphone aims to make its products with transparent practices and conflict-free materials. It recently decided to manufacture all of its smartphone accessories through 3D Hubs' printers.

"We're disrupting now how the way things are being made by companies, so it's a lot more than just connecting people with 3D printers to people who want to 3D print," Schoffer says.

Though 3D Hubs does offer opportunities for both professional engineers and makers, there are also some challenges to the program when compared to a more traditional 3D printing or rapid prototyping service bureau. First is availability of materials and equipment. Because each Hub is run by an individual, specific materials and colors may not be offered. The manufacturing is often done with a single printer, so local Hubs are often not equipped for large-scale jobs.

Another potential hurdle to using 3D Hubs is location. The network is expanding and adding new hubs regularly, but there still is no guarantee of finding a printer nearby.

The third challenge to overcome is expertise. Most traditional 3D printing service bureaus will guide customers through their project and suggest the best 3D printing technologies for their needs, but 3D Hubs relies on its community for that.

More than A Printing Service

3D Hubs' communities are a way for makers and printers to connect outside of the traditional business transaction. One popular way for community members to connect is through hosted events, which can range from 3D printing roundtables to meetups, store openings and more.

"The maker movement became very strong on our platform, so we definitely brought them in touch [with one another] to share, tell them how to be a successful Hub and basically leverage from the community as a whole," says Schoffer. "I believe [it's beneficial] to get people together and talk. Online is good for business and can do a lot, but it's missing that community aspect."

The 3D Hubs network has over 8,000 available 3D printers listed worldwide.

To monitor every community, 3D Hubs has established the role of mayor. Responsibilities for this role include event organization, community support and community growth. It is also a way for 3D Hubs to promote its business offline. Mayors are available to Hub owners as support staff to help them grow their own businesses and bring 3D printing to the community at large. With mayors, the company is able to host more events worldwide, and recently held 13 events in one week. "It's a social effect, it's also a bit of belief," Schoffer says. "We believe it's the way to go, the way to approach the maker movement."

Also available is Talk, an online community for users to ask questions, share projects and print as well as announce events. This offers Hubs that may be in remote locations — such as Tahiti or Central Russia — a chance to be a part of 3D Hubs' communities, even without needing to be physically near other Hubs. This online community is still in beta, Schoffer says, and is something the company is hoping to expand and eventually offer as specialized communities for different interest areas of 3D printing.

"Aside from connecting individuals to individuals, the whole company aspect will be very important … We really want to see the impact of bringing manufacturing into the hands of the people on a professional level," he says. **DE**

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

INFO ➜ HP: 3D Hubs: 3DHubs.com

➜ Fairphone: Fairphone.com

3D Hubs

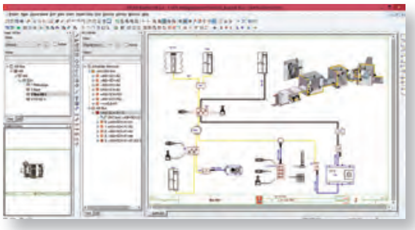
- **Founded:** 2013
- **Number of Registered Printers:** 8,635
- **Top Five Cities:**
  New York, Milan, Los Angeles, London, Amsterdam
- **Top Five Printers:**
  Formlabs' Form 1+, Zortrax M200, XYZprinting's Da Vinci 1.0, Stratasys' Dimension 1200, Wanhao's Duplicator 4

Data up to date as of October 2014

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.



Process-Oriented Engineering Solutions Updated

EPLAN works with CAE, PLM and ERP software to provide consistent data.

The theme of the EPLAN 2.4 release is greater engineering process efficiency. Perhaps the biggest step toward this is that EPLAN is now available in a 64-bit version. Efficiency also comes in such forms as simplified PLC (programmable logic controller) project planning in graphical overviews, subproject management and user-definable and configurable properties including default values for property selection lists.

Version 2.4 now implements additional check runs to automatically check and validate the parts management database and ensure managed data accuracy.

MORE ➜ deskeng.com/de/?p=19416

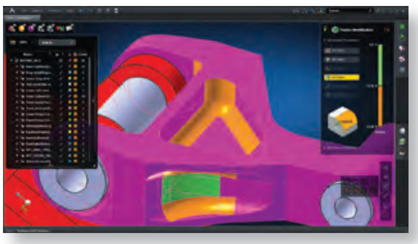
SimWise Version 9.5 Released

The program is ideal for integrated motion simulation, FEA and optimization.

SimWise enables users to simulate the rigid body dynamics of an assembly, size components, determine part interferences and collision response, identify stresses induced by motion, produce animations and even test your control systems.

Version 9.5 introduces functionality that will transfer dimensions and other parameters to SimWise for use as optimization variables. The new version also includes an updated 3D FEA (finite element analysis) mesh generator and added support for 3D navigational devices from 3Dconnexion.

MORE ➜ deskeng.com/de/?p=19752



MSC Software Launches Parts-Based CAE Platform

The application is the first system based on computational parts, MSC states.

MSC Apex is a fully integrated and generative simulation environment that provides full associativity between geometric and analysis data.

The key is that MSC Apex is built on a CAE-specific direct modeling and meshing engine. It supports integrated solver methods that let you interactively validate parts and subsystem models by pulling, pushing and doing all those other neat direct-modeling actions.

The first component available is MSC Apex Modeler, which provides the CAE-specific direct modeling and meshing functionality for streamlining CAD cleanup.

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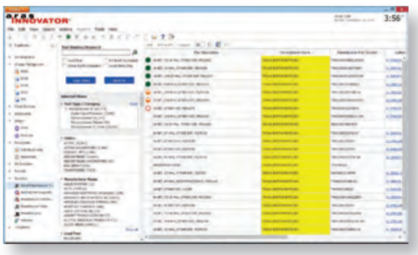

Aras Adds 100 Million Electrical Components for PLM

The company embeds the IHS CAPS database into its Innovator suite.

Aras Component Engineering embeds access to the cloud-based IHS CAPS Universe electronic component database inside of Aras Innovator. This functionality means that designers, engineers and sourcing people get access to data on some 100 million commercial electronic components in 400 categories from 2,000 or so manufacturers directly from your Aras PLM (product lifecycle management) environment.

Users can search by manufacturer part number, manufacturer name and keywords and compare parts side by side.

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LMS Imagine.Lab Amesim Optimizes Engine Block Early

MCE-5 DEVELOPMENT uses Siemens PLM Software solutions to clarify costs and save time on VCRi project.

Automotive original equipment manufacturers (OEMs), suppliers and research institutes are working around the clock to come up with a cleaner and greener automotive engine. One research company in Lyon, France, MCE-5 DEVELOPMENT SA, is in the midst of developing an engine block, the MCE-5 VCRi, a promising research and development (R&D) project that seeks to combine ideal gas engine performance with requisite eco-friendliness.

Variable compression ratio (VCR) may be one of the most reliable solutions to get the most out of gasoline engines. Saab and FEV Motorentechnik took the first steps with this technology in 2000. Both companies demonstrated that VCR enables spark ignition engines to meet market expectations.

But producing VCR engines represents a technological challenge and requires large changes to the mechanical definition of the engine. Different VCR prototypes have confirmed the technology's potential, but they also revealed that designing VCR engines that meet mass-production requirements is a tremendous technological feat. The next step is to study and identify a design that fulfills all the necessary features for a mass-produced engine in terms of functionality, robustness, reliability and durability at a reasonable production cost.

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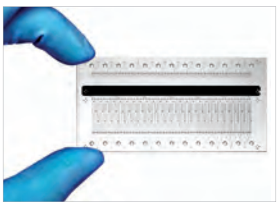
Cytonome Optimizes Workflow with Omnify Empower

Centralized and automated development processes get Cytonome accolades from ISO auditor.

Cytonome develops, manufactures and markets cell purification systems worldwide for BioMedicine, BioIndustry, and BioScience. The company's technology is combined with optical detection for the precise and safe selection of discrete cell subpopulations. Its BioMedicine products are aimed at cGMP-compliant cell purification using a closed, sterile and disposable cartridge to guarantee operator safety and sample isolation.

Manual Data Entry, Disparate Systems

Cytonome's engineering department has an innovative focus to developing new products. Engineering works quickly to develop concepts and manufacturing works in parallel during the prototype phase. Efficient communication among engineering, manufacturing and purchasing is critical, so Cytonome needed to create a product development environment to ensure this. The company managed product development with tools that did not communicate with each other. Product information was converted from SolidWorks to Excel spreadsheets. Cytonome was having a difficult time with this environment because information had to be manually entered into each system, which took up valuable employee time, introduced costly human data entry errors and resulted in systems containing incorrect or out-of-date information.



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Commentary

by Jacek Marczyk

Manage Design Complexity

The complexity of modern products, as well as the associated manufacturing processes, has increased over the past few decades and there is evidence the trend will continue. Complexity means functionality. Consider how many things can be done with smartphones, in addition to making phone calls. Think of automobiles, which can maintain distance from the car in front, or engage emergency braking, not to mention warn drivers if they drift from one lane into another. Evidently, an increase in complexity points to growth, to evolution. Think of the biosphere. From single-cell organisms, capable of performing only basic functions, evolution has spawned intelligent and sentient beings. So, on paper, an increase in complexity is good, but it comes at a price.

Creating a Definition

Let's first define complexity. Complexity is not about counting the number of parts or components in an assembly, or the number of functions a product performs. Complexity is a function which takes into account two major aspects of a system: the topology of the information flow inside it — basically the "mapping" of what happens between the inputs — and the outputs and the "uncertainty" involved in this flow. This second component, of paramount importance in nature, is called entropy. In engineering, entropy has many faces: manufacturing tolerances, scatter in material properties, assembly imperfections, uncertainty in operational conditions, etc. The more entropy, the less accurate and predictable a system's behavior is. But, because in nature entropy can only increase, things degrade and become less predictable and precise. In essence, the number of inputs and outputs, as well as the network of inter-dependencies between them define how complicated — not complex — a system is.

Complexity: If you can't measure it, you can't manage it.

When entropy (uncertainty) is added to the picture, we obtain a measure of complexity. Complexity manifests itself in the ability of a system to deliver unexpected behavior. A complicated watch movement cannot deliver surprises. A child can. The higher the complexity the more "modes of behavior" a given system can embrace. This means that if products become more sophisticated and more functional, it is necessary to resort to higher manufacturing quality, to better materials, and to stricter tolerances to maintain quality and avoid surprises.

The Changing Workforce

Evidently, complexity means cost. A more complex product is more expensive to design, engineer, manufacture, service and operate. An experienced engineer may be recognized by the fact that they instinctively seek a simpler more elegant solution to a given problem. However, today there are less experienced engineers around than there were in, say, the 1970s or 1980s. The speed of our economy pushes people to change jobs more often, meaning that it is increasingly difficult to find engineers who remain for decades in the same company, gaining huge amounts of specialized experience and knowledge. Moreover, the turbulences in the global economy are affecting corporations at top management levels, not just the employees. When turnover of management is high, it may inhibit the chances for long-term programs to complete successfully. This is why programs such as the F-35 multi-role/multi-everything fighter, the 787 and the A380 have been slow to deliver products that, in some cases, still cause problems long after launch.

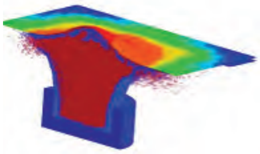
In the mentioned cases we're talking of innovative products that are highly complex and built by international consortia, scattered over the globe. Cultural differences, high employee turnover, a plethora of different procedures, very low profit margins, focus on short-term revenue and a turbulent economy all make it very difficult to run a complex program of global proportions and finish in time as well as within budget. If that were not enough, another alarming trend is the declining level of preparation seen in university graduates. Putting all these factors together may help explain why the manufacturing industry is struggling to roll out complex innovative products in a timely and efficient manner.

Moving Forward

There are two possible approaches at this point. One is to focus on the development of less complex, less ambitious products and, maybe most importantly, with less geographic dispersion. In the past aerospace companies built an entire aircraft, today their function is to try to fit together fuselage sections manufactured on two continents. The second approach is to incorporate complexity as a design attribute and objective, just like stiffness, safety factor, mass or cost. However, to accomplish that, one must measure complexity. If you can't measure it, you can't manage it. Counting parts or suppliers won't do the trick. DE

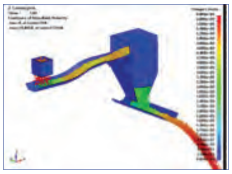
Jacek Marczyk *is president, head of reserach & development at Ontonix Quantitative Complexity Management. Send email about this article to DE-editors@deskeng.com.*

Livermore Software Technology Corporation

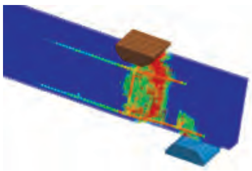


Four New Solvers for Multiphysics Purposes

Discrete Element Sphere (DES)



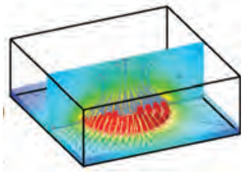
The DES (Discrete Element Sphere) is a particle-based solver that implements the Discrete Element Method (DEM), a widely used technique for modeling processes involving large deformations, granular flow, mixing processes, storage and discharge in silos or transportation on belts. In LS-DYNA, each DE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



Here are some distinct features of the bond model:

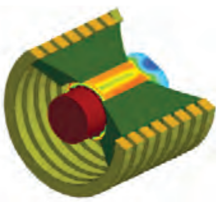
1. The stiffness of the bond between particles is determined automatically from Young's modulus and Poisson's ratio.
2. The crack criteria are directly computed from the fracture energy release rate.
3. The behavior of bond particles is particle-size independent.

Incompressible CFD



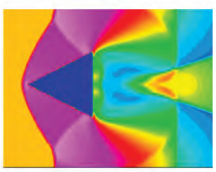
The incompressible flow solver is based on state of the art finite element technology applied to fluid mechanics. It is fully coupled with the solid mechanics solver. This coupling permits robust FSI analysis via either an explicit technique when the FSI is weak, or using an implicit coupling when the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

Electromagnetics



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

CESE/Compressible CFD



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

LS-OPT 5.1.0 is currently available with the following new features:

- Parallel Neural Networks to accelerate the building of complex metamodels.
- Exporting metamodel formulae, e.g. for plotting or use in third party solvers.
- Solver interfaces to additional Third Party FE solver, Excel and LS-OPT. The last feature allows construction a multilevel optimization problem.
- Graphical enhancements such as categorization of simulation results, subdomain-based sensitivity analysis and enhanced histogram displays for reliability analysis.

Available for Purchase:

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- Getting Started with LS-DYNA® Implicit Course Notes
- Available pdf presentation (no fee) LS-DYNA CFD Analysis ICFD Solver Features

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